VEGETATION PATTERNS, FLORISTICS, AND ENVIRONMENTAL RELATIONSHIPS IN THE BLACK AND CRAGGY MOUNTAINS OF NORTH CAROLINA

by

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DONALD EVANS McLEOD. Vegetation Patterns, Floristics, and Environmental Relationships in the Black and Craggy Mountains of North Carolina (under the direction of Albert E. Radford.)

ABSTRACT. The Black and Craggy Mountains of North Carolina consist of approximately 35,000 ha with a topographic relief of over 1219m, and include the highest mountain in eastern North America, Mt. Mitchell (2037m). The overall objectives of the study were (1) to inventory and analyze the flora and (2) to document the correlations between vegetation and environmental factors/gradients with the goal of determining those factors most likely controlling the vegetational variation.

The flora consists of 972 species in 115 families which indicates high floral diversity compared with other southern Appalachian areas. Sixty-four southern Appalachian endemics are found in the study area. These can be categorized into upper and lower-middle elevation species. The upper elevation species are mostly species of treeless open areas which probably became isolated in patchy subalpine barrens during the Pleistocene. The lower-middle elevation endemic species are species of acid soils, oak forests, and mesophytic forests. Disjunct patterns include disjunctions between the flora of the study area and Asia (26 genera), so-called Arcto-Tertiary refugia (37 genera) and the Coastal Plain (21 species). Separation of species during the

Tertiary with subsequent distribution by migration best explains the Arcto-Tertiary disjunctions while the Coastal Plain-mountain disjuncts may represent jump dispersal during the Holocene.

The vegetation was studied through the combined use of numerical classification (TWINSPAN) and ordination (DECORANA) analysis of 156 0.1 ha sample plots. The vegetation was classified into five community cover classes and 17 vegetation types, named primarily for canopy dominants. Vegetational composition was highly correlated with three complex gradients: (1) elevation, (2) topographic-moisture and, (3) soil nutrients-pH. These relationships were used to generate a vegetation-environmental gradient model of the Craggy and Black Mountains which is generally applicable to other southern Appalachian areas.

Species richness (number of species per 0.1ha) is greatest in moderately low elevation mixed forests in a mesic to dry-mesic position on the topographic-moisture gradient which are growing on soils slightly less nutrient rich than the richest soils. Soil reaction (pH) is a moderately good predictor of species richness (r^2 =.71).

Based on floristic differences the hypothesis is developed that grassy balds develop from fire meadows that have been grazed and trampled.

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INTRODUCTION

The Black and the Craggy Mountains of North Carolina include the highest mountains in eastern North America, with topographic relief of over 1219 m (4000 Ft.). These mountains support a number of vegetation types and a rich and diverse flora.

The overall objectives of this study are (1) to inventory and analyze the flora and (2) to document the correlations between vegetation and environmental factors with the goal of determining those factors most likely controlling the vegetational variation.

The southern Appalachian mountains, including the Black and the Craggy Mountains, have attracted botanists and plant collectors since the early settlement of the New World (see Core 1970). The first European known to have ascended the Black Mountains was Andre' Michaux, a French plant explorer, who traversed the area in 1789 (Schwarzkopf 1985). Other early botanists known to have explored these mountains include M.A. Curtis, S.B. Buckley and L.R. Gibbs.

The most comprehensive vegetation study of the area was performed by Davis (1929, 1930). He classified the vegetation into three major formations: the Spruce-Fir Formation of high mountains slopes and ridges; the Northern Hardwood Forest Formation of intermediate slopes, ridges and coves; and the Appalachian Forest Formation of lower coves, slopes and ridges. He states that he identified over 700 species of plants, including

bryophytes, although he did not collect voucher specimens. Davis, who worked out of Montreat, North Carolina, during his studies did not have the advantage of the Blue Ridge Parkway for access. He did not go north of Big Tom peak on the main ridge of the Black Mountains and spent little time in the mesic, north flowing Cane, Ivy and South Toe River Systems (Davis personal communication).

Among studies that include portions of the study area are those of Ramseur (1958, 1960: high mountain communities); Dickison (1980: arborescent plants in Walker Cove Research Natural Area); Runkle (1979: gap phase dynamics in Walker Cove Research Natural Area); DeLapp (1978: red oak communities in upper South Toe drainage); Kring (1965: succession in Craggy Gardens); McLeod (1981: plant communities in Black Mountain Research Natural Area); and Richardson and Valentine (1983: arborescent vegetation and soils in Black Mountain Research Natural Area). A number of inventory reports prepared for the North Carolina Natural Heritage Program, the National Landmarks Study, and reports for A.E. Radford's ecosystematic classes include parts of the area, especially the Craggies (e.g., Boufford et al. 1974; Pittillo 1976; Pittillo and Govas 1978; Smith 1976; Seaton 1980; Radford 1976). Because Craggy Scenic Area has been proposed as a Wilderness Area, an Environmental Impact Statement and Wilderness Study Report has been prepared of this area (USDA 1982). Although

these studies provide information about the area, there has been no comprehensive vegetation or floristic study of the Black and Craggy Mountains since that of Davis (1929, 1930) over fifty years ago.

STUDY AREA CHARACTERISTICS

The Black and the Craggy Mountains are located in Yancey and Buncombe Counties, North Carolina in the Southern Section of the Blue Ridge Province of the Appalachian Highlands (Radford et al. 1980). The area encompasses approximately 35,000 ha (86,485 acres) between latitude 35° 41' and 35° 53' N and longitude 82° 9' and 82° 25' W. These mountains, located west of the Blue Ridge Divide and east of the Smokies, are roughly the shape of a 'Y', with the Black Mountains forming the arms and the Craggy Mountains forming the stem (Figure 1). The Black Mountains have 21 peaks over 1830m (6000 feet) including Mt. Mitchell-2037m (6684ft.) the highest mountain in eastern North America. Above 1500m (4921 feet) the Blacks support a well-developed spruce-fir (Picea-Abies) forest and contain the southernmost station for Betula cordifolia (mountain paper birch). The Craggies are somewhat lower; their highest peak, Craggy Dome, is 1853m (6080 feet). In the Craggies deciduous forests (yellow birch, beech, mountain ash, and yellow buckeye), heath balds, and grassy balds, rather than spruce-fir forests, are found at elevations of 1500-1850m (4921-6070 feet). The elevation ranges from 730-2037m (2395-6684 feet), with the mean differential to baselevel of the major streams being approximately 1100m (3609 feet) in the Black Mountains and 914m (3000 feet) in the Craggies.

Drainage Systems

The Black Mountains are drained on the east by the South Toe River and on the west by the Cane River, both flowing north and joining the North Toe. Their merging forms the Nolichucky River, which flows into the French Broad River which is a part of the Mississippi Drainage System. The Craggies are drained on the east by the Swanannoa River, and on the west by the Ivy. These two rivers also flow into the French Broad River. The only area that is in the Atlantic Drainage is along the Blue Ridge Escarpment, which drains on the east and south into the Catawba River (Figure 1).

Geology

The Black and Craggy Mountains are part of the Blue Ridge Thrust Sheet, which is composed of Precambrian rocks of the lower Ocoee Series, a very thick, late Precambrian sequence of clastic rocks (Butler 1972 and 1973). Keith (1905) mapped the rocks of the area as part of his Carolina Gneiss. Hadley and Nelson (1971), in their maps of the Knoxville Quadrangle, included most of the rocks in their Great Smokey Group, undivided, with the lower slopes of the east side of the Blacks and the South Toe Valley being in the Spruce Pine Rock Group. More recently, Howell (1974) and Lesure et al.(1982) have prepared reports on the Celo Quadrangle and Craggy

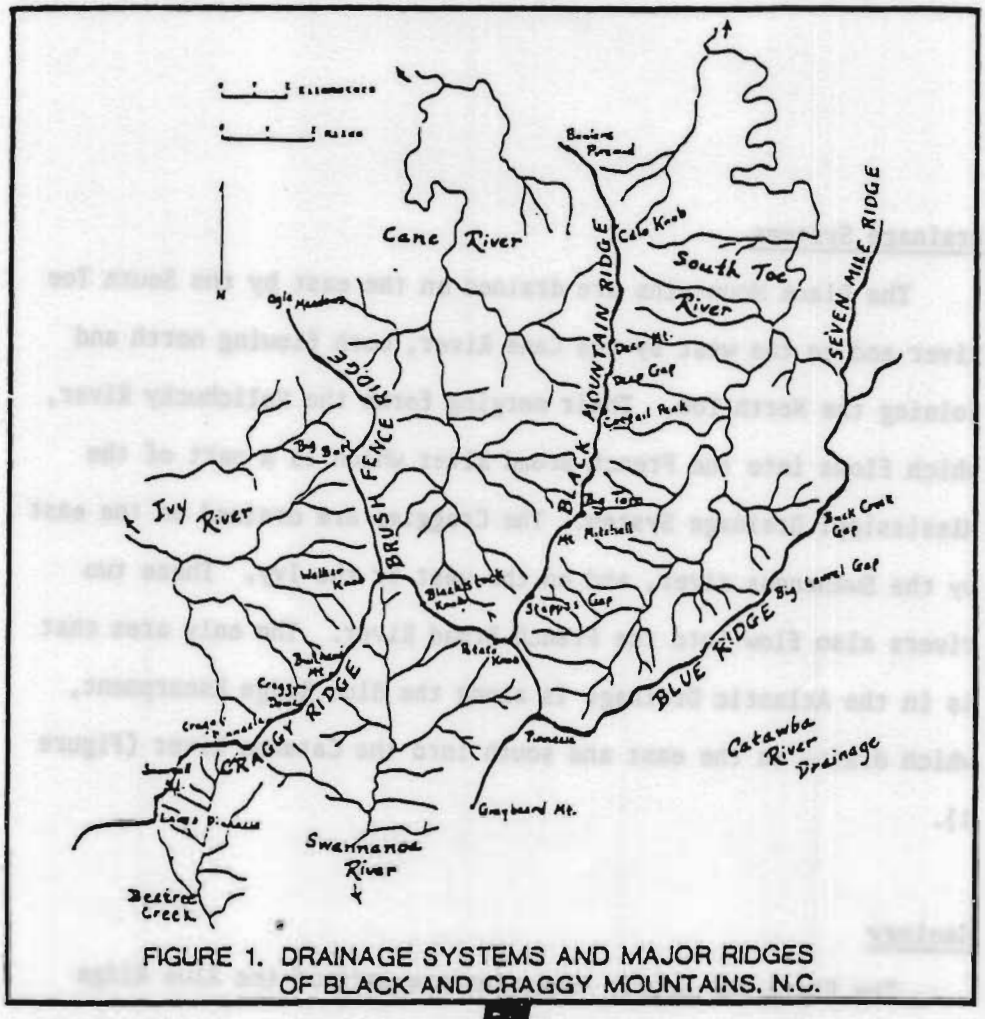
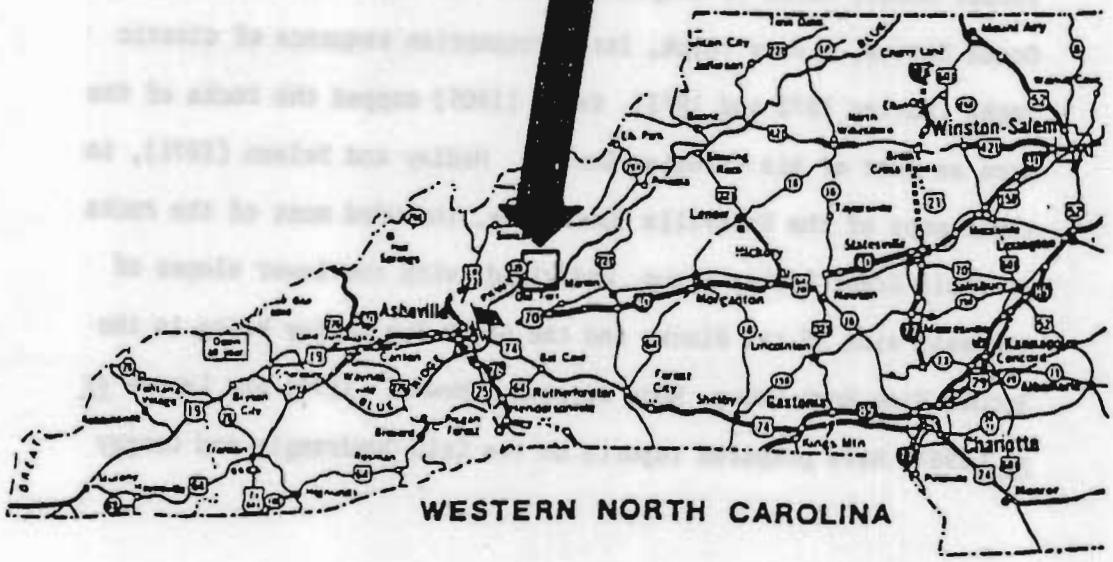


FIGURE 1. DRAINAGE SYSTEMS AND MAJOR RIDGES OF BLACK AND CRAGGY MOUNTAINS, N.C.



WESTERN NORTH CAROLINA

Mountain Wilderness Study Area, respectively. Both of these studies report mica-garnet schist as the most common rock type in the area; the rocks in the Blacks usually contain slightly more kyanite than those in the Craggies. There are also layers of quartz-biotite gneiss, or metasandstone, interlayered with the mica-garnet schist. A few lenses and thin layers of hornblende-feldspar gneiss, or amphibolite, are found at various localities, notably on the lower west slopes of Seven Mile Ridge (Howell 1974), Cattail Creek, the north fork of Ivy Creek (Hadley and Nelson 1971), and a small dike in Carter Creek drainage (Lesure et al. 1982).

Soils

The soil surveys for both Yancey and Buncombe Counties are in progress. The following section is based on an interim report for Buncombe County (Bailey et al. 1977) and discussions with Robert Ransom, the soil scientist in Yancey County. Due to the ongoing nature of the soil survey, certain of the names are tentative and subject to change. Table 1 is based on a preliminary outline of the soils of the area by Robert Ransom using modern soil taxonomy criteria (Soil Survey Staff 1975). This table presents the soils of the area in three categories by genesis (residial, colluvial, alluvial), then breaks these into groups by topography, especially elevation.

The lower elevation 1067m (3500ft) residual and colluvial soils are all Ultisols which are generally deep and weathered. These soils are generally acid in reaction (Buol et al. 1980) with the exception of Clifton series soils which have developed over Amphibolite (hornblende gneiss) which are less acid (pH 5.0 - 6.0) than the others. These Ultisols are Udults (in the great group Hapludults) which are soils of humid regions where dry periods are short, organic contents are low and the water table is below the solum most of the year (Buol et al. 1980).

The intermediate to high mountain residual and colluvial soils are all Inceptisols "which are soils having profile features more weakly expressed than mature soils and retaining close resemblances to the parent material" (Buol et al. 1980). These upland soils are generally found on highly resistant parent material and on steep lands. There is some disagreement among soil scientists whether some of these soils are residual or colluvial (Daniels et al. 1984).

Above about 1400m (4600ft.) on north to east facing slopes and above about 1525m (5000ft.) on south and west facing slopes are soils which are recognized as being in the frigid soil temperature regime (Daniels et al. 1984). Three residual soils are recognized in these upper elevations, Burton, Craggey and Wayah. The only colluvial soil currently recognized is Tannasee

Table 1. Soils of the Black and Craggy Mountains, North Carolina

1. Residual (formed over bedrock)

A. Low to intermediate elevation mountain ridges, side slopes and rolling to steep valley foothills 610-1067m (2000-3500 feet)

ORDER	SERIES	SOIL FAMILY	BRIEF DESCRIPTION	PERCENT SLOPES
Ultisol	1. Clifton	Clayey, mixed, mesic Typic Hapludults	Deep, red clay or clay loam subsoil, more than 60" to bedrock (Amphibolite)	15-30
Ultisol	2. Cowee	Fine-loamy, mixed, mesic Typic Hapludults	moderately deep, red, medium textured, 20 to 40" to rippable bedrock	30-50
Ultisol	3. Evard	Fine, loamy, oxidic, mesic Typic Hapludults	Deep, red, medium textured, more than 40" to rippable bedrock and more than 60" to hard bedrock	8-15
Ultisol	4. Fannin	Fine-loamy, micaceous, mesic Typic Hapludults	Deep, or very deep red high mica, medium textured, more than 6' to bedrock	8-15

Ultisol	5. Watauga	Fine-loamy, micaceous mesic Typic Hapludults	Deep, or very deep, yellowish,brown or strong brown, high mica, medium textured more than 6' to bedrock	8-15

B. Intermediate to high elevation mountain ridges and side slopes 1067-1463m (3500-4800 ft.)

Inceptisol	6. Cashiers	Coarse-loamy, highly micaceous, mesic Typic Dystrochrepts	Dark surfaced, deep brown loams, highly micaceous	5-30
Inceptisol	7. Chandler	Coarse-loamy,micaceous mesic Typic Dystrochrepts	Deep yellowish, brown, loamy, highly micaceous	2-8
Inceptisol	8. Chestnut	Coarse-loamy, mixed, mesic Typic Dystrochrepts	Moderately deep, yellowish brown loams and sandy loams 20-40" to rippable bedrock	8-15
Inceptisol	9. Edneyville	Coarse-loamy, mixed mesic Typic Dystrochrepts	Deep, coarse textured loams and sandy loams more than 40" to rippable bedrock more than 60" to hard bedrock	8-15
Inceptisol	10. Porters	Coarse-loamy, mixed, mesic umbric Dystrochrepts	Dark surfaced, moderately deep loams	15-50

C. Very high elevation mountain tops and slopes 1463m (4800 Ft)

Inceptisol	11. Burton	Coarse-loamy, mixed frigid Typic Haplumbrepts	Very dark surfaced, high organic matter, moderately deep loams 20 to 40" to rippable bedrock	5-60
Inceptisol	12. Craggey	Loamy, mixed, Frigid, Litnic Haplumbrepts	Very dark surfaced high organic matter, shallow loams 10-20" to hard bedrock	8-40
Inceptisol	13. Wayah	Coarse-loamy, mixed frigid Typic Haplumbrepts	Very dark surfaced high organic matter with depth greater than 60"	8-15

2. Colluvial Soils (gravity deposited materials)

A. Low to intermediate valley footslopes, coves and benches.

Ultisol	14. Brevard	Fine-loamy oridic mesic Typic Hapludults	Very deep, red, oxidic loamy subsoil, greater than 6' and often greater than 10' to bedrock	0-8

B. Intermediate to high elevation mountain coves, benches and footslopes along streams

Inceptisol	15. Tusquittee	Coarse-loamy, mixed mesic Umbric Dystrochrepts	Very deep soil with thick dark loam surface layers and yellowish brown subsoil greater than 6' to bedrock	15-30

Inceptisol	16. Spivey	Loamy-skeletal, mixed mesic Typic Haplumbrepts	Very deep soil with thick dark very stony loam surface layers and yellowish brown very stony or very bouldery subsoil, more than 5' to bedrock	8-30

C. Very high elevation mountain tops and slopes 1463 m (4800 ft.)

Inceptisol	17. Tanasee	Loamy-skeletal, mixed, frigid Typic Haplumbrepts	Very deep soil with thick dark very stony loam surface layers and yellowish, brown very stony subsoil, more than 5' to bedrock	8-30

3. Alluvial (formed in sediments deposited by flood waters) — Flood Frequency

A. Flood plains or low lying bottom lands

Entisol	18. Biltmore	Sandy, mixed, mesic Typic Udifluvents	Well drained to moderately well drained loamy fine sandy, sandy loam, over loamy sand or sand	Frequently
Inceptisol	19. French	Fine-loamy over sandy or sandy-skeletal, mixed mesic Fluvaquentic Dystrochrepts	Moderately well to somewhat poorly drained fine-loamy over sand or gravel	Occasional

Inceptisol	20. Rosman	Coarse-loamy, mixed, mesic Fluventic Haplumbrepts	Well to moderately well drained, coarse loamy (loam, fine sandy loam, silt loam)	Occasional
Inceptisol	21. Toxaway	Fine-loamy mixed, nonacid mesic cumulic Humaquepts	Very poorly drained black surfaced, loamy	Frequently
Inceptisol	22. Dellwood	Coarse-loamy, over sandy, skeletal, mixed mesic. Fluventic Haplumbrepts	'A' horizon 12" thick usually 1 to 1.5' over sandy gravel	Occasional
B. Stream terraces and lower valley footslopes				
Ultisol	23. Unison	Clayey, mixed, mesic Typic Hapludults	Very deep, red clay well drained high stream terrace	None

(Ransom personal communication).

These soils are all Umbrepts (great group: Haplumbrepts).

The alluvial soils of the area are also Inceptisols with the exception of the Biltmore Series which is an Entisol and Unison which is an Ultisol. In the South Toe Valley, Biltmore soils are next to the stream with Toxaway usually adjacent to them and then either French or Dellwood on the flood plain. Stream terraces are usually formed of soils of the Unison series.

Since the soil surveys are not complete, no attempt was made to correlate vegetation with soil types in this study.

Climate

The general climate of the area is warm temperate mesothermal (Köppen in Trewartha 1954). There are two weather stations located within the study area; Celo, 823m (2700ft) in the South Toe Valley and Mt. Mitchell, 2022m (6635ft) on the crest of the Black Mountains. A third station at the town of Black Mountain, 730m (2395ft) is to the south, just outside the study area. Data from these three stations are summarized in Figure 2 using climate diagrams as suggested by Walter and Lieth (1967).

The mean annual temperature varies from 12.9°c (55°F) at Black Mountain (730m) to 6°c(43°F) at Mt. Mitchell (2022m) which

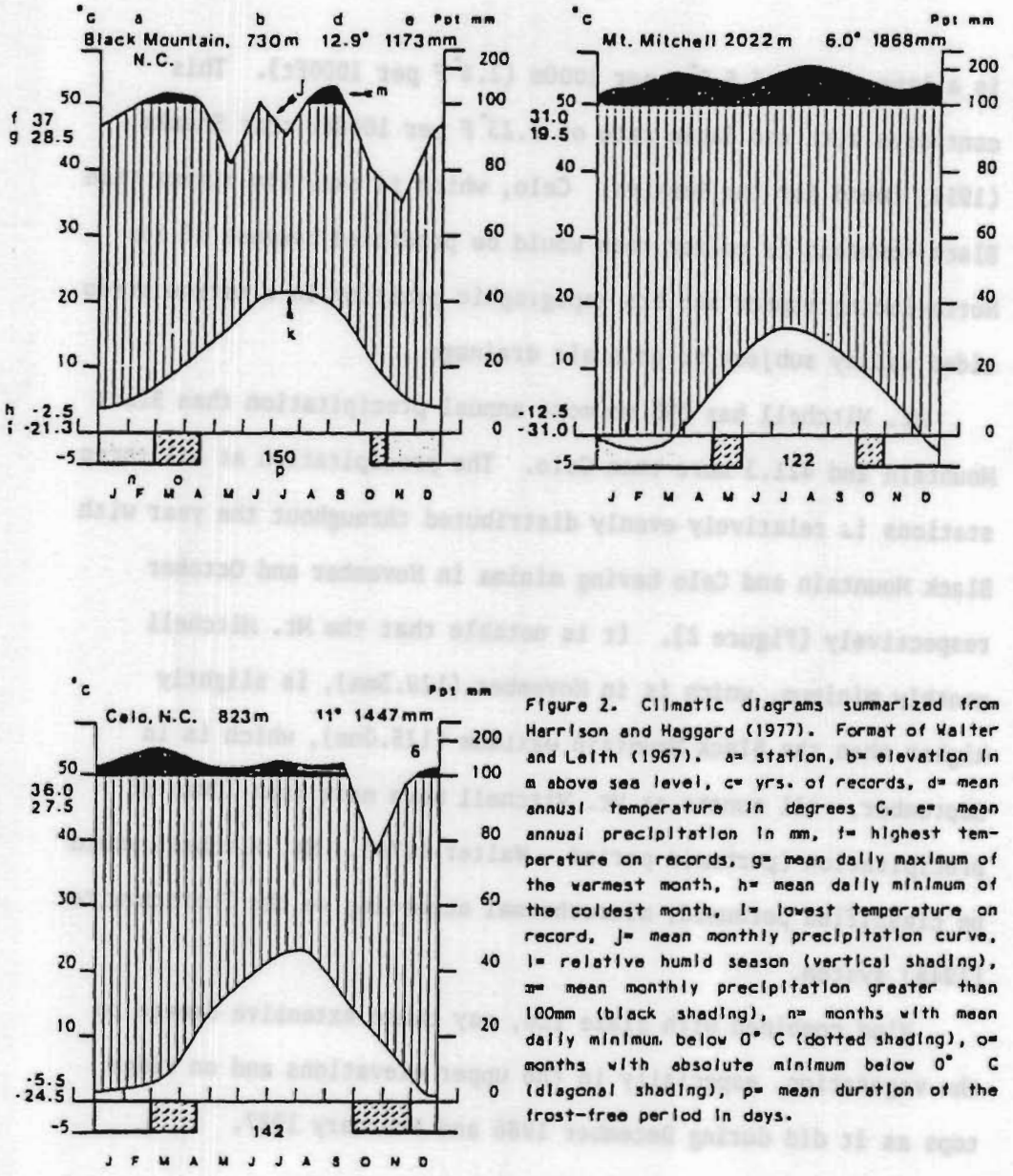


Figure 2. Climatic diagrams summarized from Harrison and Haggard (1977). Format of Walter and Leith (1967). a= station, b= elevation in m above sea level, c= yrs. of records, d= mean annual temperature in degrees C, e= mean annual precipitation in mm, f= highest temperature on records, g= mean daily maximum of the warmest month, h= mean daily minimum of the coldest month, i= lowest temperature on record, J= mean monthly precipitation curve, l= relative humid season (vertical shading), m= mean monthly precipitation greater than 100mm (black shading), n= months with mean daily minimum below 0° C (dotted shading), o= months with absolute minimum below 0° C (diagonal shading), p= mean duration of the frost-free period in days.

is a lapse rate of 5.5°c per 1000m (2.8°F per 1000ft). This contrasts with the lapse rate of 2.23°F per 1000ft that Shanks (1954) found for the Smokies. Celo, which is only 93m higher than Black Mountain is colder than would be predicted because of its North-facing aspect and its topographic position in a narrow steep sided valley subject to cold air drainage .

Mt. Mitchell has 695 mm more annual precipitation than Black Mountain and 421.3 more than Celo. The precipitation at all three stations is relatively evenly distributed throughout the year with Black Mountain and Celo having minima in November and October respectively (Figure 2). It is notable that the Mt. Mitchell monthly minimum, which is in November (129.3mm), is slightly higher than the Black Mountain maximum (125.0mm), which is in September. All months at Mt. Mitchell have more than 100mm of precipitation (perhumid period - Walter 1979). Mt. Mitchell would be classified perhumid, microthermal according to the Thornthwaite (1948) system.

Wind combined with glaze ice, may cause extensive damage to the vegetation, especially in the upper elevations and on ridge tops as it did during December 1986 and February 1987.

Land Use and Disturbance History

The larger valleys of the area have been occupied by European

settlers since the latter part of the 18th Century. By the 1860's many of the valleys and lower slopes of the mountains had been cleared for agriculture and pasture (Eller 1982). Selective cutting of choice trees in accessible areas had relatively little impact on the forests. With the coming of the railroads around the turn of the century and the acquisition of timber rights by large outside companies a timber boom occurred (Eller 1982). Much of the spruce-fir forest of the Black Mountains was cut between 1912 and 1917 (Noyes 1917). In 1914 an intense fire occurred on the southeast side of the main Black Mountain Ridge and in 1916 an even larger fire burned the southwest side of the Ridge (Holmes 1918). A bill directing the purchasing of land for a state park was passed by the North Carolina General Assembly in 1915 and land acquisition began in 1916. The establishment of Mount Mitchell State Park was in large part, the result of a desire by prominent officials and local citizens for protection of the area, after much of it had been devastated by logging and fire (Schwarzkopf 1985).

Fire is probably the most frequent and widespread form of disturbance in forest ecosystems (White 1979), however, the frequency of fire has decreased in southern Appalachian forests since the initiation of fire suppression in the 1930's by Federal and State Agencies (Eller 1982, Runkle 1985; cf: Ayers and Ashe

1905, Frothingham 1917). Some community types such as pine covered ridges have always had a higher fire frequency (Barden and Woods 1976, Harmon et al. 1984) than other more moist and sheltered types (e.g. cove forests-Runkle 1985).

Grazing by domesticated animals (Eller 1982), the death of the once broadly dominant chestnut (Keever 1953, Woods and Shanks 1959), windthrow (Lorimer 1976, 1980; Runkle 1979, 1981) and ice damage have all been factors in the dynamics of southern Applachian forests including those of the Black and Craggy Mountains. More recently, the Fraser fir population has been devastated by an infestation of the balsam wooly aphid (Speers 1958, Nagel 1959, Ward et al. 1973, Eager 1984, whitter and Ragenovich 1986). In addition, many destructive floods and landslides have occurred on the east slopes of the Black Mountains. These landslides have left scars on the upper slopes, enlarged the stream channels, and destroyed many trees along the water courses.

FLORA

The objectives of this section on flora are: (1) to catalogue the vascular plant flora; (2)to describe and explain certain floristic patterns including endemism and geographic affinities.

Methods

I collected extensively the vascular plants of the Black and Craggy Mountains between 1970 and 1986. Voucher specimens are deposited at both the University of North Carolina at Chapel Hill Herbarium (NCU) and Mars Hill College Herbarium (MHC). Dr. A.E. Radford verified certain taxa, particularly those in the Poaceae and Cyperaceae. In addition, a herbarium search was conducted at the Western Carolina University (WCUH), University of North Carolina (NCU), North Carolina State University (NCSU), and Duke University (DUKE) Herbaria. Dr. James Matthews provided xerox copies of herbarium sheets from collections in the study area deposited in the UNC Charlotte Herbarium (UNCC). The Poaceae may be somewhat underrepresented since many of the specimens of this family at UNC were on loan in connection with the Southeastern Flora Project. In a few cases literature citations are incorporated. Documentation for taxa I have not collected is presented in Appendix B.

Nomenclature primarily follows Kartesz and Kartesz (1980) except for the Asteraceae which follows Cronquist (1980). An

effort was made to incorporate recent nomenclature changes that have occurred since these publications. Commonly used synonyms including those used by Radford et al. (1968) are listed in brackets following the preferred name.

RESULTS

A total of 972 species representing 115 families were documented as comprising the Flora of the Black and Craggy Mountains. Approximately 323 (33.3%) are "weedy" species, primarily of roadsides, old fields and other disturbed areas. The majority of these are introduced species (Fernald 1950). Five families dominate the flora comprising 35.2% of the total number with ten families containing over 50% of the species (Table 2). The two largest families, Asteraceae and Poaceae, also contain the most weedy species with 61 of 121 (50%), and 37 of 64 (58%) respectively. Members of the grass family, in particular, are primarily components of early stages of secondary succession, usually not being abundant in older stands. The native flora contains approximately 750 vascular plant species.

Comparison with other areas, primarily in the southern Appalachians, indicates that floral diversity (number of species/unit area) is high in the study area compared to others (Table 4, Figure 3). This probably is a consequence of high

habitat diversity and elevation differential, and perhaps also collecting time and effort.

Thirty-one plants on the current North Carolina State List of endangered, threatened and rare plant species (Sutter et al. 1983, Massey et al. 1983) occur in the study area (Table 5). Many of these plants will be discussed in the following sections since most are endemics and/or disjuncts.

Table 2. Most diverse families of Black and Craggy Mountains.

Family	Number of Species	Percent native species (approx.)	Percent of Total Taxa
Asteraceae	121	50	12.5
Poaceae	64	58	6.6
Cyperaceae	63	81	6.5
Rosaceae	51	71	5.3
Liliaceae	44	91	4.5
Fabaceae	36	47	3.7
Lamiaceae	29	59	3.0
Orchidaceae	26	100	2.8
Ericaceae	26	100	2.7
Ranunculaceae	26	81	2.7
Scrophulariaceae	23	52	2.4
Brassicaceae	22	50	2.3
Apiaceae	22	77	2.3
Caryophyllaceae	21	29	2.2
Saxifragaceae	19	100	2.0

Table 3. Summary of flora of Black and Craggy Mountains by major Category.

	Pteridophyta	Gymnospermae	Angiospermae		Totals
			Monocots	Dicots	
Families	9	2	16	88	115
Genera	23	6	174	264	467
Species	42	13	232	685	972

Table 4. Comparisons with floras of other selected areas.

	Author(s)	Study Area	Size	No. of Vascular Plant Species
1.	Radford et al. 1968	N.C. & S.C.	20,333,572.0 ha	3,395
2.	Radford et al. 1968	Mountains N.C. & S.C.	1,719,501.0 ha	1,842
3.	White 1982	G.S.M.N.P. N.C. & Tenn.	209,000.0 ha	1,492
4.	Clarkson 1966	Monongahela Nat. For. W. Va.	656,792.4 ha	1,353
5.	Cooperrider & Thorne 1964	Giles County, Va.	93,758.0 ha	1,026
6.	McLeod	Black & Craggy Mtns., N.C.	35,000.0 ha	972
7.	Jones 1974	Pine Mtn., Ga.	116,550.0 ha	829
8.	Hinkle 1975	Cumberland Gap Tenn., Va., Ky.	4,272.0 ha	566
9.	Sole et al. 1983	Lilly Cornett Woods, Ky.	220.0 ha	516
10.	Smith 1982	South Mtn. State Park, Burke Co., N.C.	2,335.0 ha	446
11.	Ramseur 1960	Upper Elevations South. Appal. (>5500 ft.)	12,110.0 ha	392
12.	Caplenor 1955, 1978	Fall Creek Falls State Park, Tenn.	6,311.0 ha	295

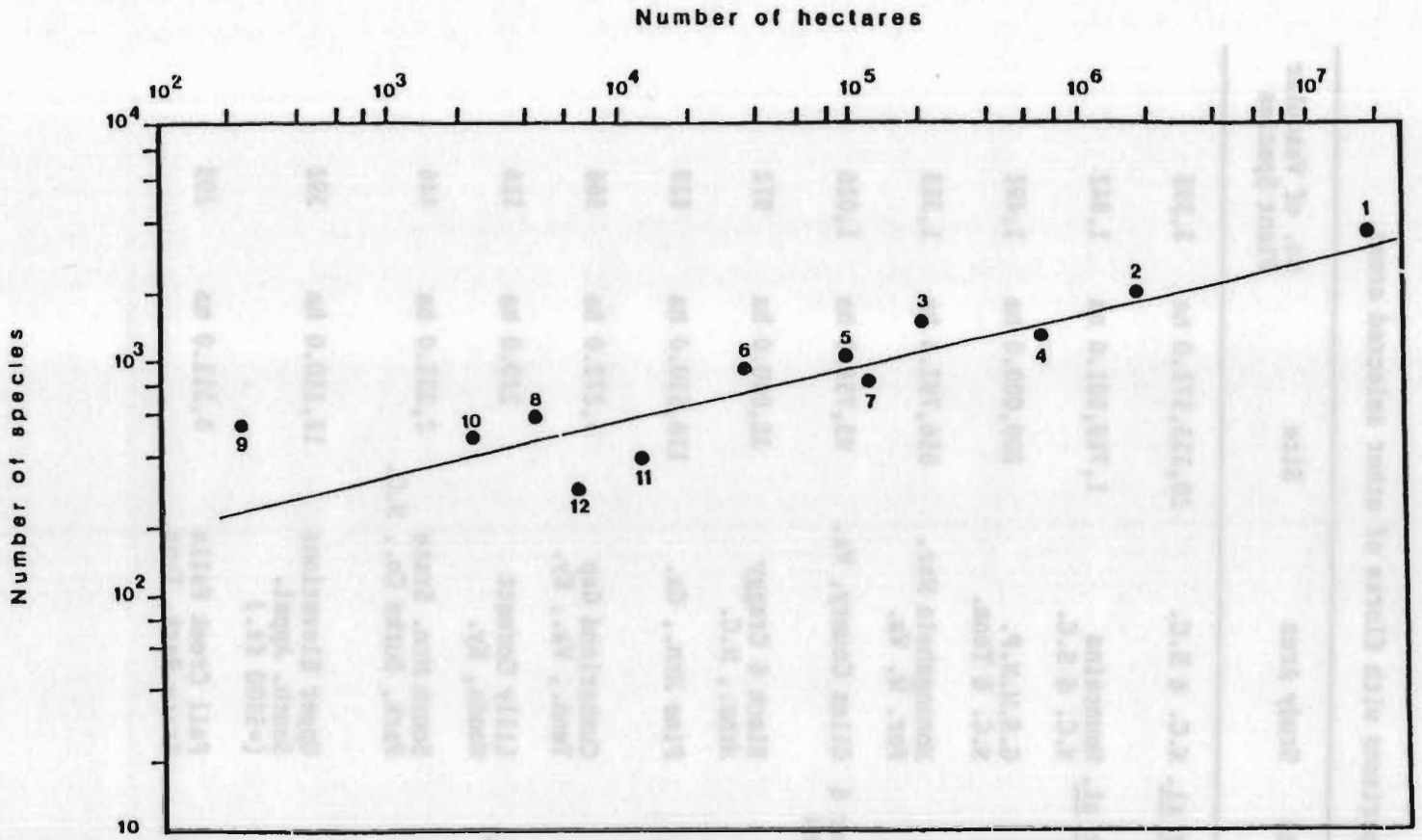


Figure 3. Relationship between floras (species richness) in selected areas. Numbers on graph refer to authors in Table 4. Logarithmic scale.

Table 5. Endangered, threatened, and rare plant species in the Black(B) and Craggy(C) Mountains.

Species	Category	Range
Aconitum reclinatum	PP	B,C
Agrostis mertensii (=A. borealis)	PP	B
Arabis glabra	SRS	C
Betula cordifolia	PP	B
Botrychium oneidense	PP	C
Campanula aparinoides	SRS	B
Carex biltmoreana	E	C
Carex buxbaumii	PP	B
Carex misera	T	C
Carex trisperma	SRS	B
Coreopsis latifolia	E	C
Dicentra eximia	SRS	C
Disporum maculatum	SRS	B,C
Filipendula rubra	PP	B
Geum radiatum	T	B,C
Hydrastis canadensis	E	C
Juncus trifidus ssp. carolinianus	E	C
Lilium grayi	T	B,C
Lycopodium selago	SRS	B,C
Panax quinquefolium	SC	B,C
Phlox subulata	SRS	C
Prenanthes roanensis	SRS	B,C
Rhododendron vaseyi	SC	B
Rubus idaeus ssp. sachalinensis	SRS	B,C
Saxifraga caroliniana	PP	B,C
Scirpus caespitosus var. callosus	SRS	C
Senecio pauperculus	SRS	B
Silene ovata	PP	C
Stellaria corei	SRS	B,C
Streptopus amplexifolius	PP	B,C,
Thaspium pinnatifidum	SRS	C

Endangered (E)

Threatened (T)

Special Concern (SC)

Primary Proposed (PP)

Significantly Rare Species (SRS)

Floristic Relationships

The flora of the Black and Craggy Mountains displays a number of distributional patterns. In the following sections some of these are discussed.

Northern Species Ranging South Along the Mountains.

These species are primarily of northern distribution but follow the uplands south along the Appalachians (Table 6). There are three major subtypes of this pattern namely; (1) species which are primarily limited to Appalachian uplands (Figure 2), e.g., Asplenium montanum, Betula lenta, Dicentra eximia, Poa cuspidata, Rhododendron maximum; (2) widespread northern species that range south along the Appalachian uplands (Figure 4), e.g., Dryopteris intermedia, Acer pensylvanicum, Betula alleghaniensis, Clintonia umbellulata, Ribes rotundifolium, and; (3) widespread northern species that range south only at the upper elevations (Figure 5), e.g., Betula cordifolia, Agrostis mertensii (=borealis), Circaea alpina, Maianthemum canadense, Sorbus americana, Streptopus amplexifolius.

Species Widespread in Eastern North America

Species which are widespread in the East and are important members of the flora include Polystichum acrostichoides, Thelypteris noveboracensis, Acer rubrum, Alnus serrulata, Carex intumescens, Carya glabra, Cornus florida, Kalmia latifolia,

Liriodendron tulipifera, Podophyllum peltatum, Robinia pseudo-acacia, Quercus alba, Viola sororia (=papilionacea). A more complete list is presented in Table 8.

Species of Roadsides, Old Fields and Disturbed Areas.

These plants, many of which are exotics, are identified with an asterisk in the general floral list (Table 15).

Table 6. Some Northern species ranging south along mountains

* Asplenium montanum	* Disporum lanuginosum
* Aspienium trichomanes	Disporum maculatum
# Dryopteris campyloptera	Glyceria melicaria
Dryopteris intermedia	Goodyera repens
Lycopodium lucidulum	Ilex montana
Lycopodium obscurum	Juncus brevicaudatus
# Lycopodium selago	Lonicera canadensis
Osmunda claytoniana	Lonicera dioica
Polypodium virginianum	# Maianthemum canadense
#*Picea rubens	Monarda didyma
Pinus strobus	# Oxalis acetosella
Acer pensylvanicum	Platanthera orbiculata
Acer spicatum	Physocarpus opulifolius
# Agrostis mertensii (=borealis)	Poa alsodes
Allium tricoccum	* Poa cuspidata
Aralia nudicaulis	# Populus grandidentata
Asclepias incarnata var. pulchra	Polygonum cilinode
Aster lowrieanus	# Potentilla tridentata
Aster novae-angliae	# Prunus pensylvanica
Betula alleghaniensis	* Rhododendron maximum
# Betula cordifolia	Ribes glandulosum
Betula lenta	* Ribes rotundifolium
* Carex aestivalis	Rubus candensis
Carex brunnescens	# Rubus idaeus var. sachalinensis
Carex communis	Rubus odoratus
Carex crinita var. gynandra	# Sambucus racemosa ssp. pubens
Carex pensylvanica	Sanguisorba canadensis
Carex stricta	#*Scirpus caespitosus
Caulophyllum thalictriodes	#*Sedum telephioides
Chrysosplenium americanum	Sedum ternatum
Cimicifuga racemosa	Smilax hispida
# Circaea alpina	Solidago umbellatus
# Clintonia borealis	# Sorbus americana
* Clintonia umbellulata	# Streptopus amplexifolius
Comptonia peregrina	Tiarella cordifolia
Cornus alternifolia	Trillium erectum
Corylus cornuta	Trillium undulatum
# Danthonia compressa	Tsuga canadensis
* Dicentra eximia	Veratrum viride
	# Viburnum lantanoides

* Plants primarily confined to Appalachian Uplands

Plants primarily found only at upper elevations (above 1524m)

Table 7. Some species widely distributed in Eastern United States and important in study area.

Onoclea sensibilis	Kalmia latifolia
Osmunda cinnamomea	Liriodendron tulipifera
Polystichum acrostichoides	Lycopus virginicus
Thelypteris noveboracensis	Lyonia ligustrina
Pinus echinata	Medeola virginiana
Acer rubrum	Mitchella repens
Actaea pachypoda	Nyssa sylvatica
Agrostis perennans	Pilea pumila
Alnus serrula a	Platanus occidentalis
Amianthium muscaetoxicum	Platanthera clavellata
Apios americana	Podophyllum peltatum
Aronia arbutifolia	Polygonatum biflorum
Carex intumescens	Polygonum virginianum
Carex lurida	Pycnanthemum incanum
Carpinus caroliniana	Robinia pseudo-acacia
Carya glabra	Rosa palustris
Carya cordiformis	Salix nigra
Carya tomentosa	Sanicula canadensis
Chamaelirium luteum	Smilax rotundifolia
Chimaphila maculata	Tipularia discolor
Cornus florida	Quercus alba
Desmodium nudiflorum	Quercus coccinea
Dichanthelium dichotomum	Quercus rubra
Dioscorea villosa	Quercus velutina
Epifagus virginiana	Vaccinium corymbosum(=constablaei)
Euonymus americanus	Vaccinium pallidum
Eupatorium fistulosum	Vaccinium stramineum
Fagus grandifolia	Vernonia noveboracensis
Fraxinus americana	Viola sororia (=papilionacea)
Geum canadense	Viola primulifolia
Impatiens capensis	
Juncus acuminatus	
Juglans nigra	

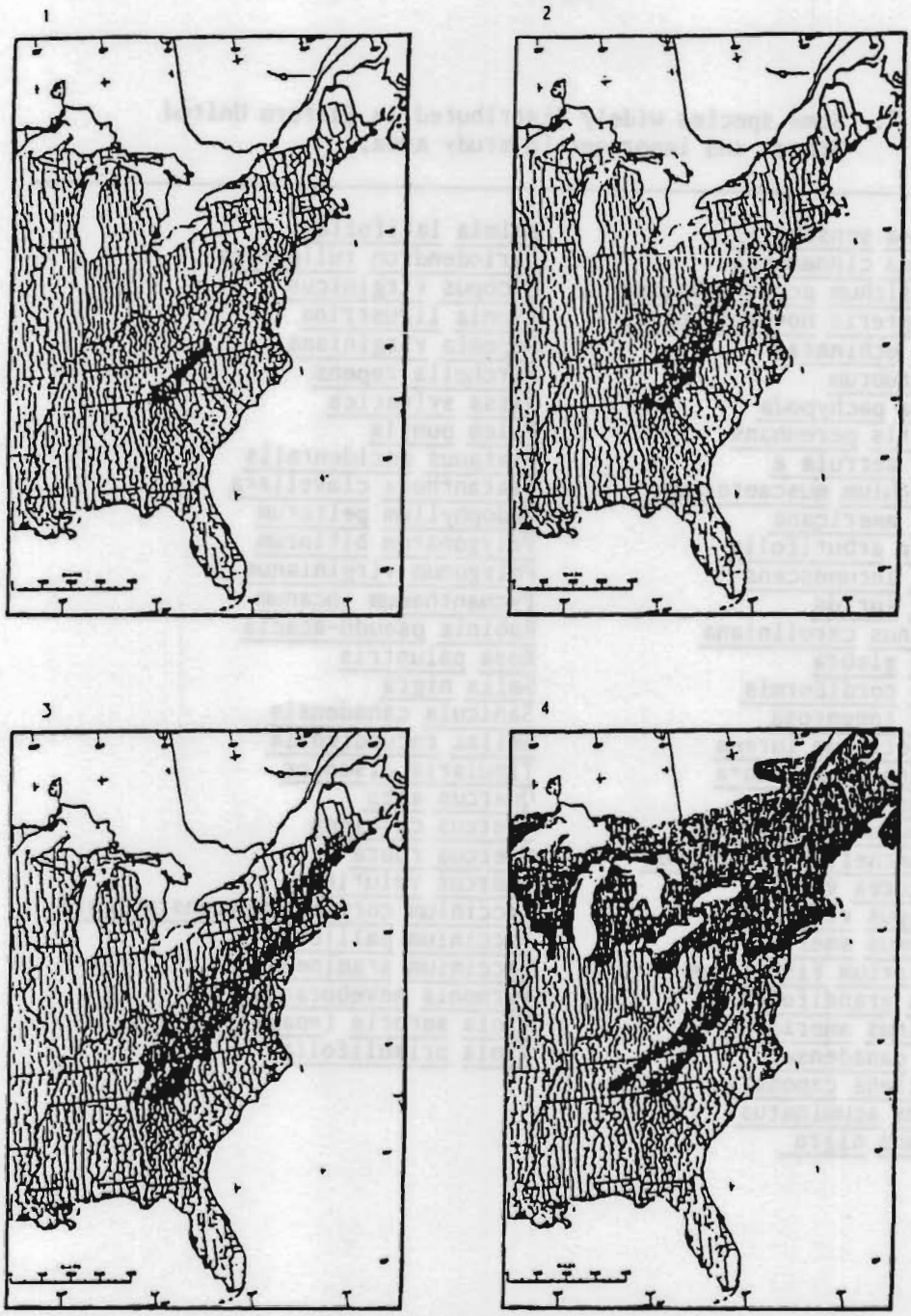


FIGURE 4. 1. Generalized distribution of southern Appalachian endemics south of Roanoke River.
2. Generalized distribution of southern Appalachian endemics south of Wisconsin terminal moraine.
3. Generalized distribution of plant species primarily limited to Appalachian uplands.
4. Generalized distribution of widespread northern species that range south along the Appalachians.

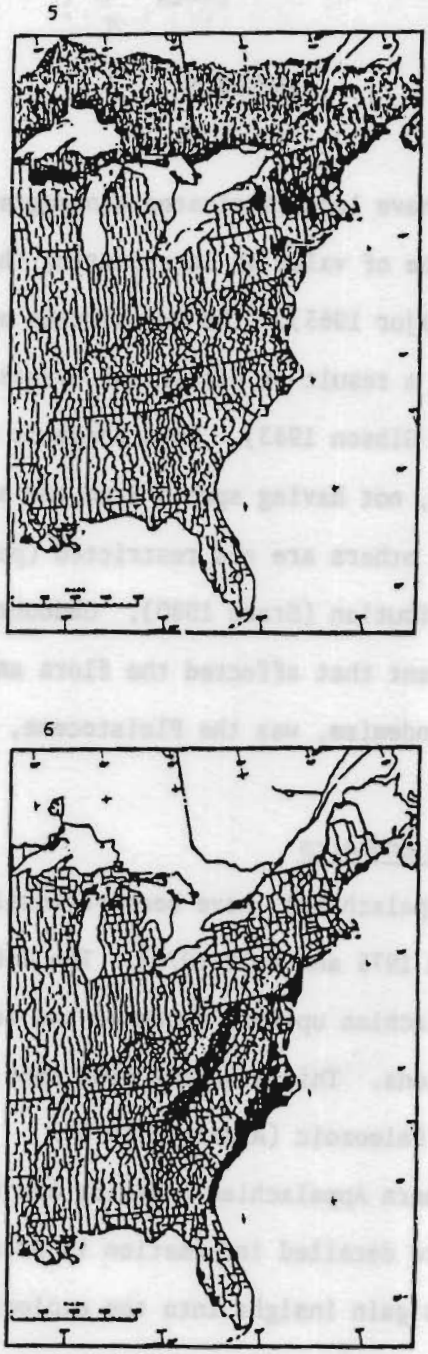


FIGURE 5. 5. Generalized distribution of widespread northern species that range south only at the upper elevations.
6. Generalized distribution of southern Appalachian - Coastal Plain disjunct populations.

ENDEMICS

Endemic species have long fascinated biogeographers and taxonomists and may be of value in interpreting the history of an area (Stebbins and Major 1965). The restriction of a taxon to a particular region is a result of historical events and ecological processes (Brown and Gibson 1983). Some endemics are evolutionarily young, not having spread from the site of origin (neoendemics), while others are now restricted (paleoendemics) but once had wider distribution (Stace 1980). Undoubtedly, the major recent historical event that affected the flora and vegetation of the area including endemism, was the Pleistocene, with its periods of climatic change.

Southern Appalachian Endemics

The "southern Appalachians" have been variously defined (see Ramseur 1960, Blauch 1975 and Holt 1970). The definition used here is the area of Appalachian uplands south of the terminal moraine of Pleistocene glaciations. This area has been open to terrestrial organisms since the Paleozoic (Anderson 1970).

Sixty-four southern Appalachian endemics are found in the study area (Table 8). More detailed information is presented in Appendix A. In an attempt to gain insight into the ecological requirements of these species and to discern some common patterns, these endemics are compared by general habitat preference (Table 9). These relationships are summarized in the following section.

Table 8. Southern Appalachian endemics in the Black and Craggy Mountains

*	Abies fraseri		Juncus gymnocarpus
	Pinus pungens	*	Juncus trifidus ssp. carolinianus
*	Tsuga caroliniana	*	Krigia montana
	Aconitum reclinatum		Leucothoe recurva
	Aesculus flava	*	Lilium grayi
	Angelica triquinata		Listera smallii
*	Aster curtisii		Magnolia fraseri
	Aristolochia macrophylla		Menziesia pilosa
*	Aster divaricatus		Parnassia asarifolia
	Astilbe biternata		Paronychia argyrocoma
	Boykinia aconitifolia	*	Penstemon smallii
*	Cardamine clematitis	*	Prenanthes roanensis
*	Carex biltmoreana		Pyrularia pubera
*	Carex misera		Pycnanthemum montanum
	Carex ruthii		Rhododendron calendulaceum
*	Chelone lyoni	*	Rhododendron carolinianaum
	Cimicifuga americana		Rhododendron catawbiense
	Clethra acuminata	*	Rhododendron minus
	Convallaria montana	*	Rhododendron vaseyi
*	Coreopsis latifolia	*	Rhododendron x wellesleyanum
	Cuscuta rostrata		Robina viscosa
	Cymophyllus fraseri	*	Saxifraga careyana
*	Diervilla sessilifolia		Saxifraga caroliniana
*	Diphylleia cymosa		Saxifraga michauxii
	Eupatorium rugosum		Saxifraga micranthidifolia
	Galium latifolium		Solidago curtisii
*	Geum radiatum	*	Solidago glomerata
	Hedyotis michauxii	*	Solidago roanensis
	Heuchera villosa		Streptopus roseus
	Hexastylis shuttleworthii		Thalictrum clavatum
*	Hypericum graveolens		Vaccinium erythrocarpum
	Hypericum mitchellianum		Veratrum parviflorum

* Species endemic to Appalachians south of Roanoke River

Upper Elevations

Twenty-nine of the endemics are predominantly upper elevation species with fourteen of these (48.3%) preferring balds and disturbed areas; seven (24.1%) occurring on cliffs and rock ledges; six (20.7%) primarily established in closed forests; one (3.4%) the hybrid Rhododendron x wellesleyanum, limited to the ecotone of the spruce-fir forest and northern hardwoods in a burned area (Ramseur 1958). Two species (6.9%), Rhododendron catawbiense and Aster divaricatus var. chlorolepis have wide ecological amplitudes occurring in all upper elevation habitats. Combining the first two categories, twenty-one (72.4%) prefer treeless open areas. This is even more remarkable when one considers that these open areas are a small percentage of the total upper elevation habitats. White et al. (1984) using Ramseur's floristic data (1960) from upper elevation > 1676m (5500ft.) communities of the southern Appalachians found a positive correlation (.84) between endemic species and "meadow" species (Table 6, p. 55). They suggest that these "patchy" open habitats support species that may be remnants of a southern alpine flora. They postulate that the meadow species grew in alpine meadows and barrens in earlier times.

The endemics of the upper elevation closed forests probably

became isolated in these upper elevation "islands" during interglacial times with at least some of the taxa evolving into distinct entities (e.g., Abies fraseri and Aster divaricatus var. chlorolepis).

Lower and Middle Elevations

The habitat preferences of the endemics below 1500m show quite different patterns. Of these thirty-four species; six (17.6%) occur in highly acid soils, nine (26.5%) in oak forest, sixteen (47.1%) are plants of closed mesic forests with six of these (37.5%) confined to seepage areas and/or stream sides, two (5.9%) are primarily ecotonal species and one (2.9%) is a plant of mucky marsh or bog soils.

The large number of mesophytic Appalachian endemics along with a large number of eastern North American and Asian disjuncts, has caused a number of authors; (e.g. Cain 1943, Braun 1950, Li 1952, Iltis 1966) to suggest that the mesophytic forests of the southern Appalachians are remnants of the Arctotertiary Flora that remained in place during the ice age. This concept has been questioned with the accumulation of palynological studies by a number of investigators; (e.g. Whitehead 1967, 1973, Watts 1970, 1971 1980, Davis 1983, Delcourt 1979, and Delcourt and Delcourt 1987). These

studies indicate that there was a major displacement of forest types during the Wisconsin and earlier glacial periods. Hazel and Paul Delcourt (1977) have postulated that "bluffheads" along the major rivers of the southeast provided refugia for the mesic species during the full glacial period and migration routes for their redistribution as the climate warmed. They also suggest that mesic deciduous forest may have persisted at low elevations in protected coves of the southern Appalachians (Delcourt and Delcourt 1975).

Table 9. Habitat preference of southern Appalachian endemics in the Black and Craggy Mountains. Explanation of symbols: X - preferred habitat; x - often found; p - present occasionally or rarely.

SPECIES	HABITAT CATEGORIES					
	UPPER ELEVATIONS (1524-2012 m)			LOWER AND MIDDLE EL. (762-1524 m)		
Plants Primarily of Upper Elevation	Balds	Rock Outcrop & Ledges	Closed Forests	Acid Soils	Oak For.	Cove For.
Angelica triquinata	X	p	p	-	p	p
Cuscuta rostrata	X	-	p	-	p	-
Diervilla sessilifolia	X	p	p	-	p	-
Eupatorium rugosum	X	p	x	-	p	p
Hypericum graveolens	X	p	p	-	-	-
*Hypericum mitchellianam	X	p	p	-	-	-
Prenanthes roanensis	X	p	p	-	-	-
Rhododendron catawbiense	X	p	x	x	p	-
Solidago glomerata	X	p	p	-	p	p
Solidago roanensis	X	p	p	-	-	-
Hedyotis michauxii	X	x	p	-	p	-
Lilium grayi	X	p	p	-	p	-
*Parnassia asarifolia	X	-	p	-	-	-
Listera smallii	X	-	-	-	-	-
Geum radiatum	p	X	-	-	-	-
Juncus trifidus	p	X	-	-	-	-
Krigia montana	x	X	-	-	-	-
Saxifraga michauxii	p	X	p	-	p	-
Carex biltmoreana	-	X	-	-	-	-
Carex misera	-	X	-	-	-	-
Paronychia argyrocoma	-	X	-	-	-	-
Abies fraseri	p	p	X	-	-	-
*Cardamine clematitis	-	-	X	-	-	-
*Carex ruthii	p	-	X	-	p	p
Chelone lyoni	p	-	X	-	p	p
Aster divaricatus	x	p	X	-	p	x

Table 9. (cont.)

Plants Primarily of Lower and Middle Elevation	Balds	Rock Outcrop & Ledges	Closed Forests	Acid Soils	Oak For.	Cove For.
Vaccinium erythrocarpum	p	p	X	-	p	-
Streptopus roseus	-	-	X	-	-	x
Rhododendron X wellesleyanum	-	-	X	-	-	-
Clethra acuminata	X	p	-	x	p	-
Pinus pungens	-	p	-	X	p	-
Tsuga caroliniana	p	p	-	X	p	-
Leucothoe recurva	p	p	-	X	p	-
Menziesia pilosa	p	p	-	X	p	-
Rhododendron caroliniana	x	p	-	X	p	-
Hexastylis shuttleworthii	p	-	-	X	p	-
Robinia viscosa	p	p	-	x	x	-
Penstemon smallii	-	-	-	-	X	p
Aster curtisii	-	-	-	-	X	p
Pycnanthemum montanum	-	-	-	-	X	-
Pyrularia pubera	-	-	-	-	X	-
Rhododendron calendulaceum	x	-	-	-	X	p
Rhododendron minus	x	x	-	x	X	-
Solidago curtisii	-	-	-	-	X	-
Veratrum parviflorum	p	-	p	-	X	p
Rhododendron vaseyi	p	-	-	-	X	-
Magnolia fraseri	-	-	-	x	x	x
Aconitum reclinatum	-	-	-	-	-	X
Aesculus flava	p	-	x	x	x	X
Astilbe biternata	-	-	-	-	p	X
Cimicifuga americana	-	-	-	-	p	X
Convallaria montana	-	-	-	-	p	X
Coreopsis latifolia	-	-	-	-	-	X
Galium latifolium	-	-	-	-	p	X
Cymophyllus fraseri	-	-	p	-	p	X
Aristolochia macrophylla	-	-	-	-	p	X
*Boykinia aconitifolia	-	-	-	-	-	X
*Saxifraga careyana	-	-	-	-	-	X
*Saxifraga caroliniana	-	-	-	-	-	X
*Saxifraga micranthidifolia	-	-	p	-	-	X
*Thalictrum clavatum	-	-	-	-	-	X
*Diphyllea cymosa	-	-	x	-	-	X
**Heuchera villosa	-	p	p	-	x	X
***Juncus gymnocarpus	-	-	-	X	-	-

* species of seeps and/or stream sides

** mossy rock species

*** species of mucky soils in bogs and marshes

The endemics of acid soils which are generally limited to the Blue Ridge Province have probably become isolated within this area of siliceous parent rock material between the higher pH soils of the Valley and Ridge and Piedmont Plateau.

It is notable that there are few oak forest endemics relative to the large area containing oaks, which supports the notion of endemics being more abundant in patchy, island-like environments (Diamond 1975).

Juncus gymnocarpus, the only wetland endemic has an intriguing distribution, occurring locally in the mountains of eastern Pennsylvania to the mountains of western North Carolina and eastern Tennessee with a disjunct population in Walton County, Florida (Fernald 1950). It is found in a small bog-fen in the South Toe Valley of the Black Mountains at 853m (2800 feet) (McLeod 1981).

Endemics - Families

The number of endemic species per family is presented in Table 10. It is perhaps not surprising that the Ericaceae includes the largest number of endemics (14.1%) with the acid parent rock of the Blue Ridge favoring members of this family along with isolation in patchy island-like habitats producing suitable conditions for endemism. The relatively large number of endemic members of the Saxifragaceae may be related to extension of this primarily northern family into the southern Appalachians

during the glacial maxima with fragmentation into isolated populations during the Holocene. The presence of three conifer endemics; Abies fraseri, Pinus pungens and Tsuga caroliniana may indicate the antiquity of certain elements in the flora. Little (1970) suggests that Abies fraseri is the only young southern Appalachian endemic tree, having been derived from Abies balsamea (see also Ramseur 1958). He says that Tsuga caroliniana is more closely related to Asian species than to Tsuga canadensis. Little further suggests that the southern yellow pines subsect. Australes which includes Pinus pungens apparently evolved in eastern North America.

Table 10. Families of the Southern Appalachian Endemics

Family	No. of Species	% of Total Endemics
Ericaceae	9	14.1
Saxifragaceae	8	12.5
Asteraceae	8	12.5
Liliaceae	4	6.3
Cyperaceae	4	6.3
Rosaceae	4	6.3
Pinaceae	3	4.7
Ranunculaceae	2	3.1
Aristolochiaceae	2	3.1
Juncaceae	2	3.1
Rubiaceae	2	3.1
Scrophulariaceae	2	3.1
Clusiaceae	2	3.1
Apiaceae	1	1.5
Hippocastanaceae	1	1.5
Brassicaceae	1	1.5
Lamiaceae	1	1.5
Fabaceae	1	1.5
Caryophyllaceae	1	1.5
Gentianaceae	1	1.5
Magnoliaceae	1	1.5
Orchidaceae	1	1.5
Clethraceae	1	1.5
Santalaceae	1	1.5

Disjunctions

Pielou (1979) classifies disjunctions into two major categories by cause namely: (1) separation into parts of a once-continuous range and (2) establishment of new subranges by long-distance jump dispersal. Present patterns of disjunctions may be the result of a combination of these. The following section discusses some of the disjunctions between the Black and Craggy Mountains and other areas.

Eastern North America - Southeast Asia

The number of genera with eastern North American - Southeast Asian disjunction (Table 11) coupled with other Arcto-Tertiary disjuncts is impressive (also see Boufford and Spongberg 1983). There is little wonder that many authors (e.g. Asa Gray 1846, 1859, 1860, Good 1927, Fernald 1929, Hu 1935, Cain 1944, and Li 1952) have postulated a continuous range for this mesophytic flora during the Tertiary. The major cause for the separation is suggested to be climatic change since the Miocene, especially during the Pleistocene (Li 1952). It is questionable, however, whether these disjunct elements persisted as closed floras at their present locations. This has been challenged on two main grounds: (1) palynological studies have demonstrated that there were major displacements of floras (or species) during the latest

ice age as discussed under the endemics section and (2) the nature of floras, i.e., how do they change over geological time? Do they migrate more or less as units or is distribution individualistic with species populations migrating separately?

Table 11. Some distribution patterns of vascular flora of the Black and Craggy Mountains.

Genera confined to Eastern North America and Eastern Asia (data adapted from Li 1952).

Genus	Habit	Genus	Habit
Apios	hv	Liriodendron	t
Astilbe	h	Lyonia	s
Campsis	wv	Mitchella	s
Carya	t	Nyssa	t
Caulophyllum	h	Panax	h
Chionanthus	s	Parthenocissus	wv
Diervilla	s	Phryma	h
Diphylleia	h	Podophyllum	h
Epigaea	s	Pyrularia	s
Halesia	t	Sassafras	s
Hamamelis	s	Tipularia	h
Hydrastis	h	Triosteum	h
Lindera	s	Tovara (=Polygonum)	h

Genera thought to be relicts of Arcto-Tertiary floras or showing relict patterns of distribution with survivors in Eastern and Western North America and in one or more other areas notable as refugia for Arcto-Tertiary relicts. (data adapted from Wood 1970)

Genus	Habit	Genus	Habit
Pinus	t	Boykinia	h
Tsuga	t	Philadephus	s
Hystrix	h	Tiarella	h
Clintonia	h	Platanus	t
Erythronium	h	Physocarpus	s
Maianthemum	h	Rubus	s
Stenanthium	h	Thermopsis	h
Trillium	h	Euonymus	hv
Veratrum	h	Acer	t
Juglans	t	Aesculus	t
Ostrya	t	Aralia	s
Aristolochia	wv	Cornus	s
Asarum	h	Leucothoe	s
Cimicifuga	h	Menziesia	s
Clematis	hv	Rhododendron	s
Trautvetteria	h	Agastache	h
Calycanthus	s	Viburnum	s
Disporum	h	Prenanthes	h
Dicentra	h		

h - herbs, s - snrubs, t - trees, hv - herbaceous vine, wv - woody vine

Wolfe in a series of papers (e.g. 1972, 1978, 1981) on vegetation changes in western North America suggests that species are distributed individually over time (see also Wood 1970). This agrees with the redistribution of species into the glaciated area in eastern North America (Davis 1981, 1983). The notion of stable geofloras as envisioned by Axelrod (1975, 1979) and others has largely been replaced by the concept of floras being dynamic with often a mixture of a number of elements.

Southern Appalachian - Coastal Plain Disjuncts

Eighteen (85.7%) of the twenty-one species showing this disjunctive pattern are primarily bog species in both the mountains and the coastal plain (Table 12), with three (14.3%) found in sandy pinelands or acid sands on the coastal plain. In the mountains these latter species are plants of acid woods (Zigadenus leimanthoides, Symplocos tinctoria) or rock outcrops (Leiophyllum buxifolium).

Sixteen of the bog species are found in, but not limited to, a small (0.5 ha) bog-fen in South Toe Drainage (McLeod and Croom 1983).

It has been suggested that the mountains provided sites for coastal plain plants during interglacial times when the coastal plain was submerged, with subsequent jump dispersal back to the coastal plain during climatic cooling (Braun 1937, 1950). Based on

Table 12. Disjunct Species: Mountains - Coastal Plain

Species	Habitat	Species	Habitat
Bartonia virginica	b	Oxypolis rigidior	b
Calamagrostis cinnoides	b	Polygala cruciata	b
Calopogon tuberosus	b	Pycnanthemum flexulosum	b
Carex howei	b	Rhynchospora capitellata	b
Chelone cuthbertii	b	Rhynchospora gracilenta	b
Cleistes divaricata	b,aw	Rubus hispidus	b,aw
Eriocaulon decangulare	b	Scleria ciliata	b
Iris virginica	b	Symplocos tinctoria	aw
Leiophyllum buxifolium	ar	Utricularia subulata	b
Malaxis unifolia	b.aw	*Xerophyllum asphodeloides	aw
		*Zigadenus leimanthoides	b

*Found on Coastal Plain of New Jersey, Delaware, and Maryland
b - bog species
aw - acid woods species (or sandy pinelands)
ar - acid rock species (or acid sand)

present knowledge of changes in the vegetation in the last 18,000 years (Watts 1980, Delcourt 1979, Davis 1983) it seems likely that the larger valleys, e.g. the South Toe Valley, consisted of extensive bog systems during the late Wisconsin and early Holocene times with a rich bog flora. Remnants of this bog flora may have persisted in small bogs like Celo Bog and Bluff Mountain Bog (Tucker 1967) to the present. It seems unlikely that these coastal plain species were dispersed to these areas within the last few thousand years since they are so small.

Summary - Floristic Relationships

The present flora of the Black and Craggy Mountains, which may be viewed as representative of the Blue Ridge Section of the southern Appalachians, is an assemblage of species with different affinities and distribution patterns. These include firstly, endemics (mostly paleoendemics) which can conveniently be categorized into upper and lower elevation species, which generally have narrow habitat requirements, many without specialized means of seed and fruit dispersal. These plants are probably mostly relicts that have persisted somewnere in southeastern North America since the Tertiary. A few of them may be neoendemics which diverged in the isolated island-like environments of the southern mountains. However, as Good (1974) points out, "there is no ready means except in very rare cases, of knowing whether an endemic species is new or old."

Secondly, species which range south in the mountains can be divided into three categories; (1) widespread northern species that are found only in the upper elevations e.g. Betula cordifolia and Sorbus americana, (2) widespread northern species found at various elevations e.g. Betula alleghaniensis, Rubus odoratus and (3) species confined to Appalachian uplands e.g. Rhododendron maximum, Clintonia umbellulara.

These patterns generally reflect the sorting out of species of northern affinities during the Holocene, with group 1 being left as disjuncts only at the higher, colder elevations, group 2 limited to colder northern regions and uplands and group 3 limited to uplands because of edaphic and other factors.

Thirdly, many species widespread in eastern North America have found suitable habitats and are important members of the study area vegetation, (e.g., Fagus grandifolia, Fraxinus americana, Carya glabra, Cornus florida, Medeola virginiana, Viola sororia).

The remaining group of species contains species of disturbed areas, some of which are native (e.g. Sassafras albidum, Rhus typhina) but most of which are exotic.

The large number of genera disjunct between the Black and Craggy Mountains and eastern Asia (26 genera) and the genera in other so-called Arcto-Tertiary refugia (37 genera) probably represent a separation of wide-ranging species with subsequent distribution by migration.

The mountain-coastal plain disjuncts may represent jump dispersal especially of wetland species, during the Holocene.

Table 13. Floral List of Black and Craggy Mountains North Carolina

Explanation For Symbols:

* Plants Primarily Of Disturbed Areas, Old Fields, Roadsides Etc.

\+ New County record Yancey County

\# New County record Buncombe County

" New County record McDowell County

! Plants That Are Persisting After Planting Within Otherwise Natural Areas

ê Taxa Not Collected In This Study, Documented Elsewhere (See Appendix B)

Commonly used synonyms, including those used by Radford et al.(1968) are listed in brackets following the preferred name.

Pteridophyta

Adiantaceae
- Adiantum pedatum L. +
- Cheilanthes lanosa (Michx.) D.C. Eat.
- Vittaria sp. Sm. ê

Aspleniaceae
- Asplenium montanum Willd.
- Asplenium platyneuron (L.) Oakes ex D.C. Eat.
- Asplenium rhizophyllum L.
- Asplenium trichomanes L.
- Athyrium filix-femina var.asplenioides (Michx.) Farw.
- Cystopteris protrusa (Weatherby) Blasdell
- Deparia acrostichoides (Sw) M.Kato Ined. [=Athyrium theypterioides (Michaux) Desvaux]
- Diplazium pycnocarpon (Spreng.) Brown [=Athyrium pycnocarpon Spreng.]
- Dryopteris campyloptera (Kunge) Clarkson
- Dryopteris goldiana (Hook.) Gray +
- Dryopteris intermedia (Willd.) Gray
- Dryopteris marginalis (L.) Gray
- Dryopteris spinulosa (O. F. Muell.) Watt ê

Onoclea sensibilis L.
Polystichum acrostichoides (Michx.) Schott
Thelypteris hexagonoptera (Michx.) Weatherby
Thelypteris noveboracensis (L.) Nieuwl.
Thelypteris palustris Schott
Woodsia obtusa (Spreng.) Torr. ª

Dennstaedtiaceae
Dennstaedtia punctilobula (Michx.) T. Moore *
Pteridum aquilinum (L.) Kuhn

Equisetaceae
Equisetum arvense L.
Equisetum hyemale L. *

Lycopodiaceae
Lycopodium clavatum L.
Lycopodium digitatum A. Braun
[=Elabelliforme (Fernald)]
Lycopodium lucidulum L.
Lycopodium obscurum L.
Lycopodium selago L. +
Lycopodium tristachyum Pursh +

Ophioglossaceae
Botrychium dissectum Spreng. #
Botrychium oneidense (Gilbert) House ª
Botrychium virginianum (L.) Sw.

Osmundaceae
Osmunda cinnamomea L.
Osmunda claytoniana L. +
Osmunda regalis var. spectabilis (Willd.)Gray +

Polypodiaceae
Polypodium polypodioides (L.) Watt
Polypodium virginianum L.

Selaginellaceae
Selaginella apoda (L.) Fern.
Selaginella rupestris (L.) Spring ª

Gymnospermae

Cupressaceae
Juniperus virginiana L.
Thuja occidentalis L. !

Pinaceae
- Abies fraseri (Pursh) Poir. #
- Picea abies (L.) !
- Picea rubens Sarg.
- Pinus echinata P. Mill. +
- Pinus pungens Lamb. +
- Pinus resinosa Ait. !
- Pinus rigida P. Mill. +
- Pinus strobus L.
- Pinus virginiana P.Mill.* +
- Tsuga canadensis (L.) Carr.
- Tsuga caroliniana Engelm.

Angiospermae

Aceraceae
- Acer negundo L. +
- Acer nigrum Michx. f.
- Acer pensylvanicum L.
- Acer rubrum L.
- Acer saccharinum L. +
- Acer saccharum Marsh. #
- Acer spicatum Lam.

Aizoaceae
- Mollugo verticillata L. *

Alismataceae
- Sagittaria latifolia Willd.

Amaranthaceae
- Amaranthus hybridus L. *

Anacardiaceae
- Rhus copallina L. * +
- Rhus glabra L. *
- Rhus typhina L. *
- Toxicodendron radicans (L.) Kuntze *
  [=Rhus radicans L.]

Apiaceae
- Aegopodium podagraria var. variegatum Bailey +
- Angelica triquinata Michx.
- Angelica venenosa (Greenway) Fern. *
- Cicuta maculata L. *
- Conium maculatum L. * +

Cryptotaenia canadensis (L.) DC.
Daucus carota L. *
Heracleum lanatum Michx. *
Ligusticum canadense (L.) Britt.
Osmorhiza claytonii (Michx.) C.B. Clarke
Osmorhiza longistylis (Torr.) DC. +
Oxypolis rigidior (L.) Raf.
Sanicula canadensis L.
Sanicula gregaria Bickn. #
Sanicula marilandica L. +
Sanicula smallii Bickn. +
Sanicula trifoliata Bickn.
Thaspium barbinode (Michx.) Nutt.
Thaspium pinnatifidum (Buckl.) Gray
Thaspium trifoliatum (L.) Gray +
Zizia aptera (Gray) Fern. +
Zizia trifoliata (Michx.) Fern.

Apocynaceae
Apocynum androsaemifolium L. * +
Apocynum cannabinum L. * +
Vinca minor L. * +

Aquifoliaceae
Ilex montana Torr. & Gray +
Ilex opaca Ait. +
Ilex verticillata (L.) Gray

Araceae
Acorus americanus (Raf.) Raf.
Arisaema triphyllum (L.) Schott
Peltandra virginica (L.) Schott +

Araliaceae
Aralia nudicaulis L.
Aralia racemosa L. #
Aralia spinosa L. +
Panax quinquefolium L. + #

Aristolochiaceae
Aristolochia macrophylla Lam. +
Asarum canadense L.
Hexastylis shuttleworthii (Britten & Baker) +

Asclepiadaceae
Asclepias amplexicaulis Sm. * +
Asclepias exaltata L.
Asclepias incarnata ssp. pulchra (Ehrh.ex Willd.)
Asclepias quadrifolia Jacq.
Asclepias syriaca L. *

Asclepias tuberosa L. *
Asclepias variegata L. +
Asclepias verticillata L.

Asteraceae
Achillea milliefolium L. *
Ambrosia artemisiifolia L. *
Ambrosia trifida L. *
Antennaria plantaginifolia (L.) Richards +
Antennaria solitaria Rydb. +
Anthemis arvensis L. * +
Arctium minus Schkuhr. *
Artemisia vulgaris L. *
Aster acuminatus Michx.
Aster cordifolius L.
Aster curtisii T.& G.
Aster divaricatus var. chlorolepis (Burgess) Ahles
Aster drummondii Lindl. + #
Aster dumosus L. *
Aster infirmus Michx. *
Aster lateriflorus (L.) Britton *
Aster linariifolius L. +
Aster lowrieanus Porter *
Aster macrophyllus L.
Aster novae-angliae L.
Aster patens Ait. *
Aster paternus Cronq. *
Aster pilosus Willd. *
Aster prenanthoides Muhl. *
Aster puniceus L.
Aster sagittifolius Willd.
Aster tataricus L.f. +
Aster umbellatus P. Mill. +
Aster undulatus L.
Bellis perennis L. *
Bidens bipinnata L. *
Bidens cernua L. *
Bidens frondosa L. *
Bidens tripartita L. *
Bidens vulgata Greene *
Cacalia atriplicifolia L.
Cacalia muhlenbergii (Schultz-Bip.) Fern. #
Centaurea maculosa Lam. *
Chrysopsis mariana (L.) Ell. +
Cichorium intybus L. *
Cirsium altissimum (L.) Spreng. *
Cirsium arvense (L.) Scop.
Cirsium discolor (Muhl.) Sprengel
Cirsium muticum Michx.
Cirsium vulgare (Savi) Tenore *

Coreopsis latifolia Michx. a
Coreopsis major Walt. *
Coreopsis pubescens Ell. * a
Crepis capillaris (L.) Wallr. *
Erigeron annuus (L.) Pers. *
Erigeron canadensis Heller *
Erigeron pulchellus Michx.
Erigeron strigosus Muhl. ex Willd. *
Eupatorium aromaticum L.
Eupatorium fistulosum Barratt
Eupatorium maculatum L.
Eupatorium perfoliatum L.
Eupatorium purpureum L.
Eupatorium rotundifolium var. saundersii
(Porter) Cronq. * +
Eupatorium rugosum var. roanense (Small) Fern.
Eupatorium sessilifolium L. a
Galinsoga quadriradiata Ruig & Pavon *
Gnaphalium obtusifolium L. *
Helenium autumnale L. * a
Helenium flexuosum Raf. *
Helianthus atrorubens L. *
Helianthus decapetalus L.
Helianthus giganteus L. *
Helianthus microcephalus Torr. & Gray * +
Helianthus strumosus L.
Helianthus tomentosus Michx.
Helianthus tuberosus L. *
Heliopsis helianthoides (L.) Sweet
Hieracium caespitosum Dumont *
Hieracium florentinum All. * a
Hieracium paniculatum L.
Hieracium venosum L.
Krigia biflora (Walt.) Blake a
Krigia montana (Michx.) Nutt.
Krigia virginica (L.) Willd. *
Lactuca biennis (Moench) Fern. *
Lactuca canadensis L. *
Lactuca floridana (L.) Gaertn. *
Lactuca serriola L. *
Leucanthemum vulgare Lam. *
[=Chrysanthemum leucanthemum L.]
Liatris spicata (L.) Willd.
Liatris squarrosa (L.) Michx. a
Matricaria matricarioides (Less.) Porter *
Parthenium integrifolium L. a
Polymnia uvedalia L. #
Prenanthes altissima L.
Prenanthes roanensis (Chickering) Chickering a
Prenanthes serpentaria Pursh * +

Prenanthes trifoliata (Cass.) Fern.
Rudbeckia hirta L. *
Rudbeckia laciniata L.
Rudbeckia triloba L. *
Senecio anonymus Wood
Senecio aureus L.
Senecio pauperculus Michx.
Senecio vulgaris L. *
Silphium trifoliatum L. *
Solidago arguta Ait. *
Solidago bicolor L.
Solidago curtisii Torr. & Gray
Solidago erecta Pursh
Solidago gigantea Ait. *
Solidago glomerata Michx.
Solidago juncea Ait. *
Solidago nemoralis Ait.*
Solidago patula Muhl.
Solidago roanensis Porter
Solidago rugosa ssp. aspera (Aiton) Cronq.
Solidago rugosa var. villosa (Pursh) Fern.
Solidago sphacelata Raf.
Solidago uliginosa Nutt.
Sonchus asper (L.) Hill *
Taraxacum officinale Weber *
Tussilago farfara L. * + #
Verbesina alternifolia (L.) Britt. *
Vernonia noveboracensis (L.) Michx.
Xanthium strumarium var glabratum (DC.) Cronq. *

Balsaminaceae
Impatiens capensis Meerb.
Impatiens pallida Nutt.

Berberidaceae
Berberis canadensis Miller *
Caulophyllum thalictroides (L.) Michx.
Diphylleia cymosa Michx.
Podophyllum peltatum L.

Betulaceae
Alnus serrulata (Ait.) Willd. + #
Betula alleghaniensis Britt. [=lutea Michaux f.]
Betula cordifolia Regel
[=papyrifera var. cordifolia (Regel) Fern.]
Betula lenta L.
Carpinus caroliniana Walt.
Corylus americana Walt.
Corylus cornuta Marsh
Ostrya virginiana (P.mill.) K. Koch +

Bignoniaceae
Campsis radicans (L.) Seem. ex Bureau * +
Paulownia tomentosa (Thumb.) Sieb. & Zucc. ex Steud.

Boraginaceae
Buglossoides arvense Moench *
Cynoglossum virginianum L.
Echium vulgare L. *
Myosotis scorpiodes L.

Brassicaceae
Arabidopsis thaliana (L.) Heynh *
Arabis canadensis L.
Arabis glabra (L.) Bernh. @
Arabis laevigata (Muhl.) Poir.
Arabis missouriensis Greene @
Barbarea verna (P. Mill.) Aschers. * +
Barbarea vulgaris R. Brown *
Capsella bursa-pastoris (L.) Medic. *
Cardamine clematitis Shuttlw. ex Gray
Cardamine hirsuta L. *
Cardamine parviflora var arenicola (Britt.) ex Schulz
Cardamine pensylvanica Muhl. ex Willd.
Dentaria diphylla Michx.
[=Cardamine diphylla (Michx.) Wood]
Dentaria laciniata Muhl. ex Willd.
[=Cardamine concatenata (Michx) Ahles]
Erophila verna (L.) Chev. *
Hesperis matronalis L.
Lepidium campestre (L.) R. Br. *
Lepidium virginicum L. *
Rorippa palustris ssp.fernaldiana (Butt.& Abbe) * @
[=islandica (Oeder) Borbas]
Sisymbrium officinale var leiocarpum *
Thlaspi arvense L. *
Thlaspi perfoliatum L. * +

Cactaceae
Opuntia humifusa (Raf.) Raf. * +

Calycanthaceae
Calycanthus floridus var. laevigatus (Willd.)
Torr. & Gray

Campanulaceae
Campanula americana L.
Campanula aparinoides Pursh
Campanula divaricata Michx.
Campanula rapunculoides L. *

Specularia perfoliata (L.) A. DC. *
Lobelia cardinalis L.
Lobelia inflata L.
Lobelia siphilitica L.
Lobelia spicata Lam.

Caprifoliaceae
Diervilla lonicera P. Mill.
Diervilla rivularis Gattinger
Diervilla sessilifolia Buckl.
Lonicera canadensis Bartr. #
Lonicera dioica L.
Lonicera japonica Thunb. *
Sambucus canadensis L.
Sambucus racemosa ssp.pubens (Michx.)House
[=S. pubens Michx.]
Symphoricarpos orbiculatus Moench. *
Triosteum aurantiacum Bickn. #
Viburnum acerifolium L.
Viburnum cassinoides L.
Viburnum dentatum L. +
Viburnum lantanoides Michx.
[=alnifolium Marshall]

Caryophyllaceae
Agrostemma githago L. *
Arenaria serpyllifolia L. *
Cerastium fontanum ssp.triviale (Link) Jalas *
Cerastium glomeratum Thuill. *
Cerastium nutans Raf. *
Dianthus armeria L. *
Paronychia argyrocoma (Michx.) Nutt.
Paronychia canadensis (L.) Wood *
Paronychia fastigiata (Raf.) Fern. *
Saponaria officinalis L. *
Silene alba (P. Mill.) Krause *
Silene antirrhina L. *
Silene armeria L. *
Silene dichotoma Ehrh. *
Silene ovata Pursh
Silene stellata (L.) Ait. F.
Silene virginica L. *
Silene vulgaris (Moench) Garcke *
Stellaria corei Shinners #
Stellaria media (L.) Vill. *
Stellaria pubera Michx.

Celastraceae
Celastrus scandens L. +
Euonymus americanus L.
Euonymus obovatus Nutt.

Chenopodiaceae
- Chenopodium album L. *
- Chenopodium ambrosioides L. *

Cistaceae
- Lechea racemulosa Michx. *

Clethraceae
- Clethra acuminata Michx.

Clusiaceae
- Hypericum canadense L.
- Hypericum densiflorum Pursh
- Hypericum gentianoides (L.) B.S.P. * +
- Hypericum graveolens Buckl.
- Hypericum mitchellianum Rydb.
- Hypericum mutilum L. *
- Hypericum perforatum L. *
- Hypericum prolificum L.
- Hypericum punctatum Lam. *
- Hypericum stragulum P. Adams & Robson * #

Commelinaceae
- Commelina communis L. *
- Commelina erecta L. *
- Tradescantia subaspera Ker.

Convolvulaceae
- Calystegia sepium (L.) R. Br.
- Cuscuta campestris Yuncker *
- Cuscuta rostrata Shuttlw. ex Engelm.
- Ipomaea coccinea L. * +
- Ipomoea pandurata (L.) G. F. W.Mey. *
- Ipomoea purpurea (L.) Roth. *

Cornaceae
- Cornus alternifolia L. f.
- Cornus florida L.

Crassulaceae
- Sedum telephioides Michx.
- Sedum ternatum Michx.

Cucurbitaceal
- Sicyos angulatus L.

Cyperaceae
- Bulbostylis capillaris (L.) C. B. Clarke *
- Carex aestivalis M. A. Curtis
- Carex albursina Sheldon

Carex amphibola var. turgida Fern. +
Carex artitecta Mackenzie
Carex atlantica var. imcomperta (Bickn.) F. J. Herm.
Carex baileyi Britt. +
Carex biltmoreana Mackenzie
Carex brunnescens (Pers.) Poir.
Carex buxbaumii Wahlenb.
Carex communis Bailey +
Carex crinita var. gynandra Lam.
Carex debilis Michx.
Carex debilis var rudgei Bailey
Carex digitalis Willd.
Carex folliculata L.
Carex frankii Kunth
Carex gracillima Schwein.
Carex grisea Wahl.
Carex howei Mackenzie +
Carex intumescens Rudge
Carex laevivaginata (Kukenth.) Mackenzie
Carex laxiculmis Schweinitz
Carex leptalea Wahlenb.
Carex leptonervia Fern Carex lurida Wahlenb. *
Carex misera Buckl.
Carex muhlenbergii Willd. *
Carex normalis Mackenzie
Carex pensylvanica Lam.
Carex plantaginea Lam. +
Carex rosea Willd.
Carex ruthii Mackenzie
Carex scoparia Schkuhr ex Willd.
Carex stipata Muhl. ex Willd. *
Carex stricta Lam. +
Carex styloflexa Buckl.
Carex torta Boott #
Carex tribuloides Wahlenb.
Carex trisperma Dewey
Carex virescens Willd.
Carex vulpinoidea Mackenzie *
Cladium mariscoides (Muhl.) Torr. +
Cymophyllus fraseri (Andr) Mackenzie
Cyperus dipsaciformis Fern. *
Cyperus filiculmis Vahl
Cyperus flavescens L.
Cyperus refractus Engelm. ex Steud. *
Cyperus strigosus L. *
Cyperus tenuifolius (Steud.) Dandy *
Eleocharis obtusa (Willd.) Schultes *
Eleocharis tenuis (Willd.) Schultes
Eriophorum virginicum L.
Fimbristylis autumnalis (L.) Roemer & Shultes *

Rhynchospora capitellata (Michx.) Vahl
Rhynchospora gracilenta Gray +
Scirpus atrovirens Willd.
Scirpus caespitosus L.
Scirpus cyperinus (L.) Kunth
Scirpus expansus Fern. *
Scirpus purshianus Fern. *
Scirpus tabernaemontanii K. C. Gmel.
Scleria ciliata Michx. +
Scleria pauciflora Muhl. ex Willd.

Diapensiaceae
Galax urceolata (Poir.) Brummitt
[=aphylla sensu auctt nov L.]
Shortia galacifolia Torr. & Gray !

Dioscoreaceae
Dioscorea batatas Dcne. *
Dioscorea villosa L.

Droseraceae
Drosera rotundifolia L.

Ericaceae
Chimaphilia maculata (L.) Pursh
Epigaea repens L.
Gaultheria procumbens L. #
Gaylussacia baccata (Wang.) K. Koch
Kalmia latifolia L.
Leiophyllum buxifolium (Berg.) Ell. "
Leucothoe fontanesiana(Steud.)Sleumer
[=axillaris var. editorum (Fern. & Schubert) Ahles]
Leucothoe recurva (Buckl.) Gray +
Lyonia ligustrina (L.) Dc.
Menziesia pilosa (Michx.) Juss.
Monotropa hypopithys L.
Monotropa uniflora L.
Oxydendrum arboreum (L.) DC.
Rhododendron arborescens (Pursh) Torr.
Rhododendron calendulaceum (Michx.)Torr. +
Rhododendron carolinianum Rehd.
Rhododendron catawbiense Michx.
Rhododendron maximum L.
Rhododendron minus Michx.
Rhododendron vaseyi Gray + "
Rhododendron viscosum (L.) Torr. +
Rhododendron x wellesleyanum Waterer ex Rehd.
Vaccinium corymbosum L. [=constablaei Gray]
Vaccinium erythrocarpum Michx.
Vaccinium pallidum Ait. + [=vacillans Kalm ex Torr.]
Vaccinium stamineum L.

Eriocaulaceae
Eriocaulon decangulare L.

Euphorbiaceae
Acalypha rhomboidea Raf. *
Chamaesyce maculata (L.) Small *
Euphorbia corollata L. *
Euphorbia cyparissias L. *

Fabaceae
Albizia julibrissin Durz. *
Amorpha glabra Desf. ex Poir. +
Amphicarpaea bracteata L. (Fern.)*
Apios americana Medic.
Astragalus canadensis L.
Baptisia tinctoria (L.) R. Br.
Cassia nictitans L. *
Cytisus scoparius (L.) Link * +
Desmodium nudiflorum (L.) DC. +
Desmodium paniculatum (L.) DC.
Desmodium perplexum Schub.
Desmodium rotundifolium DC. +
Galactia volubilis (L.) Brirt. *
Gleditsia triacanthos L. +
Kummerowia stipulacea (Maxim.) Makino *
Lathyrus latifolius L. *
Lespedeza virginica (L.) Britt.*
Medicago lupulina L. *
Medicago sativa L. *
Melilotus alba Medic *
Melilotus officinalis (L.) Pallas *
Pueraria lobata (Willd.) Ohwi
Robinia hispida L.
Robinia pseudo-acacia L. +
Robinia viscosa Vent. ex Vauq.
Tephrosia virginiana (L.) Pers.
Thermopsis fraxinifolia (Nutt.) M. A.Curtis
Trifolium arvense L.*
Trifolium aureum Pollich *
Trifolium campestre Schreb. *
Trifolium hydridum L. *
Trifolium pratense L. *
Trifolium repens L. *
Vicia americana ssp.minor(Hook.)C.R.Gunn. *
Vicia caroliniana Walt.
Vicia villosa Roth. *

Fagaceae
Castanea dentata P. Mill.

Castanea pumila (L.) P. Mill.
Fagus grandifolia Ehrh.
Quercus alba L.
Quercus coccinea Muenchh.
Quercus falcata Michx.
Quercus imbricaria Michx.
Quercus montana Willd. "
Quercus rubra L.
Quercus stellata Wang.
Quercus velutina Lam.

Gentianaceae
Bartonia virginica (L.) B.S.P. +
Gentiana clausa Raf.
Gentiana decora Pollard #
Gentiana saponaria L.
Gentianella quinquefolia (L.) Small *
Obolaria virginica L.
Sabatia angularis (L.) Pursh * + "

Geraniaceae
Geranium carolinianum L. *
Geranium maculatum L.

Hamamelidaceae
Hamamelis virginiana L. #

Hippocastanaceae
Aesculus flava Soland [=octandra Marshall]

Hydrocharitaceae
Elodea nuttallii (Planch.) St. John

Hydrophyllaceae
Hydrophyllum canadense L.
Hydrophyllum macrophyllum Nutt.
Hydrophyllum virginianum L.
Phacelia bipinnatifida Michx. +
Phacelia dubia (L.) Trel.
Phacelia fimbriata Michx.

Iridaceae
Iris cristata Soland.
Iris verna var. smalliana Fern. ex M. E. Edwards "
Iris virginica L. +
Sisyrincnium angustifolium P. Mill.
Sisyrinchium mucronatum Michx. +

Juglandaceae
Carya cordiformis (Wang.) K. Koch +

Carya glabra (P. Mill.) Sweet + #
Carya ovata (P. Mill.) Koch + #
Carya tomentosa (Poir.) Nutt. +
Jugians cinerea L. + #
Juglans nigra L. + #

Juncaceae
Juncus acuminatus Michx.
Juncus brevicaudatus (Engelm.) Fern.
Juncus coriaceus Mackenzie * +
Juncus effusus L. *
Juncus gymnocarpus Coville
Juncus marginatus Rostk. *
Juncus subcaudatus (Engelm.)Coville & Blake +
Juncus tenuis Willd. *
Juncus trifidus ssp. carolinianus Hamet - Ahti
Luzula acuminata var. carolinae (S. Wats.) Fern.
Luzula echinata (Small) F. J. Herm.
Luzula multiflora (Retz.) Lej.

Lamiaceae
Agastache scrophulariaefolia (Willd.) Kuntze
Clinopodium vulgare L.
Collinsonia canadensis L.
Glechoma hederacea L. *
Hedeoma pulegioides (L.) Pers. *
Lamium amplexicaule L. *
Lamium purpureum L. *
Leonurus cardiaca L. *
Lycopus americanus Muhl. ex Bart.
Lycopus virginicus L. *
Monarda clinopodia L.
Monarda didyma L.
Monarda fistulosa L.
Physostegia virginiana (L.) Benth.
Prunella vulgaris L. *
Pycnanthemum flexuosum (Walt.) B.S.P. +
Pycnanthemum incanum (L.) Michx.
Pycnanthemum montanum Michx.
Pycnanthemum muticum (Michx.) Pers.
Pycnanthemum tenuifolium Schrad. *
Pycnanthemum verticillatum (Michx.) Pers.
Salvia lyrata L. *
Scutellaria elliptica Muhl. *
Scutellaria incana Biehler.
Scutellaria integrifolia L. *
Scutellaria ovata Hill
Stachys latidens Small
Teucrium canadense L.
Trichostema dichotomum L. *

Lauraceae
Lindera benzoin (L.) Blume
Sassafras albidum (Nutt.) Nees

Lentibulariaceae
Utricularia subulata L. +

Liliaceae
Aletris farinosa L.
Allium canadense L.
Allium cernuum Roth
Allium tricoccum Ait.
Allium vineale L.*
Amianthium muscaetoxicum (Walt.) Gray
Asparagus officinalis L. * + #
Chamaelirium luteum (L.) Gray
Clintonia borealis (Ait.) Raf.
Clintonia umbellulata (Michx.) Morong
Convallaria montana Raf.
Disporum lanuginosum (Michx.) Nichols.
Disporum maculatum (Buckl.) Britt. +
Erythronium americanum Ker-gawl.
Erythronium umbilicatum ssp.monostolum Parks & Hardin
Hemerocallis fulva (L.) L. *
Hypoxis hirsuta (L.) Coville
Lilium grayi S. Wats. "
Lilium michauxii Poir.
Lilium superbum L.
Maianthemum canadense Desf.
Medeola virginiana L.
Melanthium virginicum L. +
Polygonatum biflorum (Walt.) Ell. #
Polygonatum pubescens (Willd.) Pursh #
Smilacina racemosa (L.) Desf.
Stenanthium gramineum (Ker - Gawl.)
Streptopus amplexifolius (L.) DC.
Streptopus roseus Michx.
Trillium catesbaei Ell. +
Trillium cernuum L. +
Trillium erectum L.
Trillium erectum var album (Michx.) Pursh
Trillium grandiflorum (Michx.) Salisb.
Trillium undulatum Willd.
Uvularia grandiflora Sm.
Uvularia perfoliata L.
Uvularia puberula Michx.
Uvularia sessilifolia L. * #
Veratrum parviflorum Michx.
Veratrum viride Ait.
Xerophyllum asphodeloides (L.) Nutt.
Yucca filamentosa L.
Zigadenus leimanthoides Gray +

Linaceae
Linum striatum Walt.
Linum virginianum L. *

Loranthaceae
Phoradendrom serotinum (Raf.) M.C. Johnston

Magnoliaceae
Liriodendron tulipifera L. +
Magnolia acuminata (L.) L.
Magnolia fraseri Walt. #

Malvaceae
Abutilon theophrastii Medic. * +
Malva neglecta Wallr. *

Melastomataceae
Rhexia virginica L. *

Moraceae
Morus rubra L.

Myricaceae
Comptonia peregrina (L.) Coult.

Nyssaceae
Nyssa sylvatica Marsh. + #

Oleaceae
Chionanthus virginicus L.
Fraxinus americana L. + #
Ligustrum sinense Lour. * +

Onagraceae
Circaea alpina L.
Circaea lutetiana ssp. canadensis(L.)
Aschers. & Magnus *
Epilobium angustifolium L. *
Epilobium coloratum Biehler *
Ludwgia alternifolia L. *
Oenothera biennis L. *
Oenothera fruticosa L. *
Oenothera fruticosa ssp.glauca (Michx.) Straley *
Oenothera laciniata Hill

Orchidaceae
Aplectrum hyemale (Muhl. ex Willd.) + #
Calopogon tuberosus (L.) B.S.P. +
Cleistes divaricata (L.) Ames +
Coeloglossum viride (L.) Hartman +

Corallorniza odontorhiza (Willd.) Nutt.
Cypripedium acaule Ait.
Cypripedium pubescens Willd. +
Galearis spectabilis (L.) Raf.
(=Orchis spectabilis L.)
Goodyera pubescens (Willd.) R. Br.
Goodyera repens (L.) R. Br.
Isotria verticillata (Muhl. ex Willd.) Raf.
Liparis liliifolia (L.) L.C. Rich. ex Lindl.
Listera cordata (L.) R. Br. a
Listera smallii Wieg. #
Malaxis unifolia Michx.
Platanthera clavellata (Michx.) Luer
[=Habernaria clavellata (Michaux) Sprengel]
Platanthera grandifolia (Bigelow) Lindl. +
[=Habernaria pyscodes var. grandifolia (Bigelow) Gray]
Platanthera lacera (Michx.) G. Don
[=Habernaria lacera (Michx.) R. Br.]
Platanthera orbiculata (Pursh) Lindl. +
[=Habernaria orbiculata (Pursh) Torr.
Platantnera psycodes (L.) Lindl.
[=Habernaria pyscodes (L.) Spreng.]
Platanthera ciliaris (L.) Lindl. *
[=Habernaria ciliaris (L.) R. Br.]
Pogonia ophioglossoides (L.) Juss. +
Spiranthes cernua (L.) L. C. Rich. +
Spiranthes lacera var. gracilis (Bigelow) Luer
Tipularia discolor (Pursh) Nutt. +
Triphora trianthophora (Sw.) Rydb.

Orobanchaceae
Conopholis americana (L.) Wallr.
Epifagus virginiana (L.) Bart. #
Orobanche uniflora L. +

Oxalidaceae
Oxalis acetosella L.
Oxalis dillenii Jacq. *
Oxalis grandis Small *
Oxalis stricta L. *
Oxalis violacea L. *

Papaveraceae
Corydalis flavula (Raf.) DC. a
Corydalis sempervirens (L.)Pers. +
Dicentra canadensis (Goldie) Walp. #
Dicentra cucullaria (L.) Bernh.
Dicentra eximia (Ker-gawl.) Torr.
Sanguinaria canadensis L.

Passifloraceae
Passiflora incarnata L. *

Phytolaccaceae
Phytolacca americana L. *

Plantaginaceae
Plantago aristata Michx. *
Plantago lanceolata L. *
Plantago rugelii Dcne. *
Plantago virginica L. *

Platanaceae
Platanus occidentalis L. +

Poaceae
Agropyron repens L. (Beauv.) *
Agrostis mertensii Trin.
Agrostis perennans (Walt.) Tuckerman
Agrostis stolonifera L.
Andropogon virginicus L. *
Aristida dichotoma Michx. *
Arundinaria gigantea (Walt.) Muhl.
Brachyelytrum erectum (Schreb.) Beauv.
Bromus commutatus Schrad. *
Bromus pubescens Much. ex Willd.
Calamagrostis cinnoides (Muhl.) Bart. *
Chasmanthium latifolium (Michx.) Yates *
Cinna latifolia (Trev.ex Goepp.) Griseb.
Cynodon dactylon (L.) Pers. *
Dactylis glomerata L. *
Danthonia compressa Austin
Danthonia spicata (L.) Beauv. ex Roemer & Schultes *
Deschampsia flexuosa (L.) Trin.
Dichanthelium boscii (Pori) Gould & Clark
Dichanthelium commutatum (Schultes) Gould
Dichanthelium depauperatum (Muhl.) Gould
Dichanthelium dichotomum (L.) Gould
Digitaria sanguinalis (L.) Scop. *
Echinochloa crusgalli (L.) Beauv. *
Eleusine indica (L.) Gaertn. *
Elymus villosus Muhl. ex Willd.
Elymus virginicus L. *
Eragrostis capillaris (L.) Nees. *
Eragrostis cilianensis (All.) E. Mosher *
Eragrostis hirsuta (Michx.) Nees *
Eragrostis pilosa (L.) Beau. *
Festuca elatior L. *
Glyceria melicaria (Michx.) F.t.hubbard
Glyceria striata (Lam.) A.s. Hitchc.
Helictotricnon pubescens (Huds.) Pilger
Holcus lanatus L. *
Hystrix patula Moench

Leersia virginica Willd. *
Leersia oxyzoides (L.) Sw. *
Melica mutica Walt. *
Miscanthus sinensis Anderss. *
Muhlenbergia frondosa (Poir.) Fern. *
Muhlenbergia glomerata (Willd.) Trin.
Muhlenbergia schreberi J.F.Gmel.
Panicum dichotomiflorum Michx. *
Panicum gattingeri Nash *
Panicum philadelphicum Bernh. ex Trin.
Paspalum setaceum Michx. *
Phleum pratense L. *
Poa alsodes Gray
Poa annua L. *
Poa autumnalis Muhl. ex Ell.
Poa compressa L. *
Poa cuspidata Nutt.
Poa pratensis L. *
Schizachyrium scoparium (Michx.) Nash *
Setaria glauca (L.) Beauv. *
Setaria viridis (L.) Beauv. *
Sorghastrum nutans (L.) Nash
Sorghum halepense (L.) Pers. *
Sphenopholis nitida (Biehler) Scribn.
Sporobolus indicus (L.) R. Br *
Stipa avenacea L.
Tridens flavus (L.) A.S. Hitchc. *

Polemoniaceae
Phlox amplifolia Britt.
Phlox carolina L.
Phlox glaberrima ssp. triflora (Michx.) Wherry
Phlox maculata ssp. pyramidalis(Sm.)Wherry
Phlox ovata L.
Phlox paniculata L. *
Phlox stolonifera L.
Phlox subulata L.

Polygalaceae
Polygala cruciata L. +
Polygala curtissii Gray
Polygala sanguinea L. * +
Polygala verticillata L. *

Polygonaceae
Polygonum caespitosum var longisetum(Debruyn)A.N.Stew.*
Polygonum cilinode Michx.
Polygonum pensylvanicum (L.) Small *
Polygonum persicaria L. *
Polygonum punctatum Ell. *

Polygonum sagittatum L. *
Polygonum scandens L. *
Polygonum virginiananum L. *
Rumex acetosella L. *
Rumex crispus L. *
Rumex obtusifolius L. *

Portulacaceae
Claytonia caroliniana Michx
Claytonia virginica L.
Talinum teretifolium Pursh +

Primulaceae
Dodecatheon meadia L.
Lysimachia ciliata L. *
Lysimachia lanceolata Walter
Lysimachia quadrifolia Sims *
Lysimachia terrestris (L.) B.S.P.

Ranunculaceae
Aconitum reclinatum Gray #
Aconitum uncinatum L.
Actaea pachypoda Ell. #
Anemone quinquefolia L.
Anemone virginiana L. *
Aquilegia canadensis L.
Cimicifuga americana Michx.
Cimicifuga racemosa (L.) Nutt.
Clematis viorna L.
Clematis virginiana L.
Delphinium tricorne Michx.
Hepatica nobilis var. acutiloba (Pursh) Steyermark
(=acutiloba DC.)
Hydrastis canadensis L. #
Ranunculus abortivus L. *
Ranunculus acris L. *
Ranunculus bulbosus L. * +
Ranunculus hispidus Michx. +
Ranunculus recurvatus Poir.
Ranunculus repens L. *
Thalictrum clavatum DC.
Thalictrum coriaceum (Britt.) Small
Thalictrum dioicum L.
Thalictrum pubescens Pursh
Thalictrum thalictroides (L.) Eames & Boivin
Trautvetteria carolinensis Fisch. & Mey.
Xanthorhiza simplicissima Marsh.

Rhamnaceae
Ceanothus americanus L. *

Rosaceae

Agrimonia gryposepala Wallr. *
Agrimonia pubescens Wallr. *
Agrimonia rostellata Wallr. * #
Amelanchier arborea var. laevis (Wieg.) Ahles
Amelanchier sanguinea (Pursh) DC.
Aronia arbutifolia (L.) Pers. +
[=Sorbus arbutifolia (L.) Heynhold]
Aronia melanocarpa (Michx.) Ell.
[=Sorbus melanocarpa (Michx.) Schneider]
Aronia prunifolia (Marsh.) Rehd.
[=Sorbus arbutifolia var. atropurpurea
(Britton) Schneider]
Aruncus dioicus (Walt.) Fern.
Crataegus crus-galli L.
Crataegus flabellata (Bosc) K. Koch
Crataegus punctata Jacq.
Duchesnea indica (Andr.) Focke * # +
Filipendula rubra (Hill) B.L. Robins.
Fragaria virginiana Duchesne *
Geum canadense Jacq.
Geum radiatum Michx. +
Geum virginianum L.
Malus angustifolia (Ait.) Michx. +
Malus coronaria (L.) P. Mill.
Malus pumila P. Mill. * +
Physocarpus opulifolius (L.) Maxim. +
Porteranthus trifoliatus (L.) Britt.
[=Gillenia trifoliatus (L.) Moench
Potentilla canadensis L. *
Potentilla norvegica L. *
Potentilla recta L. *
Potentilla simplex Michx. +
Potentilla tridentata (Soland.) Ait.
Prunus americana Marsh
Prunus avium (L.) L. !
Prunus cerasus L.
Prunus pensylvanica L.
Prunus serotina Ehrh.
Prunus virginiana L.
Rosa carolina L.
Rosa multiflora Thun. *
Rosa palustris Marsh.
Rubus allegheniensis Porter ex Bailey *
Rubus argustus Link *
Rubus canadensis L.
Rubus flagellaris Willd. *
Rubus hispidus L.
Rubus idaeus var. sachalinensis (Levl.) Focke
Rubus occidentalis L. *

Rubus odoratus L.
Rubus phoenicolasius Maxim. *
Sanguisorba canadensis L.
Sorbus americana Marsh.
Spiraea alba Du Roi +
Spiraea japonica L. F.
Spiraea tomentosa L. * +

Rubiaceae
Diodia teres Walt. *
Diodia virginiana L. *
Galium aparine L. *
Galium circaezans Michx.
Galium latifolium Michx.
Galium tinctorium L.*
Galium triflorum Michx.
Hedyotis caerulea (L.) Hook.
Hedyotis michauxii Fosberg
Hedyotis purpurea (L.) Torr. & Gray
Mitchella repens L.

Salicaceae
Populus balsamifera L. * + # [=candicans Ait.]
Populus deltoides Bartr. ex Marsh. * +
Populus grandidentata Michx. +
Salix humilis Marsh. +
Salix nigra Marsh. +
Salix sericea Marsh.

Santalaceae
Pyrularia pubera Michx.

Sarraceniaceae
Sarracenia flava L. !
Sarracenia purpurea L. !

Saxifragaceae
Astilbe biternata (Vent.) Britt.
Boykinia aconitifolia Nutt. + #
Chrysosplenium americanum Schwein. ex Hook. + #
Heuchera americana L.
Heuchera pubescens Pursh
Heuchera villosa Michx.
Hydrangea arborescens L.
Mitella diphylla L.
Parnassia asarifolia Vent.
Philadelphus hirsutus Nutt.
Ribes cynosbati L.
Ribes glandulosum Grauer
Ribes rotundifolium Michx.

Saxifraga careyana Gray
Saxifraga caroliniana Gray + #
Saxifraga michauxii Britt.
Saxifraga micranthidifolia (Haw.) Steud.
Saxifraga virginiensis Michx.
Tiarella cordifolia L.

Scrophulariaceae
Agalinis tenuifolia (Vahl) Raf.
Aureolaria flava (L.) Farw.
Aureolaria laevigata (Raf.) Raf.
Castilleja coccinea (L.) Spreng. *
Chelone cuthbertii Small +
Chelone glabra L.
Chelone lyonii Pursh
Lindernia dubia (L.) Pennell *
Melampyrum lineare Desr.
Mimulus ringens L.
Pedicularis canadensis L.
Penstemon canescens L. *
Penstemon smallii Heller
Scrophularia marilandica L. *
Verbascum blattaria L. *
Verbascum thapsus L. *
Veronica americana (Raf.) Schwein. ex Benth.*
Veronica arvensis L. *
Veronica officinalis L. *
Veronica peregrina L. *
Veronica persica Poir. *
Veronica serpyllifolia L. *
Veronicastrum virginicum (L.) Farw.

Simaroubaceae
Ailanthus altissima (Miller) Swingle *

Smilacaceae
Smilax bona-nox L. +
Smilax glauca Walt.
Smilax herbacea L.
Smilax hispida Muhl. +
Smilax rotundifolia L.

Solanaceae
Datura stramonium L. *
Nicandra physalodes (L.) Gaertn. *
Physalis heterophylla Nees * + #
Physalis pubescens var grisea Waterfall *
Physalis virginiana P. Mill. * +
Solanum americanum P. Mill. *
Solanum carolinense L. *
Solanum dulcamara L.

Sparganiaceae
Sparganium americanum Nutt.

Styracaceae
Halesia carolina L. +

Symplocaceae
Symplocos tinctoria (L.) L'her. +

Tiliaceae
Tilia caroliniana P. Mill.
Tilia heterophylla Vent.

Typhaceae
Typha latifolia L.

Ulmaceae
Celtis occidentalis L.
Ulmus rubra Muhl. #

Urticaceae
Boehmeria cylindrica (L.) Sw.
Laportea canadensis (L.) Weddell
Pilea pumila (L.) Gray #

Valerianaceae
Valerianella radiata (L.) Dufr. *

Verbenaceae
Phryma leptostachya L. +
Verbena urticifolia L. *

Violaceae
Viola arvensis Murr. *
Viola canadensis var.corymbosa Nutt. ex Torr. & Gray #
[=var. rugulosa (Greene) C.L. Hitchc.]
Viola fimbriatula Sm. * +
Viola hastata Michx.
Viola hirsutula Brainerd #
Viola macloskeyi ssp.pallens (Banks ex DC.)M.S. Baker
[includes V. blanda Willd.]
Viola obliqua Hill (V. cucullata) Ait.
Viola palmata L.
Viola pedata L. "
Viola primulifolia L.
Viola pubescens var. leiocarpa (Fern.& Wieg.) Seymour#
[=V. eriocarpa Schwein. var leiocarpa]
Viola rafinesquii Greene *
Viola rotundifolia Michx.
Viola sagittata Ait. +

Viola sororia Willd. [=papilionacea Pursh pro parte]
Viola striata Ait *

Vitaceae
Parthenocissus quinquefolia (L.) Planch. + #
Vitis aestivalis Michx.
Vitis cinerea Engelm. ex Millard
Vitis labrusca L. #

Xyridaceae
Xyris torta Sm. +

VEGETATION

OBJECTIVES AND METHODS

Objectives

The study integrates certain Anglo-American and European methods of sampling and analysis in order to: (1) inventory and classify the vascular plant communities, (2) characterize the major plant communities, (3) document the variation in vegetation relative to environmental factors and/or gradients, and (4) generate a model of vegetation-environmental relationships.

Sample Selection

Following field reconnaissance and examination of topographic maps and aerial photographs, sample plots were subjectively selected. Potential stands were evaluated to assure that they were homogeneous at all levels: canopy, subcanopy, shrub and ground layers, and located within homogeneous topographic units. An attempt was made to cover a grid of possible elevation and moisture conditions. Although the majority of the stands were old-growth forests (>75 years old), some younger stands were sampled to determine successional trends. A total of 156 stands were sampled.

Sample Design and Data Collection

Vegetation was sampled using 0.1 ha (20 x 50m) plots. All woody stems (exclusive of evergreen heaths) ≥5cm dbh were recorded by species and dbh. All vascular plants were recorded with an estimation of cover-abundance using the Braun-Blanquet (1932) scale. Notes were taken on stand history, and special features of the flora and vegetation. The following physical environmental data were recorded for each sample plot: elevation, aspect, topographic position, slope degree, annual potential solar radiation (Frank and Lee 1966), percent rock cover, rock type, stream order of nearest stream, and drainage area size (Hack and Goodlett 1960). Four soil samples were taken in each plot (upper 12cm, beneath litter), composited, and sent to the North Carolina Department of Agriculture, Raleigh for nutrient analysis.

This sampling procedure resulted in two vegetation data sets. First, 156 sample plots with estimation of cover-abundance for all vascular plants (357 species) and secondly, 140 sample plots which contained trees ≥5cm dbh values.

Reference Areas

The Black and Craggy Mountain study region covers in excess of

Table 14 Summary of characteristics of reference areas

Number of plots	Area	Size	Mountain Range	Drainage System	General Aspect	Elevation Range	Topographic Unit Types
30	BMRNA (Middle Creek)	568 ha (1405 acres)	Black	South Toe	E	853 - 2012 m (2800-6600')	Watershed of 3rd order stream
18	Big Poplar (Sugar Camp Creek)	607.3 ha (1500 acres)	Black	Cane	NNW	975-2012 m (3200-6600')	Watershed of 3rd & 4th order stream
22	Celo Community	404.4 ha (1000 acres)	Black	South Toe	W	823-1067 m (2700-3500')	Lower elevation slopes and ridges, flood plain of 5th order stream
31	Craggy Scenic Area (Carter Creek)	809.7 ha (2000 acres)	Craggy	Ivy	N	853-1853 m (2800-6080')	Watershed of 3rd order stream
8	Bee Tree-upper portion (Asheville water-shed)	607.3 ha (1500 acres)	Craggy	Swannanoa	S	762-1402 m (2500-4600')	Watershed of 3rd order stream
8	Mount Mitchell State Park	595.7 ha (1469 acres)	Black	Cane South Toe	N-S Ridge	1768-2037 m (5800-6684')	Ridge Top and slope
39	Others						
156	Total						

35,000 ha, an area too large to intensively sample. As an alternative, reference areas were sampled as suggested by Hills (1960), who describes them as: "areas of comparatively small size, characterized by physiography and forest types which are representative of those occurring commonly throughout broad areas, and are mapped and described with such thoroughness and detail . . . that the report will serve as a reference for the larger area." For this study, I selected 6 primary reference areas (Table 14) which represent a variety of topographic positions, contain old growth stands, will be protected in the future, and are representative of the plant communities of the region.

Data Analysis

The following strategy was used to analyze the data:

1. ordinate the sample plots and species within the plots,
2. determine extreme groups in the ordination (classify),
3. check correlations between environment and ordination,
4. delete the plots present in the classified extreme groups,
5. iterate (steps 1-4),
6. name vegetation types,
7. compare with a different classification technique (TWINSPAN) to check on validity of subjective decisions in above, and

8. synthesize into generalized model of vegetation - environmental relationships in the study area.

Ordination

Ordination arranges samples or species in a low dimensional, abstract space in such a manner that similar species or samples are placed close together and dissimilar ones are further apart (Gauch 1982). The arrangement of samples presumably corresponds to underlying environmental relationships, however the interpretation of environmental correlation or control occurs in a later step.

Data were ordinated using detrended correspondence analysis (DCA), (Hill 1979a). DCA is based on simple correspondence analysis but corrects its two main faults, the arch effect and the compression of stands near the axis ends relative to the axis middle (Hill and Gauch 1980). Detrending is accomplished by dividing axis 1 into a number of segments and within each segment, the axis 2 scores are adjusted to have an average of zero (Gauch 1982). In this study, analysis of the data set was done by progressive fragmentation (Peet 1980) in which identifiable vegetation types were removed and the remaining stands reordinated. This method is described more fully in the discussion of the ordination results.

TWINSPAN Classification

In order to check the robustness of the classification into vegetation types generated using DECORANA, two-way indicator species analysis (TWINSPAN) was used (Hill 1979b). The use of TWINSPAN in concert with DECORANA is consistent with the current view that these methods are complementary (Gauch and Whittaker 1981, Gauch 1982, Kershaw and Looney 1985, Pielou 1984). TWINSPAN is a hierarchical, polythetic, divisive technique. Stands are first ordinated by reciprocal averaging (RA). Then the species at the RA axis extremes are used to polarize the samples which are then divided by breaking the RA axis near the middle. The division is refined using information on species abundances (pseudospecies) which are used as differential indicator species (Kershaw and Looney 1985) much in the same manner as the approach of the Braun - Blanquet school (Gauch 1982). This process continues through repeated dichotomies with each cluster having no more than a chosen minimum number of members (Gauch and Whittaker 1981). It is then possible to produce a dendrogram of the classification, the end points of which are decided by the investigator based on what makes ecological sense.

Constancy, Character Species, and Ecological Species Groups

European phytosociologists, especially of the Braun-Blanquet

school, have developed methods of classification and ordination which involve the concepts of constancy (percentage of sample plots in which the species is present), and character species which are those which show maximum concentration (fidelity) in a vegetation type (Poore 1955, Whittaker 1960, Mueller-Dombois and Ellenberg 1974, see also the use of constancy by Curtis 1959 and Peet 1981). One of the strengths of this approach is that character species may be used to determine vegetation types in fragmented or disturbed stands since most character species are understory species which have a narrow ecological amplitude and therefore may be useful as plant indicators (Cajander 1926, Rowe 1956, Spurr and Barnes 1980).

The following method was used to determine character species. First, constancy was calculated for each species in a given vegetation type. Next, species were ranked using the following classes of fidelity (Mueller-Dombois and Ellenberg 1974 p.203):

1. Absolutely restricted (fidel), meaning that species is exclusively or almost exclusively found only in a single association.
2. Strongly associated, meaning that the species is represented also in other associations, however, much more sparsely.
3. Favorably associated, meaning that the species is represented more or less commonly in several associations,

but it is optimally developed or abundant only in one particular association.

Only those with a ranking of 1 or 2 were considered for charcter species in this study. Character species are listed at the end of the community type descriptions.

Extreme environmental conditions, such as nutrient rich or extremely xeric, tend to have species with stronger fidelity than intermediate portions of the gradients.

Ecological species groups, which are defined as species which show similar relationships to site factors and have closely similar life forms (Mueller-Dombois and Ellenberg 1974), can be valuable in indicating environmental variables once the relationships have become established (Spurr and Barnes 1980, Billings 1978, Rowe 1956). In many cases ecological species groups will be a combination of the character species for a particular vegetation type. For example, character species for cove hardwoods are Asarum canadense, Aconitum reclinatum, Astilbe biternata, Cimicifuga americana, Disporum maculatum, Uvularia grandiflora, Mitella diphylla, and Dryopteris goldiana. These are all highly correlated with moist, nutrient-rich soil conditions, and are similar in life form. These can be considered an ecological species group - the Asarum group. In other cases species groups range across several vegetation types. For instance, the Saxifraga group which includes

Saxifraga careyeana, Saxifraga caroliniana, Saxifraga micranthidifolia, Thalictrum clavatum, Diphylleia cymosa, Veratrum viride and Chelone lyoni are all plants of seepage areas which may be found in a number of vegetation types. Ecological species groups are presented in Appendix D.

Results

Ordinations

This section summarizes the ordinations of the 156 sample plots (represented by dots on the diagrams) and the correlation of these ordinations with environmental factors (see Table 15).

Each of the 14 environmental variables is represented as a vector with length equal to the multiple correlation with the two dimensional ordination and angle determined by the ratio of the coefficients of the regression of the environmental variables on the first two ordination axes (Peet, R.K. and N.L. Christensen: Hardwood forest vegetation of Duke Forest, Piedmont, N.C. Unpublished manuscript U.N.C. Chapel Hill, N.C.).

First Ordination

The first two axes of the DECORANA ordination of all 156 sample plots correlate strongly with solar beam irradiation and elevation (Figure 6) respectively. The trends for most soil nutrients and pH

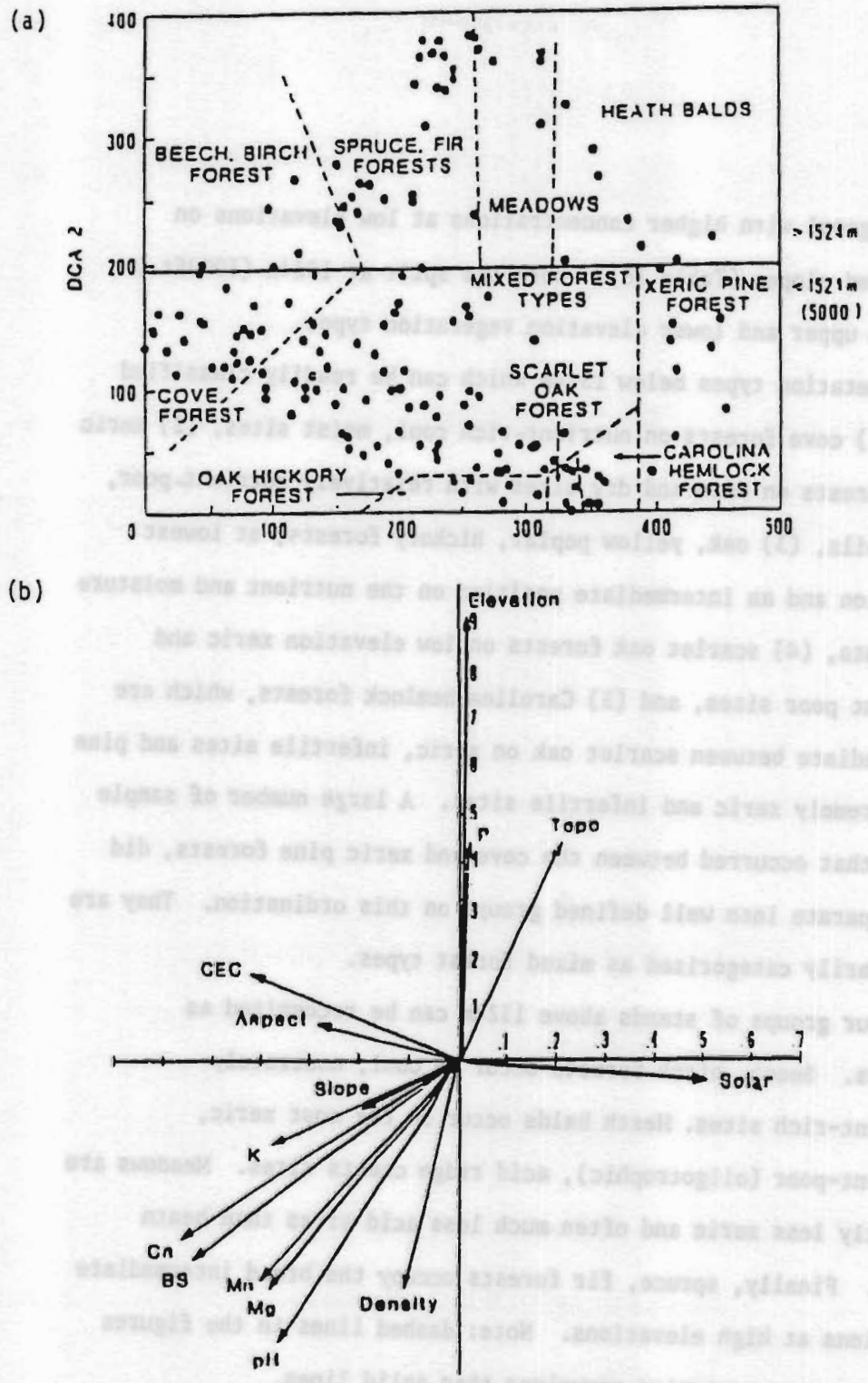


Figure 6. First ordination of all 156 sample plots with (a) vegetation types indicated and (b) environmental factors overlayed on DCA axes.

are diagonal with higher concentrations at low elevations on sheltered slopes (Table 16). Note the split at 1524m (5000ft.) between upper and lower elevation vegetation types.

Vegetation types below 1524m which can be readily classified are: (1) cove forests on nutrient-rich cool, moist sites, (2) xeric pine forests on warm and dry sites with relatively nutrient-poor, acid soils, (3) oak, yellow poplar, hickory forests, at lowest elevation and an intermediate position on the nutrient and moisture gradients, (4) scarlet oak forests on low elevation xeric and nutrient poor sites, and (5) Carolina hemlock forests, which are intermediate between scarlet oak on xeric, infertile sites and pine on extremely xeric and infertile sites. A large number of sample plots that occurred between the cove and xeric pine forests, did not separate into well defined groups on this ordination. They are temporarily categorized as mixed forest types.

Four groups of stands above 1524m can be recognized as follows. Beech, birch forests occur on cool, moderately nutrient-rich sites. Heath balds occur on the most xeric, nutrient-poor (oligotrophic), acid ridge crests sites. Meadows are slightly less xeric and often much less acid sites than heath balds. Finally, spruce, fir forests occupy the broad intermediate positions at high elevations. Note: dashed lines in the figures indicate more tentative groupings than solid lines.

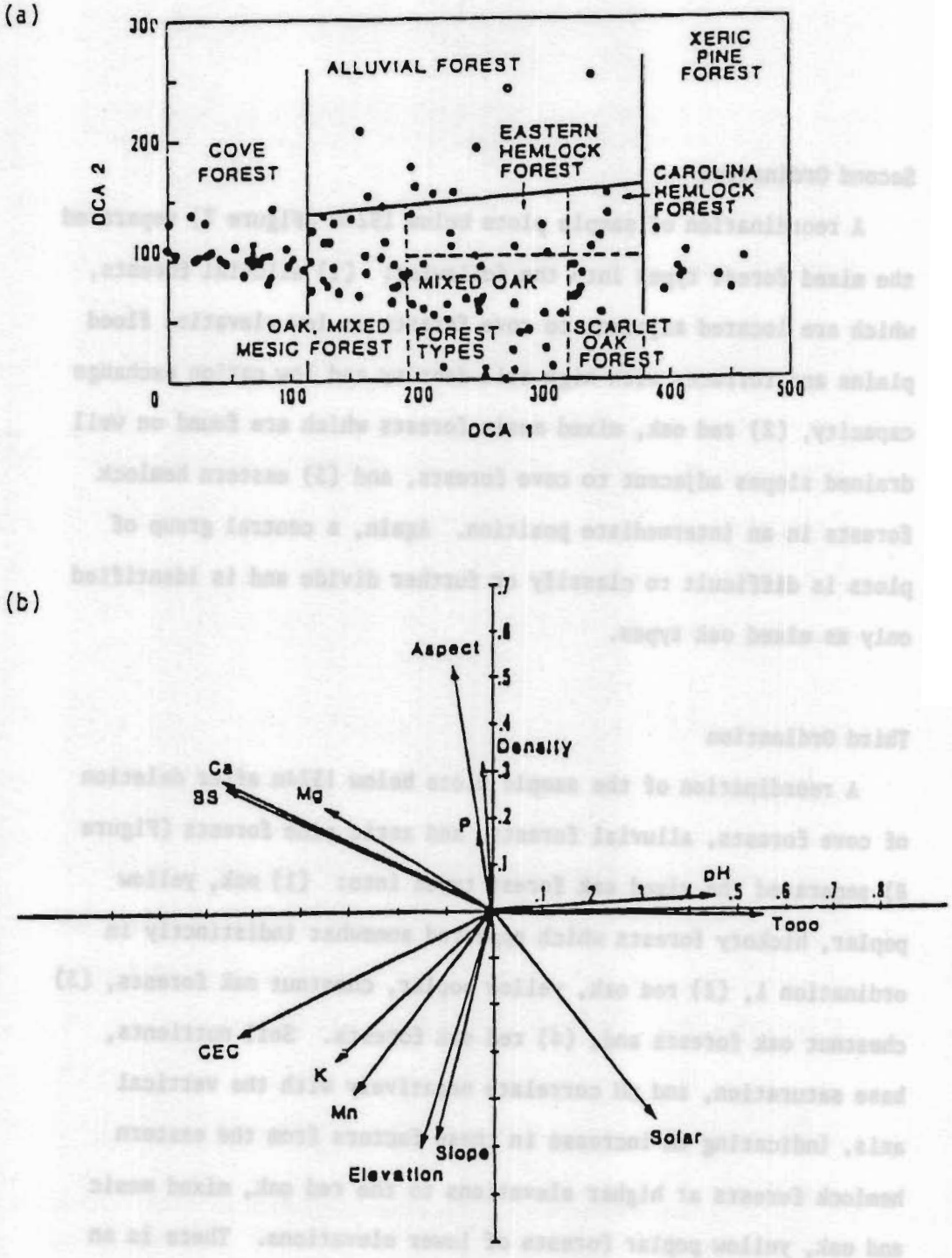


Figure 7. Second ordination, including plots below 5000 feet (1524 m), with (a) vegetation types indicated and (b) environmental factors overlayed on DCA axes.

Second Ordination

A reordination of sample plots below 1524m (Figure 7) separated the mixed forest types into the following: (1) alluvial forests, which are located adjacent to cove forests on low elevation flood plains and terraces with high soil density and low cation exchange capacity, (2) red oak, mixed mesic forests which are found on well drained slopes adjacent to cove forests, and (3) eastern hemlock forests in an intermediate position. Again, a central group of plots is difficult to classify or further divide and is identified only as mixed oak types.

Third Ordination

A reordination of the sample plots below 1524m after deletion of cove forests, alluvial forests, and xeric pine forests (Figure 8) separated the mixed oak forest types into: (1) oak, yellow poplar, hickory forests which appeared somewhat indistinctly in ordination 1, (2) red oak, yellow poplar, chestnut oak forests, (3) chestnut oak forests and, (4) red oak forests. Soil nutrients, base saturation, and pH correlate negatively with the vertical axis, indicating an increase in these factors from the eastern hemlock forests at higher elevations to the red oak, mixed mesic and oak, yellow poplar forests of lower elevations. There is an increase in temperature from eastern hemlock forest to scarlet oak forest (Table 16).

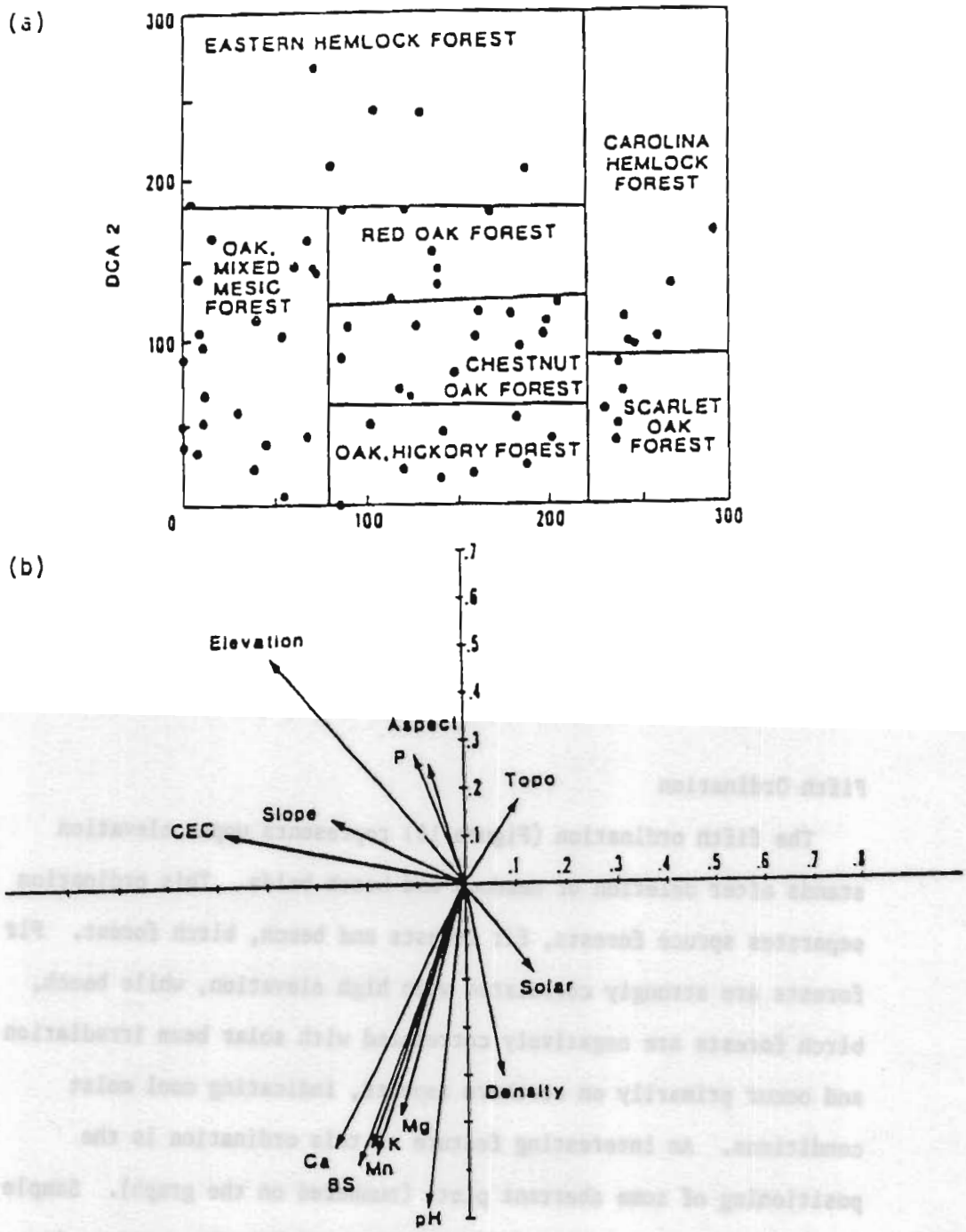


Figure 8. Third ordination, including sample plots below 5000 feet, after deletion of cove forests, alluvial forests and xeric pine forests with (a) vegetation types indicated and (b) environmental factors overlayed on DCA axes.

Fourth Ordination

A reordination of sample plots above 1524m showed soil nutrients to be not as highly correlated with vegetation or each other as below 1524m. The first DCA axis is most strongly correlated with solar beam irradiation, indicating a topographic-moisture gradient with heath balds at the xeric extreme. The second axis appears to be primarily an elevation axis but with soil phosphorus, slope degree and cation exchange capacity increasing from the meadows to the spruce, fir forests. The diagonal pH vector indicates a corresponding decrease in acidity from the spruce, fir forests to the meadows (Table 16).

Fifth Ordination

The fifth ordination (Figure 10) represents upper elevation stands after deletion of meadows and heath balds. This ordination separates spruce forests, fir forests and beech, birch forest. Fir forests are strongly correlated with high elevation, while beech, birch forests are negatively correlated with solar beam irradiation and occur primarily on northern aspects, indicating cool moist conditions. An interesting feature of this ordination is the positioning of some aberrant plots (numbered on the graph). Sample plots 90, 91 and 113 are in the Craggy mountains where spruce is

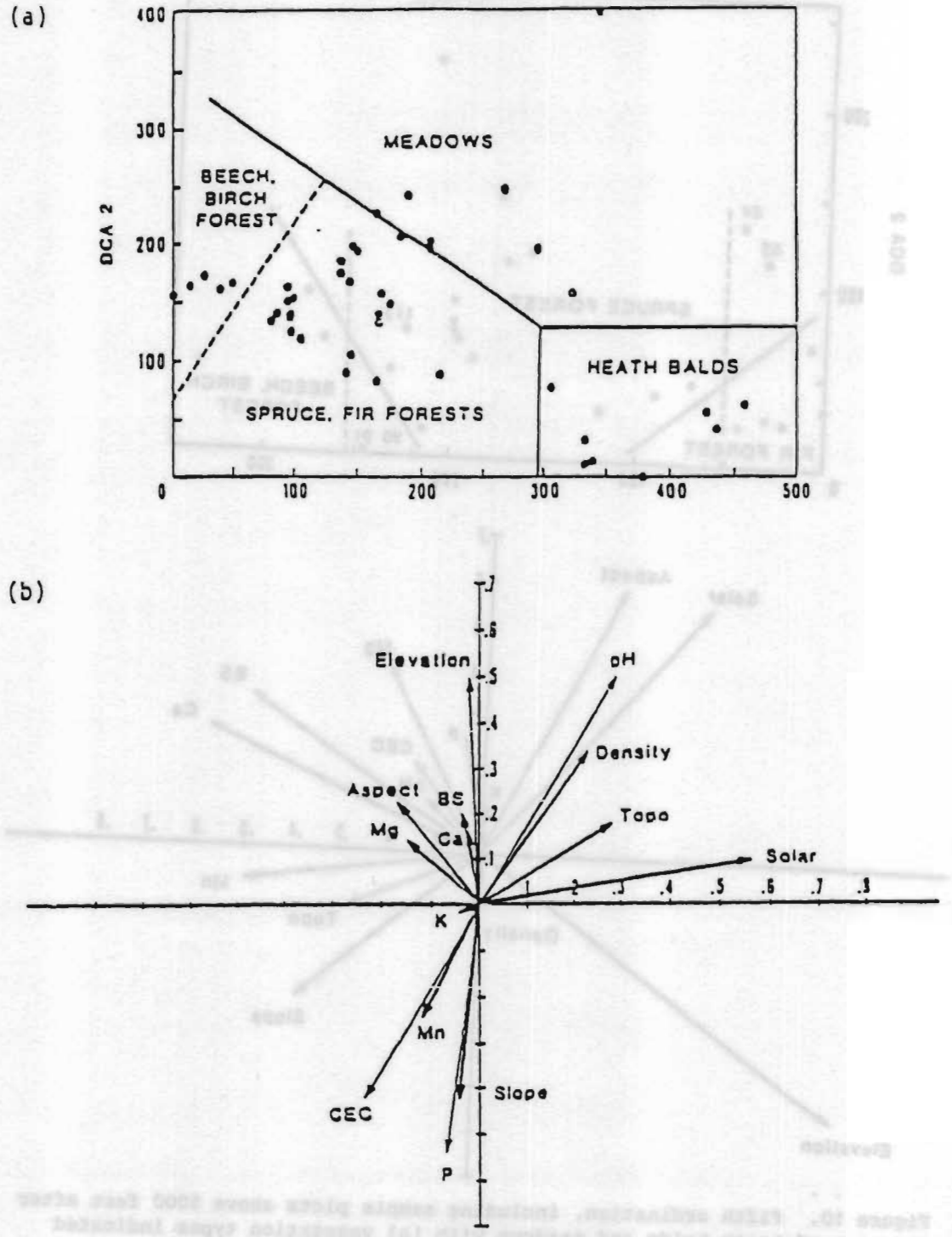


Figure 9. Fourth ordination including sample plots above 5000 feet with (a) vegetation types indicated and (b) environmental factors overlayed on DCA axes.

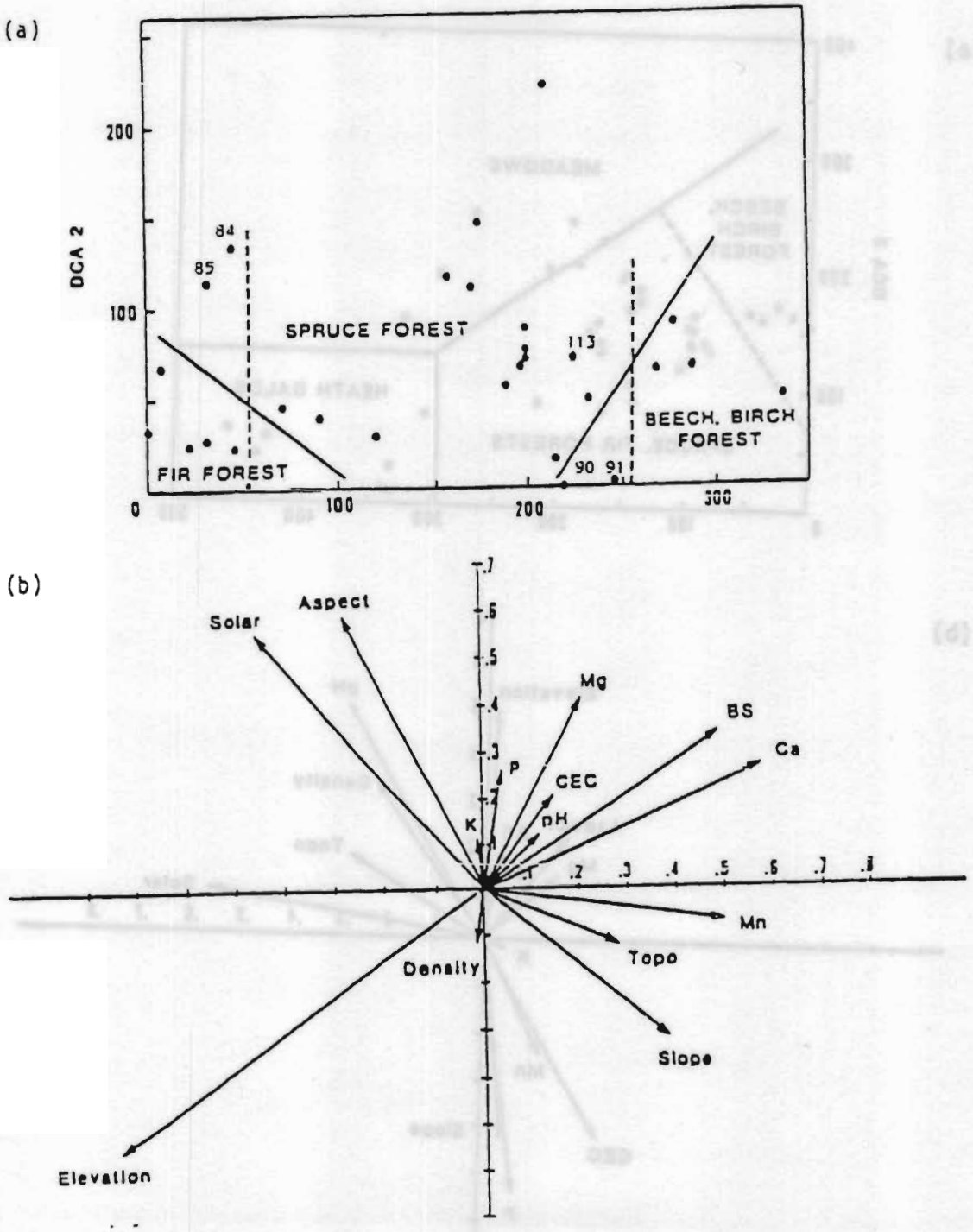


Figure 10. Fifth ordination, including sample plots above 5000 feet after deletion of heath balds and meadows with (a) vegetation types indicated and (b) environmental factors overlayed on DCA axes.

Table 15 Average environmental characteristics of vegetation types

Vegetation Type	Soil Dens. (g/100 cm)	CEC (meg/ 100cm)	BS %of CEC	pH	1 P (ind)	1 K (ind)	Ca %of CEC	Mg %of CEC	1 Mn (ind)	Elev (in ft)	Aspect (-180)	Slope Degree	2 Sol Rad. (ind)	3 Topo (slope posi.)
C Hl	0.65	12.00	61.2	5.12	6.5	72.9	46.8	11.3	368.3	3994	131.1	16.5	5030	3.11
Be,Bi	0.52	8.48	17.0	4.12	9.0	41.3	10.9	3.6	202.5	5166	146.7	13.8	4350	3.50
O Me	0.67	9.15	44.2	4.94	5.5	67.8	30.2	10.3	367.0	3681	83.6	16.7	5029	2.52
Al	0.81	7.00	39.4	4.83	10.1	39.2	27.5	9.0	195.5	2889	157.5	3.9	4923	1.20
E. He	0.54	8.85	15.2	4.03	8.2	25.7	7.8	5.5	71.0	4007	113.3	6.2	5189	2.33
O,YP,Hi	0.68	7.69	43.9	5.04	5.1	63.8	31.3	8.6	377.9	3111	50.6	8.8	5337	2.44
WO	0.76	10.10	54.0	5.06	8.0	67.1	45.5	12.5	320.0	2840	90.0	6.0	5051	1.05
SO RM	0.63	6.05	41.8	4.90	3.5	51.0	24.4	13.3	391.3	2824	88.0	6.2	5152	3.60
RO,YP,CO	0.62	6.77	25.0	4.91	3.6	54.3	14.4	6.9	312.6	3685	34.9	17.9	5463	3.15
CO	0.74	6.80	21.0	4.40	3.4	20.0	11.8	5.5	66.0	3215	12.0	12.2	5592	3.00
RO	0.53	8.45	17.0	4.41	8.5	39.0	10.8	4.1	225.3	4371	80.0	15.9	5239	3.86
Cr He	0.72	5.00	13.8	4.44	4.4	33.2	5.5	4.4	67.6	2696	85.0	9.2	5080	2.00
XP	0.50	7.49	11.3	4.03	17.0	38.6	4.6	3.8	112.0	3823	100.6	13.2	4988	4.00
HB	0.59	8.90	14.3	4.10	18.3	35.3	9.4	2.9	162.7	5149	81.9	14.1	5324	4.25
RS	0.39	10.36	15.2	3.74	18.0	49.9	9.1	3.7	67.1	5453	86.5	9.8	4962	3.76
F	0.49	8.42	10.8	3.85	11.0	43.5	5.2	3.0	33.8	6404	116.0	6.4	5052	2.40
Mea	0.60	8.07	21.0	4.57	3.5	47.5	13.4	4.4	65.0	5738	91.3	7.5	5202	4.63

1. An index indicating relative amount of element (soil test report, N.C. Dept. of agriculture, Raleigh, N.C.)
2. Potential solar beam irradiation (Frank and Lee 1966) - listed as a radiation index (R.I.) - the ratio of the total annual potential insolation to the maximum potential insolation at the site.
3. Slope position - 5=top of ridge, 1=valley.

absent. These plots are at elevations of 1648m (5400ft), 1615m (5300ft) and 1737m (5700ft) respectively and are dominated by yellow birch and/or beech. If these plots had been in the Black Mountains, they would undoubtably have contained spruce and would likely be dominated by it. DECORANA placed them in a position on the two axes indicating that these are essentially spruce sites even though spruce is absent. In a parallel example, plots 84 and 85 at 1798m (5900ft) and 1768m (5800ft) are intermediate to fir and were probably co-dominated by fir before the widespread death of the canopy fir owing to attack by the balsam wolly aphid. The uncertain affinity of these stands is indicated by the dashed boundary on the graph.

Ordinations Summary

Both classification of the vegetation into community types and correlation of these types with environmental variables/gradients was achieved. Fifteen vegetation types were recognized: cove forests; beech, birch forests; alluvial forests; oak, mixed mesic forests; eastern hemlock forests; oak, yellow poplar, hickory forests; red oak, yellow poplar, chestnut oak forests; red oak forests; scarlet oak forests; Carolina hemlock forests; xeric pine forests; spruce forests; fir forests; heath balds and meadows.

Table 16 Spearman rank correlation coefficients of environmental variables with ordination axis

	Elev.	CEC	BS	Soil Density	Ca	Mg	pH	Sol. Rad.	Aspect	Slope degree	Slope position	P	K	Mn
Ordination 1		All plots												
DCA 1	-0.097	-0.517*	-0.550*	-0.081	-0.607*	-0.394*	-0.276+	0.514*	-0.309*	-0.257+	0.194	-0.026	-0.408*	-0.421*
DCA 2	0.908*	0.386*	-0.309+	-0.518*	-0.199	-0.429*	-0.551*	-0.140	0.135	0.017	0.442*	0.425*	-0.062	-0.372*
Ordination 2		All plots under 1524m (5000ft)												
DCA 1	-0.357*	-0.580*	-0.645*	0.090	-0.677*	-0.461*	-0.409*	0.499*	-0.301+	-0.303+	0.071	-0.014	-0.450*	-0.450*
DCA 2	-0.313+	0.043	0.184	0.272'	0.188	0.125	0.104	-0.441*	0.591*	-0.368*	-0.517*	0.164	-0.078	-0.169
Ordination 3		Plots under 1524m minus coves, alluvial and xeric pine stands												
DCA 1	-0.487*	-0.468+	-0.361'	-0.085	-0.437+	-0.263	-0.140	0.148	-0.125	-0.180	-0.186	-0.113	-0.257	-0.254
DCA 2	0.474*	0.038	-0.592*	-0.375'	-0.537*	-0.482+	-0.637*	-0.164	0.203	0.174	0.174	0.191	-0.523*	-0.526*
Ordination 4		All plots above 1524m												
DCA 1	-0.089	-0.203	-0.121	0.246	-0.190	-0.184	0.299	0.623*	-0.383'	-0.016	0.329	0.117	-0.081	-0.194
DCA 2	0.630*	-0.347	-0.104	0.355	-0.137	-0.185	0.276	-0.118	0.198	-0.465+	0.042	-0.516+	-0.019	-0.283
Ordination 5		Spruce, fir and Beech, birch plots without meadows and heath balds												
DCA 1	-0.723*	0.055	0.472+	0.081	0.505+	0.244	0.172	-0.627+	0.473+	0.423	0.218	0.009	0.050	0.538+
DCA 2	-0.433	0.050	0.194	-0.099	0.151	0.345	0.117	0.292	-0.451'	-0.131	-0.052	0.130	-0.043	0.125

* - indicates significant at 0.0001 level
+ - indicates significant at 0.001 level
' - indicates significant at 0.01 level

The first ordination showed correlation with elevation on the vertical axis, solar beam irradiation on the horizontal axis, and soil nutrients as a diagonal gradient. Subsequent ordinations revealed strong correlations of the vegetation below 1524m (5000ft) with soil nutrients, aspect, slope position, slope degree, solar irradiation and elevation. Correlations above 1524m were strongest with pH, P, elevation, solar irradiation and aspect.

TWINSPAN Classification

Figure 11 is a dendrogram of the 156 sample plots (herb data set) of the study area based on the TWINSPAN method. TWINSPAN divides the sample plots at the highest level into two groups based on the topographic - moisture gradient with the xeric pine - heath, heath balds and oaks separated from the more mesic cove forest, hemlock, and spruce, fir plots. Next, the xeric pine - heath plots were separated from the oaks. This is primarily a soil nutrient - pH gradient. Then, elevation separation is accomplished by splitting off the spruce-fir from the cove forest and hemlock sample plots. Finally, additional separation occurs which is apparently related to a combination of the three gradients (topographic moisture, elevation and nutrients-pH) plus in some instances stand history (e.g., grazed meadows were split off from heath balds and fire meadows).

There is much similarity between the TWINSPAN dendrogram and

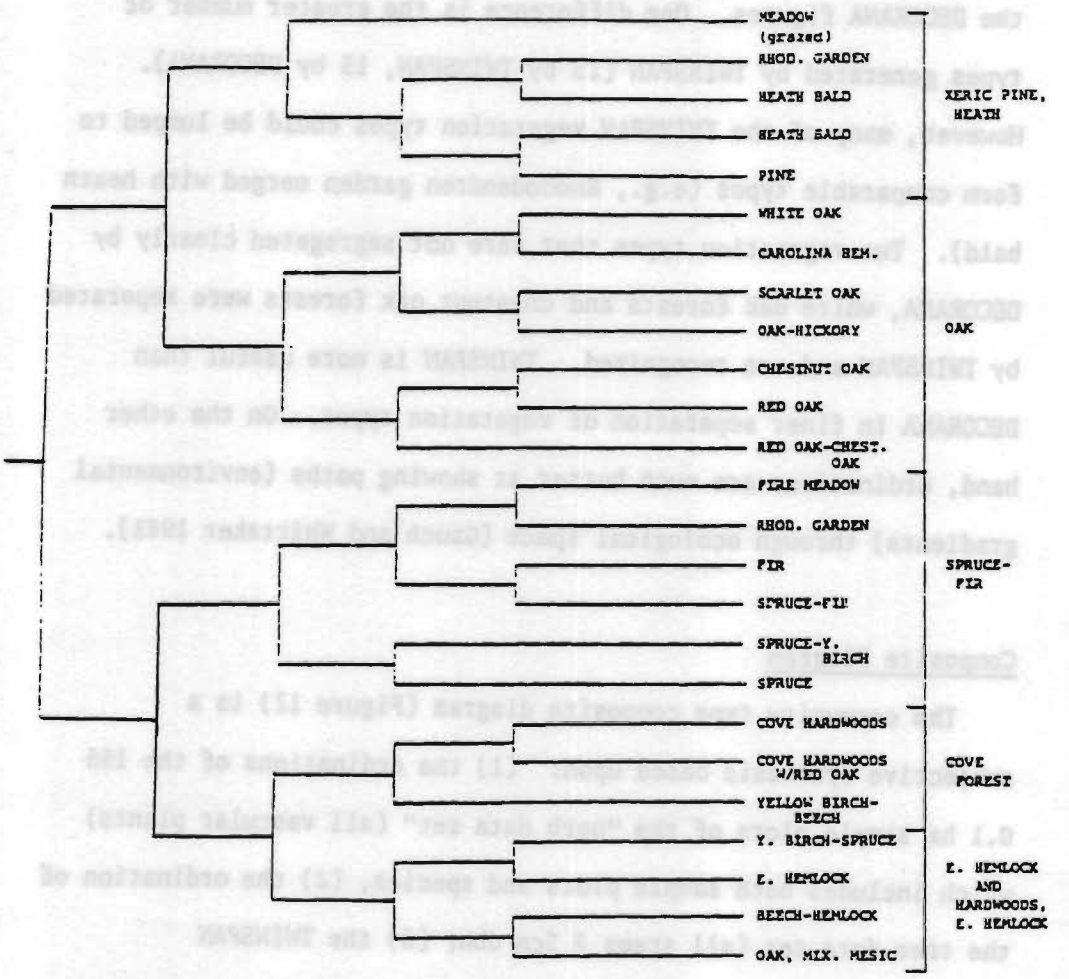


Figure 11. TWINSPAN dendrogram of 156 sample plots in the Black and Craggy Mountains, N. C., U.S.A.

the DECORANA figures. One difference is the greater number of types generated by TWINSPAN (25 by TWINSPAN, 15 by DECORANA). However, many of the TWINSPAN vegetation types could be lumped to form comparable types (e.g., Rhododendron garden merged with heath bald). Two vegetation types that were not segregated clearly by DECORANA, white oak forests and chestnut oak forests were separated by TWINSPAN and are recognized. TWINSPAN is more useful than DECORANA in finer separation of vegetation types. On the other hand, ordinations are much better at showing paths (environmental gradients) through ecological space (Gauch and Whittaker 1981).

Composite Diagram

The community type composite diagram (Figure 12) is a subjective synthesis based upon: (1) the ordinations of the 156 0.1 ha sample plots of the "herb data set" (all vascular plants) which includes both sample plots and species, (2) the ordination of the tree data set (all stems ≥ 5cm dbh; (3) the TWINSPAN classification dendrogram and; (4) my judgment based on experience in studying the vascular flora and vegetation of the area for over 15 years.

The use of all vascular plants in data analysis parallels European phytosociology systems while the use of dominant arboreal vegetation for naming the vegetation types is a component of Anglo-American ecological methods.

Five community cover classes with 17 vegetation types are recognized. There are three major environmental gradients to which the vegetation is responding; elevation, topographic-moisture and soil nutrients-pH.

Community Characterization

The fact that species populations are distributed individually (Gleason 1926) does not negate the heuristic value of classifying groups of species into communities, giving them names and describing them. Effective communication requires the use of entities that can be described and analyzed.

This section summarizes data for both the herb data set (all vascular plants with estimate of cover) and the tree data set (all woody plants ≥ 5cm dbh) along with environmental parameters. Tree data are summarized by percent density and percent basal area for each vegetation type. Species richness (number of species per 0.1ha) is listed for each community type along with average basal area per ha. Percent constancy (percentage of sample plots in a type in which the species is present) was used to determine "character species" (sensu Braun-Blanquet) which are those species which show maximum concentration (fidelity) in a vegetation type (Mueller-Dombois and Ellenberg 1974). Character species are listed for each vegetation type.

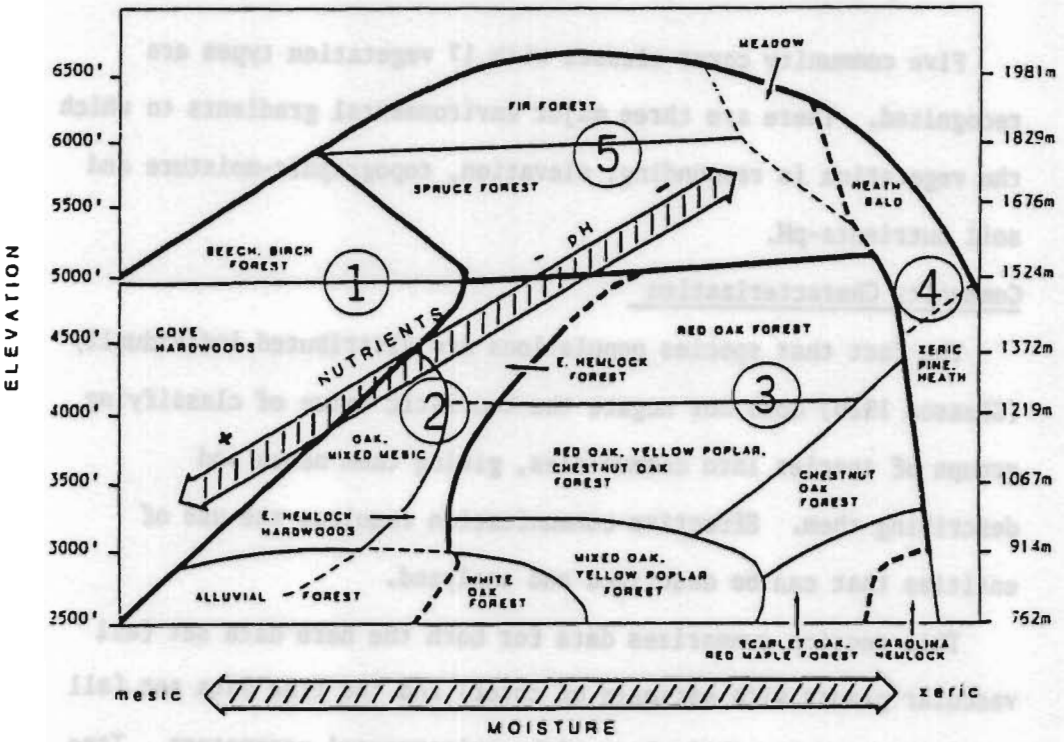


Figure 12. Composite diagram illustrating the distribution of community types and community cover classes (bold lines) relative to elevation, nutrients - pH, and moisture-topography gradients. Community cover classes are (1) deciduous mesic forest, (2) mesic forest with eastern hemlock, (3) oak forests, (4) xeric coniferous heathlands, and (5) spruce, fir forests.

MESIC DECIDUOUS FORESTS (1)

North-facing footslopes, sheltered valleys, and coves support forests dominated by mixed decidous trees with mesic shrubs and numerous herbs in the understory. These stands are found up to about 1524m (5000ft), where in the Black Mountains, they give way to spruce, fir forests (Figure 12). However, in the Craggy Mountains, hardwood forests dominated by Fagus grandifolia and Betula alleghaniensis are found up to about 1,829m (6000ft) which is the height of the highest peaks. This is similar to the distribution of these stands in the Smokies which Whittaker (1956) suggested owe their present distribution to depletion of spruce-fir on peaks under 1,829m (6000ft) during the xerothermic (hypsithermic) period.

Sheltered stands below 1,372m (4500ft) have traditionally been called cove forest and those with appreciable amounts of Tsuga canadensis have sometimes been split off. For example, Cain (1943) divided the cove forests of the Smokies into two alliances, the Aesculion (all hardwood) and the Tsugion (hemlock dominated). Braun (1950) also separated mixed mesophytic communities into all deciduous forest and deciduous forest with hemlock. Whittaker (1956), on the other hand, includes hemlock as one of the cove forest dominants.

Liriodendron tulipifera, which is abundant in disturbed stands

at low elevations is rare or absent above 1,219m (4000Ft). Concomitantly, Betula alleghaniensis and Fagus grandifolia increase in abundance. Acer spicatum, Viburnum lantanoides (=alnifolium) and Sambucus racemosa (=pubens) are abundant shrubs.

Above about 1524m (5000ft) most tree species of the lower elevation cove forest are absent leaving Fagus grandifolia and Betula alleghaniensis as the major dominants with Aesculus flava (=octandra) sometimes codominant. Acer saccharum may be present, but is usually not abundant. In the Black Mountains, Picea rubens and Abies fraseri are often present in these forests and Picea may be dominant.

Cove Hardwoods

Mixed deciduous hardwood forests occupy lower, predominately north-facing footslopes and coves and sheltered slopes of most aspects up to about 1524m (5000ft). They are at the wet-mesic, and eutrophic ends of the moisture and nutrient gradients. Canopy dominance is distributed among more than 20 species but the major tree dominants are Acer saccharum, Tilia heterophylla, Aesculus flava, Fagus grandifolia and Betula alleghaniensis (Table 17). This delineation of cove forest is narrower than that of Whittaker (1956), but corresponds to Braun's (1950) sugar maple-basswood-buckeye segregate of the all deciduous, mixed

mesophytic forest, and to Cain's (1943) Aesculion Alliance of cove forests in the Smokies. Both DECORANA and TWINSPAN separated these stands from those with appreciable percentages of Tsuga canadensis or Quercus rubra. These two species may be present in small amounts in some stands, but are completely absent in most.

In old-growth stands, the canopy trees are widely spaced, 60 to 120cm in diameter and 30 to 40 meters tall. The subcanopy and shrub layer are generally sparse (5-30% cover). Some transgressives, and the small trees Ostrya virginiana, and Acer pensylvanicum, typically are present. Lindera benzoin and Hydrangea arborescens are the most abundant shrubs. The ground flora is rich and luxurient, with cover approaching 100%.

Spring flowering herbs such as Asarum canadense, Dicentra canadensis, Dicentra cucullaria, Mitella diphylla, Osmorhiza claytonii, Trillium erectum, Disporum maculatum, Viola canadensis, Uvularia grandiflora and the fern, Deparia acrostichoides (=Athyrium thelypteroides), are particularly abundant. Herbs make up 72.2% of the total flora. Species richness for all vascular plants averages 51.1 species per 0.1 ha.

Cove hardwoods have the highest values of all vegetation types for soil calcium concentration, potassium concentration, pH, percent base saturation, and cation exchange capacity (CEC). They receive very low solar beam irradiation (Table 15).

Character species: Astilbe biternata, Cimicifuga americana, Asarum canadense, Disporum maculatum, Uvularia grandiflora, Mitella diphylla, Dryopteris goldiana, Cryptotaenia canadensis, Aconitum reclinatum, Viola canadensis, Dicentra cucullaria.

Beech, Birch Forests

Above 1524m (5000ft) in the Craggies are forests generally dominated by Fagus grandifolia and Betula alleghaniensis, with Aesculus flava codominant in some stands. Acer saccharum may also be present, and locally, Prunus serotina may be important (Table 17). In the Black Mountains, similar sites usually support mixed forests of Picea rubens, Betula alleghaniensis, and Fagus grandifolia, or pure stands of Picea with Abies fraseri (see spruce, fir forests.)

On exposed peaks, gaps and ridge tops, the trees are dwarfed, twisted and asymmetrical, due, in part, to desiccating winds and ice damage (Russell 1953). These stands are sufficiently distinctive that they are often considered a separate vegetation type. They have been called sub-alpine orchards (Davis 1929, 1930), beech gaps (Russell 1953, Whittaker 1956) and more recently wind forest (Schafale and Weakley 1985). Davis (1929) considered these forests as ecotonal between northern hardwood climax forest and bald. Floristically, these forests are likely to be dominated

Table 17. Species composition of Mesic Forests.

Species	1. Mesic Deciduous Forests: Cove Hardwoods a % Den.	a %B.A.	Beech, Birch b % Den	b %B.A.	2. Mesic Forests with E. Hemlock: Red oak, mesic a % Den.	a %B.A.	Alluvial b % Den.	b %B.A.	Hemlock Hardwoods c %Den	c %B.A.	E. Hemlock d % Den.	d %B.A.
Acer saccharum	23.8	21.7	5.1	10.9	9.7	11.0	0.3	0.9	2.9	2.8	---	---
Tilia heterophylla	12.9	15.8	---	---	7.2	9.3	0.2	0.3	3.2	4.4	1.8	1.4
Aesculus flava	13.4	14.2	10.9	9.6	4.4	3.1	2.0	4.1	5.4	4.2	---	---
Fagus grandifolia	19.4	10.4	59.0	23.2	14.2	9.0	2.3	6.5	3.7	6.6	5.1	1.4
Betula alleghaniensis	5.8	10.4	9.4	43.9	6.1	4.1	9.9	6.9	11.5	10.4	16.1	11.2
Fraxinus americana	3.6	6.9	---	---	2.3	3.5	0.8	0.6	1.3	5.9	---	---
Liriodendron tulipifera	3.0	4.9	---	---	3.9	14.9	3.1	5.3	7.4	23.5	4.4	5.0
Prunus serotina	2.3	3.2	1.3	9.2	2.1	3.1	0.5	0.3	---	---	0.4	0.1
Quercus rubra	1.0	2.9	---	---	6.1	15.6	1.0	0.6	1.2	3.9	1.1	0.9
Robinia pseudoacacia	1.3	2.4	---	---	0.7	0.7	0.2	0.1	0.4	1.1	---	---
Carya cordiformis	1.4	2.0	---	---	1.4	0.4	---	---	---	---	---	---
Tsuga canadensis	1.3	1.7	---	---	13.0	6.1	29.3	27.6	29.2	19.5	46.4	69.2
Ostrya virginiana	4.6	1.4	---	---	3.5	1.0	0.2	---	---	---	0.4	0.1
Betula lenta	1.3	0.6	---	---	2.5	3.1	4.9	2.1	8.2	5.9	5.1	1.7
Acer rubrum	0.6	0.5	---	---	7.5	4.1	9.0	5.5	8.2	8.3	2.6	3.0
Juglans nigra	0.1	0.4	---	---	---	---	---	---	---	---	---	---
Magnolia acuminata	0.1	0.3	---	---	1.8	1.5	0.5	1.1	0.8	0.3	0.7	0.4
Magnolia fraseri	0.1	0.1	---	---	0.8	0.8	0.8	0.6	2.9	1.9	4.0	2.1
Carya glabra	---	---	---	---	0.6	0.8	0.2	1.3	---	---	---	---
Carya ovata	---	---	---	---	1.1	2.0	0.3	0.8	---	---	---	---
Carya tomentosa	---	---	---	---	0.3	0.4	---	---	---	---	---	---
Carya ovalis	---	---	---	---	0.2	0.1	---	---	---	---	---	---
Quercus alba	---	---	---	---	0.6	0.7	4.2	16.6	---	---	---	---
Quercus coccinea	---	---	---	---	0.2	0.2	0.6	1.4	---	---	---	---
Quercus montana	---	---	---	---	1.3	3.2	---	---	0.8	0.3	---	---
Tsuga sylvatica	---	---	---	---	P	---	1.3	1.4	---	---	---	---
Acer pensylvanica	2.0	0.2	2.8	0.7	1.1	0.2	0.2	---	0.4	0.1	0.4	0.1
Hamamelis virginiana	1.4	0.1	---	---	2.0	0.3	3.1	0.2	9.5	0.6	---	---
Amelanchier laevis	0.1	0.1	---	---	0.4	0.1	0.6	0.2	---	---	---	---
Acer spicatum	0.1	---	5.8	0.7	0.2	---	---	---	---	---	---	---
Cornus florida	P	---	---	---	3.5	0.4	3.0	0.6	1.7	0.1	---	---
Cornus alternifolia	P	---	P	---	P	---	---	---	---	---	---	---
Ilex montana	---	---	---	---	P	---	---	---	0.4	---	P	---
Oxydendrum arboreum	---	---	---	---	P	---	1.6	0.7	---	---	0.4	0.1
Carpinus caroliniana	---	---	---	---	1.3	0.2	10.4	1.7	---	---	---	---
Crataegus species	---	---	---	---	P	---	0.3	0.1	---	---	---	---
Picea rubens	---	---	5.3	0.6	0.2	0.3	---	---	---	---	10.9	3.7
Sorbus americana	---	---	0.3	0.5	---	---	---	---	---	---	---	---
Platanus occidentalis	---	---	---	---	---	---	5.9	11.4	---	---	---	---
Quercus velutina	---	---	---	---	---	---	0.3	0.7	---	---	---	---
Tsuga caroliniana	---	---	---	---	---	---	0.2	0.1	---	---	---	---
Malus coronaria	---	---	---	---	---	---	0.3	0.1	---	---	---	---
Totals	525.9 stems/ha		656.7 stems/ha		602.4 stems/ha		614.0 stems/ha		608.2 stems/ha		456.7 stems/ha	
	41.65 m^2/ha		41.03 m^2/ha		43.00 m^2/ha		36.79 m^2/ha		46.52 m^2/ha		59.47 m^2/ha	
No. of woody species ≥ 5 cm dbh	24		10		36		33		20		16	
No. of sample plots	27		6		14		7		5		7	

by Fagus, with few shrubs and often 75-95% cover of Carex pensylvanica.

On protected slopes, bowls and ravines, the trees are well formed and widely spaced, giving the forest the same general appearance as the cove hardwood forest. These stands have fewer species of trees than cove forests, but often have greater shrub cover (25-75%) owing to the abundance of Viburnum lantanoides (=alnifolia) and Acer spicatum.

Species richness averages 38.2 species per 0.1 ha; however herb percent cover is usually a hign 75-95%. These stands have a positive correlation with cation exchange capacity and typically have a northern aspect. They also have the lowest potential solar beam irradiation of any community type studied. This, combined with their high elevation means that these sites are generally very cool.

Character species: Ribes cynosbati; Claytonia caroliniana, Phacelia bipinnatifida, Impatiens pallida, Diphylleia cymosa.

MESIC FORESTS WITH EASTERN HEMLOCK (2)

Mesic forests with eastern hemlock (Tsuga canadensis) occupy seemingly heterogeneous habitats such as slopes adjacent to

deciduous cove forests, flood plains, ravines, and deeply entrenched gorges and adjacent ridges and slopes (Table 17). The one factor that conspicously unites these diverse forests is the presence of hemlock, a species claimed to have a major impact on understory vegetation (Oosting and Bourdeau 1955, Whittaker 1956, Braun 1950, Glenn-Lewin 1975).

Herb cover varies from almost 90% with hemlock having importance value (importance value equals percent density plus percent base area divided by 2) of less than 20, to cover of less than 5% with importance value of hemlock more than 30. Similarly, species richness varies from an average of 61 species per 0.1 ha in sites with little hemlock to 24 species per 0.1 ha in sites where hemlock is dominant. This result parallels that of Glenn-Lewin (1975) who found the presence of hemlock to be the most important factor for predicting species diversity in the Finger Lakes region of New York.

Variation in hemlock dominance and the parallel variation in understory diversity correlate with differences in soil nutrients and acidity, but it is unclear the extent to which dominance by hemlock causes nutrient leaching and increased acidity.

Oak, Mixed Mesic Forest

Adjacent to the all deciduous cove hardwoods on mesotrophic

sites, are stands that contain a high proportion of Quercus rubra and Liriodendron tulipifera in the canopy. In the understory, however, are Acer saccharum, Tsuga canadensis and in some stands Fagus grandifolia, which are three of the most shade tolerant trees in eastern North American forests (Baker 1949, Lorimer 1976). The majority of ground flora species are mesic herbs. Quercus rubra and Liriodendron probably became established following disturbance such as fire or windthrow. Since this community is found in The Black Mountain Research Natural Area, a virgin cove (USDA 1933, McLeod 1981) we can assume considerable antiquity for some stands. Others are successional after logging. Both Liriodendron and Quercus rubra are intolerant of shade (Spurr and Barnes 1980, Fowells 1965) and therefore require openings in the canopy for establishment. These forests appear to be moving toward dominance by shade tolerant species, with a high percentage of eastern hemlock in many, but not all stands (see size class tables in Appendix E). These stands are closely allied with the cove hardwood forests and could be considered a part of them as Cain (1943), Braun (1950) and Whittaker (1956) perceive them to be.

The more mixed composition of these stands compared to cove hardwoods is reflected in their physiognomy with higher woody understory cover at 25-80%. In many stands, transgressives of Acer saccharum and/or Tsuga canadensis form an almost continuous

understory layer. The ground flora varies from 50-90% and is, for the most part, inversely related to woody understory cover. This type has a higher species richness than any other type, with 61.6 species per 0.1 ha.

In general, the environmental conditions associated with this type are similar to but slightly less eutrophic and less moist than cove forests. (Table 15).
Character species: Aruncus dioicus, Geranium maculatum, Ligusticum canadense, Poa cuspidata, Trillium grandiflorum.

Alluvial Forests

Alluvial forests grow on flood plains and terraces of the larger streams draining the area. With the exception of Platanus occidentalis, which is confined to this community type, the tree species are the same as those in the surrounding forests. Tsuga canadensis is a major component of the stands of the north flowing Cane and South Toe River alluvial forests. The abundance of eastern hemlock in alluvial forests is not usually stressed, although Hack and Goodlett (1960) found hemlock and white pine dominant in the central Appalachian flood plains of Virginia.

The shrub and ground flora are characteristic, containing species which are limited to, or centered in, this community type. Some of these are the shrubs Alnus serrulata, Rhododendron

viscosum, Leucothoe fontanesiana (=axillaris), Rhododendron viscosum and the streamside herbs Glyceria melicaria, Polyganum punctatum, Senecio aureus and Conium maculatum. Species richness is variable with an average of 51.5 species per 0.1 ha. One particularly species-rich sample plot in an alluvial flat by a small stream contained 86 species.

Soil density is the highest and cation exchange capacity (CEC) the lowest of any vegetation type recognized. Soil fertility as indicated by Ca, Mg and K concentrations is moderately high (Table 15).

Character species: Platanus occidentalis, Leucothoe fontanesiana; Conium maculatum. Claytonia virginica, Polygonum persicaria, Solidago parula.

Eastern Hemlock Forests

Stands dominated by Tsuga canadensis occur on slopes and hollows adjacent to red oak, mixed mesic forests, and upstream from the alluvial forests, on first and second order stream flats and in ravines. Fagus grandifolia or Liriodendron tulipifera are often codominants at lower elevations, below 1036m (3400ft). Betula alleghaniensis, Fagus grandifolia and sometimes, Acer saccharum may codominant from 1036m to 1524m. In the Black Mountains, these stands may interdigitate with Picea rubens at about 1463m (4800ft),

especially on north slopes. On steep, north-facing slopes, entrenched gorges, and protected benches and ridges, eastern hemlock may comprise up to 96% of the relative basal area and 75% of the relative density. In one 0.1 ha sample plot in the Craggy Scenic Area, the basal area for eastern hemlock was 89.96m^2/ha, with stem diameters of several trees in excess of 112cm. (45in). The physiognomy of old growth eastern hemlock stands is distinctive with widely spaced, large, tall trees often having no branches on the lower 20m (60Ft). Generally, transgressives exist only where there is an opening in the canopy. Often there is a continuous evergreen heath layer of Rhododendron maximum with only 2-10 herb species per 0.1 ha, with 1-10% cover (see Oosting and Billings 1939; Oosting and Bourdeau 1955, Lorimer 1976). In the Craggies, Viburnum lantanoides (=alnifolium) may replace evergreen heath with the associated herb diversity and cover being substantially greater.

Woody vegetation makes up about one half of the species present, with trees 27.5%, shrubs 17.3%, lianas, 4.3%, and herbs 50.7%. Average species richness is 28.9 species per 0.1 ha.

Most soil nutrients, percent base saturation, soil density, and pH are low for these stands. These data are consistent with the findings of other workers (Rogers 1978; Bormann and Platt 1978; Daubenmire 1929). These stands generally occur on slopes with a northern aspect and low solar beam irradiation (Table 15). Character species: Mitchella repens.

OAK FOREST (3)

Below 1524m (5000ft) communities dominated by oaks (Quercus spp.) occupy the broad central position on the topographic-moisture gradient. These sites are primarily mesotrophic on the nutrient gradient and dry-mesic to subxeric on the moisture gradient. Because of their accessibility and commercial value few of these stands are completely undisturbed. However, Black Mountain Research Natural Area, Craggy Scenic Area, stands along the Blue Ridge Parkway corridor and old growth forests in Celo Community Inc. provided adequate stands for sampling.

Mixed Oak, Yellow Poplar, Hickory

Forests with a mixture of Quercus spp., Liriodendron tulipifera, Acer rubrum, Fagus grandifolia, and Carya spp. occupy the lower elevation 762 - 1036m (2500 - 3400ft), mesotrophic, dry-mesic portion of the nutrient and moisture gradients and are usually on moderately sheltered low ridges, flats and valleys. These forests might be viewed as the upper most extension of the widespread oak-hickory forests that dominate the Piedmont (see Braun 1950, Peet and Christensen 1980). Although hickory is not dominant in all stands, it has high constancy and is dominant in some stands.

Most stands of this type have been disturbed to varying degrees

because of their accessibilty. Older stands may have tall, well-formed trees; however, many of these forests have been "high graded" resulting in current dominance of poorly formed trees and probably a change in species composition from the original forest. The average basal area is 33.8m^2/ha for these forests (Table 18). Shrub cover may be high (35-90%). Cornus florida, Hamamelis virginiana and Viburnum acerifolium are the most abundant shrubs; however, Rhododendron maximum and Kalmia latifolia are abundant in some stands. Ground flora cover varies from 30-80%, depending primarily, upon the amount of light reaching the forest floor and possibly the fertility of the site. The most abundant herbs are Medeola virginiana, Dioscorea villosa, Smilacina racemosa, Prenanthes altissima and Collinsonia canadensis. Smilax rotundifolia and Toxicodendron radicans are abundant lianas. Species richness is high, averaging 57.9 species per 0.1 ha.

In contrast to the Piedmont oak-hickory forests (Peet and Christensen 1980), soil nutrients, percent base saturation, and pH are high in these stands. However, they are in the dry-mesic position on the moisture gradients as judged by potential incident solar radiation. These forests contain a mixture of shade tolerent (e.g. Fagus grandifolia), intermediately tolerant (e.g. Quercus montana) and intolerent (e.g. Liriodendron tulipifera) trees. The understory also reflects this mixed composition. This is probably

because of the history of logging in the majority of these stands and perhaps burning by Indians and early European settlers. The high percentage of Liriodendron, in particular reflects that at least in part, these stands are successional.
Character species: Carya tomentosa; Aster curtisii, Aster undulatus, Cypripedium pubescens, Iris cristata, Pycnanthemum incanum, Scutelleria ovata, Uvularia perfoliata, Veratrum parviflorum, Uvularia pudica.

White Oak Forests

Stands dominated by Quercus alba occupy well-drained valley flats and terraces, which may be removed from present day streams, but appear to be of colluvial or alluvial origin. These forests often grow between the alluvial forests and the mixed oak, yellow poplar, hickory forests. Braun (1950) discusses white oak communities which occupy flats (straths) in valleys of a former erosion cycle in the Ridge and Valley Province. The white oak dominated stands in the South Toe Valley appear to occupy similar topographic positions, though the erosion cycle concept may not be acceptable (see Hack 1969).

White oak is not limited to such sites but is found, although usually not as a dominant, in oak woods up to about 1524m (5000ft) in the Blacks and Craggies. Curiously, it is absent, or rare, in

some coves (e.g. Middle Creek in South Toe Drainage). Whittaker (1956) noted a hiatus for white oak between 762 and 1524m in the Smokies, at least on the Tennessee side. In his monograph Baranski (1976) indicates that white oak is continuously distributed on the elevational gradient up to about 1615m (5300ft). Further, he found that white oak prefers south-west facing sites and suggested that a lack of large suitable sites accounts for the absence of white oak at middle elevations on the Tennessee side of the Smokies.

The valley stands of white oak have a distinctive physiognomy with the characteristic white-gray furrowed bark of the dominant white oak rising from a continuous ground flora, usually composed of Thelypteris noveboracensis, Uvularia pudica, Medeola virginiana and Melampyrum lineare. In many cases New York fern cover is over 75%. Shrub cover is usually a low 15-45%, but Pyrularia pubera, a root parasite of white oak, is abundant. Fagus grandifolia is often associated with white oak in valley flats, and in some cases, is codominant. Species richness is 50.3 species per 0.1 ha.

Valley flat white oak stands are located toward the nutrient rich, high pH end of the nutrient, pH gradients, but are in a dry-mesic position on the moisture gradient. The soils where these stands are found are derived from hornblende gneiss (Clifton Series, see Table 1). The soil conditions and topography may be similar to those in the Ridge and Valley Province, which is

underlain by calcareous rocks.

Character species: Pyrularia pubera, Vitis aestivalis; Apiectrum hyemale, Lonicera dioica, Podophyllum peltatum.

Scarlet Oak, Red Maple Forests

Quercus coccinea and Acer rubrum dominate stands below 1036m (3400ft) on south and west facing ridges, slopes and flats. These stands are in a dry-mesic to subxeric position on the moisture gradient but are intermediate in pH and most nutrients. Oxydendrum arboreum is the subcanopy dominant. On nutrient poor rocky sites the trees are often small and scrubby, especially on ridge crests; however on sites with more available moisture and nutrients, the trees are well formed and tall (30m). This is consistent with Doolittle's data (1957) for the site index (50 years) for scarlet oak, which had a range of 13 to 30m (37 to 91 ft), depending on site conditions. In many but not all stands the evergreen heaths, Kalmia latifolia and Rhododendron maximum, plus the deciduous Vaccinium pallidum (=vacillans) and Vaccinium stamineum dominate the understory. Under these conditions the herb cover is a low 10-25%. In other stands where the dominant shrub is Corylus cornuta, the herb cover is 30-60%. These latter sites are also less acid than the former ones. Abundant herb species include Potentilla canadensis, Medeola virginiana, Conopholis americana,

and Prenanthes altissima. Species richness is 48.9 species per 0.1 ha.

The major environmental conditions correlated with this community are high solar irradiation, southwest aspect, and intermediate soil nutrients and pH.

Character species: Quercus velutina, Corylus cornuta, Vaccinium stamineum; Isotria verticillata, Porteranthus trifoliatus, Trillium catesbaei, Triphora trianthophora.

Red Oak, Yellow Poplar, Chestnut Oak

At moderate elevations 975-1219m (3200-4000ft), on open slopes of all aspects, usually adjacent to red oak, mixed mesic forests, or ravines dominated by eastern hemlock, is a mixed forest, dominated by Quercus rubra, Quercus montana and Liriodendron tulipifera in the canopy and Acer rubrum in the subcanopy.

In old growth stands (e.g. Black Mountain Research Natural Area) the trees are large, tall and thrifty. Basal area in these stands averages 41.5m^2/ha, with some stands having basal areas over 50m^2/ha. Shrub cover is often high (35-70%), with Hamamelis virginiana and Acer pensylvanicum as the most abundant shrubs. The evergreen Rhododendron maximum is often present but usually not abundant. Herb cover, as in most forest types in the area, is inversely related to the amount of evergreen heath. Under witch

hazel and striped maple, herb cover may be as much as 40-85%, whereas under Rhododendron maximum, it is 5-15%. Herbs include Solidago curtissi, Lysimachia quadrifolia, Thelypteris noveboracensis, Gentiana decora, Sanicula trifoliata and Prenanthes altissima. The percentage of life forms is 20.8% trees, 12.7% shrubs, 4.0% lianas, 62.4% herbs. Species richness averages 50.7 species per 0.1 ha.

An abundance of stems and living sprouts indicate that before the blight of the early 1900's, this community type had a high dominance of Castanea dentata. These stands are still in a state of flux, with various trees, but mostly oaks and yellow poplar, filling in the openings in the canopy.

The combination of red oak, chestnut oak, and yellow poplar as canopy dominants is a curious occurrence and is undoubtably related to stand history. A possible explanation is that a major natural disturbance followed by minor disturbances, occurred many years ago. The major disturbance favored yellow poplar (Sims 1932, Little 1974) which became widely established. Successive disturbances, especially fire, favored the oaks (Little 1974, Loftis 1978, Swan 1970).

Steep slopes and solar radiation are positively correlated with this community, while most of the soil nutrients and pH are intermediate (Table 15).

Character species: Aureolaria laevigata, Pedicularis canadensis, Sanicula trifoliata, Thalictrum dioicum.

Chestnut Oak Forests

Stands dominated by Quercus montana (=prinus), grow at elevations of 914-1372m (3000-4500ft), on south, southwest facing slopes and narrow ridges of most aspects. They occur on more xeric and less fertile sites than red oak, yellow poplar, chestnut oak stands. At the xeric extreme, these stands are scrubby, with a continous understory of evergreen heath (=chestnut oak-heath of Whittaker, 1956). At the more mesic-mesotrophic end of the moisture and nutrient gradients, the trees are well formed and tall. Trees associated with chestnut oak in these stands include Quercus coccinea, Quercus velutina, Quercus rubra, Carya glabra, Acer rubrum, and Nyssa sylvatica. In addition to Rhododendron maximum and Kalmia latifolia, the most abundant shrubs are Symplocos tinctoria and Cornus florida. Herb cover is usually a low 10-30%, although in some stands, Galax urceolata (=aphylla) cover may be greater than 75%. Other ground flora species include Viola hastata, Chimaphila maculata and Aureolaria laevigata. Species richness is 44.3 species per 0.1 ha.

Solar radiation, south aspect, steep slopes, and thin rocky soils combine to produce subxeric to xeric conditions. Soils are

Table 18. Species composition of Oak Forests:

3. Oak Forests

Species	Mixed Oaks a		White Oak b		Scarlet Oak c		Red Oak, Chestnut Oak-Vel.pop d		Chestnut Oak e		Red Oak f	
	%Den.	%B.A.	%Den.	%B.A.	%Den.	%B.A.	%Den.	%B.A.	%Den.	%B.A.	%Den.	%B.A.
Quercus alba	3.9	13.3	19.8	51.7	11.1	12.4	1.3	2.8	3.0	4.0	---	---
Quercus montana	5.5	12.5	0.8	0.9	9.9	9.0	11.6	20.8	24.7	41.6	4.6	7.4
Liriodendron tulipifera	14.8	11.6	8.5	2.9	2.0	1.2	5.9	23.0	1.2	1.1	1.6	4.6
Quercus rubra	5.8	10.9	1.6	0.8	---	---	18.6	35.6	10.2	16.4	20.6	61.4
Acer rubrum	10.4	9.7	10.1	6.4	13.6	17.1	22.8	5.1	30.1	7.8	20.1	8.2
Fagus grandifolia	8.9	6.2	18.6	11.6	6.5	6.8	3.3	0.4	0.4	---	8.2	1.7
Quercus coccinea	3.3	5.7	2.0	2.0	10.2	16.8	---	---	4.3	9.1	---	---
Carya tomentosa	4.0	4.5	---	---	3.4	7.2	---	---	1.0	0.3	---	---
Carya glabra	5.8	3.7	2.0	0.8	2.3	1.8	0.7	0.2	2.8	1.4	---	---
Quercus velutina	1.6	3.6	---	---	4.5	6.8	---	---	3.0	7.5	---	---
Oxydendrum arboreum	5.8	3.3	7.3	2.6	23.0	11.1	7.3	1.9	12.2	4.5	---	---
Betula lenta	3.7	1.8	1.6	0.3	---	---	2.3	0.7	---	---	8.7	4.5
Robinia pseudoacacia	1.3	1.6	1.6	1.4	2.3	2.2	1.5	1.4	1.6	1.3	0.5	0.9
Magnolia fraseri	2.9	1.3	2.0	0.5	0.3	---	1.2	0.7	---	---	0.2	---
Magnolia acuminata	4.0	1.1	1.2	2.2	0.3	---	2.1	2.3	0.4	0.1	0.2	0.1
Acer saccharum	1.3	0.8	0.8	0.1	---	---	1.1	0.9	---	---	2.1	1.9
Carya ovata	0.9	0.7	0.8	2.4	---	---	---	---	0.8	0.9	---	---
Cornus florida	5.3	0.7	0.3	0.1	0.9	0.3	1.9	0.2	10.2	2.0	---	---
Tsuga canadensis	1.5	0.6	8.1	7.9	1.1	0.6	3.7	0.5	1.0	0.9	6.9	2.2
Prunus serotina	0.7	0.6	0.8	0.1	---	---	0.1	---	---	---	0.2	0.4
Aesculus flava	0.5	0.5	0.8	0.5	---	---	0.3	0.4	---	---	0.9	0.3
Fraxinus americana	0.4	0.5	0.4	0.6	---	---	0.3	0.2	---	---	---	---
Carpinus caroliniana	2.6	0.4	7.3	0.6	---	---	---	---	---	---	---	---
Nyssa sylvatica	0.4	0.4	2.0	3.5	3.4	4.5	0.5	0.1	0.8	0.1	---	---
Amelanchier laevis	1.4	0.2	1.2	0.2	2.3	0.7	0.4	0.1	1.0	0.2	---	---
Carya cordiformis	0.2	0.2	---	---	---	---	---	---	---	---	---	---
Acer pensylvanicum	1.2	0.2	---	---	0.3	---	1.6	0.2	0.4	0.1	0.5	0.1
Hamamelis virginiana	0.7	0.1	---	---	---	---	4.7	0.4	1.0	0.2	5.1	0.6
Castanea dentata	0.5	0.1	---	---	---	---	---	---	---	---	1.8	0.2
Sassafras albidum	0.2	---	---	---	1.1	0.1	---	---	---	---	---	---
Ilex montana	0.2	---	---	---	---	---	---	---	0.1	---	0.5	---
Tsuga caroliniana	0.2	---	---	---	---	---	---	---	---	---	---	---
Picea rubens	---	---	---	---	---	---	---	---	---	---	9.6	3.4
Betula alleghaniensis	---	---	---	---	---	---	3.2	1.1	---	---	2.5	1.5
Ostrya virginiana	---	---	---	---	---	---	3.2	0.5	---	---	5.3	0.7
Tsuga caroliniana	---	---	0.4	0.1	1.7	1.4	---	---	0.8	0.7	---	---
Tilia heterophylla	---	---	---	---	---	---	---	---	0.3	0.5	---	---
Juglans cinerea	---	---	---	---	---	---	0.1	0.1	---	---	---	---
Castanea dentata	---	---	---	---	---	---	P	---	---	---	---	---
Totals	687.08 stems/ha		617.5 stems/ha		770 stems/ha		642.3 stems/ha		760.0 stems/ha		734.28 stems/ha	
	33.846 m^2/ha		45.708 m^2/ha		34.639 m^2/ha		41.501 m^2/ha		33.850 m^2/ha		44.303 m^2/ha	
No. of woody species ≥ 5 cm dbh	32		24		20		26		22		20	
No. of sample plots	9		4		6		10		4		7	

nutrient poor and acid.

Character species: Aster cordifolius, Carex aestivalis, Hexastylis shuttleworthii, Lilium michauxii.

Red Oak Forests

Quercus rubra stands dominate a broad intermediate area on the moisture and nutrient gradients at elevations of 1219-1524m (4000-5000ft). The physiognomy of these stands varies from orchard-like (Davis 1929; Wells 1932) on ridgetops to stands with well-formed trees on middle and upper slopes, which are often open and spacious. These latter stands have a relatively high average basal area of 44.3m^2/ha while the ridgetop stands average 27.0m^2/ha.

Acer rubrum is commonly associated with red oak in these stands and often Betula lenta, Fagus grandifolia and Tsuga canadensis are present. Picea rubens is usually present above 1463m (4800ft) in the Black Mountains. Shrub cover varies from 20-75%, with Rhododendron calendulaceum and Hamamelis virginiana as dominant shrubs. Herb cover is moderately high (50-80%) in the absence of evergreen heath, which is not as abundant as in the chestnut oak type. Abundant herb species include Thelypteris noveboracinsis, Carex pensylvanica, Aster acuminatus, Lysimachia quadrifolia and Aster macrophyllus. Species richness averages 45.7 species per 0.1 ha, with herbs making up 64% of the species.

Taxonomically, Quercus rubra has been treated in various ways

with the upper elevation populations variously considered as a distinct species, a variety, or an ecotype (Fernald 1946, Little 1979, Radford et al. 1968, McDougal and Parks 1984). The populations of red oak in the Black and Craggy Mountains are continuous without any noticeable elevational break.

Delapp (1978) classified these upper elevation red oak stands into seven phases based on understory composition. His study indicates that variation in species composition within these stands is in response to a complex moisture gradient, which, in turn, is a function of topography and amount of solar radiation. I found five of the seven phases given by Delapp.

The environmental factors which are positively correlated with these stands are elevation, solar beam irradiation, and relatively low nutrients. Soils are acid with a pH range from 3.9-4.6. Character species: Rhododendron calendulaceum; Aster macrophyllus.

XERIC CONIFEROUS HEATHLANDS (4)

The extreme xeric, and oligotrophic soil positions on the moisture and nutrient gradients are occupied by community types that are dominated by coniferous trees in the canopy (if there is a canopy) and evergreen heath in the understory.

These stands are formed on sites of extreme exposure such as narrow ridges, bluffs, generally steep south to southwest-facing

slopes with thin rocky soils.

Coniferous canopy dominants include Pinus rigida, Pinus pungens, Tsuga caroliniana and, above 1524m, Picea rubens. The xeric oaks, Quercus coccinea, Quercus montana (=prinus), and Acer rubrum may also be abundant with Nyssa sylvatica, Amelanchier laevis and Ilex montana usually present.

The shrub layer is dominated by members of the Ericaceae. Rhododendron maximum and Kalmia latifolia are most abundant at elevations under 1524m, Rhododendron catawbiense and Vaccinium corymbosum are shrub dominants above 1524m.

The ground flora has low cover, (usually less than 10%) and species richness is low (average: 7 herb species per 0.1 ha). Goodyera repens, Gaultheria procumbens, Galax urceolata (=aphylla), Listera smallii are the most abundant ground flora species.

These stands are primarily found on nutrient poor, dry, acid sites and are maintained, at least in part, by fire.

Carolina Hemlock Forests

Tsuga carolinana dominated stands are generally considered limited to steep bluffs and cliffs (Coker and Totten 1950). However, in the South Toe Drainage of the Black Mountains, Carolina hemlock stands occur on gentle slopes and individual trees may be found throughout the mixed oak, yellow poplar, hickory and scarlet oak woods in the valley. Carolina hemlock stands, which DECORANA - lumped with heath balds, also occur on bluffs and cliffs,

especially in the Craggies.

The valley stands of Carolina hemlock contain tall, straight trees, which resemble old growth eastern hemlock forests, while the bluff sites contain trees that are wind shorn, gnarled and twisted. The average basal area of 45.61m^2/ha and 735 stems /ha (Table 19) is from valley stands, which have trees with diameters in excess of 90cm (3 ft).

Herb cover is very low (1 to 10%), while herb diversity is limited to only a few species, including Goodyera pubescens, Galax urceolata (=aphylla), Chimaphila maculata, Viola hastata and Goodyera repens. The evergreen heath shrubs, Rhododendron maximum and Kalmia latifolia, are often not continuous, but have cover of 50-75% and patches of open areas with no ground flora. Other shrub or small tree species usually present are Acer pensylvanicum, Cornus florida, Amelanchier laevis and Ilex montana. Oxydendrum arboreum, and Acer rubrum dominate the subcanopy. Canopy trees associated with Carolina hemlock are Quercus coccinea, and in some stands, Tsuga canadensis. Total species richness is very low, with an average of 23.5 species per 0.1 ha. Reproduction of the dominant Carolina hemlock is usually good, with all size classes found in most stands.

Soil nutrients, especially Ca and Mg, and percent base saturation are low, while pH ranges from 4.0-5.0. Cation exchange

capacity is the lowest of any community type. It appears that low soil nutrients and CEC rather than soil moisture and pH, may be responsible for these valley stands of Carolina hemlock.
Character species: Goodyera repens

Xeric Pine Forests

Pinus pungens and Pinus rigida dominate stands on exposed ridges and steep, rocky, generally south-facing slopes below 1524m, at the xeric extreme of the moisture gradient. Quercus coccinea, Nyssa sylvatica, Quercus montana and Acer rubrum also contribute to the canopy. The more xeric scarlet oak stands share many species with these pine forests as indicated by DECORANA. Oxydendrum arboreum, Amelanchier laevis and, often Tsuga caroliniana, are abundant subcanopy species. Ericaceous shrubs comprise 52.1% of the shrub layer species and about 90% of the shrub cover. Kalmia latifolia, Vaccinium pallidum (=vacillans), Vaccinium corymbosum (=constablaei), Rhododendron maximum, Symplocos tinctoria, Gaylussacia baccata, and Rhododendron catawbiense are abundant shrubs. The ground flora is depauparate, with low cover (2-15%) and few species; only 41.8% of the total species present are ground flora plants. Galax urceolata (=aphylla), Epigaea repens, Melampyrum lineare, Gaultheria procumbens, Pteridium aquilinum and Lysimachia quadrifolia are the most abundant ground flora plants.

In many cases the greenbriars Smilax glauca and Smilax rotundifolia bind the understory together. There is an average of 28.4 species per 0.1 ha in this vegetation type.

A number of workers have pointed out the high frequency of fire in pine stands (e.g. Little and Moore 1949, Harshberger 1916, Mutch 1970). Davis (1929), Whittaker (1956), Harmon (1981 and Harmon et al. 1984) have suggested that these southern Appalachian pine stands are maintained by fire.

Most soil nutrients and cation exchange capacity are low, while base saturation and amount of soil calcium are the lowest in any community type. Soil pH ranges from 3.4 to 4.5. Topographic position (exposed ridgetops), primarily with southern aspect, places these stands at the xeric extreme of the moisture gradient. Character species: Pinus pungens, Pinus rigida, Gaylussacia baccata, Leucothoe recurva, Vaccinium pallidum; Epigaea repens, Gaultheria procumbens, Lycopodium complanatum, Melampyrum lineare.

Heath Balds

Shrubby vegetation, mostly dominated by species of Ericaceae grow on exposed peaks, narrow, sharp ridges and adjacent slopes at elevations above 1219m (4000ft). The physiognomy of these so-called "heath balds" varies from dense, almost impenetrable thickets, which may be 2 to 4m tall, to more open "Rhododendron gardens", which have patches of herbs between the shrubs.

Rhododendron catawbiense, Vaccinium corymbosum (=constablaei)

and Kalmia latifolia are the three most important shrubs and make up about 85% of the cover of the average stand. Generally Rhododendron maximum replaces Rhododendron catawbiense below 1524m where Kalmia is also more abundant. Of the ten most frequent shrubs, seven are members of the heath family (Table 20).

In his study of the heath balds of the Smokies (1930), Stanley Cain listed 54 species of vascular plants of which 40 (74%) were shrubs, or scrubby trees, and 14 (26%) were herbs. In contrast, I found 77 species including 39 woody species and 38 species of herbs. The chief difference between Cain's study and mine is that I sampled within Rhododendron gardens, as well as closed heath balds, while Cain did not.

Galax urceolata (=aphylla), Dennstaedia punctilobula, Angelica triquinata, Saxifraga michauxii, Pteridium aquilinum, and Melampyrum lineare are abundant herbs. Under continuous stands of Rhododendron catawbiense, Listera smallii may be the only herb present. Species richness averages 27.8 species per 0.1 ha.

Cain (1930) concludes that the origin of these stands is most likely related to the catastrophic factors of windfall, landslide and fire, with fire being the most important. He says that, in general, they seem to be maintaining themselves from the encroachment of trees because of edaphic conditions and the shading of the understory by the evergreen shrubs. Recent studies,

Table 19. Species composition of:

Species	4. Coniferous Heathlands: Xeric Pine % Den.	Xeric Pine %B.A.	Carolina Hemlock % Den.	Carolina Hemlock %B.A.	5. Spruce, Fir Forest: Spruce % Den.	Spruce %B.A.	Fir % Den.	Fir %B.A.
Pinus pungens	32.2	42.7	—	—	—	—	—	—
Pinus rigida	10.8	20.9	—	—	—	—	—	—
Quercus coccinea	6.3	10.4	4.8	14.8	—	—	—	—
Acer rubrum	11.6	6.6	11.3	4.8	1.2	2.8	—	—
Nyssa sylvatica	11.3	4.2	0.7	0.4	—	—	—	—
Quercus montana	3.5	4.2	4.7	4.9	—	—	—	—
Oxydendrum arboreum	8.5	3.5	9.2	8.7	—	—	—	—
Amelanchier laevis	2.5	2.8	0.6	—	0.2	—	—	—
Tsuga caroliniana	0.9	1.3	45.0	47.0	—	—	—	—
Tsuga canadensis	3.2	1.1	13.0	10.1	1.2	0.7	—	—
Hamamelis virginiana	4.3	0.7	0.6	—	0.1	—	—	—
Quercus alba	1.3	0.7	—	—	—	—	—	—
Sassifras albidum	1.3	0.3	—	—	—	—	—	—
Ilex montana	0.8	0.2	—	—	0.2	—	—	—
Magnolia fraseri	0.2	0.2	—	—	—	—	—	—
Quercus rubra	0.7	0.2	0.9	2.1	0.4	2.7	—	—
Quercus velutina	0.2	0.1	1.2	2.6	—	—	—	—
Symplocos tinctoria	0.4	0.1	—	—	—	—	—	—
Quercus alba	—	—	1.9	2.5	—	—	—	—
Pinus strobus	—	—	0.3	1.2	—	—	—	—
Cornus florida	—	—	3.8	0.6	—	—	—	—
Liriodendron tulipifera	—	—	0.3	0.2	—	—	—	—
Betula lenta	—	—	0.6	0.1	—	—	—	—
Carya glabra	—	—	0.6	0.1	—	—	—	—
Prunus serotina	—	—	0.6	0.1	0.3	1.7	—	—
Picea rubens	0.2	0.1	—	—	47.1	46.4	33.3	29.0
Betula alleghaniensis	—	—	—	—	18.6	29.8	—	—
Fagus grandifolia	—	—	—	—	16.5	5.6	—	—
Acer saccharum	—	—	—	—	1.1	4.0	—	—
Abies fraseri	—	—	—	—	3.9	2.3	20.5	43.5
Sorbus americana	—	—	—	—	3.0	1.2	41.0	25.7
Betula cordifolia	—	—	—	—	1.3	1.1	2.5	1.1
Aesculus flava	—	—	—	—	0.3	0.7	—	—
Prunus pensylvanica	—	—	—	—	1.1	0.4	2.5	0.7
Acer pensylvanicum	—	—	—	—	1.7	0.4	—	—
Acer spicatum	—	—	—	—	1.9	0.3	—	—
Crataegus punctata	—	—	—	—	0.2	0.1	—	—
Crataegus sp.	—	—	—	—	0.2	—	—	—
Totals	962.5 stems/ha		735 stems/ha		1,167 stems/ha		210 stems/ha	
	30.138 m^2/ha		45.609 m^2/ha		44.168 m^2/ha		5.556 m^2/ha	
No. of woody species ≥ 5 cm dbh	19		18		20		5	
No. of sample plots	9		5		16		5	

however, indicate that at least some heath balds are being invaded by tree species (Smathers 1981, Barden 1978). Whittaker (1956) says that the balds are successional, at least in part; however, he adds that they can be considered topographic climaxes, with exposure producing microclimate and edaphic conditions which maintain them.

Heath balds are at the xeric, oligotropnic extreme of the moisture, nutrient and pH gradients, and are generally at higher elevations than xeric pine forests, although the two may be found together. They both probably represent secondary successional communities after disturbance, especially fire, in extreme exposure sites.

Character species: Aronia melanocarpa, Diervilla sessilifolia, Leiophyllum buxifolium, Menziesia pilosa, Robinia hispida, Rhododendron catawbiense; Listera smallii, Lycopodium obscurum, Lycopodium tristachyum, Pteridium aquilinum, Zigadenus leimanthoides.

SPRUCE, FIR FOREST (5)

Above approximately 1524m (5000ft) in the Black Mountains are forests dominated by Picea rubens and Abies fraseri. The Craggy Mountains do not have well developed spruce, fir stands even though

they are well within the elevation range of these species, 1524 - 1829m (5000-6000ft). In the Craggies some spruce have been planted, and a few spruce and even fewer fir, have become established on bluffs and cliffs on Craggy Dome and Bullhead Mountain at about 1768m (5800ft). This distribution pattern of the Craggies is similar to that in the Smokies, where there is no spruce-fir forest southwest of Double Spring Gap. Whittaker (1956) postulated that this pattern originated in the xerothermic (hypsithermal) period, with the spruce and fir persisting only on peaks above 1829m (6000ft). During subsequent cooling these species migrated back down, but were lost from lower peaks (under 1829m). Areas such as the Craggies have closed beech, birch forests and are not within the prevailing wind patterns of the seed sources of spruce and fir. Consequently, these trees have reestablished themselves slowly if at all.

The canopy Fraser fir of the Black Mountains have been decimated by the balsam wooly aphid (Adelges piceae), which was detected on Mt. Mitchell in 1955 (Speers 1958). This was its first known appearance in the southern Appalachians.

Spruce Forests

Picea rubens dominates, or codominates, many stands at 1524-1829m (5000-6000ft) in the Black Mountains. The best

development of these forests is at elevations between 1585-1829m (5200-6000ft), where on good sites, the trees are tall, straight and well formed. The basal area for red spruce in some old growth stands is over 50m^2/ha, while the total basal area for the stands can exceed 75m^2/ha. In addition to Abies fraseri, Betula alleghaniensis (which may be codominant), Fagus grandifolia, Acer saccharum, Quercus rubra, Betula cordifolia and occasionally Acer rubrum can be associated with red spruce in these stands. Shrub coverage varies from 20 to 90%, and Rhododendron catawbiense, Acer spicatum, Acer pensylvanicum, and Viburnum lantanoides (=alnifolium) are prevalent shrubs. Herb coverage may be as high as 95% and is inversely related to the amount of evergreen heath. Abundant herbs in these stands (see Crandall 1958, Oosting and Billings 1951, Ramseur 1958) include Carex pensylvanica, Oxalis acetosella, Aster acuminatus, Dryopteris campyloptera, Dryopteris intermedia, Clintonia borealis and Streptopus roseus. Herbs comprise an average of 67.2% of the species in these stands. Species richness averages 30.8 species per 0.1 ha.

Soil nutrients in these stands are generally low (Table 15), especially calcium and magnesium; however, phosphorus content is high probably because of the high level of soil organic matter. Soil pH is the lowest of any community type (range pH 3.2 to 4.2). Character species: Sambucus racemosa ssp. pubens, Carex crinita,

Maianthemum canadense, Circaea alpina.

Fir Forests

Before the balsam wooly aphid infestation, Abies fraseri was dominant above about 1829m (6000ft). Today all stands which were formerly dominated by fir show various signs of disturbance. There are few healthy fir trees over 8cm dbh or 3m tall. A sample plot about 1 km north of Deer Mountain, at 1829m, had 27 living canopy trees in 1984, one of which was 56.3 cm dbh. Why this stand is relatively healthy is unknown, but perhaps its separation from the main body of fir has impeded the spread of the aphid.

In addition to aphid damage, windthrow, logging, fire and erosion have dramatically affected these fragile upper elevation stands in the Black Mountains especially in the vicinity of Mt. Mitchell. Recently, it has been suggested that the death of the fir and possible stagnation of growth of spruce may be caused by atmospheric pollutants, which have been blamed for the demise of European and New England spruce forest (Bruck 1985, Siccama et al. 1982). Presently, these stands are in a state of flux and it is difficult to predict their future, however there is good regeneration of fir (also see Witter and Ragenovich 1986).

Species richness is the lowest of any community type studied, averaging only 22 species per 0.1 ha. Only 7 species of trees are

present. In addition to fir, Picea rubens, Sorbus americana, Betula alleghaniensis, Betula cordifolia, Prunus pensylvanica and the small tree Acer spicatum may be present (Table 19). Rubus idaeus, Vaccinium erythrocarpum, Sambucus racemosa ssp. pubens, Rhododendron catawbiense, Viburnum lantanoides (=alnifolium), and Vaccinium corymbosum are abundant shrubs. Oxalis acetosella, Cheloni lyonii, Aster acuminatus, Dryopteris campyloptera, Athyrium felix-femina, Carex brunnescens, Carex debilis, Cinna latifolia, Solidago glomerata, Saxifraga michauxii and Hypericum graveolens are abundant herbs.

In plots over 1890m (6200ft), the average basal area for living fir is a low 2.41m^2/ha, while the basal area for all trees at this elevation is 5.56m^2/ha. However, the basal area for living fir in plot 109 mentioned earlier is 9.43m^2/ha. The basal area for all trees in plot 109 is 18.409m^2/ha. The data for trees at both elevations are comparable to those of DeSelm and Boner (1984), who reported average basal areas of 8.9 m^2/na for fir and 15.8m^2/ha for all trees at elevations less than 6000 feet in the Black Mountains, 11 to 15 years after disturbance. Sixteen to 20 years after disturbance, they found 4.8m^2/ha basal area for fir and 7.8m^2/ha for all stems at elevations greater than 6000 feet. In contrast they found undisturbed stands in the Smokies to average 19.4m^2/ha for fir and 53.2m^2/ha for all species below 6000 feet,

while averaging 32.1m^2/ha for fir and 47.2m^2/ha for all stems above 6000 feet.

Most soil nutrients and percent base saturation are very low; pH has a range of 3.6-4.3. There is a strong positive correlation with elevation and these fir communities.
Character species: Prunus pensylvanica, Rubus idaeus; Carex debilis, Chelone lyoni, Cinna latifolia, Clintonia borealis, Cuscuta rostrata, Deschampsia flexuosa, Dryopteris campyloptera, Hedyotis michauxii, Hypericum graveolens.

Meadows

Above 1524m on exposed, usually south to southwest facing ridge crests and knobs are meadows dominated by herbaceous vegetation. These upper elevation, treeless areas in the southern Appalachians have traditionally been called grassy balds (Davis 1929, Cain 1930, Camp 1931, Fink 1931, Wells 1936, 1956) and have intrigued biologists and others for years.

In his study of southern Appalachian grassy balds, Mark (1958, 1959) considered Craggy Pinnacle Bald and Craggy Knob in the Craggies as "true" balds, i.e., presumably in existence prior to European settlement. These two areas were used as pastures to some extent until 1950 (Eller 1981, Smathers 1981). Mark (1958) listed two areas in the Black Mountains; Little Mountain Bald and Middle

Ridge Bald, as fields which he defined as areas showing evidence of having been cleared by humans.

In addition to the areas Mark listed, a number of openings created by fire during the last 75 years exist in the Black Mountains. Although many of these "fire meadows" were not used as pastures, the physiognomy is similar to that of the balds but floristically they are different (Table 20).

Solidago glomerata, Angelica triquinata and Aster divaricatus are the usual dominant herbs in fire meadows, but Carex debilis and Carex intumescens are important in some. In the pastured balds, Danthonia compressa, Agrostis stolonifera, Phlox spp., and sometimes Potentilla tridentata, are dominant herbs. Rubus canadensis and Vaccinium corymbosum are abundant shrubs in both the fire meadows and the balds. Crataegus punctata is usually found in the pastured balds, and Rhododendron catawbiense is more abundant there, while Prunus pensylvanica is more abundant in the fire meadows (Table 20). Picea rubens also may be present in these stands. Herbs make up 75.5% of the flora, and usually about 90% of the cover. Species richness is 31.9 species per 0.1 ha.

Soils are moderately low in most nutrients (Table 15). The average pH is 4.57 (range, 4.3-4.8) which is less acid than that in any of the other upper elevation community types. High solar beam irradiation, west to southwest aspect and ridge top position

combine to make these stands subxeric to xeric. Wind which is predominantly westerly and stronger on ridge tops also has a drying effect on these stands.

Character species: Crataegus punctata; Agrostis stolonifera, Danthonia compressa, Phlox glaberrina, Potentilla tridentata, Solidago bicolor.

Table 20 Species Composition of:

Species	Heath Balds % Constancy	Heath Balds Average Cover Value	Fire Meadows % Constancy	Fire Meadows Average Cover Value	Grass Balds % Constancy	Grass Balds Average Cover Value
Rhododendron catawbiense	100.0	5.75	25.0	2.5	100.0	4.10
Vaccinium corymbosum	100.0	5.38	100.0	2.6	80.0	3.18
Ilex montana	100.0	3.63	----	---	20.0	2.00
Galax urceolata	87.5	5.86	----	---	20.0	2.00
Kalmia latifolia	87.5	4.71	----	---	20.0	4.00
Picea rubens	87.5	4.00	75.0	3.15	----	----
Acer rubrum	75.0	3.83	----	---	----	----
Viburnum cassinoides	62.5	3.20	----	---	20.0	2.00
Robinia hispida	62.5	2.60	----	---	----	----
Sorbus americana	62.5	3.60	25.0	3.12	80.0	2.65
Sorbus melanocarpa	62.5	3.40	----	---	----	----
Leucothoe recurva	50.0	3.50	----	---	----	----
Quercus rubra	50.0	3.75	----	---	20.0	2.50
Lyonia ligustrina	50.0	2.50	----	---	----	----
Hamamelis virginiana	50.0	3.25	----	---	----	----
Vaccinium erythrocarpum	50.0	3.50	35.0	2.50	20.0	2.50
Tsuga canadensis	50.0	2.75	----	----	-----	----
Saxifraga michauxii	50.0	2.00	25.0	2.00	40.0	3.00
Menziesia pilosa	50.0	3.50	----	----	20.0	2.50
Angelica triquinata	50.0	2.75	100.0	3.75	80.0	3.25
Solidago glomerata	12.5	2.00	100.0	5.56	100.0	3.10
Rubus canadensis	12.5	2.00	100.0	3.11	80.0	4.23

Table 20 Species Composition of:

(cont.)	Heath Balds		Fire Meadows		Grass Balds	
Athyrium filix-femina	12.5	2.00	100.0	3.05	60.0	2.31
Aster divaricatus	----	----	100.0	3.89	60.0	3.26
Carex debilis	----	----	100.0	3.17	60.0	2.50
Ribes rotundifolium	12.5	3.00	25.0	3.08	60.0	3.10
Agrostis stolonifera	----	----	25.0	1.01	100.0	3.61
Agrostis perennans	----	----	25.0	1.75	60.0	2.15
Danthonia compressa	37.5	3.00	25.0	2.15	100.0	5.48
Eupatorium rugosum	----	----	25.0	1.00	40.0	3.00
Prunus pensylvanica	25.0	2.00	50.0	3.65	20.0	2.80
Luzula acuminata	----	----	25.0	1.50	60.0	2.00
Crataegus punctata	----	----	----	----	80.0	3.60
Phlox carolina	----	----	----	----	60.0	5.15
Potentilla tridentata	----	----	----	----	60.0	2.00
Polygonum cilinode	----	----	75.0	1.50	20.0	1.00

Braun-Blanquet Cover-Abundance Scale

7 - Any number, with cover more than 3/4 of the reference area (75%)
6 - Any number, with 1/2-3/4 cover (50-75%)
5 - Any number, with 1/4-1/2 cover (25-50%)
4 - Any number, with 1/20-1/4 cover (5-25%)
3 - Numerous, but less than 1/20 cover, or scattered with cover up to 1/20 (5%)
2 - Few, with small cover
1 - Solitary, with small cover

Synopsis of Vegetation Types and Environmental Factors in Black and Craggy Mountains, N.C. (Format follows Radford et al. 1980)

I. Mesic Hardwoods 610 - 1829m (2000 - 6000Ft)

(1) 1. Cove hardwoods 610 - 1524m (2000 - 5000ft)

Dominants: Acer saccharum, Aesculus flava, Tilia heterophylla, Fagus grandifolia / Acer pensylvanicum / mixed mesic herbs // Aristolochia macrophylla.

Topography: N-NE facing footslopes; sheltered slopes and coves of all aspects.

Environmental descriptors: Cool, mesic, eutrophic.

Character species: Astilbe biternata, Cimicifuga americana, Disporum maculatum, Uvularia grandiflora, Mitella diphylla, Dryopteris goldiana, Cryptotaenia canadensis, Aconitum reclinatum, Asarum canadense.

(2) 2. Beech, birch forests 1524 - 1829m (5000 - 6000ft)

Dominants: Fagus grandifolia, Betula alleghaniensis / Acer spicatum, Viburnum lantanoides / Carex pensylvanica, Stellaria pubera.

Topography: upper elevation sheltered slopes and bowls above 1524m in Craggy Mountains.

Environmental descriptors: cold, mesic, mesotrophic

Character species: Ribes cynosbati; Claytonia

caroliniana, Impatiens pallida, Phacelia bipinnatifida.

II. Hardwoods, eastern hemlock forests 610 - 1524m (2000 - 5000ft)

(3) 1. Oak, mixed mesic forest 610 - 1219m (2000 - 5000ft)

Dominants: Quercus rubra, Liriodendron tulipifera, Acer saccharum / Acer saccharum, Tsuga canadensis / mixed mesic herbs.

Topography: adjacent to all-deciduous cove forests on similar sites.

Environmental descriptors: cool, mesic, mesotrophic.

Character species: Aruncus dioicus, Geranium maculatum, Ligusticum canadense, Poa cuspidata, Trillium grandiflorum.

(4) 2. Alluvial forests 610 - 1036m (2000 - 3400ft)

Dominants: Platanus occidentalis, Tsuga canadensis, Quercus alba / Carpinus caroliniana / Alnus serrulata / Senecio aureus, Glyceria melicaria, Polystichum acrostichoides.

Topography: flood plains and terraces of larger rivers.

Environmental descriptors: subhydric, mesotrophic, with high soil density and low CEC.

Character species: Platanus occidentalis, Leucothoe

fontanesiana; Conium maculatum, Polygonum persicaria, Solidago patula, Claytonia virginica.

(5) 3. Eastern hemlock forests 610 - 1524m (2000 - 5000ft)

Dominants: Tsuga canadensis, Betula alleghaniensis, Fagus grandifolia / Rhododendron maximum / Galax urceolata, Goodyera repens, Viola rotundifolia.

Topography: ravines, flats, steep north facing slopes, entrenched gorges and adjacent benches and ridges.

Environmental descriptors: cool, mesic acid, oligotrophic.

Character species: Mitchella repens.

III. Oak Forests 610 - 1524 (2000 - 5000ft)

(6) 1.Mixed oak, yellow poplar, hickory forests 610 - 1067m (2000 -3500 ft)

Dominants: Quercus montana, Quercus alba, Quercus rubra, Liriodendron tulipifera, Carya glabra / Cornus florida /Medeola virginiana, Prenanthes altissima, Smilacina racemosa.

Topography: moderately sheltered low ridges, flats and valleys.

Environmental descriptors: dry mesic, mesotrophic.

Character species: Carya tomentosa; Uvularia perfoliata, Uvularia pudica, Aster curtisii,

Aster undulatus, Cypripedium pubescens, Veratrum parviflorum, Iris cristata, Pycnanthemum incanum, Scutellaria ovata.

(7) 2. White oak forests 610 - 1524 (2000 - 5000ft)

Dominants: Quercus alba, Fagus grandifolia, Tsuga canadensis / Acer rubrum / Pyrularia pubera / Thelypteris noveboracensis, Uvularia pudica.

Topography: valley flats; slopes especially south west facing, up to 1524m.

Environmental descriptors: warm, dry-mesic, mesotrophic, less acid.

Character species: Pyrularia pubera, Vitis aestivalis; Aplectrum hyemale, Lonicera dioica, Podophyllum peltatum.

(8) 3. Scarlet oak, red maple forests 610 - 1036m (2000 - 3400ft)

Dominants: Quercus coccinea, Acer rubrum / Oxydendrum arboreum / Rhododendron maximum, Kalmia latifolia / Conopholis americana.

Topography: below 1036m on south, west ridges, slopes and flats.

Environmental descriptors: warm, subxeric, mesotrophic.

Character species: Quercus velutina, Corylus cornuta, Vaccinium stamineum; Isotria verticillata, Trillium catesbaei, Porterantnus trifoliatus, Triphora trianthophora.

(9) 4. Red oak, yellow poplar, chestnut oak forests 975 - 1219m (3200 - 4000ft)

Dominants: Quercus rubra, Quercus montana, Liriodendron tulipifera / Solidago curtisii, Lysimachia quadrifolia.

Topography: open slopes of all aspects.

Environmental descriptors: warm, dry-mesic, mesotrophic.

Character species: Aureolaria laevigata, Pedicularis canadensis, Sanicula trifoliata, Thalictrum dioicum.

(10) 5. Chestnut oak forests 914 - 1372m (3000 - 4500ft)

Dominants: Quercus montana, Quercus coccinea, Quercus velutina, Nyssa sylvatica / Oxydendrum arboreum / Symplocos tinctoria, Vaccinium stamineum / Galax urceolata, Viola hastata, Aureolaria laevigata.

Topography: south, southwest facing slopes and narrow ridges of most aspects.

Environmental descriptors: warm, subxeric-xeric, acid oligotrophic.

Character species: Carex aestivalis, Lilium michauxii, Hexastylis shuttleworthii.

(11) 6. Red oak forests 1219 - 1524m (4000 - 5000ft)

Dominants: Quercus rubra, Acer rubrum, Betula lenta, Fagus grandifolia / Rhododendron calendulaceum / Thelypteris noveboracensis, Aster macrophyllus.

Topography: ridges and open slopes between 1219 - 1524m.

Environmental descriptors: cool, dry-mesic, mesotrophic.

Character species: Rhododendron calendulaceum; Aster macrophyllus.

IV. Xeric Coniferous Heathlands

(12) 1.Carolina hemlock forests 762 - 1372m (2500 - 4500ft)

Dominants: Tsuga caroliniana, Quercus coccinea, Tsuga canadensis / Oxydendrum arboreum, Acer rubrum / Amelanchier laevis, Ilex montana / Rhododendron maximum, Kalmia latifolia / Galax urceolata, Goodyera pubescens, Goodyera repens, Chimaphala maculata.

Topography: two populations - valley stands on flats slopes and bluffs along river, cliff sites on exposed bluffs and cliffs.

Environmental descriptors: cool, dry-mesic to subxeric, acid oligotrophic.

Character species: Goodyera repens.

(13) 2. Xeric pine forests 762 - 1524m (2500 - 5000ft)

Dominants: Pinus pungens, Pinus rigida, Nyssa sylvatica, Quercus coccinea / Oxydendrum arboreum, Amelanchier arborea, Vaccinium pallidum (= vacillans), Rhododendron maximum / Galax urceolata, Epigaea repens, Melampyrum lineare, Gaultheria procumbens // Smilax spp.

Topography: exposed ridges and steep, rocky generally south facing slopes below 1524m

Environmental descriptors: very warm, xeric, acid, oligotrophic

Character species: Pinus pungens, Pinus rigida; Gaylussacia baccata, Leucothoe recurva, Vaccinium pallidum; Epigaea repens, Gaultheria procumbens, Lycopodium complanatum, Melampyrum lineare.

(14) 3. Heath balds 1219 - 1981m (4000 - 6500ft)

Dominants: Rhododendron catawbiense, Viburnum cassinoides, Vaccinium corymbosum (=constablei), Kalmia latifolia - below 5000 ft. - Rhododendron maximum / Galax urceolata, Listera smallii,

Angelica triquinata, Pteridium aquilinum, Dennstaedtia punctilobula.

Topography: exposed peaks, narrow sharp ridges and adjacent slopes.

Environmental descriptors: warm, xeric, acid, oligotrophic.

Character species: Aronia melanocarpa, Diervilla sessilifolia, Leiophyllum buxifolium, Menziesia pilosa, Robinia hispida, Rhododendron catawbiense; Listera smallii, Lycopodium obscurum, Lycopodium tristachyum, Pteridium aquilinum, Zigadenus leimanthoides.

V. Spruce, Fir Forests

(15) 1.Spruce forests 1524 - 1829m (5000 - 6000ft)

Dominants: Picea rubens, Betula alleghaniensis, Fagus grandifolia, Abies fraseri / Rhododendron catawbiense, Acer spicatum, Viburnum lantanoides (=alnifolium) / Carex pensylvanica, Oxalis acetosella, Aster acuminatus.

Topography: most topographic positions, between 5000 - 6000 ft. in Black Mountains.

Environmental descriptors: cool, dry mesic to mesic, very acid, oligotrophic.

Character species: Sambucus racemosa, ssp. pubens Carex crinita, Maianthemum canadense, Circaea alpina.

(16) 2. Fir forests 1829 - 2012m (6000 - 6600ft)

Dominants: Abies fraseri, Picea rubens, Sorbus americana, Betula cordifolia / Acer spicatum / Viburnum lantanoides, Rubus canadensis, Rubus idaeus / Oxalis acetosella, Chelone lyonii, Dryopteris campyloptera, Carex debilis, Carex intumescens, Clintonia borealis.

Topography: above 1829m on all topographic sites.

Environmental descriptors: cold, dry-mesic to mesic, acid oligotrophic.

Character species: Prunus pensylvanica, Rubus idaeus; Carex debilis, Chelone lyonii, Cinna latifolia, Clintonia borealis, Cuscuta rostrata, Deschampsia flexuosa, Dryopteris campyloptera, Hedyotis michauxii, Hypericum graveolens.

(17) 3. Meadows 1524 - 2012m (5000 - 6600ft)

Dominants: Solidago glomerata, Angelica triquinata, Aster divaricatus in fire meadows; Danthonia compressa, Agrostis stolonifera, Phlox spp. in pascured balds.

Topography: upper elevation ridge crests, domes and adjacent southwest facing slopes.

Environmental descriptors: cool, subxeric to xeric, moderately acid, mesotrophic.

Character species: Crataegus punctata; Agrostis stolonifera, Danthonia compressa, Phlox glaberrima, Potentilla tridentata, Solidago bicolor.

DISCUSSION AND CONCLUSIONS

Comparison with other authors

Davis

The only previous comprehensive study of the Black and Craggy Mountains was that of J.H. Davis, Jr. (1929, 1930). Davis divided the vegetation of the area into three major plant formations based on dominants and elevation. These are: (1) the Spruce-fir Forest Formation of high mountain slopes and ridges, which is dominated by red spruce and Fraser fir, (2) the Northern Hardwood Forest Formation of intermediate slopes, ridges and coves, dominated by beech, buckeye, yellow birch, hard maple and basswood with many other hardwoods as codominants, (3) the Appalachian Forest Formation of lower coves, slopes and ridges dominated by American chestnut, yellow poplar, chestnut oak, northern red oak, white oak, eastern hemlock, and on xeric slopes and ridges, Table mountain pine, pitch pine and Carolina hemlock. In addition, he divided each of these formations into "minor" communities (associations) based on dominants. He listed the floristic composition of each of these associations with symbols for "abundance or frequency, constancy, and exclusiveness of certain important species."

In addition to classification of the vegetation, Davis discussed ecological factors affecting the vegetation based on "instrumental work". He used Livingston atmometers to measure the

evaporation power of the air which "is a satisfactory summation of the atmospheric factors that determine and limit plant growth" (Davis 1929). The results from these studies were primarily differences between the climax associations with the lowest evaporation in climax-mesic associations (1.816cc/day), preclimax-mesic associations were intermediate (6.227cc/day), and pioneer and xeric associations had the most evaporation (9.932cc/day). He listed a number of other environmental factors that may be important in the distribution of the vegetation but did not give supporting evidence for them. He concludes that the most important environmental factor affecting the vegetation is air temperature which is correlated with elevation and aspect of slope.

Braun

E.L. Braun's interpretation of the vegetation of the Black Mountains (1950) was based on Davis' work. She wrote that the cove forests of the Black Mountains are intermediate or transitional between the mixed mesophytic cove forests and the chestnut slope forest, displaying characteristics of each type. She also wrote that the cove forests of the Blacks are unlike the cove mixed mesophytic forests of the Smokies. She based this conclusion on Davis' list of chestnut, tuliptree, hemlock, red oak and red maple as being the most frequent species in the "cove climax association"

of the Appalachian forest formation. This is curious, since Davis listed as the dominants in his "Northern Hardwoods" formation sugar maple, sweet buckeye, basswood, beech, yellow birch and northern red oak which Braun considers the typical canopy dominants of the mixed mesophytic forest (or cove forest). There may be two reasons for her suggested intermediacy of the Black Mountains cove forests: (1) the acceptance by Braun of the name "cove climax" as representing the most mesic condition in the region and (2) the notion that the cove forests of the Black Mountains are intermediate between the rich coves of the Smoky Mountains and the mesic phases of the Oak-Chestnut forest region. This latter, possibility fits her hypothesis for the development of the Eastern Deciduous Forest, with the Cumberland Mountains being the central area of mixed mesophytic forest and the Oak-Chestnut forest region being peripheral (cf. Whittaker 1956).

Cain

Stanley Cain in a series of papers (e.g. 1930, 1931, 1943, 1945) characterized the vegetation of the Tennessee portion of the Smoky Mountains (which lie approximately 140 kilometers west-southwest of the Black Mountains). He was especially intrigued with the cove forests which he divided into two alliences (1) Aesculion which is all deciduous and includes buckeye-basswood,

sugar maple-silverbell, yellow birch and beech types, and (2) Tsugion dominated or codominated by eastern hemlock which includes hemlock-beech, hemlock-tuliptree, and hemlock types. He noted the similarily between these forests and the so-called Arcto-Tertiary forests (Cain 1943).

Whittaker

In his monograph on the vegetation of the Smoky Mountains (1956), R.H. Whittaker classified the vegetation into 15 types based on field transects taken at fixed intervals along topographic-moisture gradients plus site-samples taken more-or-less at random throughout the vegetation complex. He measured all stems greater than 2.5cm (1 inch)dbh and noted the presence of understory species in the samples. He concluded that the vegetation is controlled primarily by a complex moisture-topographic gradient and by elevation which is likewise a complex-gradient. Whittaker's study was mainly conducted on the Tennessee side of the Smokies which he considered to have steeper gradients than the North Carolina side. He reported mesic forests to be more narrowly restricted to valleys on the North Carolina side, and pine stands to be more limited and oak types more prevalent on the North Carolina side.

Golden

Golden (1974,1981), in a study of the arborescent vegetation

of the central portion of the Smokies, used multivariate techniques (RA and CA ordinations) to classify and ordinate the vegetation. As did Cain and Whittaker, Golden used a portion of the Tennessee side of the Smokies centered on Mt. Leconte as his study area. He limited his study to elevations between 750-1600m. He classified the vegetation into 19 types, and supported Whittaker in the view that the vegetation pattern was primarily related to elevation and topographic-moisture gradients. In addition he found clay content of the 'B' horizon and the pH of the soil 'A' horizon to be important. Golden reported the vegetation pattern of his study was similar to that of Whittaker, but was different in important ways including the absence of the upper elevation white oak type of Whittaker and a greater prominence of eastern hemlock in his study area. Golden also found Betula alleghaniensis to be more abundant and Quercus rubra not as abundant above 1100m relative to Whittaker's findings.

Vegetation Types

The vegetation types of these various authors vary but can be synonomized reasonably well (Table 21). The chief differences between the classification proposed here and previous classifications are:

(1) my recognition of Alluvial forests which may have been overlooked in sampling by others,

(2) my recognition of Carolina hemlock forests, probably because a major river valley (South Toe) contains a number of stands of this type,

(3) my recognition of a red oak-mixed mesic type which is considered cove forest transition or cove forest by Whittaker. This appears to be a matter of judgment, but may reflect differences in the two areas,

(4) my recognition of a low elevation white oak type which may be present because of the edaphic-topographic regime in portions of the study area,

(5) my recognition of more oak types (6) than Whittaker (5) which is consistant with his suggestion that North Carolina has more oak types than Tennessee, and

(6) my use of the term meadow for upper elevation non-woody areas rather than grassy bald. This is based on the numerous "fire meadows" in the Black Mountains whose ages are documented and the fact that species composition changes in these meadows when subject to grazing.

Environmental Relationships

Davis (1929, 1930) considered temperature the primary

Table 21 Community type comparisons of various authors

Davis(1929)	Cain(1937,1943)	Whittaker(1950)	Golden (1981)	McLeod
Cove Climax Northern hardwoods	Mixed Cove hardwoods w/segregates	Cove hardwoods	Cove hardwoods Hemlock-buckeye Buckeye-y. birch	Cove hardwoods
Sub-alpine orchard Sub-alpine beech-birch Savannah	Yellow birch Rhododendron Sub-alpine beech-gap	Gray beech	Slope yellow birch Beech	Beech, birch
Mesic slope	Oak-chestnut	Cove forest transition	Northern red oak (in part)	Red oak, mixed mesic
----	----	----	----	Alluvial
High cove Hemlock beech	Hemlock ridge	E. hemlock	Hemlock	E. hemlock
Mesic slope	Yellow poplar	Oak-hickory	Yellow poplar	Mixed oak, yellow poplar, hickory
----	----	White oak (upper elevation)	----	White oak (valley)
Xeric slope	Chestnut oak	Chestnut oak-heath (in part)	Chestnut oak (in part) Chestnut oak-Red Maple Scarlet oak-Chestnut oak	Scarlet oak, Red maple

Table 21 (con't.)

Davis(1929)	Cain(1937,1943)	Whittaker(1956)	Golden (1981)	McLeod
Mesic slope	Oak-chestnut	Red oak (in part)	Chestnut oak (in part) Chestnut oak-N. red oak	Red oak, yellow poplar, chestnut oak
Xeric slope	Chestnut oak	Chestnut oak-chestnut Chestnut oak-heath	Chestnut oak	Chestnut oak
Mesic slope	Oak-chestnut	Red oak-chestnut	Northern Red oak	Red oak
Xeric slope and ridge	Pine heath	Va. pine-heath Pitch pine-heath Table mountain pine-heath	Pine	Xeric pine
----	----	----	----	Carolina hemlock
Balds	Heath Bald	Heath Bald	----	Heath Bald
Spruce-fir	Spruce-fir	Red spruce	----	Red spruce
Spruce-fir	Spruce-fir	Fir	----	Fir
Balds	Grass Bald	Grassy Bald	----	Meadows

1. Did not list as a type

controlling factor of the vegetation in the Black Mountains, which he said is correlated with elevation and slope aspect. He also suggested pH as a possible factor as did Cain in the Smokies. Cain also listed elevation and stand history as important factors. Whittaker proposed a two dimensional vegetation pattern controlled by the complex gradients of elevation and topographic moisture. Golden supported the importance of topography and elevation as described by Whittaker and added soil factors including clay content of the 'B' horizon and pH of the 'A' horizon.

I have documented the importance of the topographic-moisture and elevation gradients in the distribution of vegetation in the Black and Craggy Mountains which is similar to the vegetation patterns of the Smokies. In addition, I have documented the correlation of a soil nutrients-pH gradient with the vegetation patterns of the Black and Craggy Mountains which appears to be equally important in determining the composition of these forests.

Succession Following Fire and its Relationship to Balds

The first plants to become established after fire at upper elevations are generally the tree, Prunus pensylvanica and the herbaceous species Solidago glomerata, Angelica triquinata, Athyrium filix-femina, Aster divaricatus, Carex debilis and Epilobium angustifolium. Rubus canadensis, Vaccinium corymbosum (=constablei), and Diervilla spp. are shrubs that usually appear

soon after fire. Sorbus americana, Betula alleghaniensis and in the Black Mountains Betula cordifolia, are the next trees to become established. Eventually, conditions may be suitable for establishment and growth of Picea rubens and/or Abies fraseri which are the dominants of the climax.

This scenario may be altered or delayed by various site conditions including soil moisture, nutrients, distance from seed source, intensity of the fire, topography, and human activity. For instance, on steep rocky thin-soiled ridges and slopes, shrubs of the heath family may predominate (heath bald), while on windy upper slopes and domes an herb community may persist (fire meadow) also see Gersmehl (1969, 1970).

Danthonia compressa, which has traditionally been considered the dominant plant on grassy balds (Wells 1937, Mark 1958), is found along trails in the fire meadows but rarely within the meadow proper. However, if the fire meadow is grazed, there is a change in floristic composition with Danthonia compressa along with other grasses (e.g. Agrostis stolonifera and Agrostis perennans) increasing dramatically presumably because of trampling (Table 20).

Therefore, if an opening is created by fire and pastured by animals, the resulting species composition would be that of a "grassy bald". Figure 13 summarizes these possible relationships.

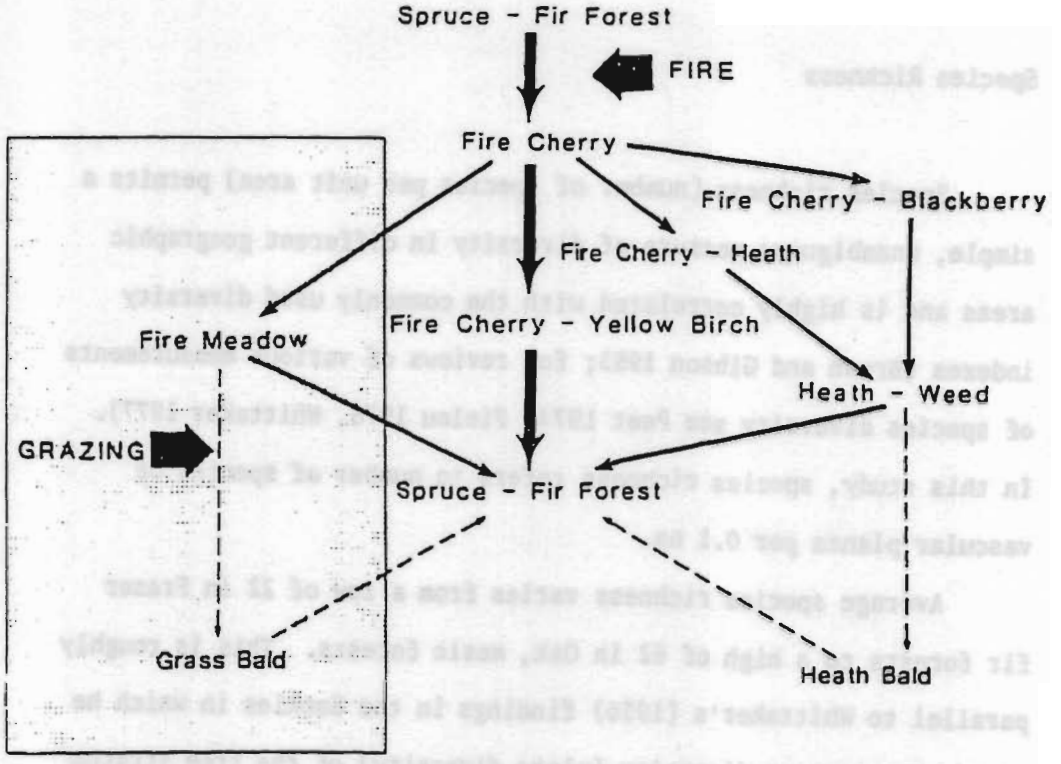


Figure 13. Possible secondary succession after fire in the upper elevations. (Modified from Ramseur 1958)

Species Richness

Species richness (number of species per unit area) permits a simple, unambiguous measure of diversity in different geographic areas and is highly correlated with the commonly used diversity indexes (Brown and Gibson 1983; for reviews of various measurements of species diversity see Peet 1974, Pielou 1975, Whittaker 1977). In this study, species richness refers to number of species of vascular plants per 0.1 ha.

Average species richness varies from a low of 22 in Fraser fir forests to a high of 62 in Oak, mesic forests. This is roughly parallel to Whittaker's (1956) findings in the Smokies in which he found the greatest diversity (alpha diversity) of the tree stratum in the transition between cove forests and oak-hickory forests below 914m (3000ft) and oak-chestnut forests above 914m.

Table 24, (Appendix C) summarizes the average species richness for each community type with percentages for life forms. It is apparent from these data that there are a number of factors (gradients) influencing species richness in the study area. One appears to be pH (Figure 14) which is moderately correlated with species richness (r^2=0.71). Other factors which appear to be important are elevation, soil moisture, soil nutrients and disturbance.

Species diversity has been reported to be highest at low elevations in the southern Appalachians (Whittaker 1956), but at middle elevations in the Colorado Rockies (Peet 1978, 1981), the Santa Catalina Mountains of Arizona (Whittaker and Niering 1975) and the forests of eastern Washington and northern Idaho (Daubenmire and Daubenmire 1968). In the Black and Craggy Mountains species richness is greatest at moderately low elevations.

Whittaker (1956) found highest tree diversity values at intermediate sites of the moisture gradient at all elevations, while others have reported maximum richness at the mesic end (Daubenmire and Daubenmire 1968, Glenn-Lewin 1975, Peet 1981). Species richness appears to be greatest in sites that are mesic to dry-mesic on the moisture gradient in the Black and Craggy Mountains.

Peet and Christensen (1980) found the sum of exchangeable calcium, magnesium, and potassium to be highly correlated (r^2= 0.85) with average species richness in hardwood forests of the Piedmont, North Carolina. Monk (1965, 1967) reported soil fertility as a major factor influencing tree diversity in central Florida. However, Huston (1980) found that very high nutrient availability lowers tree species diversity in Costa Rican forests. This appears to be the case in the Black and Craggy Mountains with cove forests having the highest available soil nutrients (Table 15)

but not as many species as the oak, mesic forests or oak, yellow poplar, hickory forests.

A mitigating factor in the above considerations is the effect of disturbance upon these various factors. It has been suggested that intermediate disturbance regimes will maximize species richness (Connell 1978). The relative high diversity in the oak, yellow poplar, hickory forest may be because of intermediate levels of disturbance in these forests, but this is difficult to document (see Peet et al. 1983).

In summary, species richness in the Black and Craggy Mountains appears to be influenced by a number of environmental gradients with soil reaction (pH) being a fairly good predictor of richness.

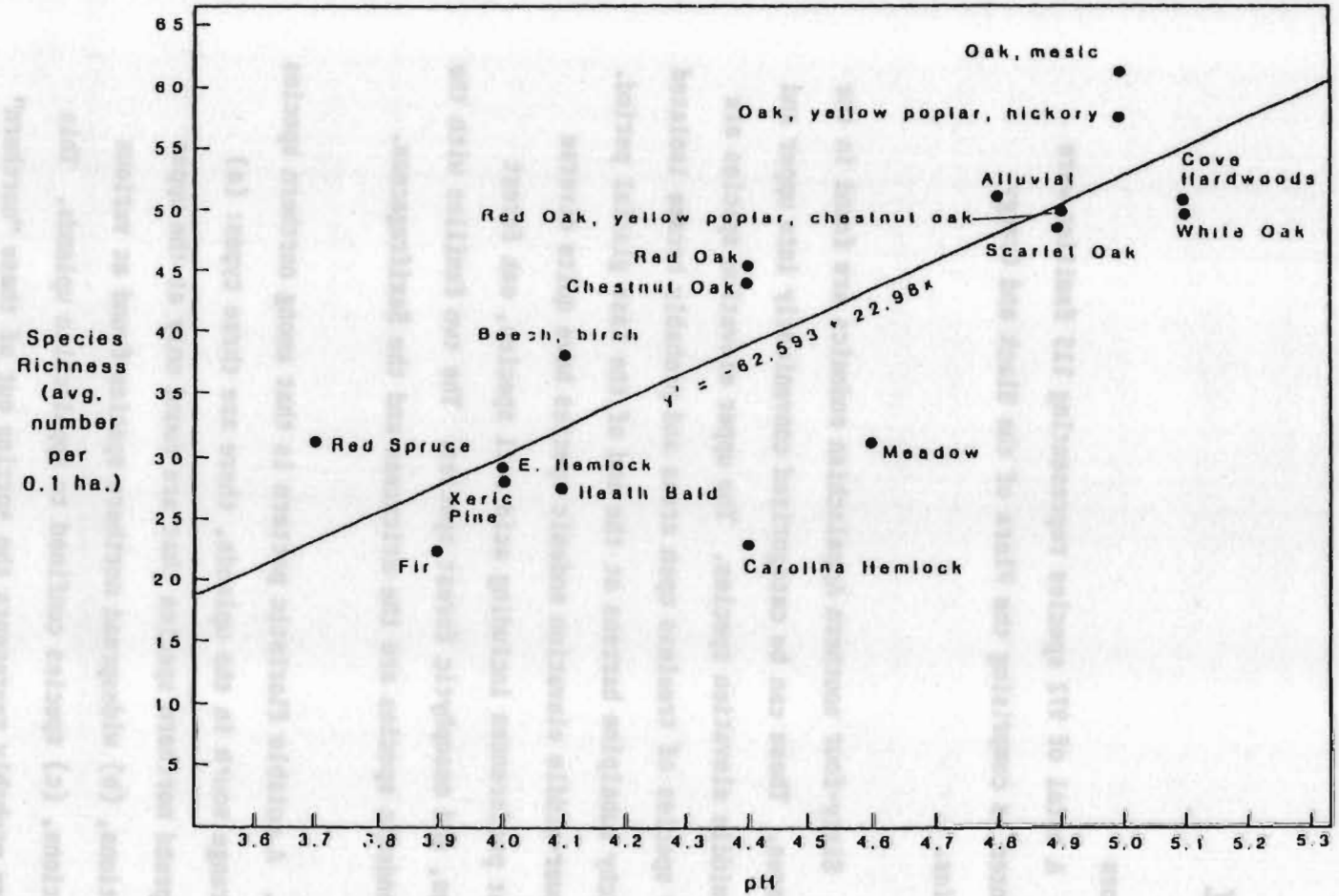


Figure 14. Relationship between species richness for community types and average pH.

SUMMARY

I. Flora

1. A total of 972 species representing 115 families were documented as comprising the Flora of the Black and Craggy Mountains.

2. Sixty-four southern Appalachian endemics are found in the study area. These can be categorized conveniently into upper and lower-middle elevation species. The upper elevation species are mostly species of treeless open areas and probably became isolated in patchy subalpine barrens at the end of the last glacial period. The lower-middle elevation endemic species have quite diverse habitat preferences including acid soil species, oak forest species, and mesophytic forest species. The two families with the most endemic species are the Ericaceae and the Saxifragaceae.

3. A notable floristic pattern is that among northern species that range south in the uplands, there are three types: (a) widespread northern species that are found only at the upper elevations, (b) widespread northern species found at various elevations, (c) species confined to Appalachian uplands. This pattern probably represents the sorting out of these "northern" species during the Holocene.

4. The large number of disjunct genera between the flora of the study area and Asia (26 genera) (37 genera) can be best explained by separation of species during the Tertiary and subsequent distribution by migration. It would be interesting and perhaps informative to analyze these genera using current cladistic methods.

5. The 21 mountain-coastal plain disjuncts, eighteen (85.7%) of which are wetland species, may represent jump dispersal events during the Holocene.

II Vegetation

6. The vegetation of the Black and Craggy Mountains was classified into 5 community cover classes and 17 vegetation types, here named primarily by canopy dominants. This classification was based on ordinations (DECORANA), numerical classification (TWINSPAN) and subjective evaluation of data from 156 0.1 ha sample plots

7. Statistical analysis of the ordination results showed the vegetation types to be highly correlated with three complex gradients: (1) elevation, (2) topographic-moisture and, (3) soil nutrients-pH. Although the relationships between a

topographic-moisture gradient and an elevation gradient to vegetation in the southern Appalachians has been pointed out, this study documents a high correlation between them. In addition, the high correlation between vegetation and a nutrients-pH gradient in the southern Appalachians appears to be documented for the first time.

8. Character species were determined for each vegetation type based on constancy and fidelity. These can be used to determine vegetation types in vegetation fragments.

9. Ecological species groups were determined based on character species and ordinations of species with environmental correlations.

10. These data were used to generate a vegetation-environment gradient model of the Black and Craggy Mountains, North Carolina which is generally applicable to other southern Appalachian areas.

11. Species richness is greatest in moderately low elevation mixed forests in a mesic to dry-mesic position on the topographic-moisture gradient which are slightly less nutrient-rich than the richest stands. The relationsnip between disturbance and

species richness is not clear, but stands with the most species richness appear to have an intermediate disturbance regime. Soil reaction (pH) is a moderately good predictor of species richness (r^2=.71).

12. A hypothesis that grassy balds develop from fire meadows by grazing and trampling is presented.

LITERATURE CITED

Anderson, L.E. 1970. Geographical relationships of the mosses of the southern Appalachian mountains In: The distributional history of the biota of the southern Appalachians. Part II: Flora pp.101-115. VPI and State University. Blacksburg, Va.

Ayers, H.B., and W.W. Ashe. 1905. The southern Appalachian forests. U.S. Geol. Survey Prof. Pap. 37.

Axelrod, D.I. 1975. Evolution and biogeography of Madrean - Tethyan sclerophyllous vegetation. Ann. Missouri Bot. Gard. 62:280-334.

Axelrod, D.I. 1979. Age and origin of the Sonoran Desert vegetation. California Acad. Sci. Occas. Pap.132:1-74.

Bailey, M.A., D.A. Clapp, J.V. Stimpson, and J.M. King. 1977. Interim soil survey report for Buncombe County, N.C. Soil Conservation Service, USDA.

Baker, F.S. 1949. A revised tolerance table. J. Forestry 47:179-181.

Baranski, M.J. 1975. An analysis of variation within white oak (Quercus alba L). North Carolina Ag. Exp. Sta. Tech. Bul. No. 230.

Barden, L.S., and F.W. Woods. 1976. Effects of fire on pine and pine-hardwood forests in the southern Appalachians. For. Sci. 22:399-403.

Barden, L.S. 1978. Regrowth of shrubs in grassy balds of the southern Appalachians after prescribed burning. Castanea 43:236-246.

Billings, W.D. 1978. Plants and the ecosystem. 3rd ed. Wadsworth, Belmont, Calf.

Blauch, D.S. 1975. Toward a natural delineation of the area known as the southern Appalachian highlands. Castanea 40(3): 197-201.

Bormann, F.H., and R.B. Platt. 1978. A disjunct stand of hemlock in the Georgia piedmont. Ecol. 39:16-23.

Boufford, D., E. Wood, L. Schram, and D. Wickland. 1974. Natural area study of the Southern Blue Ridge of N.C., Highlands Biological Sta., Highlands, N.C.

Boufford, D.E., and S.A. Spongberg. 1983. Eastern Asian - Eastern North American phytogeographical relationships - a history from the time of Linnaeus to the Twentieth Century In: Ann. Missouri Bot. Gar. 70:423-439.

Braun, E.L. 1937. A remarkable colony of coastal plain plants on the Cumberland Plateau in Laurel County, Kentucky. Amer. Midl. Nat. 18:363-366.

Braun, E.L. 1950. Decidous forests of Eastern North America Blakeston, Philadelphia.

Braun-Blanquet, J. 1932. Plant sociology (Transl. by G.D. Fuller and H.S.Conard). McGraw-Hill.

Brown, J.H. and A.C. Gibson. 1983. Biogeography. C V Mosby, St. Louis.

Bruck, R.I. 1985. Boreal montane decline in the southern Appalachian Mountains: potential role of anthropogenic pollution. In:Air pollution effects on forest ecosystems, p.137-155. Proc Symp, St. Paul, Minn.

Butler, J.R. 1972. Geologic Map of the Black Mountain Quadrangle, N.C. North Carolina Div. Mineral Resources, map series.

Butler, J.R. 1973. Paleozoic deformation and metamorphism in part of the Blue Ridge Thrust Sheet, N.C. Am. Journ. Sci. 273-A:72-88.

Buol, S.W., F.D. Hole and R.J. McCracken. 1980. Soil genesis and classification. Iowa State U. Press, Ames.

Cain, S.A. 1930. An ecological study of the heath balds of the Great Smoky Mountains. Butler Univ. Bot. Studies 1:177-208.

Cain, S.A. 1931. Ecological studies of the vegetation of the Great Smoky Mountains I. Soil reaction and plant distribution. Bot. Gaz.91:22-41.

Cain, S.A. 1943. The tertiary character of the cove hardwood forests of the Great Smoky Mountains National Park. Torrey Bot. Club, Bull. 70:213-235.

Cain, S.A. 1944. Foundations of plant geography. Harper, New York.

Cain, S.A. 1945. A biological spectrum of the flora of the Great Smoky Mountains National Park. Butler Univ. Bot. Stud. 7:11-24.

Cajander, A.K. 1926. The theory of forests types. Acta For. Fenn. 29.

Camp, W.H. 1931. The grass balds of the Great Smoky Mountains of Tennessee and North Carolina. Ohio J. Sci. 31:157-164.

Caplenor, D. 1955. An annotated list of the vascular plants of the gorges of the Fall Creek Falls State Park. J. Tenn. Acad. Sci. 30(2):93-108.

Caplenor, D. 1978. Additions to the list of plants of the gorges at Fall Creek Falls. J. Tenn. Acd. Sci. 53(4):135.

Clarkson, R.B. 1966. The vascular flora of the Monongahela National Forest, West Virginia. Castanea 31(1):1-119.

Coker, W.C., and H.R. Totten. 1945. Trees of the Southeastern States. UNC Press, Chapel Hill.

Connell, J.H. 1978. Diversity in tropical rain forests and coral reefs. Science 199:1302-1310.

Cooper, J.E., S.S. Robinson and J.B. Funderburg. 1977. Endangered and threatened plants and animals of North Carolina. N.C. State Museum of Natural History, Raleigh.

Cooperrider, T.S., and R.F. Thorne. 1964. The flora of Giles County, Virginia II. Castanea 29:46-70.

Core, E.L. 1970. The botanical exploration of the southern Appalachians In: The distributional history of the biota of the southern Appalachians Part II: Flora P.C. Holt (ed.) VPI and State U. Blacksburg, Va.

Crandall, D.L. 1958. Ground vegetation patterns of the spruce-fir area of the Great Smoky Mountains National Park. Ecol. Monogr. 28:337-360.

Cronquist, A. 1980. Vascular flora of the Southeastern United States: The Asteraceae. UNC Press, Chapel Hill.

Curtis, J.T., and R.P. McIntosh. 1951. An upland forest continuum in the prairie-forest border region of Wisconsin. Ecology 32:476-496.

Curtis, J.T. 1959. Vegetation of Wisconsin. An ordination of plant communities. U. Wis. Press, Madison.

Daniels, R.B., H.J. Kleiss, S.W. Buol, H.J. Byrd, and J.A. Phillips. 1984. Soil systems in North Carolina N.C. Agri. Res. Serv. NCSU, Raleigh.

Daubenmire, R.F. 1929. The relation of certain ecological factors to the inhibition of forest floor herbs under hemlock. Butler Univ. Bot. Stud. 1.

Daubenmire, R.F., and J.B. Daubenmire. 1968. Forest vegetation of eastern Washington and northern Idaho. Wash. Agr. Exp. Stat. Techn. Bull. 60.

Davis, J.H., Jr. 1929. The vegetation of the Black Mountains of North Carolina. Ph.D. Dissertation, U. of Chicago. Chicago, Ill.

Davis, J.H., Jr. 1930. Vegetation of the Black Mountains of North Carolina: an ecological study. J. Elisha Mitchell Sci. Soc. 45:291-318.

Davis, M.B. 1981. Quaternary history and the stability of deciduous forests. In: H.H. Shugart, D.C. West and D.B. Botkin (editors). Forest Succession. p.132-177 Springer-Verlag, New York.

Davis, M.B. 1983. Quaternary history of deciduous forests of eastern North America and Europe In: Ann. Missouri Bot. Gard. 70:550-563.

Delapp. J.A. 1978. Gradient analysis and classification of the high elevation red oak community of the southern Appalachians. Masters Thesis N.C.S.U., Raleigh.

Delcourt, H.R. 1979. Late Quaternary vegetation history of the eastern highland rim and adjacent Cumberland Plateau of Tennessee. Ecological monog. 49(3):255-280.

Delcourt, H.R., and P.A. Delcourt. 1975. The blufflands. Pleistocene pathway into the Tunica Hills. Am. Midl. Nat. 94:385-400.

Delcourt, P.A. and H.R. Delcourt. 1977. The Tunica Hills, Louisiana, Mississippi: late-glacial locality for spruce and deciduous forest species. Quaternary Research 7:218-223.

Delcourt, P.A. and H.R. Delcourt. 1987. Long-term forest dynamics of the temperate zone. Ecological Studies Vol. 63. Springer-Verlag, New York.

DeSelm, H.R. and R.R. Boner 1984. Understory changes in spruce-fir during the first 16-20 years following death of the fir. In: The Southern Appalachian Spruce-Fir Ecosystem: Its biology and threats. P.S. White (editor) National Park Service - Southeast Region Research/Resources Management Report SER-71.

Diamond, J.M. 1975. Assembly of species communities. In M.L. Cody and J.M. Diamond (eds). Ecology and evolution of communities. p.342-444. Belknap Press, Cambridge, Mass.

Dickison, G. 1980. Composition and stand dynamics of an old growth upper cove hardwood forest in Walker Cove Research Natural Area, Pisgah Nat. For. N.C. Master's Thesis, Duke U. Durham.

Doolittle, W.T. 1957. Site index of scarlet and black oak in relation to southern Appalachian soil and topography. Forest Sci. 3:114-124.

Eager, C. 1984. Review of the biology and ecology of the balsam wooly aphid in southern Appalachian Spruce-Fir forests. In: P.S. White (ed) the southern Appalachian Spruce-Fir Ecosystem: its biology and threats. National Park Service - Southeast Region Research/Resources Management Report SER-71

Eller, R. 1982. Miners, millhands and mountaineers. U. Tenn. Press, Knoxville.

Fernald, M.L. 1929. Some relationships of the floras of the northern hemisphere. Proc. Intern. Congr. Plant Sci. Ithaca 2:1487-1507.

Fernald, M.L. 1946. Types of some American trees. J. Arnold Arbor. 27:386-394.

Fernald, M.L. 1950. Gray's manual of botany. Eighth ed. American Book Co. New York.

Fink, P.M. 1931. A forest enigma. American Forests. 37:538.

Fowells, H.A. 1965. Silvics of forest trees of the United States. U.S. Dept. Agri. Agri. Handbk. No. 271.

Frank, E.C. and R. Lee. 1966. Potential solar beam irradiation on slopes. U.S. For. Serv. Res. Pap. RM-18.

Frothingham, E.H. 1917. Report on cut over areas in the southern Appalachians. Southeastern Experiment Station, USFS, Asheville, N.C. 229 p.

Gauch, H.G., Jr. 1982. Multivariate analysis in community ecology. Cambridge U. Press, Cambridge England.

Gauch, H.G. and R.H. Whittaker. 1981. Hierarchical classification of community data. Jour, of Ecology 69,537-557.

Gersmehl, P.J. 1969. A geographic evaluation of the ecotonal hypothesis of bald location in the southern Appalachians. Assoc. Amer. Geogr. Proc. 3:56-61.

Gersmehl, P.J. 1970. A geographic approach to a vegetation problem: The case of the Southern Appalachian grassy balds. Ph.D. Dissertation, U. of Georgia, Athens.

Gleason, H.A. 1926. The individualistic concept of the plant association. Bull. Torrey Bot. Club, 53:7-26.

Glenn-Lewin, D.C. 1975. Plant species diversity in ravines of the southern Finger Lakes region, New York. Can. J. Bot. 53:1465-1472.

Golden, M.S. 1974. Forest vegetation and site relationships in the central portion of the Great Smoky Mountains National Park. Ph. D. Dissertation, U. of Tennessee, Knoxville.

Golden, M.S. 1981. An integrated multivariate analysis of forest communities of the central Great Smoky Mountains. Amer. Midl. Nat.106:37-53.

Good, R.O. 1927. A summary of discontinuous distribution in the angiosperms. New Phyt. 26:249-259.

Good. R.O. 1974. The geography of flowering plants. 4th ed. Longman, London. 557 pp.

Gray, A. 1846. Analogy between the flora of Japan and that of the United States. Amer. Jour. Sci. and Arts II 2:135-136.

Gray, A. 1859. Diagnostic characters of phanogamous plants, collected in Japan by Charles Wright with observations upon the relations of the Japanese flora to that of North America. Mem. Amer. Acad. Arts Sci. N.S. 6:377-453.

Gray, A. 1860. Illustration of botany of Japan and its relation to that of central and northern Asia, Europe, and North America. Proc. Amer. Arts Sci. 4:131-135.

Hack, J.T., and J.C. Goodlett. 1960. Geomorphology and forest ecology of a mountain region in the central Appalachians. U.S. Geol. Survey Map I-654.

Hack, J.T. 1969. The area, its geology: Cenozoic development of the southern Appalachians In: The distributional history of the biota of the southern Appalachians Part I: Invertebrates Research Division monograph 1 VPI and State U. Blacksburg, Va.

Hadley, J.B., and A.E. Nelson. 1971. Geologic map of the Knoxville Quadrangle, N.C., Tenn. and S.C. U.S. Geol. Survey Map I-654.

Harmon, M.E. 1981. Fire history of Great Smoky Mountains National Park 1940-1979. USDI, National Park Service, Southeast Regional Office, Res./Resource Manage. Rept. 46.

Harmon, M.E., S.P. Bratton, and P.S. White. 1984. Disturbance and vegetation response in relation to environmental gradients in the Great Smoky Mountains. Vegetatio 55:129-139.

Harrison, H.T., and W.H. Haggard. 1977. The climates of Western North Carolina. Asheville Chamber of Commerce, Inc. Asheville, N.C.

Harshberger, J.W. 1916. The vegetation of the New Jersey Pine Barrens. Dover, New York.

Hill, M.O. 1979a. DECORANA - A FORTRAN program for detrended correspondence analysis and reciprocal averaging. Cornell U. Ithaca, New York.

Hill, M.O. 1979b. TWINSPAN - A FORTRAN program for arranging multivariate data in an ordered two-way table by classification of the individuals and attributes. Cornell U., Ithaca, N.Y.

Hill, M.O., and H.G. Gauch, Jr. 1980. Detrended correspondence analysis: an improved ordination technique. Vegetatio 42:47-58.

Hills, G.A. 1960. Regional site research. Forestry Chronicle 36:401-423.

Hinkle, C.R. 1975. A preliminary study of the flora and vegetation of Cumberland Gap National Historical Park, Middlesboro, Kentucky. M.S. Thesis. U. Tenn. Knoxville.

Holmes, J.S. 1918. Forest fires in North Carolina during 1915, 1916, and 1917. N.C. Geological and Economic Survey. Edwards and Broughton Printing Co., Raleigh, N.C.

Holt, P.C. 1970. The distributional history of the biota of the southern Appalachians. Part II: Flora - Preface.

Howell, D. 1974. Geology of the southern two-thirds of the Celo Quadrangle, N.C. Masters Thesis. UNC, Chapel Hill.

Hu, H.H. 1935. Comparison of the ligneous flora of China and eastern North America. Bull. Chinese Bot. Soc. 1:79-97.

Huston, M. 1979. A general hypothesis of species diversity. Amer. Nat. 113:81-101.

Huston, M. 1980. Soil nutrients and tree species richness in Costa Rican forests. J. Biogeogr. 7:147-157.

Iltis, H.H. 1966. The western element in the eastern North American flora and its phytogeographic implications. (Abs.) A.J.B. 53:634.

Jones, S.B., Jr. 1974. The flora and phytogeography of the Pine Mountain region of Georgia. Castanea 39:113-149.

Kartesz, J.T., and R. Kartesz. 1980. A synonymized checklist of the vascular flora of the United States, Canada, and Greenland. Univ. N.C. Press. Chapel Hill.

Keever, C. 1953. Present composition of some stands of the former Oak-Chestnut forest in the southern Blue Ridge Mountains. Ecology 34:44-54.

Keith, A. 1905. Description of the Mount Mitchell Quandrangle, N.C. and Tenn. U.S. Geo. Surv. Geol. Atlas, Folio 124.

Kershaw, K.A. and J.H.H. Looney. 1985. Quantitative and dynamic plant ecology. Third Ed. Edward Arnold Baltimore, Maryland.

Kring, J.B. 1965. Vegetational succession at Craggy Gardens, N.C. M.S. Thesis. U. Tenn., Knoxville.

Lesure, F.G., A.E. Grosz, B.B. Williams and G.C. Gazdik. 1982. Mineral resources of the Craggy Mountain Wilderness Study Area and Extension, Buncombe County, N.C. Geol. Surv. Bull 1515. Washington.

Li, H.L. 1952. Floristic relationships between eastern Asia and eastern North America. Trans. Philos. Soc. 42:37-429.

Little, E.L. Jr. 1970. Endemic, disjunct and northern trees in the Southern Appalachians In: The Distributional History of the Biota of the Southern Appalachians Part II: Flora Research Division Monograph 2. Virginia Polytechnic Institute and State University Blacksburg, Va.

Little, E.L., Jr. 1979. Checklist of United States Trees Agriculture Handbook No. 541 USDA Forest Service. Washington.

Little, S. 1974. Effects of fire on temperate forests: Northeastern U.S. In: Fire and Ecosystems (T.T. Kozlowski ed.).

Loftis, D. 1978. Effects of periodic fire on species composition of understory in southern Appalachian hardwoods. Study Plan FS-SE-1102-21(2). Southeastern Exp. Sta., Asheville, N.C.

Lorimer, G.C. 1976. Stand history and dynamics of a southern Appalachian virgin forest. Ph.D. Dissertation, Duke Univ., Durham.

Lorimer, C.G. 1980. Age structure and disturbance history of a southern Appalachian virgin forest. Ecology 61:1169-1184.

Mark, A.F. 1958. The ecology of the southern Appalachian grass balds. Ecol. Monogr. 28:293-336.

Mark, A.F. 1959. The flora of the grass balds and fields of the southern Appalachian Mountains. Castanea. 24:1-21.

Massey, J.R., D.K.S. Otte, T.A. Atkinson and R.D. Whetstone. 1983. An atlas and illustrated guide to the threatened and endangered vascular plants of the mountains of North Carolina and Virginia. USDA, Southeastern Forest Experiment Station, Asheville, N.C., Gen. Tech. Rept. SE-20.

McDougal, K.M. and C.R. Parks. 1984. Elevational variation in foliar flavonoids of Quercus rubra L. (Fagaceae). Amer. J. Bot. 71(3): 301-308

McLeod, D.E. 1981. Baseline data for hardwood forests in the Black Mountain Research Natural Area, including vegetation patterns. Southeastern Exp. Sta., USFS, Asheville, N.C.

McLeod, D.E., and J.A. Croom. 1983. Vegetation patterns and habitat types in a small southern Appalachian bog-fen. (abs.) ASB Bulletin 30, No. 2.

Monk, C.D. 1965. Southern mixed hardwood forest of north central Florida. Ecol. Monogr. 35:335-354.

Monk, C.D. 1967. Tree species diversity in the eastern deciduous forest with particular reference to north central Florida. Amer. Nat. 101:173-187.

Mueller-Dombois, D. and H. Ellenberg. 1974. Aims and methods of vegetation ecology. John Wiley and Sons, New York.

Mutch, R.W. 1970. Wildland fires and ecosystems - a hypothesis. Ecology 51:1046-1051.

Nagel, W.P. 1959. Forest insect conditions in the Southeast during 1958. U.S. Forest Service, Stn. Paper SE-100.

Noyes, R.J. 1917. Lands of Mt. Mitchell company (no.115), Mt. Mitchell Area. In files of USFS, Toecane Ranger District, Pisgah Nat. For., Burnsville, N.C.

Oosting, H.J., and W.D. Billings. 1939. Edapho-vegetational relations in Ravenell's Woods, a virgin hemlock forest near Highlands, North Carolina. Amer. Nat. 22:333-350.

Oosting, H.J., and W.D. Billings. 1951. A comparison of virgin spruce-fir forest in the northern and southern Appalachian system. Ecology 32:84-103.

Oosting, H.J., and P.F. Bourdeau. 1955. Virgin hemlock forest segregates in the Joyce Kilmer Memorial Forest of Western North Carolina. Bot. Gaz. 116:340-349.

Peet, R.K. 1974. The measurement of species diversity. Ann. Rev. Ecol. Syst. 5:285-307.

Peet, R.K. 1978. Forest vegetation of the Colorado Front Range: Patterns of species diversity. Vegetatio 37:65-78.

Peet, R.K. 1980. Ordination as a tool for analyzing complex data sets. Vegetatio 42:171-174.

Peet, R.K. 1981. Forest vegetation of the Colorado Front Range: Composition and dynamics. Vegetatio 45:3-75.

Peet, R.K., and N.L. Christensen. 1980. Hardwood forest vegetation of the North Carolina Piedmont. Veroff. Geobot. Inst. ETH, Stiftung Rübel, Zürich 69, Heft, 14-39.

Peet, R.K., D.C. Glenn-Lewin and J.Walker Wolf. 1983. Prediction of man's impact on plant species diversity. In: Man's impact on vegetation p.41-53. Junk, The Hague.

Pielou, E.C. 1979. Biogeography. John Wiley, New York.

Pielou, E.C. 1984. The interpretation of ecological data: A primer on classification and ordination. John Wiley and Sons, New York.

Pittillo, J.D. 1976. Potential natural landmarks of the southern Blue Ridge. Report for the National Park Service.

Pittillo, J.D., and T.E. Govus. 1978. A manual of important plant habitats of the Blue Ridge Parkway. Report for the National Park Service.

Poore, M.E.D. 1955. The use of phytosociological methods in ecological investigations. I. The Braun-Blanquet system. J. Ecol. 43:226-244.

Radford, A.E. 1976. Vegetation-habitats-floras-natural areas in the Southeastern U.S. Field Data and Information. UNC Student Stores, Chapel Hill, N.C.

Radford, A.E., H.J. Ahles and C.R. Bell. 1968. Manual of the vascular flora of the Carolinas. Univ. N.C. Press, Chapel Hill.

Radford, A.E., D.K.S. Otte, L.J. Otte, J.R. Massey, P.D. Whitson and Contributors. 1980. Natural heritage: classification, inventory, and information. Univ. N.C. Press, Chapel Hill.

Ramensky, L.G. 1926. Die Grundgesetzmassigkeiten im Aufbau der Vegetationsdecke. Botanisches centralblatt N.F. 7:453-455, an abstract by Selma Ruoff of the original. Russian article in Westnik Opitnogo Dela Woronej, 1924. Translated by E.J. Kormondy In: Readings in Ecology p.151-152. Prentice-Hall, Inc. Englewood Cliffs, N.J.

Ramseur, G.S. 1958. The vascular flora of high mountain communities of the southern Appalachians, Ph.D. Dissertation. Univ. N.C., Chapel Hill.

Ramseur, G.S. 1960. The vascular flora of high mountain communities of the southern Appalachians. J. Elisha Mitchell Sci. Soc. 76:82-112.

Richardson, C.J., and D.W. Valentine. 1983. Forest vegetation, soils and other environmental characteristics in the Black Mountains of North Carolina. Report for Southeastern Experiment Station, Asheville, N.C. Duke Univ., Durham, N.C.

Rogers, R.S. 1978. Forests dominated by hemlock (Tsuga canadensis): distribution as related to site and post-settlement history. Can. J. Bot. 56-843-854.

Rowe, J.S. 1956. Uses of undergrowth species in forestry. Ecology 37:461-473.

Runkle, J.R. 1979. Gap phase dynamics in climax mesic forests. Ph.D. Dissertation Cornell U., Ithaca.

Runkle, J.R. 1981. Gap regeneration in some old-growth forests of the eastern United States. Ecology 62:1041-1051.

Runkle, J.R. 1985. Disturbance regimes in temperate forests. In: The ecology of natural disturbance and patch dynamics. S.T.A. Pickett and P.S. White (editors) Academic Press, Orlando.

Russell, N.H. 1953. The beech gaps of the Great Smoky Mountains. Ecology 34:366-374.

Schafale, M.P., and A.S. Weakley. 1985. Classification of the natural communities of North Carolina-second approximation. N.C. Natural Heritage Program, Raleigh, N.C.

Schwarzkopf, S.K. 1985. A History of Mt. Mitchell and the Black Mountains. N.C. Division of Archives and History. Raleigh, N.C.

Seaton, K. 1980. Douglas Falls hemlock forest natural area. Class report for A.E. Radford, Botany 235.

Shanks, R.E. 1954. Climates of the Great Smokey Mountains. Ecology 35:354-361.

Siccama, T.G., M. Bliss, and H.W. Vogelmann. 1982. Decline of red spruce in the Green Mountains of Vermont. Bull. Torr. Bot. Club 109:162-168.

Sims, I.H. 1932. Establishment and survival of yellow-poplar following a clear cutting in the southern Appalachians. Jour. Forestry 30:409-414.

Smathers, G.A. 1981. The anthropic factor in southern Appalachian bald formation In: Saunders, P.R. (editor). Status and Management of Southern Appalacian Mountain Balds. Proceedings of a Workshop. SARRMC, WCU, Cullowhee, N.C.

Smith, E.L. 1976. Craggy Pinnacle natural area. Class Report for A.E. Radford, Botany 235.

Smith, E.L. 1982. Vegetation of the South Mountains State Park (Burke County, North Carolina) Castanea 47:298-307.

Soil Survey Staff, 1975. Soil taxonomy, USDA Agr. Handbk. 436. Washington.

Sole, J.D., S. Lassetter, and W.H. Martin. 1983. The vascular flora of Lilley Cornett Woods, Letcher County, Kentucky. Castanea 48(3):174-188.

Speers, C.F. 1958. The balsam wooly aphid in the Southeast. J. For.56:515-516.

Spurr, S.H. and B.V. Barnes 1980. Forest ecology Third Edition. John Wiley and Sons, New York.

Stace, C.A. 1980. Plant taxonomy and biosystematics. Edward Arnold, London.

Stebbins, G.L., and J. Major. 1965. Endemism and speciation in the Californian flora. Ecol. Monogr. 35:1-35.

Sutter, R.D., L. Mansberg and J. Moore. 1983. Endangered, threatened, and rare plant species of North Carolina. ASB Bulletin 30:153-163.

Swan, F.R., Jr. 1970. Post-fire response of four plant communities in south-central New York State. Ecology 51:1074-1082.

Trewartha, G.T. 1954. An introduction to climate. McGraw-Hill, New York.

Tucker, G.A. 1967. The vascular flora of bluff mountain. MS Thesis, Univ. N.C., Chapel Hill, N.C.

USDA. 1933. Report on Middle Creek watershed and order establishing Black Mountain Natural Area; on file-Southeastern Experiment Station, Asheville, N.C.

USDA. 1982. Craggy mountain final environmental impact statement and wilderness study report. National Forests in N.C., Asheville, N.C.

Walter, H. and H. Lieth. 1967. Klimadiagramm-Weltatlas. Gustav Fischer Verlag, Jena.

Walter, H. 1979. Vegetation of the earth and ecological systems of the geo-biosphere. Second Edition Springer-Verlag, New York.

Ward, J.D., E.T. Wilson, and W.M. McDonnell. 1973. Status of the balsam wooly aphid, Adelges piceae (Ralz.), in the southern Appalachians - 1972. USFS, SA, S & PF, Div. FPM Asheville, N.C. Rep. No. 73-1-35.

Watts, W.A. 1970. The full-glacial vegetation of northwestern Georgia. Ecology 51:17-33.

Watts, W.A. 1971. Postglacial and interglacial vegetation history of southern Georgia and central Florida. Ecology 52:676-690.

Watts, W.A. 1980. The Late Quaternary vegetional history of the southeastern United States. Ann. Rev. Ecol. Syst. 11:387-410.

Wells, B.W. 1932. The natural gardens of North Carolina. Univ. N.C. Press, Chapel Hill.

Wells, B.W. 1936. Origin of the southern Appalachian grass balds. Science. 83:283.

Wells, B.W. 1937. Southern Appalachian grass balds. J. Elisha Mitchell Sci. Soc. 53:1-26.

Wells, B.W. 1956. Origin of southern Appalachian grass balds. Ecology 37:592.

White, P.S. 1979. Pattern, process, and natural disturbance in vegetation. Bot. Rev. 45:229-299.

White, P.S. 1982. The flora of Great Smoky Mountains National Park: an annotated checklist of the vascular plants and a review of previous floristic work. U.S.D.I, NPS Southeast Regional Office, Res./Res. manage. Rept. SER-55.

White, P.S., R.I. Miller and G.S. Ramseur. 1984. The species area relationships of the southern Appalachian high peaks: vascular plant richness and rare plant distributions. Castanea 49:47-61.

Whitehead, D.R. 1967. Studies of full-glacial vegetation and climate in southeastern United States In: Quaternary Paleoecology. In Cushing E. and Wright H.(eds). p.237-248.

Whitehead, D.R. 1973. Late Wisconsin vegetational changes in unglaciated eastern North America. Quat. Res. 3:621-631.

Whittaker, R.H. 1956. Vegetation of the Great Smoky Mountains, Ecol. Monogr. 26:1-80.

Whittaker, R.H. 1960. Vegetation of the Siskiyou Mountains, Oregon and California. Ecol. Monogr. 30:279-338.

Whittaker, R.H. and W.A. Niering. 1975. Vegetation of the Santa Catalina Mountains, Arizona. V. Biomass, production, and diversity along the elevation gradient. Ecology 56:771-790.

Witter, J.A. and I.R. Ragenovich 1986. Regeneration of Fraser fir at Mt. Mitchell, North Carolina, after depredations by the balsam wooly adelgid. For. Sci. 32:585-594.

Wolfe, J.A. 1972. An interpretation of Alaskan Tertiary floras, In: Graham (ed.) Floristic and paleofloristics of Asia and eastern North America. p.201-233. Elsevier, Amsterdam.

Wolfe, J.A. 1978. A paleobotanical interpretation of Tertiary climates in the Northern Hemisphere. Am. Sci. 66:694-703.

Wolfe, J.A. 1981. Vicariance biogeography of angiosperms in relation to paleobotanical data, p.413-427. In G. Nelson and D.E. Rosen (eds.), Vicariance biogeography: a critique. Columbia U. Press, New York.

Wood, C.E. Jr. 1970. Some floristic relationships between the southern Appalachians and Western North America In: the distributional history of the Biota of the Southern Appalachians Part II: Flora Research Division Monograph 2 pp.331-404 Virginia Polytechnic Institute and State University Blacksburg, Va.

Woods, F.W., and R.E. Shanks. 1959. Natural replacement of chestnut by other species in the Great Smoky Mountains National Park. Ecology 40(3):349-361.

APPENDIX A

Table 22. Southern Appalachian Endemics Found in the Black and Craggy Mountains. Range and habitat.

Abies fraseri (Pinaceae). Range: Mt. Rodgers in the Balsam Mountains of Va. to the Great Smoky Mountains of N.C. and Tenn. in six upper elevations disjunctions which include Mt. Rodgers, Grandfather Mtn., the Black Mtns., the Balsam Mtns. of N.C. and the Smokies (Ramseur 1960). Balsam Wooly aphid has decimated this tree in the Black Mtns. There is good regeneration but the future is uncertain.

Angelica triquinata (Apiaceae). Range: Pa. and W. Va. to western N.C. (Fern. 1950). Found at most elevations, disturbed areas at upper elevation contain the greatest number of individuals.

Cardamine clematitis (Brassicaceae). Range: sw. Va. to Tenn. and Ala. (Fern. 1950). Seeps and stream sides primarily at upper elevations

Carex biltmoreana (Cyperaceae). Range: Blue Ridge province of sw. N.C., nw. S.C. and ne. Ga. (Gaddy 1983). Found in wet, partially-shaded rock faces. The station in the Craggies is the northernmost station known.

Carex misera (Cyperaceae). Range: w. N.C., ne. Ga. and e. Tenn. (Massey et al 1983). Found in rocky crevices and balds at upper elevations.

Carex ruthii (Cyperaceae). Range: sw. Va. to Ga. and e. Tenn. (Fern. 1950). Woods and stream sides at upper elevations.

Chelone lyonii (Scrophulariaceae). Range: w. N.C., e. Tenn. and nw. S.C. (Radford et al.1968). Population is centered in the spruce-fir forests of upper elevations, primarily in moist sites.

Cuscuta rostrata (Convolvulaceae). Range: mts. of W. Va. to nw S.C. and Tenn. (Fern 1950). Most abundant in disturbed areas at upper elevations. Found on Rubus ssp. and Aster ssp.

Diervilla sessilifolia (Caprifoliaceae). Range: Ga. and Ala., n. to Blue Ridge of Warren County, Va. (Fern. 1950). Found principally in open areas at upper elevations.

Eupatorium rugosum var. roanense (Asteraceae). Range: W. Va., w. Va. to nw Ga. (Fern. 1950). Most abundant in open areas at upper elevations.

Geum radiatum (Rosaceae). Range: w. N.C., and e. Tenn. (Massey et al. 1983). Found on balds at high elevations, usually on cliffs and rock crevices. There are two populations in the study area: one on Mt. Craig in the Blacks, the other on Craggy Pinnacle in the Craggies.

Hedyotis michauxii (=Houstonia serpyllifolia) (Rubiaceae). Range: Mts. of Pa. and W. Va. to Ga. and Tenn. (Fern. 1950). Found in damp mossy areas at upper and middle elevations.

Hyericum graveolens (Clusiaceae). Range: w. N.C., sw. Va., e. Tenn. (Radford et al. 1968). Large populations in open areas at upper elevations, especially in the fire meadows of Black Mtns.

Hypericum mitchellianum (Clusiaceae). Range: w. N.C., sw Va., e. Tenn. (Radford et al. 1968). This species ranges to lower elevations (3400ft.) than the previous. Occasionally hybridizes with H. graveolens.

Juncus trifidus ssp. carolinianus (Juncaceae). Range: (Massey et al. 1983). Rock crevices in schistose rocks at upper elevations.

Krigia montana (Asteraceae). Range: w. N.C., nw. S.C., ne. Ga. (Radford et al. 1968). Mossy rock and wet meadows at upper elevations seeps..

Lilium grayi (Liliaceae). Range: w. Va., Tenn., N.C. (Massey et al. 1983). Balds, meadows and forest openings at upper elevations.

Parnassia asarifolia (Saxifragaceae). Range: w. Va., N.C. to ne Ga. and Ala. (Fern, 1950). Seeps and boggy areas at upper elevations.

Prenanthes roanensis (Asteraceae). Range: Ky., Tenn., Va., and w N.C. (Fern. 1950). Found primarily in disturbed areas at upper elevations.

Rhododendron catawbiense (Ericaceae). Range: W. Va., Va., N.C., Ga., and Ala. with some disjunct populations in the Piedmont. (Little 1970). Occurs in almost pure stands in heath balds and gardens, at upper elevations and as an understory species in spruce-fir and northern hardwood forests.

Rhododendron x wellesleyanum (Ericaceae). Range: This hybrid occurs in two known populations; one in Caldwell County, N.C. and the other in the Black Mts. on Bear Ridge in the Cane River Drainage (Ramseur 1960).

Saxifraga michauxii (Saxifragaceae). Range: Va., W. Va. to Ga. and Tenn. (Fern. 1950). Found on mossy rock, cliffs and ledges at upper elevations and occasionally lower.

Solidago glomerata (Asteraceae). Range: w. Va., e. Tenn., w. N.C., ne. Ga. (Fern. 1950). Balds, fire meadows and forest openings at upper elevations. Type locality Roan Mtn.

Streptopus roseus var. roseus (Liliaceae). Range; Pa. to w. N.C. and e. Tenn. (Fern. 1950). Spruce-fir and upper elevation hardwood forests.

Vaccinium erythrocarpum (Ericaceae). Range: W. Va., w. Va., Ga., Tenn., and w. N.C. (Fern. 1950). Balds, spruce-fir and upper elevation hardwood forests.

Aconitum reclinatum (Ranunculaceae). Range: W. Va., w. Va., to ne. Ga. (Fern. 1950). Found on moist slopes, seeps, and ravines. Large populations in Craggy Wilderness extension study area, and Bowlens Creek of Black Mtns.

Aesculus flava (=A. octandra) (Hippocastanaceae). Range: Northern limit almost coincides with Wisconsin terminal moraine in sw. Pa. and se. Ohio. Ranges along the Appalachian Plateau to n. Ga. and in the Blue Ridge Province of N.C. (Little 1970). A dominant of mesic cove forests.

Astilbe biternata (Saxifragaceae). Range: W. Va., Va. to Ga. and Tenn. (Fern, 1950). Mesic hardwood slopes and seeps.

Boykinia aconitifolia (Saxifragaceae). Range: W. Va., Va., Ky., e. Tenn., w. N.C. to ne Ga., ne S.C. (Fern. 1950). Seeps, wet meadows and stream banks in cove forests.

Cimicifuga americana (Ranunculaceae). Range: Pa., W. Va., e. Tenn., w. N.C. to ne Ga., (Fern. 1950). Mesic slopes in hardwood forests. Found in the richest of the cove forests.

Convallaria montana (Liliacaea). Range: Va., W. Va., w. N.C., e. Tenn., to ne. Ga. (Fern. 1950). Mesic slopes and rocky woods of hardwood forests. Locally abundant in Celo Community on South Toe River.

Coreopsis latifolia (Asteraceae). Range: w. N.C., ne S.C. (Massey et al. 1935). Mesic slopes in upper hardwood forests in Craggies w. and n. of Craggy Gardens.

Diphylleia cymosa (Berberidaceae). Range: sw. Va., N.C., ne Ga. (Fern. 1950). Seepage slopes and along streams in hardwood and coniferous forests from 2500 to 6400 ft.

Galium latifolium (Rubiaceae). Range: W. Va., Pa., to Tenn. and Ala. (Fern. 1950). Mesic hardwood forests.

Penstemon smallii (Scrophulariaceae). Range: w. N.C., ne S.C., ne Ga., e. Tenn. (Radford et al. 1968). Openings in edges of forests, rocky slopes - usually oak.

Saxifraga careyana (Saxifragaceae). Range: Va., Tenn., N.C. and S.C. (Massey et al. 1983). This and next species may not be specifically distinct. Seepage slopes, moss covered rocks and ravines. Large populations of this and the following species abundent in Bowlen's Creek in Black Mtns.

Saxifraga caroliniana (Saxifragaceae). Range: Ky., W. Va., w. Va., and Tenn. (Fern. 1950). Moss covered rocks and cliffs, seepage slopes and ravines.

Saxifraga micranthidifolia (Saxifragaceae). Range: W. Va., Pa., Tenn., N.C., Ga. (Fern. 1950). Along streams, seeps, and damp ravines.

Thalictrum clavatum (Ranunculaceae). Range: W. Va., Ky., Tenn., N.C., Ga., Ala., (Fern 1950). Stream sides and spray zones of cascades and waterfalls.

Aristolochia macrophylla (Aristolochiaceae). Range: sw Pa. and W. Va., s. in the uplands to Ga. and Ala. (Fern. 1950). A cove forest woody vine.

Aster curtisii (Asteraceae). Range: w. N.C., e. Tenn., ne Ga. (Radford et al. 1968). Mixed oak woods at lower to middle elevation (2800-4000 ft.).

Aster divaricatus var chlorolepis (Asteraceae). Range: e. Tenn., W. N.C. (Radford et al. 1968). Mixed oak woods and upper elevation spruce-fir forests and balds.

Magnolia fraseri (Magnoliaceae). Range: W. Va., Va., e. Ky., e. Tenn., w. N.C., nw S.C., n. Ga., n. Ala. (Little 1970). A tree primarily found in the transition between the cove forest and oak forest, also may be associated with Tsuga canadensis.

Pyrularia pubera (Santalaceae). Range: Mts. of Pa., W. Va. to Ga. and Ala. (Fern 1950). A root parasite on deciduous trees and shrubs, mostly members of white oak group.

Rhododendron calendulaceum (Ericaceae). Range: Pa., W. Va., Va., se Ohio, N.C., S.C., Tenn., Ga., Ala. (Fern. 1950). Oak woods especially Quercus rubra, best developed at elevations between 3500-5000 ft.

Rhododendron carolinianum (Ericaceae). Range: Middle elevations (3500-4000 ft.) Rocky knobs and ridges.

Rhododendron minus)Ericaceae). Range: N.C, S.C., Tenn., Ga., Ala. (Radford et al. 1968). Rocky woods and stream banks at lower elevations (2500-3500 ft.).

Rhododendron vaseyi (Ericaceae). Range: Mtns. of N.C. (Radford et al. 1968). Best developed in red oak forest between 4000 and 5500 ft.

Robinia viscosa (Fabaceae). Range: W. Va., Pa., to Ga. and Ala. (Little 1970). Heath balds and rocky open woods.

Solidago curtisii (Asteraceae). Range: W. Va., Va., Ky., N.C., S.C., Ga., Ala. (Fern. 1950). Oak woods at lower to middle elevations (2500-4000 ft.).

Veratrum parviflorum (liliaceae). Range: w. Va., W. Va., e. Tenn., w. N.C., nw S.C., ne Ga. (Fern. 1950). Oak woods from 2500-6000 ft.

Pycnanthemum montanum (Lamiaceae). Range: W. Va., w. Va., w. N.C., nw S.C., e. Tenn. (Fern. 1950). Mixed hardwood forests, primarily oaks, and roadbanks.

Pinus pungens (Pinaceae). Range: s. Pa., e. W. Va., W. Va., e. Tenn., w. N.C., nw S.C. and ne Ga. (Little 1970). A tree primarily of elevations between 3800-5000 ft. on dry rocky usually s - sw facing ridges often subject to fire.

Tsuga caroliniana (Pinaceae). Range: Va., w. N.C., nw. S.C., ne Ga., e. Tenn. (Little 1970). Primarily cliffs, rocky ridges and ravines. In South Toe Valley is found scattered in mixed oak woods.

Leucothoe recurva (Ericaceae). Ranges: Va., W. Va., Ga., S.C., N.C. (Fern. 1950). Heath Balds, bogs and acid woods.

Menziesia pilosa (Ericaceae). Range: Pa., W. Va., Va., Tenn., ne Ga. (Fern. 1950). Heath Balds, bogs and acid woods.

Hexastylis shuttleworthii (Aristolochiaceae). Range: w. Va., and W. Va. s. to nw Ga. and Ala. (Fern. 1950). Plant of acid woods, heath balds, hemlock and xeric oak stands.

Clethra acuminata (Clethraceae). Range: W. Va., Ky., Va., Tenn., N.C., S.C. (Little 1970). There appears to be two populations of this species, a lower elevation one of bogs and stream banks and an upper elevation one of heath balds. Soil pH may be the determining factor.

Listera smallii (Orchidaceae). Range: W. Va., Va., Tenn., N.C., S.C., Ga. (Fern. 1950). Acid woods, heath balds, hemlock stands and bogs. An acidophile.

Heuchera villosa (Saxifragaceae). Range: W. Va., Tenn., Ky., Ga., Ala., S.C., N.C. (Fern. 1950). Mossy rocks, ledges and crevices, wide elevational range (2000-6000 ft.)

Cymophyllus fraseri (Cyperaceae). Range: w. Va., Va., Tenn., N.C., (Massey et al. 1983). Mixed hardwood slopes and stream banks, from low to upper elevations (2000-6000 ft.).

Paronychia argyrocoma (Caryophyllaceae). Range: W. Va., Va., Tenn., N.C., Ga. (Fern. 1950). Rocky ledges and slopes. Acid rock probably determining factor.

Juncus gymnocarpus (Juncaceae). Range: mtns. of e. Pa. to e. Tenn., w. N.C. and nw S.C. Also Walton County, Fla. - in the Fla. Panhandle (Apalachicola Drainage). (Fern. 1950). Bogs and mucky low ground. Celo Bog-Fen.

Silene ovata (Caryophyllaceae). Range: se Ky., w. N.C. to Ga., Ala. Disjunct pop. in Ark. (Fern. 1950).

APPENDIX B

Table 23 HERBARIA DOCUMENTATION

UNIVERSITY OF NORTH CAROLINA AT CHAPEL HILL (NCU)

Species	Collector	Number
Botrychium oneidense House	Bartlett	363655
Acorus americanus (Raf.) Raf.	Ahles	42796
Arctium minus Schkuhr.	Ahles	46750
Bellis perennis L.	Moffitt	no number
Bidens cernua L.	Ahles	50856
Coreopsis latifolia Michx.	Justice	no number
Coreopsis pubescens Ell.	Justice	26
Eupatorium sessilifolium L.	Ahles	46886
Helenium flexuosum Raf.	Freeman	58258
Hieracium florentinum All.	Leonard	2454
Senecio vulgaris L.	Radford	45206
Solidago patula Muhl.	Justice	40
Solidago uliginosa Nutt.	Freeman	58355
Rorippa palustris (L.) Bess.	Ahles	42861
Silene ovata Pursh	Johnson	no number
Carex buxbaumii Wahlenb.	Ahles	
Carex grisea Wahl.	Radford	6964
Carex leptonervia Fern.	Ramseur	4761
Carex misera Buckl.	Ramseur	4754
Carex stipata Muhl. ex Willd.	Ramseur	4809
Cyperus flavescens L.	Ahles	50865
Cyperus tenuifolium (Steud.) Dandy	Ahles	50864
Scirpus purshianus Fern.	Ahles	46892
Medicago lupulina L.	Ahles	42825
Melilotus officinatis (L.) Pallas	Ahles	42824
Vicia villosa Roth	Ahles	42823
Elodea nuttallii (Planch.) St. John	Radford	4956
Juncus trifidus Hamet - Ahti	Ramseur	4758
Luzula multiflora (Retz.) Lej.	Boufford	
Trichostema dichotomum L.	Freeman	58347
Agrostis mertensii Trin. (=borealis)	Ramseur	792
Eragrostis cilianensis (All.) E. Mosher	Ahles	50849
Eragrostis pilosa (L.) Beaur.	Ahles	50861
Festuca elatior L.	Ramseur	4185
Leersia oxyzoides (L.) Sw.	Boufford	11823
Poa alsodes Gray	Ramseur	4769
Penstemon smallii Heller	Justice	5
Tilia caroliniana (=T. floridana P. Mill)	Ashe	(10-7-16)

WESTERN CAROLINA UNIVERSITY HERBARIUM (WCUH)

Selaginella rupestris (L.) Spring	Govus	83
Vittaria sp. Sm.	Pittillo	19025
Woodsia obtusa (Spreng.) Torr.	Govus	82
Krigia biflora (Walt.) Blake	Govus	231
Liatris squarrosa (L.) Michx.	Govus	345
Arabis glabra (L.) Bernh.	Govus	33
Arabis missouriensis Greene	Govus	95
Silene vulgaris (Moench) Garcke	Govus	318
Carex laxiflora Lam.	Pittillo	7634
Carex misera Buckl.	Govus&Pitt.	15965
Carex rosea Willd.	Pittillo	7849
Carex tribuloides Wahlemb	Govus	103
Cyperus filiculmis Vahl.	Govus	244
Cyperus strigosus L.	Smathers	no number
Scirpus cespitosus L.	Govus&Pitt.	15989
Amorpha glabra Desf. ex Poir	Govus	86
Leonurus cardiaca L.	Govus	94
Agastache scrophulariifolia (Willd.) Kuntze	Govus	346
Allium cernuum Roth	Govus	232
Corydalis flavula (Raf.) D.C.	Govus	20
Dichanthelium boscii (Poir) Gould & Clark	Pittillo	7687
Eragrostis hirsuta (Michx.) Nees	Govus	342
Helictotrichon pubescens (Hads.) Pilger	Govus	90
Sorghastrum nutans (L.) Nash	Walters	(1968)
Phlox amplifolia Britt.	Smathers	(1959)
Phlox carolina L.	Smathers	(1959)
Phlox subulata L.	Govus	29
Amelanchier sanguinea (Pursh) D.C.	Govus	84
Prunus avium (L.) L.	Govus	16
Prunus virginiana L.	Govus	14
Philadelphus hirsutus Nutt.	Govus	15
Saxifraga virginiensis Michx.	Govus	91
Agalinis tenuifolia (Vahl) Raf.	Govus	255
Celtis occidentalis L.	Govus	28
CLEMSON UNIVERSITY (Clems)		
Carex biltmoreana Mackenzie	Gaddy	187
NORTH CAROLINA STATE UNIVERSITY (NCSU)		
Diervilla lonicera	Beaman	36972
Prenanthes roanensis	Sargent	39973
IN LITERATURE		
Dryopteris spinulosa (O.F. Muell.) Watt	Boufford et al.	1974
Listera cordata (L.) R. Br.	Boufford et al.	1974
Thaspium pinnatifidum (Buckl.) Gray	Mansberg	1984
Cymophyllus fraseri (Andrz.) Mackenzie	Cooper et al.	1977

APPENDIX C

Table 24 Community summary table

Species composition of the community types of the Black and Craggy Mountains are summarized in the community summary table by (1) percent constancy (percentage of sample plots in which species is present in a given type); (2) modal species, which are those species with highest constancy in a given type. Modal species are indicated by a line under constancy value; and (3) character species, which are those species with a high degree of fidelity (sensu Braun-Blanquet) to the community type. Character species are indicated by an asterisk after the species constancy value.

Explanation of community type symbols: CH = Cove hardwood forests; Be Bi = Beech, Birch forests; O Me = oak, mesic forests; Al = Alluvial forests; E He = Eastern Hemlock forests; O YP Hi = mixed Oak, Yellow poplar, Hickory forests; WO = White oak forests; SO RM = Scarlet oak, Red maple forests; RO YP CO = Red oak, Yellow poplar, Chestnut oak forests; CO = Chestnut oak forests; RO = Red oak forests; Cr He = Carolina Hemlock forests; XP = Xeric pine forests; HB = Heath balds; RS = Red spruce forests; F = Fir forests; Mea = Meadows.

	CH	Be Bi	O Me	Al	E He	O YP Hi	WO	SO RM	RO YP CO	CO	RO	Cr He	XP	HB	RS	F	Mea
Number of sample plots	27	06	10	08	07	09	04	06	10	04	07	05	09	08	16	05	09
Species per 0.1 ha	51.1	38.2	61.6	51.5	28.9	57.9	50.3	48.9	50.7	44.3	45.7	23.5	28.4	27.8	30.8	22.0	31.9
Percent tree species	15.0	15.4	17.9	18.0	29.0	22.6	27.4	28.4	22.1	25.9	19.4	39.3	31.1	23.4	19.0	15.4	16.3
Percent shrub species	8.7	16.7	7.2	11.9	15.9	10.1	13.7	14.7	11.4	13.4	12.4	18.0	24.3	26.0	12.1	15.4	8.2
Percent liana species	4.0	1.2	2.5	3.0	4.3	4.4	5.1	4.9	4.0	6.3	3.8	4.9	1.3	1.2	0.9	----	----
Percent herb species	72.2	67.9	72.3	66.4	50.7	62.8	53.8	51.9	62.4	54.5	64.3	37.7	41.9	49.5	67.2	69.2	75.5

Species	CH	Be Bi	O Me	AI	E He	O YP Hi	WO	SO RM	RO YP CO	CO	RO	Cr He	XP	HB	RS	F	Mea
TREES								Percent Constancy									
Abies fraseri	---	---	---	---	14	---	---	---	---	---	29	---	---	25	88	100	11
Acer pensylvanicum	85	100	100	80	100	33	50	50	92	75	100	60	---	---	69	---	22
Acer rubrum	19	---	75	100	86	100	100	83	100	100	100	100	100	75	25	---	---
Acer saccharum	100	100	95	40	43	78	50	17	77	---	29	---	---	---	31	---	---
Acer spicatum	33	67	05	---	---	---	---	---	---	---	---	---	---	13	75	40	---
Aesculus flava	96	83	95	50	14	78	25	---	23	---	57	---	---	---	31	---	11
Amelanchier arborea	11	---	35	40	---	78	75	83	62	25	29	80	78	25	13	---	11
Betula alleghaniensis	78	100	80	80	86	---	---	---	23	---	43	---	---	25	100	---	22
Betula cordifolia	---	---	---	---	---	---	---	---	---	---	---	---	---	13	13	40	---
Betula lenta	26	---	75	50	43	33	25	17	39	25	86	60	22	38	---	---	---
Carpinus caroliniana	---	---	25	50	---	44	50	---	---	25	---	---	---	---	06	---	---
Carya cordiformis	63	---	45	10	---	11	---	---	---	---	---	---	---	---	---	---	---
Carya glabra	---	---	20	10	---	89	75	83	31	50	---	60	---	---	---	---	---
Carya ovata	---	---	35	20	---	11	25	---	---	---	---	---	---	---	---	---	---
Carya tomentosa	---	---	15	10	---	89*	---	67	---	25	---	60	---	---	---	---	---
Castanea dentata	11	---	55	---	14	78	75	83	85	50	86	---	56	---	---	---	---
Castanea pumila	---	---	---	---	---	---	---	17	---	---	---	---	22	25	---	---	---
Clethra acuminata	---	---	---	---	---	---	---	---	---	25	29	---	22	38	---	---	---
Cornus alternifolia	26	33	75	10	29	44	100	67	23	---	14	---	11	13	19	---	---
Cornus florida	07	---	40	60	---	67	100	100	77	25	---	60	---	---	---	---	---
Crataegus flabellata	---	17	30	20	---	33	25	---	---	25	---	---	---	---	06	---	---
Crataegus punctata	---	---	10	---	---	---	---	---	---	---	---	---	---	---	13	---	44*
Fagus grandifolia	85	100	55	---	57	67	100	33	15	50	29	20	---	---	63	---	---
Fraxinus americana	70	---	90	40	14	89	75	33	62	50	29	---	---	---	---	---	11
Ilex montana	11	17	50	20	71	56	75	100	54	---	86	60	56	100	50	---	11

Species	CH	Be Bi	O Me	Al	E He	O YP Hi	WO	SO RM	RO YP CO	CO	RO	Cr He	XP	HB	RS	F	Me
Ilex opaca	---	---	---	---	---	---	---	---	08	---	---	60	---	---	---	---	---
Juglans cinerea	---	---	---	20	---	---	---	---	08	---	---	---	---	---	---	---	---
Juglans nigra	04	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Liriodendron tulip.	30	---	70	80	57	100	100	83	85	75	14	80	---	---	---	---	---
Magnolia acuminata	15	---	60	---	---	100	100	50	77	75	43	---	---	---	---	---	---
Magnolia fraseri	04	---	35	20	57	78	50	83	54	25	43	---	11	---	---	---	---
Nyssa sylvatica	---	---	05	---	---	67	75	67	31	50	---	80	89	13	---	---	---
Ostrya virginiana	85	---	85	10	43	11	---	---	23	25	43	---	---	---	---	---	---
Oxydendron arboreum	---	---	05	40	---	78	75	83	31	75	14	80	78	---	---	---	---
Picea rubens	---	17	10	10	14	---	---	17	39	25	71	20	56	88	100	80	22
Pinus pungens	---	---	---	---	---	---	---	---	08	---	---	---	89*	25	---	---	---
Pinus rigida	---	---	---	---	---	---	---	---	---	---	---	---	78*	---	---	---	---
Pinus strobus	---	---	---	20	---	22	75	33	---	---	---	60	---	---	---	---	---
Platanus occidentalis	---	---	---	50*	---	---	---	---	---	---	---	---	---	---	---	---	---
Prunus pensylvanica	---	---	---	---	---	---	---	---	---	---	---	---	11	25	31	60*	44
Prunus serotina	52	67	80	60	43	100	100	67	62	25	57	80	---	---	44	---	---
Quercus alba	---	---	15	50	---	89	100	100	23	50	---	80	22	---	---	---	---
Quercus coccinea	--	--	--	20	---	56	75	100	---	---	---	100	33	---	---	---	---
Quercus montana	--	--	30	--	---	44	25	83	92	100	71	20	78	---	---	---	---
Quercus rubra	33	---	95	40	100	78	25	---	100	75	100	20	33	50	19	---	11
Quercus velutina	---	---	---	10	---	44	50	83*	08	25	---	20	11	---	---	---	---
Robinia pseudoacacia	19	---	15	10	---	78	75	100	77	50	57	---	---	---	---	---	---
Sassafras albidum	---	---	---	---	---	56	---	50	31	25	14	80	44	---	---	---	---
Sorbus americana	---	17	---	---	43	---	---	---	---	---	14	---	44	63	81	100	56
Tilia heterophylla	89	---	75	20	43	33	25	---	31	---	---	---	---	---	---	---	---
Tsuga canadensis	30	---	80	100	100	56	50	83	69	25	57	80	56	50	31	---	---
Tsuga caroliniana	---	---	---	20	---	11	---	100	---	---	---	100	67	---	---	---	---

Species	CH	Be Bi	O Me	AI	E He	O YP Hi	WO	SO RM	RO YP CO	CO	RO	Cr He	XP	HB	RS	F	Me
SHRUBS																	
Alnus serrulata	---	---	---	20*	---	---	---	---	---	---	---	---	---	---	---	---	---
Aralia nudicaulis	04	---	---	---	---	---	---	---	08	25	29	---	---	---	---	---	---
Aralia racemosa	04	---	05	---	---	---	---	---	08	---	---	---	---	---	---	---	---
Aronia arbutifolia	---	---	---	10	---	---	---	---	---	---	---	---	---	---	---	---	---
Aronia melanocarpa	---	17	---	---	---	---	---	---	---	---	---	---	---	63*	---	---	---
Calycanthus floridus	---	---	---	---	---	11	---	---	---	---	14	---	---	---	---	---	---
Comptonia peregrina	---	---	---	---	---	---	---	---	---	---	---	---	11	---	---	---	---
Corylus cornuta	---	---	05	---	---	22	50	100*	---	---	---	20	---	---	---	---	---
Diervilla lonicera	---	---	---	---	---	---	---	---	---	---	---	---	---	13	---	---	---
Diervilla sessilifolia	---	---	---	---	---	---	---	---	---	---	---	---	---	38*	---	---	11
Euonymus americanus	---	---	---	30	---	---	25	---	---	---	---	---	---	---	---	---	---
Euonymus obovatus	41	17	20	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Gaylussacia baccata	---	---	---	---	---	---	---	---	---	---	---	---	67*	38	---	---	---
Hamamelis virginiana	44	---	70	80	---	56	75	50	85	---	71	60	56	50	13	---	---
Hydrangea arborescens	33	67	40	20	14	---	25	---	23	---	14	---	---	---	25	---	---
Hypericum prolificum	---	---	---	---	---	---	---	---	---	---	14	---	---	---	---	---	11
Ilex verticillata	---	---	---	10	---	---	---	---	---	---	---	---	---	---	---	---	---
Kalmia latifolia	---	17	10	50	43	44	100	83	85	100	43	100	100	88	---	---	11
Leucothoe fontanesiana	04	---	---	70	43	11	---	17	---	---	---	20	---	---	---	---	---
Leiophyllum buxifolium	---	---	---	---	---	---	---	---	---	---	---	---	---	25*	---	---	---
Leucothoe recurva	---	---	---	---	---	---	---	---	08	---	14	---	67*	50	---	---	---
Lindera benzoin	15	---	20	20	---	11	25	---	---	---	---	---	---	---	---	---	---
Lyonia ligusrrina	---	---	---	---	---	---	---	---	---	---	---	---	33	50	---	---	---
Menziesia pilosa	---	17	---	---	---	---	---	---	08	---	14	---	11	50*	---	---	22

Species	CH	Be Bi	O Me	Al	E He	O YP Hi	WO	SO RM	RO YP CO	CO	RO	Cr He	XP	HB	RS	F	Me
Pyrularia pubera	---	---	---	10	---	56	100*	50	---	25	---	20	11	---	---	---	---
Rhododendron carawbien.	---	17	---	---	---	22	---	33	15	---	14	---	---	100*	56	20	56
Rhododendron calendul.	---	---	---	---	---	22	25	33	39	25	57*	---	11	13	---	---	---
Rhododendron viscosum	---	---	---	20	---	---	---	---	---	---	---	---	---	---	---	---	---
Rhododendron maximum	19	---	65	100	86	56	75	83	92	100	57	78	---	25	13	---	---
Ribes glandulosum	---	---	---	---	---	---	---	---	---	---	---	---	---	---	13	---	---
Ribes cynosbati	---	50*	---	---	---	---	---	---	---	---	---	---	---	13	---	---	---
Ribes rotundifolium	37	67	---	---	---	---	---	---	---	---	---	---	---	---	25	---	56
Robinia hispida	---	---	---	10	---	---	---	17	---	---	---	---	11	63*	---	---	11
Rosa palustris	---	---	---	10	---	---	---	---	---	---	---	---	---	---	---	---	---
Rubus canadensis	22	50	35	30	71	33	---	---	46	25	57	60	---	13	69	100	89
Rubus hispidus	---	---	---	10	---	---	---	---	---	---	---	---	---	---	---	---	---
Rubus idaeus	---	---	---	---	---	---	---	---	---	---	---	---	---	---	19	60*	11
Rubus odoratus	07	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Sambucus canadensis	---	---	05	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Sambucus racemosa ssp. pubens	11	33	---	---	---	---	---	---	---	---	---	---	---	---	44*	---	33
Symplocos tinctoria	---	---	---	---	14	---	25	50	23	50	---	60	67	---	---	---	---
Vaccinium corymbosum	---	17	20	10	14	33	75	33	39	25	43	---	78	100	44	20	89
Vaccinium erythrocarp.	04	33	---	---	29	---	---	---	08	25	29	---	---	50	44	20	11
Vaccinium pallidum	---	---	---	10	---	---	25	50	---	25	14	60	89*	---	---	---	---
Vaccinium stamineum	---	---	---	---	---	---	---	67*	---	25	---	20	11	---	---	---	---
Viburnum acerifolium	07	---	25	10	14	78	75	33	62	50	43	---	---	---	---	---	---
Viburnum cassinoides	---	17	---	10	---	---	25	---	---	25	---	60	33	63	---	---	33
Viburnum dentatum	---	---	---	30	---	33	50	33	---	---	---	---	---	---	---	---	---
Viburnum lantanoides	37	100	25	10	71	---	---	---	---	---	43	---	11	---	50	---	---

Species	CH	Be Bi	O Me	Al	E He	O YP Hi	WO	SO RM	RO YP CO	CO	RO	Cr He	XP	HB	RS	F	Me
WOODY VINES																	
Aristolochia macrophy.	85	---	75	10	14	11	---	---	31	25	14	---	---	---	---	---	---
Parthenocissus quinq.	19	---	45	40	---	22	25	---	08	25	14	---	---	---	---	---	---
Smilax glauca	04	---	25	40	57	22	25	67	69	25	29	80	33	---	---	---	---
Smilax hispida	---	17	---	---	---	---	---	---	---	---	14	---	---	---	---	---	---
Smilax rotundifolia	04	---	30	30	29	100	100	67	46	25	14	20	67	25	06	---	---
Toxicodendron radicans	04	---	---	40	---	89	100	50	---	25	---	---	---	---	---	---	---
Viris aestivalis	---	---	---	---	---	11	25*	17	---	---	---	---	---	---	---	---	---
Vitis labrusca	11	---	20	20	---	56	25	17	39	25	14	40	---	---	---	---	---
HERBS																	
Achillea millefolium	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	44
Actaea pachypoda	48	---	30	20	14	11	---	---	---	---	---	---	---	---	19	---	---
Aconitum reclinatum	11*	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Adiantum pedatum	22	---	25	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Agrostis perennans	---	---	---	10	---	---	---	---	---	---	14	---	---	---	06	40	56
Agrimonia pubescens	---	33	---	20	11	---	---	---	---	---	---	---	---	---	---	---	---
Agrostis stolonifera	---	---	---	---	---	---	---	---	---	---	---	---	---	---	06	---	44*
Allium canadense	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	22
Allium tricoccum	52	50	30	---	---	---	---	---	---	---	---	---	---	---	13	---	---
Amianthium muscaetox.	---	---	---	---	---	---	---	---	---	---	14	---	---	13	06	---	---
Anemone quinquefolium	56	33	65	40	---	22	25	---	23	---	29	---	---	---	38	---	---

Species	CH	Be Bi	O Me	Al	E He	O YP Hi	WO	SO RM	RO YP CO	CO	RO	Cr He	XP	HB	RS	F	Me
Angelica triquinata	22	83	15	---	---	---	---	---	---	---	---	---	---	50	56	20	89
Apios americana	---	---	---	---	---	11	---	---	---	---	---	---	---	---	---	---	---
Aplectrum hyemale	15	---	05	10	---	---	25*	---	---	---	---	---	---	---	---	---	---
Arabis laevigata	26	---	30	30	---	---	---	---	08	---	14	---	---	---	---	---	---
Arisaema triphyllum	96	100	95	40	14	78	50	---	23	25	---	---	---	---	56	20	---
Aruncus dioicus	11	---	25*	10	---	---	---	---	---	---	---	---	---	---	---	---	---
Asarum canadense	56*	---	10	---	---	---	---	---	08	---	14	---	---	---	---	---	---
Asclepias exaltata	---	---	---	---	---	11	---	---	15	---	14	---	---	---	---	---	---
Asclepias quadrifolia	---	---	---	---	---	11	---	---	---	---	---	---	---	---	---	---	---
Aster acuminatus	63	50	75	10	29	22	---	17	31	25	71	---	---	25	81	100	33
Aster cordifolius	04	---	20	20	---	44	25	---	23	50	14	20	---	---	---	---	---
Aster curtisii	04	---	---	---	---	78*	---	---	08	50	14	---	---	---	---	---	---
Aster divaricatus	70	17	75	30	14	11	---	---	62	---	29	---	---	13	69	40	78
Aster macrophyllus	04	---	30	---	---	22	---	---	39	50	71*	---	---	---	---	---	---
Aster sagittifolius	---	17	---	20	---	---	---	---	---	---	---	---	---	---	---	---	---
Aster undulatus	04	---	05	---	---	44*	---	17	15	25	14	---	---	---	---	---	---
Astilbe biternata	30*	---	10	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Athyrium felix-femina	07	100	35	40	---	22	25	---	08	---	43	---	---	13	63	100	78
Aureolaria laevigata	---	---	---	---	---	11	25	33	50*	---	14	20	11	---	---	---	---
Botrychium dissectum	04	---	---	---	---	---	---	---	08	---	---	---	---	---	---	---	---
Botrychium virginianum	56	---	50	20	---	56	25	---	---	25	---	---	---	---	06	---	---
Cacalia muhlenbergii	15	---	10	---	---	---	---	---	15	---	---	---	---	---	---	---	---
Calystegia sepium	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	22
Carex aestivalis	---	---	05	---	---	---	---	---	---	25*	14	---	---	---	---	---	11
Carex brunnescens	04	50	---	10	---	---	---	---	---	---	14	---	---	---	19	80	11
Carex debilis	---	17	---	---	---	---	---	---	---	25	---	---	---	38	44	100*	67

Species	CH	Be Bi	O Me	AI	E He	O YP Hi	WO	SO RM	RO YP CO	CO	RO	Cr He	XP	HB	RS	F	Me
Carex crinita	04	---	10	---	---	---	---	---	---	---	14	---	---	---	50*	---	---
Carex intumescens	---	---	---	10	---	---	---	---	---	---	---	---	---	---	38	80	22
Carex pensylvanica	15	83	30	60	14	33	50	33	31	---	71	---	---	---	81	---	11
Carex plantaginea	19	---	10	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Carex scoparia	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	20	22
Caulophyllum thalictr.	89	50	80	10	---	11	25	---	15	---	---	---	---	---	06	---	---
Chelone lyonii	04	33	05	10	---	---	---	---	23	---	29	---	---	---	13	100*	---
Chimaphila maculata	---	---	05	---	14	22	50	50	54	50	29	60	33	---	---	---	---
Chrysopsis mariana	---	---	---	10	---	---	---	---	---	---	---	---	---	---	---	---	---
Circaea alpina	07	17	05	---	---	---	---	---	---	---	---	---	---	---	19*	---	---
Cimicifuga americana	52*	---	10	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Cinna latifolia	---	25	---	---	---	---	---	---	23	---	29	---	---	---	19	100*	11
Cimicifuga racemosa	93	83	75	30	14	67	50	---	15	---	---	---	---	---	13	---	---
Claytonia caroliniana	07	17*	05	10	---	---	---	---	---	---	---	---	---	---	06	---	---
Claytonia virginica	04	---	10	50	---	11	---	---	---	---	---	---	---	---	---	---	---
Clintonia borealis	04	17	---	---	---	---	---	---	08	---	---	---	---	---	25	40*	11
Clintonia umbellulata	19	---	55	---	---	56	25	---	39	25	14	---	---	---	19	---	---
Collinsonia canadensis	58	---	70	---	---	89	25	---	39	25	14	---	---	---	---	---	---
Conium maculatum	---	---	---	20	---	---	---	---	---	---	---	---	---	---	---	---	---
Conopholis americana	04	---	40	---	14	67	25	83	46	75	71	60	---	---	---	---	---
Convallaria montana	---	20	---	---	11	---	---	---	---	---	---	---	---	---	---	---	---
Corallorhiza odontorh.	---	---	---	10	---	---	---	---	---	---	---	---	---	---	---	---	---
Cryptotaenia canadens.	11*	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Cuscuta rostrata	04	17	20	---	---	---	---	---	---	---	29	---	---	---	13	40*	---
Cypripedium acaule	---	---	---	---	14	11	25	---	15	25	14	20	---	---	---	---	---
Cypripedium pubescens	---	---	05	---	---	22*	---	---	---	---	---	---	---	---	---	---	---

Species	CH	Be Bi	O Me	Al	E He	O YP Hi	WO	SO RM	RO YP CO	CO	RO	Cr He	XP	HB	RS	F	Me
Cystopteris protrusa	19	---	---	10	---	---	---	---	---	---	---	---	---	---	---	---	---
Danthonia compressa	---	---	---	---	---	---	---	---	---	---	29	---	---	38	---	---	56*
Delphinium tricorne	19	---	---	10	---	---	---	---	---	---	---	---	---	---	---	---	---
Dennstaedia punctilob.	---	---	---	30	---	---	---	---	23	50	43	---	22	63	25	---	---
Dentaria diphylla	41	33	65	40	14	---	---	---	08	---	---	---	---	13	---	---	11
Deparia acrostichoides	78*	17	15	10	---	---	---	---	---	---	---	---	---	---	13	---	---
Deschampsia flexuosa	---	33	---	---	---	---	---	---	---	---	29	---	---	13	06	40*	11
Desmodium nudiflorum	04	---	25	---	---	22	25	33	08	---	---	---	---	---	---	---	---
Dicentra canadensis	56	33	05	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Dicentra cucullaria	59*	17	---	10	---	---	---	---	---	---	---	---	---	---	---	---	---
Dioscorea villosa	11	---	40	10	---	100	75	67	69	25	43	---	---	---	---	---	---
Diphylleia cymosa	26	33	20	10	---	---	---	---	---	---	---	---	---	---	---	---	---
Disporum lanuginosum	93	67	75	---	---	78	25	---	54	25	14	---	---	---	---	---	---
Disporum maculatum	33*	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Dryopteris campyloptera	--	17	---	---	---	---	---	---	---	---	--	---	---	---	63	80*	---
Dryopteris goldiana	11*	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Dryopteris intermedia	82	100	25	40	86	---	---	---	---	---	14	---	---	---	56	---	---
Dryopteris marginalis	52	17	10	---	---	---	---	---	---	25	14	---	---	---	---	---	---
Epigaea repens	---	---	---	---	---	---	---	---	---	---	---	---	89*	25	---	---	11
Epifagus virginiana	22	50	20	20	---	11	---	17	08	---	14	---	---	---	38	---	---
Erythronium americanum	---	---	---	20	---	---	---	---	---	---	---	---	---	---	---	---	---
Erigeron pulchellus	---	---	15	---	---	11	---	17	08	25	---	---	---	---	---	---	---
Eupatorium purpureum	---	17	20	10	---	---	---	---	15	---	---	---	---	---	19	---	11
Eupatorium rugosum	37	100	25	20	14	22	---	---	31	55	29	---	---	---	50	40	44
Eupatorium fistulosum	---	---	---	20	---	---	---	---	---	---	---	---	---	---	---	---	---
Fragaria virginiana	---	---	---	---	---	---	---	17	---	---	---	---	---	---	---	---	33
Galax urceolata	07	---	25	30	14	11	---	17	31	100	57	60	---	88	06	---	11
Galearis spectabilis	15	---	05	10	---	22	---	---	08	---	---	---	---	---	---	---	---

Species	CH	Be Bi	O Me	AI	E He	O YP Hi	WO	SO RM	RO YP CO	CO	RO	Cr He	XP	HB	RS	F	Me
Galium latifolium	22	55	---	---	---	11	---	33	39	---	---	---	---	---	---	---	---
Galium triflorum	07	17	15	30	---	---	---	17	31	---	14	---	---	---	---	---	---
Gaultheria procumbens	---	---	---	---	---	---	---	---	---	---	---	---	67*	---	---	---	---
Gentiana decora	---	17	05	---	---	50	75	67	77	75	---	20	---	---	---	---	11
Geranium maculatum	04	---	30*	---	---	11	---	---	---	---	---	---	---	---	---	---	---
Geum canadense	---	---	05	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Glyceria melicaria	---	---	---	40	---	---	---	---	---	---	---	---	---	---	06	---	---
Glyceria striata	---	---	---	10	---	---	---	---	---	---	---	---	---	---	---	---	---
Goodyera pubescens	07	---	55	50	43	78	50	67	69	100	43	100	33	---	---	---	---
Goodyera repens	---	---	---	---	14	---	---	---	---	25	---	60*	33	---	---	---	---
Hedyotis caerulea	---	---	10	60	---	---	---	---	08	---	14	---	11	---	---	---	11
Hedyotis purpurea	---	---	---	30	---	44	50	33	54	100	71	20	---	25	---	---	---
Hedyotis michauxii	---	17	---	---	---	---	---	---	---	---	29	---	---	---	25	60*	33
Helianthus decapetalus	---	---	---	---	---	---	---	---	15	---	---	---	---	---	---	---	---
Hepatica nobilis var. acutiloba	44	---	25	10	---	---	25	---	---	---	---	---	---	---	---	---	---
Heuchera americana	07	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Heuchera villosa	15	17	30	---	---	---	---	---	08	25	29	---	---	13	---	---	---
Hexastylis shuttlewort.	---	---	---	---	---	---	---	---	---	25*	---	---	13	11	---	---	---
Hieracleum paniculatum	---	---	---	---	---	22	---	---	31	25	29	---	---	---	---	---	22
Hydrophyllum canadense	78	17	15	10	---	---	---	---	---	---	---	---	---	---	---	---	---
Hypericum graveolens	---	---	---	---	---	---	---	---	---	---	---	---	---	13	06	40*	33
Impatiens capensis	04	---	---	20	---	---	---	---	---	---	---	---	---	---	---	---	---
Impatiens pallida	70	83*	20	---	14	---	---	---	---	---	---	---	---	---	13	---	---
Iris cristata	---	---	10	---	---	44*	25	---	15	---	14	---	---	---	---	---	---
Iris verna	---	---	---	10	---	---	---	---	---	---	---	---	11	---	---	---	---
Isotria verticillata	---	---	---	---	---	11	25	33*	---	---	---	---	---	---	---	---	---

Species	CH	Be Bi	O Me	AI	E He	O YP Hi	WO	SO RM	RO YP CO	CO	RO	Cr He	XP	HB	RS	F	Me
Krigia montana	---	---	05	---	---	---	---	---	---	---	---	---	---	25	---	---	33
Laportea canadensis	78	100	55	20	---	11	25	---	---	---	---	---	---	---	---	---	---
Leucanthemum vulgare	---	---	---	10	---	---	---	---	---	---	---	---	---	---	---	---	11
Ligusticum canadense	04	---	20*	---	---	11	---	---	15	---	14	---	---	---	---	---	---
Lilium michauxii	---	---	---	---	---	11	---	---	15	25*	---	---	---	---	---	---	---
Lilium superbum	59	33	50	---	---	56	25	---	31	---	29	---	---	13	06	---	---
Listera smallii	---	---	---	20	14	---	---	---	---	---	14	---	11	25*	13	---	22
Lobelia inflata	---	---	---	10	---	---	---	---	---	---	---	---	---	---	---	---	---
Lonicera dioica	---	---	---	10	---	11	25*	---	---	---	---	---	---	---	---	---	---
Luzula acuminata	07	50	20	50	---	11	25	33	08	---	29	---	---	---	44	20	44
Lycopodium clavatum	---	---	---	---	---	---	---	---	---	---	---	---	11	---	---	---	11
Lycopodium complanatum	---	---	---	---	---	---	---	17	---	---	---	---	33*	---	---	---	---
Lycopodium lucidulum	41	67	35	40	57	11	---	---	---	---	---	---	---	---	25	---	---
Lycopodium obscurum	---	---	---	---	---	---	---	---	---	---	---	---	11	38*	---	---	11
Lycopodium tristachyum	---	---	---	---	---	---	---	---	---	---	---	---	11	25*	---	---	---
Lycopus virginicus	---	---	---	20	---	---	---	---	08	---	---	---	---	---	---	---	---
Lysimachia quadrifolia	---	---	05	10	---	56	---	50	77	25	71	20	56	38	06	---	11
Maianthemum canadense	11	67	05	---	---	---	---	---	08	25	14	---	---	13	75*	20	22
Malaxis unifolia	---	---	---	---	---	---	---	17*	---	---	---	---	---	---	---	---	---
Medeola virginiana	26	---	60	60	14	100	100	83	69	75	57	---	33	38	44	---	---
Melampyrum lineare	---	---	---	---	---	11	50	33	---	---	---	---	67*	38	---	---	---
Mitella diphylla	15*	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Mitchella repens	04	---	35	---	100*	---	25	---	---	---	---	---	---	---	---	---	---
Monarda didyma	---	17	05	20	---	---	---	---	---	---	---	---	---	---	---	---	---
Monotropa uniflora	---	---	---	10	29	---	---	33	39	---	43	20	11	---	19	---	---
Osmorhiza claytonii	74	17	30	10	---	---	---	---	---	---	---	---	---	---	---	---	---
Osmorhiza longistylis	07	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---

Species	CH	Be Bi	O Me	Al	E He	O YP Hi	WO	SO RM	RO YP CO	CO	RO	Cr He	XP	HB	RS	F	Me
Osmunda cinnamomea	04	---	---	10	---	44	50	---	---	---	14	---	---	---	06	---	---
Osmunda regalis	---	---	---	10	---	---	---	---	---	---	---	---	---	---	---	---	---
Oxalis acetosella	04	67	10	30	14	---	---	---	---	---	---	---	---	---	75	100	---
Oxalis stricta	---	---	---	20	---	---	---	---	---	---	---	---	---	---	---	---	---
Panax quinquefolium	07	---	30	---	---	---	25	---	---	---	---	---	---	---	---	---	---
Panicum sp.	---	---	---	60	---	56	---	17	54	25	---	---	11	13	---	---	---
Pedicularis canadensis	---	---	05	10	---	11	---	---	31*	29	---	---	---	---	---	---	---
Phacelia bipinnatifida	04	33*	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Phlox glaberrima	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	22*
Phlox stolonifera	07	---	30	10	---	---	25	---	---	---	---	---	---	---	---	---	---
Phryma leptostachya	07	---	05	---	---	11	---	---	---	---	---	---	---	---	---	---	---
Phleum pratense	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	33
Platanthera clavellata	---	---	---	10	---	---	---	---	---	---	---	---	---	---	---	---	11
Platanthera orbiculata	---	---	05	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Platanthera psycodes	---	---	05	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Poa cuspidata	15	---	30*	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Podophyllum peltatum	19	17	---	20	---	11	50*	---	---	---	---	---	---	---	---	---	---
Polystichum acrostich.	100	33	90	90	43	22	25	---	39	50	14	20	---	---	---	---	---
Polygonatum biflorum	---	---	10	---	---	---	---	---	---	---	---	---	---	---	---	---	11
Polygonatum pubescens	82	50	85	20	---	22	25	---	46	25	29	---	---	---	13	---	---
Polygonum cilinode	---	---	---	---	---	---	---	---	---	---	---	---	---	---	06	40	44
Polygonum persicaria	---	---	---	10*	---	---	---	---	---	---	---	---	---	---	---	---	---
Polypodium polypodoides	11	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Polypodium virginianum	19	33	20	---	29	11	---	---	---	25	43	---	22	---	44	20	---
Porteranthus trifoliat.	---	---	---	---	---	33	---	67*	23	25	14	---	---	---	---	---	---
Potentilla canadensis	---	---	10	30	---	33	50	83	54	75	---	20	---	---	---	---	11
Potentilla simplex	---	---	---	10	---	22	25	---	---	---	---	---	---	---	---	---	33

Species	CH	Be Bi	O Me	Al	E He	O YP Hi	WO	SO RM	RO YP CO	CO	RO	Cr He	XP	HB	RS	F	Me
Potentilla tridentata	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	33*
Prenanthes altissima	52	67	55	40	---	89	75	67	77	100	57	20	---	---	---	---	---
Prenanthes roanensis	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	22
Prunella vulgaris	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	22
Pteridium aquilinum	---	---	---	---	---	---	---	---	---	---	---	---	33	38*	---	---	---
Pycnanthemum incanum	---	---	35	---	---	50*	---	---	31	50	14	---	---	---	---	---	---
Pycnanthemum montanum	---	---	05	---	---	---	---	---	15	---	---	---	---	---	---	---	---
Ranunculus acris	---	---	---	30	---	---	---	---	---	---	---	---	---	---	---	---	---
Ranunculus hispidus	15	---	15	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Rumex acetosella	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	22
Rudbeckia laciniata	04	17	---	10	---	---	---	---	---	---	14	---	---	---	13	20	11
Sanquinaria canadensis	33	---	45	---	---	33	25	---	23	---	---	---	---	---	---	---	---
Sanicula gregaria	63	---	30	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Sanicula marilandica	---	---	---	10	---	11	---	---	---	---	---	---	---	---	---	---	---
Sanicula trifoliata	07	---	25	---	---	11	25	---	69*	---	29	---	---	---	---	---	---
Saxifraga careyana	---	---	05	10	---	---	---	---	---	---	---	---	---	---	---	---	---
Saxifraga michauxii	04	---	10	---	---	---	---	---	---	---	---	---	---	50	13	60	22
Scutellaria ovata	11	---	---	---	---	44*	---	17	---	---	14	---	---	---	---	---	---
Senecio aureus	---	---	10	80	---	11	50	17	---	---	---	---	---	---	---	---	11
Sedum ternatum	19	---	55	20	---	22	50	---	---	25	---	---	---	---	---	---	---
Sedum telephioides	---	---	05	---	---	---	---	---	---	---	14	---	---	13	---	---	---
Silene stellata	---	---	05	---	---	---	---	---	23	---	---	---	---	---	---	---	---
Silene virginica	---	---	---	---	---	---	---	---	---	---	14	---	---	---	---	---	11
Sisyrinchium angustif.	---	---	---	---	---	---	25	17	---	---	---	---	---	---	---	---	---
Smilax herbacea	26	50	25	---	---	11	25	---	08	25	14	---	---	---	38	---	---
Smilacina racemosa	74	50	75	---	---	89	50	17	62	50	57	---	---	---	19	---	---
Solidago bicolor	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	22*
Solidago curtisii	11	17	10	---	14	11	---	50	54	75	14	20	---	---	---	---	---

Species	CH	Be Bi	O Me	AI	E He	O YP Hi	WO	SO RM	RO YP CO	CO	RO	Cr He	XP	HB	RS	F	Me
Solidago glomerata	---	---	05	---	---	---	---	---	---	---	---	---	---	13	19	80	100
Solidago patula	---	---	---	10	---	---	---	---	---	---	---	---	---	---	---	---	---
Stenanthium gramineum	---	---	---	---	---	---	---	17	---	---	---	---	11	---	---	---	---
Stellaria pubera	85	100	50	40	---	11	25	---	15	---	14	---	---	---	25	---	---
Streptopus roseus	22	83	---	---	---	---	---	---	---	---	---	---	---	---	25	---	---
Tephrosia virginiana	---	---	---	---	---	---	25	17	---	---	---	---	---	---	---	---	---
Thaspium barbinode	22	17	25	10	---	---	---	---	---	---	---	---	---	---	---	---	---
Thalictrum clavatum	11	17	25	10	---	11	25	---	---	---	---	---	---	---	---	---	---
Thalictrum dioicum	41	---	40	---	---	11	---	---	62*	---	14	---	---	---	---	---	---
Thalictrum thalictro.	07	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Thelypteris hexagonop.	11	---	25	---	---	22	---	---	23	25	14	---	---	---	---	---	---
Thelypteris noveborac.	---	17	60	70	14	67	100	17	77	---	86	---	---	13	31	---	---
Tiarella cordifolia	59	83	30	30	14	11	25	---	---	---	---	---	---	---	13	---	---
Tradescantia subaspera	---	---	30	10	---	11	---	---	08	25	---	---	---	---	---	---	---
Trillium catesbaei	---	---	---	10	---	---	--	17*	---	---	---	---	---	---	---	---	---
Trillium cernuum	04	---	---	---	---	25	---	---	---	---	---	---	---	---	---	---	---
Trillium erectum	82	50	55	30	---	22	---	---	---	---	---	---	---	---	38	---	---
Trillium grandiflorum	07	---	40*	10	---	33	---	---	---	---	---	---	---	---	---	---	---
Trillium undulatum	---	---	---	---	29	---	25	17	15	25	14	---	11	25	19	---	---
Triphora trianthophora	---	---	---	---	---	---	25	33*	---	---	---	---	---	---	---	---	---
Uvularia grandiflora	52*	---	05	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Uvularia perfoliata	07	---	20	---	---	44*	25	---	08	---	---	---	---	---	---	---	---
Uvularia pudica	---	---	05	---	---	56*	25	17	39	25	29	---	---	---	---	---	---
Uvularia sessilifolia	---	---	---	10	---	---	---	17	---	---	---	---	---	---	---	---	---
Veratrum parviflorum	15	---	35	---	---	44*	25	---	31	---	---	---	---	---	19	---	---
Veratrum viride	11	33	05	---	---	---	---	---	---	---	---	---	---	---	06	40	11
Viola macloskeyi	19	67	30	60	14	---	25	---	---	---	---	---	---	---	63	40	---

Species	CH	Be Bi	O Me	Al	E He	O YP Hi	WO	SO RM	RO YP CO	CO	RC	Cr He	XP	HB	RS	F	Me
Viola canadensis	96*	17	40	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Viola pubescens	41	---	20	20	---	---	---	---	---	---	---	---	---	---	---	---	---
Viola hastata	---	---	25	30	---	44	100	33	23	50	29	60	---	---	---	---	---
Viola sororia	15	---	55	70	29	67	75	33	46	25	29	20	---	---	---	---	22
Viola palmata	---	---	---	---	---	11	---	---	08	---	---	---	---	---	---	---	11
Viola obliqua	04	---	---	10	---	---	---	---	---	---	---	---	---	---	---	---	---
Viola rotundifolia	37	17	40	40	57	22	50	17	23	25	29	---	---	---	25	---	---
Xerophyllum asphodel.	---	---	---	---	---	---	---	---	---	---	---	---	11	13	---	---	---
Zigadenus leimanthoides	---	---	---	---	---	---	---	---	---	---	---	---	---	25*	---	---	---
Zizia aurea	---	---	---	---	---	11	---	---	23	25	---	---	---	---	---	---	---
Zizia trifoliata	---	---	---	---	---	11	25	33	54	75	29	20	---	---	---	---	---

APPENDIX D

Table 25 Ecological species groups

I. Controlling factor: moisture

A. Mesic

1. Seepages

Saxifraga group
- Saxifraga caryeana
- Saxifraga caroliniana
- Saxifraga micranthidifolia
- Thalictrum clavatum
- Diphylleia cymosa
- Veratrum viride
- Chelone lyoni

2. Deep Mull Soil

Asarum group
- Asarum canadense
- Disporum maculatum
- Mitella diphylla
- Osmorhiza claytonii
- Uvularia grandiflora
- Laportea canadensis
- Sanicula gregaria
- Dryopteris goldiana

3. Rocky Soil

Astilbe group
- Astilbe biternata
- Actaea pachypoda
- Cimicifuga americana
- Deparia acrostichoides (=Athyrium thelypteriodes)
- Aconitum reclination

4. Slightly dry

Ligusticum group
- Ligusticum canadense
- Aruncus dioicus
- Poa cuspidata
- Geranium maculatum
- Trillium grandiflorum
- Dentaria diphylla

B. Submesic

Gentiana group
- Gentiana decora
- Uvularia perfoliata
- Thelypteris hexagonoptera
- Iris cristata

C. Subxeric
   Melampyrum group
   Melampyrum lineare
   Porteranthus trifoliatus (=Gillenia)
   Triphora trianthophora
   Viola hastata
   Hieracium paniculatum
   Aureolaria laevigata

D. Xeric (herb)
   Xerophyllum group
   Xerophyllum asphodeloides
   Pteridium aquilinum

Xeric (shrub)
   Gaylussacia group
   Leucothoe recurva
   Vaccinium pallidum (=vacillans)
   Robinia hispida
   Leiophyllum buxifolium
   Aronia melanocarpa

II. Controlling Factor: pH
A. Acidophiles
   Listera group
   Listera smallii
   Goodyera repens
   Gaultheria repens

B. Acid preferring
   Mitchella group
   Mitchella repens
   Viola rotundifolia
   Cypripedium acaule
   Trillium undulatum
   Zigadenus leimanthoides
   Epigaea repens

APPENDIX E

Representative diameter distribution of vegetation types (following 15 pages)

Table 26. Representative diameter distributions for old growth cove hardwood forests

Species (Inches) / (Centimeters)	2 / 5	4 / 10	6 / 15	8 / 20	10 / 26	12 / 31	14 / 36	16 / 41	18 / 46	20 / 51	22 / 56	24 / 61	larger individuals
Plot 124 1189m (3900ft.) Basal area-47.6m²/ha; Density-680 stems /ha													
Tilia heterophylla	4	3	0	1	0	2	0	0	2	0	0	2	2
Acer saccharum	10	2	4	1	0	0	0	0	0	0	0	0	1
Fagus grandifolia	3	2	0	1	3	0	0	1	0	0	0	0	0
Aesculus flava	2	0	0	2	1	0	1	0	0	0	0	0	0
Ostrya virginiana	1	1	1	0	0	1	0	0	0	1	0	0	0
Acer pensylvanicum	3	4	2	0	0	0	0	0	0	0	0	0	0
Betula alleghaniensis	1	0	0	0	0	0	0	0	0	0	0	0	1
Fraxinus americana	0	0	0	0	0	0	0	0	0	0	0	0	1
Carya cordiformis	0	0	0	0	0	0	0	0	0	0	0	1	0
Plot 122 1250m (4100ft.) Basal area-35.5m²/ha: Density-670 stems /ha													
Acer saccharum	27	5	3	2	1	0	0	0	0	0	0	0	1
Aesculus flava	1	0	2	0	0	1	0	2	2	3	1	1	0
Fagus grandifolia	0	0	0	0	0	0	0	0	1	0	0	1	0
Tilia heterophylla	1	3	0	1	0	0	0	0	0	0	0	0	0
Ostrya virginiana	1	3	0	0	0	0	0	0	0	0	0	0	0
Liriodendron tulipifera	0	1	1	0	0	0	0	0	0	0	0	0	0
Carya cordiformis	0	0	0	0	0	0	1	0	0	0	0	0	0
Fraxinus americana	0	0	0	0	0	1	0	0	0	0	0	0	0
Plot 35 1048m (3440ft.) Basal area-58.2m²/ha: Density-590 stems /ha													
Aesculus flava	5	2	5	1	3	0	1	1	2	1	0	0	2
Fagus grandifolia	4	2	5	1	3	0	1	1	2	1	0	0	2
Acer saccharum	8	0	0	0	1	0	0	0	0	0	0	0	1
Betula alleghaniensis	0	2	0	0	0	0	0	0	0	0	0	0	1
Tilia heterophylla	3	0	0	2	1	1	0	0	0	0	0	0	0
Fraxinus americana	0	0	0	0	0	0	0	0	0	0	0	0	1
Ostrya virginia	2	1	0	0	0	0	0	0	0	0	0	0	0
Liriodendron tulipifera	1	0	0	0	0	0	0	0	0	0	0	0	0
Plot 36 1036m (3400ft.) Basal area-35.3m²/ha: Density-730 stems /ha													
Fagus grandifolia	1	1	2	0	0	0	1	0	2	0	0	0	3
Aesculus flava	1	5	11	3	1	1	0	0	0	0	0	0	1
Acer saccharum	6	18	3	2	2	0	0	0	0	0	0	0	0
Tilia heterophylla	0	2	2	1	0	0	0	0	0	0	1	0	0
Fraxinus americana	0	0	0	0	0	0	0	0	0	1	0	0	0
Carya cordiformis	2	0	0	0	0	0	0	0	0	0	0	0	0
Ostrya virginiana	1	0	0	0	0	0	0	0	0	0	0	0	0

Table 27. Representative diameter distributions of different habitat types for beech, bi-ch forests

Species (Inches)	2	3	4	5	6	7	8	9	10
(Centimeters)	5		10		15		20		26
Plot 113 (0.04 ha)	Ridge top below knob 1737m (5700Ft.) Basal area-21.1m^2 /ha; Density 3775 stems /ha								
Fagus grandifolia	42	61	7	1	0	0	0	1	1
Betula alleghaniensis	8	7	8	13	1	1	0	0	0

(Inches)	2	4	6	8	10	12	14	16	18	20	22	24	larger
(Centimeters)	5	10	15	20	26	31	36	41	46	51	54	61	
Plot 140	North slope 1646m (5400ft.) Basal area-46.8m^2 /ha; Density-690 stems /ha												
Fagus grandifolia	71	10	11	3	11	8	2	1	2	1	0	0	0
Prunus serotina	0	0	0	0	0	0	0	0	0	0	0	0	4
Acer saccharum	2	1	0	0	0	0	0	0	1	0	0	0	1
Acer pensylvanicum	0	3	0	0	0	0	0	0	0	0	0	0	0
Betula alleghaniensis	0	0	1	0	0	0	0	0	0	0	0	0	0
Plot 90	Broad North facing sheltered ridge 1615m (5300Ft.) Basal area-41.6m^2 /ha; Density-590 stems /ha												
Betula alleghaniensis	0	0	1	0	1	0	0	1	1	2	1	0	3
Fagus grandifolia	3	15	6	3	2	2	0	0	0	0	0	0	0
Acer spicatum	2	6	1	0	0	0	0	0	0	0	0	0	0
Acer pensylvanicum	0	2	2	0	0	1	0	0	0	0	0	0	0
Sorbus americana	0	0	0	0	0	0	0	1	0	0	0	0	0
Prunus serotina	0	0	1	0	0	0	0	0	0	0	0	0	0
Aesculus flava	0	0	1	0	0	0	0	0	0	0	0	0	0
Plot 99	Craggies: Upper North facing slope 1640m (5380Ft.) Basal area-24.6m^2 /ha; Density-1130 stems /ha												
Fagus grandifolia	23	10	15	6	6	2	4	1	0	0	0	0	0
Betula alleghaniensis	0	0	0	0	0	0	0	0	1	1	0	1	0
Picea rubens	12	12	1	0	0	0	0	0	0	0	0	0	0
Acer spicatum	7	4	0	0	0	0	0	0	0	0	0	0	0
Aesculus flava	3	0	0	0	2	0	0	0	0	0	0	0	0
Acer saccharum	0	1	1	0	0	0	0	0	0	0	0	0	0

Table 28. Representative diameter distributions for oak. mesic forests

Species (Inches)	2	4	6	8	10	12	14	16	18	20	22	24	larger
(Centimeters)	5	10	15	20	26	31	36	41	46	51	56	61	
Plot 1 Age about 150 years 1077m (3535Ft.) Basal area-40.0m^2 /ha; Density-620 stems /ha													
Acer saccharum	12	6	6	5	3	0	1	0	0	0	0	0	0
Quercus rubra	0	0	0	0	0	0	0	1	0	0	0	0	2
Liriodendron tulipifera	0	0	0	0	0	0	1	0	0	0	0	0	1
Tilia heterophylla	1	1	0	1	1	1	0	0	2	0	0	0	0
Aesculus flava	1	1	0	3	1	0	0	0	0	0	0	0	0
Magnolia acuminata	1	0	0	0	0	0	1	0	0	0	0	0	0
Tsuga canadensis	3	0	0	0	0	0	0	0	0	0	0	0	0
Robinia pseudo-acacia	0	0	0	0	0	0	0	0	1	0	0	0	0
Betula alleghaniensis	0	0	0	0	1	0	0	0	0	0	0	0	0
Betula lenta	0	0	0	0	1	0	0	0	0	0	0	0	0
Ostrya virginiana	1	0	0	1	0	0	0	0	0	0	0	0	0
Hamamelis virginiana	0	1	0	0	0	0	0	0	0	0	0	0	0
Plot 102 Age about 60 years 1036m (3400Ft.) Basal area-45.5m^2 /ha; Density-700 stems /ha													
Quercus rubra	0	0	0	0	0	0	1	0	0	0	0	0	4
Tilia heterophylla	2	1	3	1	0	0	0	0	0	2	0	0	1
Acer saccharum	8	0	1	1	0	0	0	1	0	1	0	0	0
Betula alleghaniensis	4	2	2	1	0	0	0	0	0	0	0	0	0
Magnolia acuminata	2	0	0	0	0	0	0	0	0	2	0	0	0
Aesculus flava	2	0	1	2	1	0	0	0	0	0	0	0	0
Cornus florida	5	0	1	0	0	0	0	0	0	0	0	0	0
Carya cordiformis	1	0	0	1	1	0	0	0	0	0	0	0	0
Liriodendron tulipifera	0	0	1	0	0	0	1	0	0	0	0	0	0
Tsuga canadensis	2	0	1	0	0	0	0	0	0	0	0	0	0
Hamamelis virginiana	2	1	0	0	0	0	0	0	0	0	0	0	0
Betula lenta	0	0	0	0	0	0	1	0	0	0	0	0	0
Fraxinus americana	0	0	0	0	0	0	1	0	0	0	0	0	0
Acer rubrum	0	0	1	0	0	0	0	0	0	0	0	0	0
Carya ovata	0	0	1	0	0	0	0	0	0	0	0	0	0
Fagus grandifolia	0	1	0	0	0	0	0	0	0	0	0	0	0
Magnolia fraseri	1	0	0	0	0	0	0	0	0	0	0	0	0
Ostrya virginiana	1	0	0	0	0	0	0	0	0	0	0	0	0

Table 29. Representative diameter distributions for spatial sequence of alluvial forests

Species (Inches)	2	4	6	8	10	12	14	16	18	20	22	24	larger
(Centimeters)	5	10	15	20	26	31	36	41	46	51	56	61	
Plot 137 Island in river 914m (3000ft.) Basal area-51.0m^2 /ha; Density-1250 stems /ha													
Platanus occidentalis	0	0	0	2	5	1	3	3	3	1	1	1	0
Betula alleghaniensis	2	3	8	9	3	0	0	0	0	0	0	0	0
Betula lenta	1	1	9	5	2	2	1	0	0	0	0	0	0
Tsuga canadensis	6	2	6	5	1	2	0	0	0	0	0	0	0
Acer rubrum	8	2	4	3	1	0	1	0	1	0	0	0	0
Liriodendron tulipifere	0	0	1	1	1	0	0	0	0	0	1	0	0
Quercus rubra	0	2	0	0	0	1	0	0	0	0	0	0	0
Carpinus caroliniana	0	2	1	0	0	0	0	0	0	0	0	0	0
Juglans cinerea	0	0	0	0	0	1	0	0	0	0	0	0	0
Hamamelis virginiana	1	1	0	0	0	0	0	0	0	0	0	0	0
Oxydendrum arboreum	0	0	1	0	0	0	0	0	0	0	0	0	0
Cornus florida	0	1	0	0	0	0	0	0	0	0	0	0	0
Acer pensylvanicum	1	0	0	0	0	0	0	0	0	0	0	0	0
Plot 135 First terrace, about 25 meters from river 914m (3000ft.) Basal area-58.8m^2 /ha; Density-1110 stems /ha													
Tsuga canadensis	13	12	15	11	8	3	2	3	1	1	0	0	0
Platanus occidentalis	0	0	0	0	0	1	0	3	1	1	0	0	2
Betula alleghaniensis	1	0	3	0	2	2	4	3	1	0	0	0	0
Acer rubrum	1	2	1	2	2	0	2	0	0	0	0	0	0
Betula lenta	0	0	0	0	0	0	1	1	0	0	0	0	0
Liriodendron tulipifera	0	0	0	0	0	0	0	0	1	0	0	0	0
Quercus rubra	0	0	0	0	0	0	0	1	0	0	0	0	0
Robinia pseudo-acacia	0	0	0	1	0	0	0	0	0	0	0	0	0
Ostrya virginiana	0	0	1	0	0	0	0	0	0	0	0	0	0
Carpinus caroliniana	1	1	0	0	0	0	0	0	0	0	0	0	0
Plot 136 Second terrace, about 60 meters from river 917m (3010ft.) Basal area-79.4m^2 /ha; Density-380 stems /ha													
Tsuga canadensis	4	1	6	0	2	0	0	2	2	1	1	3	4
Quercus alba	0	0	0	0	0	0	0	0	0	0	0	0	1
Fagus garndifolia	0	0	0	0	0	0	0	0	1	1	0	0	1
Liriodendron tulipifera	0	0	0	0	0	0	0	0	0	0	0	1	1
Carya glabra	0	0	0	0	0	0	0	0	0	0	0	0	1
Magnolia fraseri	0	0	1	0	0	0	1	0	1	0	0	0	0
Oxydendron arboreum	0	0	0	0	0	0	0	0	1	0	0	0	0
Hamamelis virginiana	0	1	0	0	0	0	0	0	0	0	0	0	0

Table 30. Representative diameter distributions for eastern hemlock forests

Species (Inches)	2	4	6	8	10	12	14	16	18	20	22	24	larger
(Centimeters)	5	10	15	20	26	31	36	41	46	51	56	61	
Plot 21 945m (3100Ft.) Basal area-58.2m² /ha; Density-460 stems /ha													
Betula alleghaniensis	1	5	3	5	0	1	1	0	0	1	0	1	1
Tsuga canadensis	3	0	0	1	1	0	0	1	1	0	0	0	2
Liriodendron tulipifera	0	0	0	0	0	0	1	0	0	2	2	0	0
Acer rubrum	0	0	0	0	1	0	0	0	0	0	0	0	1
Tilia heterophylla	0	0	0	0	0	0	0	1	1	1	0	0	0
Magnolia fraseri	0	0	1	1	0	0	1	0	1	0	0	0	0
Betula lenta	0	0	0	1	0	0	0	0	0	0	0	0	0
Plot 22 902m (2960Ft.) Basal area-37.1m² /ha; Density-560 stems /ha													
Tsuga canadensis	6	8	4	3	0	1	0	0	0	0	0	0	1
Liriodendron tulipifera	0	0	0	0	0	0	0	3	2	2	0	0	0
Betula lenta	0	2	1	1	1	5	1	1	0	0	0	0	0
Magnolia fraseri	0	0	0	0	0	2	1	2	0	0	0	0	0
Betula alleghaniensis	0	0	0	0	1	0	1	0	0	0	0	0	0
Acer rubrum	0	1	1	1	0	0	0	0	0	0	0	0	0
Quercus rubra	0	0	1	0	0	0	0	0	0	0	0	0	0
Oxydendron aboreum	0	0	1	0	0	0	0	0	0	0	0	0	0
Plot 56 1384m (4540Ft.) Basal area-83.9m² /ha; Density-340 stems /ha													
Tsuga canadensis	4	1	2	1	0	0	2	0	0	0	0	0	13
Betula alleghaniensis	1	2	0	0	0	0	0	1	0	1	1	0	0
Acer rubrum	0	0	0	0	0	0	0	0	0	0	0	0	1
Magnolia fraseri	2	0	0	0	0	0	0	1	0	0	0	0	0
Fagus grandifolia	0	0	0	0	0	0	0	1	0	0	0	0	0
Plot 104 1158m (3800Ft.) Basal area-62.8m² /ha; Density-1220 stems /ha													
Tsuga canadensis	6	14	32	15	9	4	2	0	1	0	0	0	0
Fagus grandifolia	1	3	8	4	0	10	3	2	3	0	0	1	1
Betula lenta	0	0	0	0	0	0	1	0	0	0	2	0	0
Magnolia fraseri	0	0	2	0	0	1	0	1	0	0	1	0	0
Liriodendron tulipifera	0	0	0	0	0	0	0	0	1	1	0	0	0
Acer saccharum	1	0	0	0	0	0	0	0	0	1	0	0	0
Fraxinus americana	0	0	0	0	0	0	0	1	0	0	0	0	0
Tilia heterophylla	0	0	0	2	0	1	0	0	0	0	0	0	0
Ostrya virginiana	0	0	0	0	0	1	0	0	0	0	0	0	0

Table 31. Representative diameter distributions for mixed oak, yellow poplar, hickory

Species	(Inches)	2	4	6	8	10	12	14	16	18	20	22	24	larger
	(Centimeters)	5	10	15	20	26	31	36	41	46	51	56	61	
Plot 81 902m (2960ft.) Basal area-31.9m^2/ha; Density-800 stems /ha														
Liriodendron tulipifera		1	3	5	2	1	1	1	1	0	0	0	0	0
Quercus alba		1	1	1	1	2	0	0	0	0	0	0	0	0
Quercus rubra		1	0	0	0	1	1	1	1	0	0	0	0	0
Carya tomentosa		3	2	1	0	1	0	0	0	1	0	0	0	0
Magnolia fraseri		2	0	1	1	3	0	0	0	0	0	0	0	0
Acer saccharum		1	1	0	0	0	0	1	1	0	0	0	0	0
Quercus velutina		0	0	0	0	0	0	1	0	0	1	0	0	0
Quercus coccinea		0	0	0	0	0	0	0	1	1	0	0	0	0
Betula lenta		0	2	0	0	0	2	0	0	0	0	0	0	0
Carya glabra		0	0	1	1	0	0	1	0	0	0	0	0	0
Carya ovata		0	0	1	0	1	1	0	0	0	0	0	0	0
Quercus montana		0	0	0	0	0	0	0	1	0	0	0	0	0
Amelanchier laevis		2	1	0	0	0	0	0	0	0	0	0	0	0
Robinia pseudo-acacia		0	0	0	0	0	0	1	0	0	0	0	0	0
Prunus serotina		0	0	0	0	0	0	1	0	0	0	0	0	0
Carpinus caroliniana		0	1	1	0	0	0	0	0	0	0	0	0	0
Acer pensylvanicum		2	1	0	0	0	0	0	0	0	0	0	0	0
Cornus florida		3	0	0	0	0	0	0	0	0	0	0	0	0
Aesculus flava		0	0	0	0	1	0	0	0	0	0	0	0	0
Fraxinus americana		0	0	0	1	0	0	0	0	0	0	0	0	0
Nyssa sylvatica		0	0	1	0	0	0	0	0	0	0	0	0	0
Oxydendrum arboreum		0	0	1	0	0	0	0	0	0	0	0	0	0
Acer rubrum		0	0	1	0	0	0	0	0	0	0	0	0	0
Plot 97 914m (3000ft.) Basal area-40.1m^2/ha; Density-560 stems /ha														
Liriodendron tulipifera		5	10	0	5	2	1	1	3	0	0	0	0	1
Carya tomentosa		1	0	0	2	1	1	1	1	0	0	0	1	1
Acer rubrum		2	1	0	0	0	0	0	0	0	1	0	0	1
Quercus rubra		0	0	0	0	0	0	0	0	0	0	0	0	2
Magnolia acuminata		2	1	1	0	1	0	0	0	0	0	0	0	0
Carya cordiformis		0	0	0	0	0	1	0	0	0	0	0	0	0
Magnolia fraseri		0	0	1	0	0	0	0	0	0	0	0	0	0
Aesculus flava		0	0	1	0	0	0	0	0	0	0	0	0	0
Cornus florida		2	1	0	0	0	0	0	0	0	0	0	0	0
Fagus grandifolia		0	1	0	0	0	0	0	0	0	0	0	0	0

Table 32. Representative diameter distributions for white oak forests

Species (Inches)	2	4	6	8	10	12	14	16	18	20	22	24	larger
(Centimeters)	5	10	15	20	26	31	36	41	46	51	56	61	
Plot 42 White oak flat 853m (2800Ft.) Basal area-59.0m^2/ha; Density 750 stems /ha													
Quercus alba	0	0	0	3	3	4	4	6	6	2	2	0	3
Acer rubrum	4	4	5	1	0	0	1	0	0	0	0	0	0
Liriodendron tulipifera	5	1	1	1	0	1	0	0	0	0	0	0	0
Tsuga canadensis	0	0	2	2	0	1	0	0	0	0	0	0	0
Betula lenta	1	0	2	1	0	0	0	0	0	0	0	0	0
Oxydendrum arboreum	1	0	1	1	0	0	0	0	0	0	0	0	0
Fagus grandifolia	3	1	2	0	0	0	0	0	0	0	0	0	0
Magnolia fraseri	2	0	0	1	0	0	0	0	0	0	0	0	0
Cornus florida	2	0	0	0	0	0	0	0	0	0	0	0	0
Quercus coccinea	0	0	1	0	0	0	0	0	0	0	0	0	0
Prunus serotina	0	1	0	0	0	0	0	0	0	0	0	0	0
Carya glabra	0	1	0	0	0	0	0	0	0	0	0	0	0
Carpinus caroliniana	1	0	0	0	0	0	0	0	0	0	0	0	0
Magnolia acuminata	1	0	0	0	0	0	0	0	0	0	0	0	0
Plot 51 Ridge 1378m (4520Ft.) Basal area-36.8m^2/ha; Density 870 stems /ha													
Quercus alba	0	0	0	0	2	0	0	1	3	1	1	0	1
Quercus rubra	1	0	1	1	2	0	0	1	0	0	0	0	2
Betula alleghaniensis	3	12	6	2	0	0	0	1	0	0	0	0	0
Fagus grandifolia	11	9	7	0	0	0	0	0	0	0	0	0	0
Acer rubrum	0	5	1	4	2	1	0	0	0	0	0	0	0
Magnolia acuminata	0	1	0	2	0	0	0	0	0	0	0	0	0
Amelanchier laevis	1	0	1	0	0	0	0	0	0	0	0	0	0
Tsuga canadensis	0	0	1	0	0	0	0	0	0	0	0	0	0

Table 33. Representative diameter distributions for scarlet oak, red maple forests

Species (Inches)	2	4	6	8	10	12	14	16	18	20	22	24	larger
(Centimeters)	5	10	15	20	26	31	36	41	46	51	56	61	
Plot 120 853m (2300ft.) Basal area-34.6m² /ha; Density-900 stems /ha													
Quercus coccinea	2	0	3	1	1	2	1	1	1	1	1	1	0
Oxydendrum arboreum	4	5	4	6	2	3	0	0	0	0	0	0	0
Acer rubrum	2	2	4	5	2	2	0	0	1	0	0	0	0
Carya tomentosa	1	0	0	0	0	0	0	0	0	1	0	1	0
Quercus alba	2	0	1	0	1	1	0	0	0	0	0	0	0
Quercus montana	1	1	2	1	0	0	0	0	0	0	0	0	0
Liriodendron tulipifera	0	0	1	1	1	0	0	0	0	0	0	0	0
Sassafras albidum	4	0	0	0	0	0	0	0	0	0	0	0	0
Amelanchier laevis	0	1	1	1	0	0	0	0	0	0	0	0	0
Robinia pseudo-acacia	0	2	0	0	0	0	0	0	0	0	0	0	0
Carya glabra	0	0	0	1	0	0	0	0	0	0	0	0	0
Tsuga caroliniana	0	0	1	0	0	0	0	0	0	0	0	0	0
Nyssa sylvatica	0	1	0	0	0	0	0	0	0	0	0	0	0
Acer pensylvanicum	0	1	0	0	0	0	0	0	0	0	0	0	0
Tsuga canadensis	0	1	0	0	0	0	0	0	0	0	0	0	0
Magnolia acuminata	0	1	0	0	0	0	0	0	0	0	0	0	0
Cornus florida	2	0	0	0	0	0	0	0	0	0	0	0	0
Plot 53 853m (2800ft.) Basal area-41.2m² /ha; Density-700 stems /ha													
Quercus coccinea	0	0	1	1	2	0	2	1	0	2	1	0	0
Oxydendrum arboreum	1	0	2	4	2	1	0	1	0	0	0	0	0
Quercus velutina	0	0	0	0	0	0	2	1	0	1	1	0	0
Acer rubrum	2	1	2	0	0	0	0	0	0	0	1	1	0
Liriodendron tulipifera	0	0	3	3	1	0	0	0	1	0	0	0	0
Fagus grandifolia	0	2	3	2	1	0	0	0	0	0	0	0	0
Quercus alba	0	0	2	0	0	0	0	0	0	0	1	0	0
Quercus rubra	0	1	0	4	0	0	0	0	0	0	0	0	0
Robinia pseudo-acacia	0	0	0	0	1	1	1	0	0	0	0	0	0
Carya glabra	1	0	0	0	0	0	0	0	1	0	0	0	0
Cornus florida	0	3	0	0	0	0	0	0	0	0	0	0	0
Nyssa sylvatica	0	0	0	0	0	0	0	1	0	0	0	0	0
Sassafras albidum	0	0	1	0	0	0	0	0	0	0	0	0	0
Magnolia fraseri	0	1	0	0	0	0	0	0	0	0	0	0	0
Magnolia acuminata	0	1	0	0	0	0	0	0	0	0	0	0	0
Carpinus carolinian	0	1	0	0	0	0	0	0	0	0	0	0	0
Plot 128 823m (2700ft.) Basal area-30.6m² /ha; Density-920 stems /ha													
Quercus coccinea	0	0	0	3	3	6	3	1	1	1	0	0	0
Oxydendrum arboreum	8	7	10	2	2	0	0	0	0	0	0	0	0
Acer rubrum	4	3	4	3	3	2	0	0	0	0	0	0	0
Nyssa sylvatica	3	3	4	0	0	0	0	1	0	0	0	0	0
Tsuga caroliniana	0	0	0	0	2	2	0	0	0	0	0	0	0
Amelanchier laevis	0	0	0	1	2	1	0	0	0	0	0	0	0
Quercus alba	0	0	2	1	0	0	0	0	0	0	0	0	0
Quercus montana	0	0	1	0	1	0	0	0	0	0	0	0	0
Symplocos tinctoria	1	0	0	0	0	0	0	0	0	0	0	0	0

Table 34. Representative diameter distributions for red oak, yellow poplar, chestnut oak forests

Species (Inches)	2	4	6	8	10	12	14	16	18	20	22	24	larger
(Centimeters)	5	10	15	20	26	31	36	41	46	51	56	61	
Plot 4 960m (3150Ft.) Basal area-52.9m² /ha; Density 780 stems /ha													
Liriodendron tulipifera	0	0	0	1	1	1	0	2	0	0	1	0	6
Quercus montana	0	1	1	5	2	1	0	0	1	2	0	0	0
Quercus rubra	0	1	1	3	0	4	0	0	0	0	0	0	1
Oxydendrum arboreum	3	8	5	2	0	0	0	0	0	0	0	0	0
Acer rubrum	2	4	3	6	0	0	0	0	0	0	0	0	0
Tsuga canadensis	1	5	3	1	0	0	0	0	0	0	0	0	0
Cornus florida	1	0	0	0	0	0	0	0	0	0	0	0	0
Plot 2 1018m (3340Ft.) Basal area-48.6m² /ha; Density-710 stems /ha													
Quercus rubra	0	5	1	0	0	1	0	0	0	0	1	0	2
Liriodendron tulipifera	0	0	0	0	0	0	0	0	0	1	0	1	1
Acer rubrum	0	5	2	1	0	0	1	0	0	0	0	0	0
Quercus montana	0	1	0	0	0	1	0	1	0	0	0	0	1
Hamamelis virginiana	9	8	1	0	0	0	0	0	0	0	0	0	0
Magnolia acuminata	0	0	0	2	0	0	0	0	0	0	2	0	0
Ostrya virginiana	1	5	0	0	0	0	0	0	0	0	0	0	0
Cornus florida	1	3	1	0	0	0	0	0	0	0	0	0	0
Acer saccharum	0	0	2	0	0	0	0	0	0	0	0	0	0
Acer pensylvanicum	1	2	0	0	0	0	0	0	0	0	0	0	0
Carya glabra	0	0	0	1	0	0	0	0	0	0	0	0	0
Betula lenta	0	0	1	0	0	0	0	0	0	0	0	0	0
Fraxinus americana	0	0	1	0	0	0	0	0	0	0	0	0	0
Tsuga canadensis	2	0	0	0	0	0	0	0	0	0	0	0	0
Betula alleghaniensis	1	0	0	0	0	0	0	0	0	0	0	0	0
Plot 16 1158m (3800Ft.) Basal area-40.6m² /ha; Density-710 stems /ha													
Quercus montana	1	2	0	2	2	0	1	0	2	4	0	0	1
Quercus rubra	0	1	4	1	1	2	0	1	0	0	3	0	1
Acer rubrum	8	4	6	0	1	0	0	0	0	0	0	0	0
Oxydendrum arboreum	0	4	6	2	1	0	0	0	0	0	0	0	0
Liriodendron tulipifera	0	0	0	0	0	0	0	0	0	0	0	1	0
Carya glabra	0	3	0	0	0	0	0	0	0	0	0	0	0
Magnolia acuminata	0	0	0	0	0	0	0	1	0	0	0	0	0
Nyssa sylvatica	2	0	1	0	0	0	0	0	0	0	0	0	0
Magnolia fraseri	0	0	0	0	1	0	0	0	0	0	0	0	0
Hamamelis virginiana	1	0	0	0	0	0	0	0	0	0	0	0	0

Table 35. Representative diameter distributions for chestnut oak forests

Species (Inches)	2	4	6	8	10	12	14	16	18	20	22 larger
(Centimeters)	5	10	15	20	26	31	36	41	46	51	56
Plot 121 Craggies 902m (2960ft.) Basal area-30.3m² /ha; Density-750 stems /ha											
Quercus montana	1	2	1	2	1	2	0	5	2	2	0 0
Cornus florida	21	3	2	1	0	0	0	0	0	0	0 0
Quercus rubra	0	0	1	0	2	0	1	0	0	0	0 1
Carya glabra	5	0	2	3	1	0	0	0	0	0	0 0
Liriodendron tulipifera	0	1	1	0	0	0	0	1	0	0	0 0
Oxydendrum arboreum	1	2	1	0	0	0	0	0	0	0	0 0
Carya ovata	0	0	0	1	0	0	1	0	0	0	0 0
Acer rubrum	2	0	0	0	0	1	0	0	0	0	0 0
Hamamelis virginiana	8	3	0	0	0	0	0	0	0	0	0 0
Magnolia acuminata	0	0	1	0	0	0	0	0	0	0	0 0
Fagus grandifolia	1	0	0	0	0	0	0	0	0	0	0 0
Plot 24 Blacks 902m (2960ft.) Basal area-35.9m² /ha; Density-890 stems /ha											
Quercus montana	0	1	1	3	2	4	3	1	0	0	1 0
Acer rubrum	3	10	9	3	3	1	1	0	0	0	0 0
Oxydendrum arboreum	3	2	7	3	0	1	0	0	0	0	0 0
Quercus velutina	0	0	0	0	0	0	2	0	1	0	1 0
Cornus florida	6	4	2	0	1	0	0	0	0	0	0 0
Quercus rubra	0	0	0	0	0	0	0	1	1	1	0 0
Quercus coccinea	0	0	0	0	0	0	0	0	0	0	1 0
Tsuga canadensis	1	0	0	0	0	0	1	0	0	0	0 0
Quercus alba	0	0	0	0	0	0	1	0	0	0	0 0
Carya glabra	1	1	0	0	0	0	0	0	0	0	0 0
Nyssa sylvatica	1	0	0	0	0	0	0	0	0	0	0 0

Table 36. Representative diameter distributions for red oak forests

Species	(Inches)	2	4	6	8	10	12	14	16	18	20	22	24	larger
	(Centimeters)	5	10	15	20	26	31	36	41	46	51	56	61	
Plot 92 1463m (4800ft.) Basal area-44.2m^2/ha; Density 480 stems /ha														
Quercus rubra		0	0	0	2	2	2	0	0	1	2	4	0	4
Acer rubrum		0	2	7	9	1	5	0	0	0	0	0	0	0
Tsuga canadensis		0	0	0	1	0	0	0	0	0	0	0	0	0
Hamamelis virginiana		2	0	0	0	0	0	0	0	0	0	0	0	0
Picea rubens		2	0	0	0	0	0	0	0	0	0	0	0	0
Ilex montana		1	0	0	0	0	0	0	0	0	0	0	0	0
Acer saccharum		1	0	0	0	0	0	0	0	0	0	0	0	0
Plot 23 1292m (4240ft.) Basal area-27.0m^2/ha; Density 880 stems /ha														
Quercus rubra		0	0	1	0	4	7	0	3	1	0	1	0	0
Acer rubrum		6	8	9	4	2	0	1	0	0	0	0	0	0
Quercus montana		0	0	0	3	1	2	2	1	0	0	0	0	0
Betula lenta		1	2	1	1	0	1	0	0	0	0	0	0	0
Hamamelis virginiana		11	3	0	0	0	0	0	0	0	0	0	0	0
Picea rubens		4	3	0	0	0	0	0	0	0	0	0	0	0
Tsuga canadensis		2	1	0	0	0	0	0	0	0	0	0	0	0
Castanea dentata		1	1	0	0	0	0	0	0	0	0	0	0	0

Table 37. Representative diameter distributions for Carolina hemlock forests

Species	(Inches)	2	4	6	8	10	12	14	16	18	20	22	24	larger
	(Centimeters)	5	10	15	20	26	31	36	41	46	51	56	61	
Plot 93 792m (2600Ft.) Valley Basal area-49.4m^2 /ha; Density-570 stems /ha														
Tsuga caroliniana		1	0	1	3	8	6	4	5	4	1	0	0	0
Quercus coccinea		0	0	0	0	0	1	0	1	1	2	1	0	1
Tsuga canadensis		0	0	1	0	0	2	1	0	0	1	0	0	0
Oxydendrum arboreum		0	0	0	1	3	0	0	0	0	0	0	0	0
Acer rubrum		0	1	1	1	0	0	0	0	0	0	0	0	0
Pinus strobus		0	0	0	0	0	0	0	0	0	0	0	1	0
Betula lenta		0	1	0	0	0	0	0	0	0	0	0	0	0
Nyssa sylvatica		1	0	0	0	0	0	0	0	0	0	0	0	0
Hamamelis virginiana		1	0	0	0	0	0	0	0	0	0	0	0	0
Plot 95 792m (2600ft.)-Valley Basal area-51.7m^2 /ha; Density-800 stems /ha														
Tsuga caroliniana		1	4	2	0	2	0	2	0	2	0	0	0	0
Tsuga canadensis		0	2	1	0	1	4	0	0	1	0	0	0	0
Oxydendrum arboreum		0	0	0	0	0	1	0	0	0	1	1	0	0
Acer rubrum		0	0	1	1	0	0	0	1	0	0	0	0	0
Quercus coccinea		0	0	0	0	0	0	0	0	0	0	1	0	0
Nyssa sylvatica		1	1	0	0	0	0	0	0	0	0	0	0	0

Table 38. Representative diameter distributions for xeric pine forests

Species	(Inches)	2	4	6	8	10	12	14	16	18	20	22
	(Centimeters)	5	10	15	20	26	31	36	41	46	51	56
Plot 138 1219m (4000Ft.) Basal area-32.4m^2/ha; Density-1050 stems /ha												
Pinus pungens		0	4	3	5	10	11	2	0	0	0	0
Pinus rigida		0	0	3	2	3	5	2	0	0	0	0
Nyssa sylvatica		4	8	5	1	3	0	0	0	0	0	0
Acer rubrum		2	4	6	6	1	0	0	0	0	0	0
Quercus montana		0	0	1	2	0	0	0	0	0	0	0
Oxydendrum arboreum		0	0	2	1	0	0	0	0	0	0	0
Ilex montana		2	1	0	0	0	0	0	0	0	0	0
Tsuga canadensis		1	0	1	0	0	0	0	0	0	0	0
Amelanchier laevis		2	1	0	0	0	0	0	0	0	0	0
Quercus rubra		0	0	1	0	0	0	0	0	0	0	0
Hamamelis virginiana		2	1	0	0	0	0	0	0	0	0	0
Plot 143 853m (2800Ft.) Basal area-19.0m^2/ha; Density-510 stems /ha												
Pinus rigida		0	0	0	0	0	2	1	2	1	2	0
Quercus coccinea		1	1	1	1	1	2	1	0	0	0	0
Oxydendrum arboreum		2	4	1	1	0	0	0	0	0	0	0
Tsuga canadensis		0	2	2	1	1	0	0	0	0	0	0
Quercus montana		0	0	0	0	0	1	0	1	0	0	0
Quercus alba		0	3	0	1	0	0	0	0	0	0	0
Nyssa sylvatica		3	1	0	0	0	0	0	0	0	0	0
Acer rubrum		0	1	2	0	0	0	0	0	0	0	0
Magnolia fraseri		0	0	0	1	0	0	0	0	0	0	0
Quercus velutina		0	0	1	0	0	0	0	0	0	0	0
Tsuga caroliniana		0	0	1	0	0	0	0	0	0	0	0
Symplocos tinctoria		0	1	0	0	0	0	0	0	0	0	0
Hamamelis virginiana		4	0	0	0	0	0	0	0	0	0	0

Table 39. Representative diameter distributions for spruce forests

Species (Inches) / (Centimeters)	2 / 5	4 / 10	6 / 15	8 / 20	10 / 26	12 / 31	14 / 36	16 / 41	18 / 46	20 / 51	22 / 56	24 / 61	larger
Plot 72 North facing 1567m (5140ft.) Basal area-25.4m² /ha; Density-1240 stems /ha													
Picea rubens	21	8	6	13	7	4	1	0	0	0	0	0	0
Fagus grandifolia	4	0	0	0	1	3	3	0	0	0	0	0	0
Betula alleghaniensis	0	0	0	0	0	0	0	1	0	0	0	0	1
Abies fraseri	22	15	0	0	0	0	0	0	0	0	0	0	0
Tsuga canadensis	6	1	0	0	0	0	0	0	0	0	0	0	0
Acer pensylvanicum	4	3	0	0	0	0	0	0	0	0	0	0	0
Ilex montana	2	1	0	0	0	0	0	0	0	0	0	0	0
Acer spicatum	2	1	0	0	0	0	0	0	0	0	0	0	0
Plot 70 East facing 1573m (5160ft.) Basal area-61.5m² /ha; Density-1070 stems /ha													
Picea rubens	19	11	13	5	4	6	2	6	7	6	2	0	0
Prunus serotina	0	0	0	0	0	0	0	0	0	1	0	0	1
Tsuga canadensis	0	1	4	0	2	0	0	0	0	0	0	0	0
Quercus rubra	0	0	0	0	0	0	0	0	0	0	0	0	1
Abies fraseri	9	5	0	0	0	0	0	0	0	0	0	0	0
Fagus grandifolia	0	0	0	0	0	1	1	0	0	0	0	0	0
Plot 74 North facing 1567m (5140ft.) Basal area-68.9m² /ha; Density-870 stems /ha													
Betula alleghaniensis	0	0	1	0	1	1	0	1	0	0	2	2	9
Picea rubens	13	13	7	8	5	2	0	0	0	0	0	0	0
Acer pensylvanicum	6	4	2	1	1	0	0	0	0	0	0	0	0
Fagus grandifolia	1	0	1	2	1	0	1	0	0	0	0	0	0
Abies fraseri	1	0	0	0	0	0	0	0	0	0	0	0	0
Tsuga canadensis	1	0	0	0	0	0	0	0	0	0	0	0	0
Plot 84 South facing-Commissary Ridge 1768m (5800ft.) Basal area-35.5m² /ha; Density-1590 stems /ha													
Betula alleghaniensis	12	16	18	16	10	2	0	0	0	0	0	0	0
Picea rubens	14	17	13	3	3	1	2	2	2	0	0	0	0
Betula cordifolia	0	0	1	5	3	2	0	0	0	0	0	0	0
Sorbus americana	1	0	7	2	1	0	0	0	0	0	0	0	0
Prunus pensylvanica	0	1	1	2	0	0	0	0	0	0	0	0	0
Acer spicatum	0	2	0	0	0	0	0	0	0	0	0	0	0

Table 40. Representative diameter distributions for fir forests

Species (Inches)	2	4	6	8	10	12	14	16	18	20	22	24
(Centimeters)	5	10	15	20	26	31	36	41	46	51	56	61
Plot 109 North of Deer Mountain 1829m (6000ft.) 20x20m Basal area-18.4m² /ha; Density-900 stems /ha												
Abies fraseri	6	4	5	7	5	0	0	0	1	0	1	0
Picea rubens	2	3	11	2	7	1	1	0	0	0	0	0
Sorbus americana	11	7	3	0	0	0	0	0	0	0	0	0
Prunus pensylvanica	4	4	1	0	0	0	0	0	0	0	0	0
Acer spicatum	2	1	0	0	0	0	0	0	0	0	0	0
Betula alleghaniensis	0	0	1	0	0	0	0	0	0	0	0	0
Abies fraseri (dead)	0	0	0	2	2	1	0	0	0	0	0	0
Plot 106 South peak Deer Mountain 1841m (6040ft.) 20x20m Basal area-41.7m² /ha; Density-1125 stems /ha												
Picea rubens	1	0	2	1	3	3	3	1	0	0	0	0
Betula alleghaniensis	2	1	4	1	4	0	1	0	0	0	0	0
Abies fraseri	4	1	0	0	0	0	0	0	0	0	0	0
Acer spicatum	2	2	0	0	0	0	0	0	0	0	0	0
Sorbus americana	0	2	1	0	0	0	0	0	0	0	0	0
Prunus pensylvanica	0	1	0	0	0	0	0	0	0	0	0	0
Plot 86 South slope Hallback Mountain 1920m (6300ft.) 20x20m Basal area-12.9m² /ha; Density-350 stems /ha												
Abies fraseri	0	0	0	0	0	4	1	0	0	0	0	0
Sorbus americana	1	2	3	2	1	0	0	0	0	0	0	0
Abies fraseri (dead)	3	5	5	6	5	6	1	0	0	0	0	0
Prunus pensylvanica	1	1	0	0	0	0	0	0	0	0	0	0
Plot 87 North slope Hallback Mountain 1920m (6300ft.) 20x20m Basal area-11.1m² /ha; Density-350 stems /ha												
Picea rubens	0	1	0	2	1	1	0	0	0	0	0	0
Sorbus americana	1	3	2	1	0	0	0	0	0	0	0	0
Abies fraseri	0	0	0	0	1	1	0	0	0	0	0	0
Picea rubens (dead)	0	0	1	0	0	0	0	0	0	0	0	0
Abies fraseri (dead)	1	1	4	5	4	6	0	1	0	0	0	0
Plot 101 250m East of Mt. Mitchell Tower 1981m (6500ft.) 20x20m Basal area-1.5m² /ha; Density-150 stems /ha												
Picea rubens	1	2	1	0	0	0	0	0	0	0	0	0
Abies fraseri	1	0	1	0	0	0	0	0	0	0	0	0
Betula cordifolia	0	0	1	0	0	0	0	0	0	0	0	0
Abies fraseri (dead)	6	9	6	12	8	1	3	5	1	0	0	0