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Phytogeography of the Balsam Mountains and Pisgah Ridge, Southern Appalachian Mountains

by

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Contents

1. Introduction

The Balsam Mountains occupy a central position in the southern Appalachians. They represent a cross range connecting the northeast and southwest trending Blue Ridge Mountains to the south and Great Smoky Mountains to the north (Fig. 1). The Appalachians have had a long and complex geologic history and are considered to be a product of plate tectonics of the Jurassic Period 180 to 250 million years ago (HATCHER 1974). All the overburden of sedimentary rock that once capped these mountains has eroded away, leaving metamorphic gneisses and schists with minor intrusions of igneous rocks. The predominant process of erosion yielded the present rounded and deep-soiled features. Soils of the region may be shallow on the ridges but colluvial soils of coves are often in excess of 25 m deep. The latest geological events have been alternating glacial and warm interglacial periods.

The vegetation of the southern Appalachians has long been recognized as one of the most diverse temperate floras in the world. The complex geologic history with land masses available for plant colonization has lasted over 200 million years, longer than existence of the predominant angiosperm forests. Accumulation of deep soils in coves supports cove hardwoods, often considered the most diverse type in temperate systems. Intervening warm periods and continental advancement of ice sheets has allowed extension of prairie or dryland plants and boreal plants into the area during the past 25,000 years (see DELCOURT and DELCOURT, in this volume).

Acknowledgements

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2. Geology

The bedrock geology of the study area has been mapped and described by HADLEY and NELSON (1971). In addition, these mapped rock units have been further interpreted by WINNER (1977) in his investigation of the ground-water resources along the Blue Ridge Parkway in North Carolina. For an overview of geology of North Carolina see ROBINSON (1979a, this volume). The five major rock units and their distribution in the study area (by kilometers south of the Parkway origin in Virginia) are shown on the topographic profile in Figure 2. WINNER (1971) and HADLEY and NELSON (1971) have given a classification and description of each rock unit as shown in Table 1.

A generally accepted explanation of the Parkway geology is that the mountains are of Paleozoic Age. The rocks are primarily metamorphosed sediments of the Appalachian geosyncline which were uplifted, folded, and in some

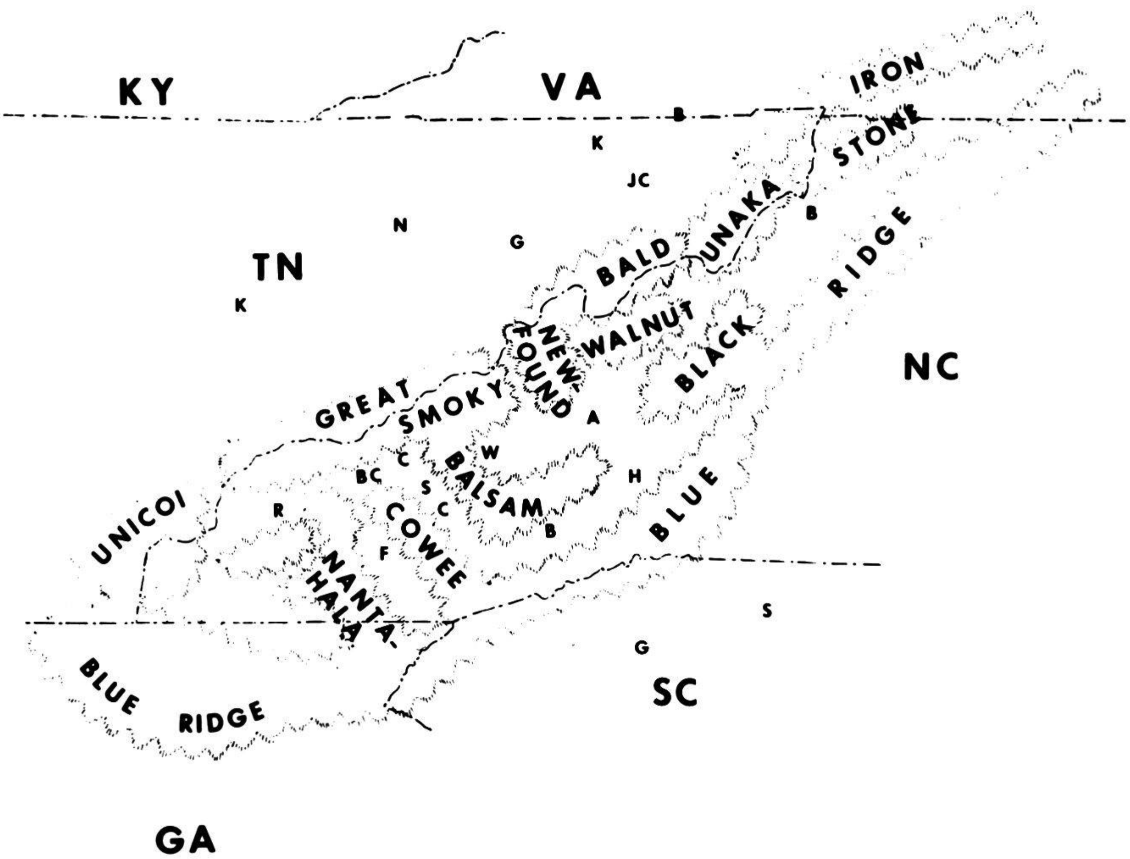

Fig. 1. Map of the southern Blue Ridge Province of the Appalachian Mountains. Mountain ranges are indicated. Individual letters represent first letters of towns and cities.

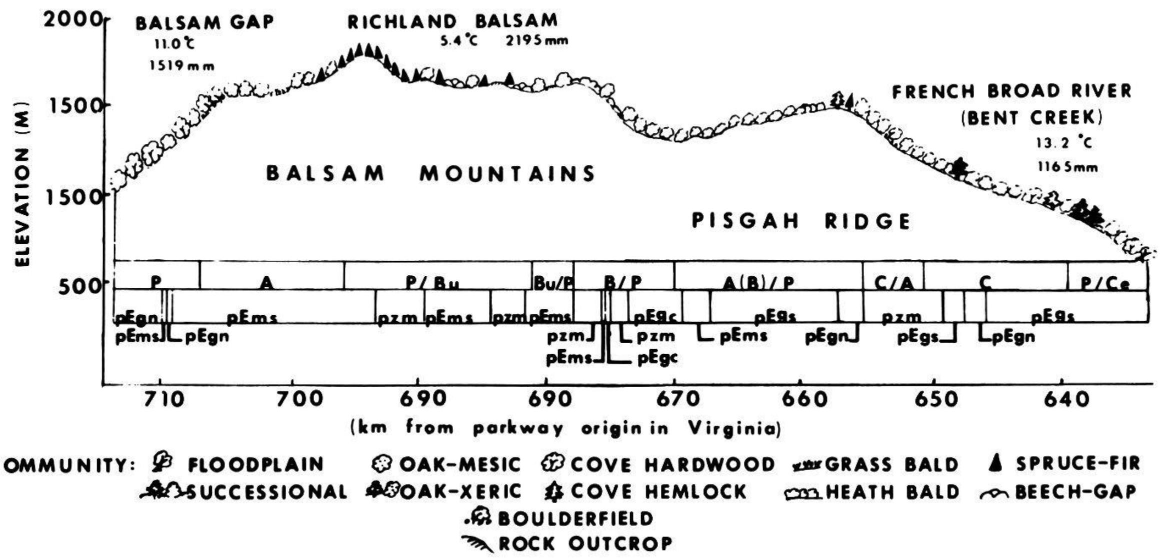

Fig. 2. Profile of the Balsam Mountains and Pisgah Ridge along the Blue Ridge Parkway between the French Broad River and Balsam Gap. Mean annual temperature and precipitation estimate are given for three locations. Soil series abbreviations are: A = Ashe, B = Brandywine, Bu = Burton, C = Chandler, Ce = Chester, P = Porters. Rock units are: pEgc = biotite schist and gneiss, pEgn = layered gneiss and magmatite, pEgs = Great Smoky group, pEms = muscovite schist and gneiss, pzm = magmatite.

Table 1. Classification and description of rock in study area (Description from HADLEY and NELSON 1971, and WINNER 1977)

Rock Unit (Class, type, geologic age)	Description
Magmatite (Igneous, intrusive, Devonian?)	Gneiss and schist containing abundant granitic and pegmatic material, probably palingenetic, in thin layers, lenses, and irregular bodies
Biotite schist and gneiss (metamorphic, foliated, Upper(?) Precambrian)	Biotite-quartz-plagioclase gneiss and schist, commonly characterized by porphyroblasts of muscovite, microline, garnet, or kyanite; locally contains sillimanite, graphite, or hornblende; commonly thinly interlayered with micaceous quartz-feldspar gneiss (metasandstone); less commonly interlayered with amphibolite and hornblende schist
Muscovite schist and gneiss (metamorphic, foliated, Upper(?) Precambrian)	Mica-quartz-plagioclase schist generally interlayered with gneissic micaceous metasandstone; schist locally graphitic and sulfidic, commonly garnetiferous and/or sillimanite bearing; locally contains hornblende-garnet granofels
Great Smoky Group, undivided (metamorphic, foliated, Upper(?) Precambrian)	Largely feldspathic metasandstone, medium to thick bedded, with interbeds of feldspathic quartz-mica schist or gray phyllite; includes local beds of quartz-feldspar pebble conglomerate, graphitic and sulfidic mica schist, and rare thin interbeds of garnet-hornblende-quartz-feldspar granofels. Metasandstone is generally more abundant and thicker bedded toward northwest.
Layered gneiss and magmatite (metamorphic/igneous, foliated/intrusive, Middle Precambrian)	Mafic and calc-alkaline magmatite gneiss and various biotite-, hornblende-, or garnet-bearing gneisses; rare muscovite schist or gneiss and very rare marble; contains abundant layers and lenses of granitic rocks; variably foliated and blastomylonitic. Includes small bodies of biotic augen gneiss locally.

localities moved from their original point of deposition. However, it is generally held that those rocks that form Mount Mitchell, and those that form most of the other side spurs and cross ranges of the southern portion of the Parkway route, such as the study area, have stayed in their original position.

The deposition of the geosynclinal sediments began in late Precambrian and extended into early Paleozoic time (probably 1 billion to 450 million years ago?). Uplift and major folding (mountain building) and metamorphism of the sediments began about 450 million years ago and ended about 330 million years ago. The bulk of rock consisted of a wide variety of gneisses (layered and unlayered), schists, and granitic gneisses representing intrusive bodies (KING 1968). Uplift accelerated stream erosion, which produced peneplanation that characterized a monotonous plain with wandering streams and high uplands to the west. It is believed that three such periods of peneplanation and uplift without folding or extensive metamorphism have taken place since the original folding (personal communication with J.L. STUCKEY).

3. Soils

The Pisgah Ridge and Balsam Range have a variety of soils. This diversity is a result of the environmental complex found along the mountainous gradient. Here soil forming factors of climate, plant and animal life, parent material, relief, and time may vary considerably from one locality to another. For hundreds of thousands of years these factors have interacted with one another to produce the soils that cover the summits, slopes, ridges, and mountain coves. Although all the above factors have been instrumental in soil formation along the gradient, one or two may have dominated the process. It seems likely that climate, physiography, and parent materials have dominated most of the time.

Associated with the natural soils are those that are "man-made". The latter have been developed through the roadway construction activity. In making numerous road cuts large masses of natural soils and comminuted bedrock have been removed. These materials are then used for fills and roadbed construction. Barren slopes and shoulders have been stabilized through planting and seeding. Boundaries of the "man-made" and natural soils are most often distinguishable in rock cuts and fills made of comminuted bedrock.

The natural soil subgroups and their associated series found along the roadway gradient are shown in Table 2. These subgroups are further depicted in their relationship to the area geology, topography, climate, and vegetation in Figure 2. In Table 2 it is shown that Humic Hapludults and Dystrochrepts are the most common soil subgroups present. However, they represent two different soil orders, the Ultisols and Inceptisols respectively. In addition, the subgroup Typic Haplumbrepts is found to dominate only at the highest elevations, i.e. above 1525 m. Table 3 makes it apparent that the soil subgroups are represented by a variety of soil series, which in turn indicates the complex pedogenesis of the Parkway soils.

Table 2. Parkway soils soubgroups/series from the French Broad River (634) to Balsam Gap (713). (Pisgah National Forest, Management Unit Soil Map, KING et al. 1974).

Kilometer Location	Subgroup	Series	(Other series included in this section)
634-639	Humic Hapludults Typic Hapludults	Porters Chester	(Ashe, Haywood, Rosman)
639-650	Typic Dystrochrepts	Chandler	(Ashe)
650-655	Typic Dystrochrepts Typic Dystrochrepts	Chandler Ashe	(Porters, Stony Land)
655-670	Typic Dystrochrepts Humic Hapludults	Ashe (Brandywine?) Porters	(Hayesville, Stony Land, Stony Colluvial Land)
670-678	Typic Dystrochrepts Humic Hapludults	Brandywine Porters	(Burton, Haywood, Stony Land, Stony Colluvial Land)
678-681	Typic Haplumbrepts Humic Hapludults	Burton Porters	(Brandywine, Haywood, Stony Land, Stony Colluvial Land, Rock Outcrop)
681-696	Humic Hapludults Typic Haplumbrepts	Porters Burton	(Stony Land, Ashe, Stony Colluvial Land)
696-707	Typic Dystrochrepts	Ashe	(Brandywine, Porters, Stony Colluvial Land)
707-713	Humic Hapludults	Porters	(Ashe, Haywood)

Most of the Parkway soils have formed from residual materials, which in turn have formed from weathering of the bedrock beneath. These parent rocks consist of granites, gneisses, and schists, which have been important factors in soil formation. For example a certain soil series may have a high mica content that has been derived from the residuum of mica gneiss or schist. The Chandler series shown in Table 2 has a micaceous surface horizon as a result of its having been formed on mica gneiss.

Natural rock colluvium and man-made rock colluvium in road fills are found in several localities, especially at the higher elevations. The former are often referred to locally as boulder fields or rock stripes, and they exhibit little weathering.

The following description of the different soil series are summarized from KING et al. (1974).

3.1. *Ashe series*

The Ashe series consist of extremely well drained, sloping to very steep soils on narrow, convex ridgetops and uneven side slopes. These soils formed under forest vegetation in residuum derived from gneiss or granite. Depth to bedrock is generally 0.76 to 1.8 m with water table below a depth of 1.5 m. In a typical profile, these soils have a fine sandy loam surface layer about 17 cm thick that is very dark grayish-brown in the upper part and brown in the lower part.The subsoil is yellowish-brown sandy loam about 45 cm thick. Below this layer to a depth of about 75 cm is yellowish-brown sandy loam mixed with weathered coarse gneiss fragments.

3.2. *Brandywine series*

The Brandywine series consists of well-drained, moderately steep to very steep soils on the higher mountains. Elevations are above 915 m. These soils formed under forest vegetation in residuum derived from gneiss. Depth to bedrock is 0.6 to 1.2 m and the seasonally high water table remains below 1.5 m. In a typical profile, these soils have a very dark grayish-brown loam surface layer about 15 cm thick. The subsoil is brown, very friable loam

Table 3. Balsam Mountains soil series description and classification (KING et al. 1974)

Series	Family	Subgroup	Order
Ashe	stony,fine,sandy,loam	Typic Dystrochrepts	Inceptisols
Brandywine	loamy,skeletal,mixed,mesic	Typic Dystrochrepts	Inceptisols
Burton	coarse,loamy,mixed,mesic	Typic Haplumbrepts	Inceptisols
Chandler	stony, loam	Typic Dystrochrepts	Inceptisols
Chester	stony,fine,sandy,loam	Typic Hapludults	Ultisols
Hayesville	clayey,oxidic,mesic	Typic Hapludults	Ultisols
Haywood	coarse,loamy,mixed,mesic	Cumulic Haplumbrepts	Inceptisols
Porters	fine,loamy,mixed,mesic	Humic Hapludults	Ultisols
Rock Ourcrops			
Stony Colluvial Land			
Stony Land			

about 35 cm thick and is about 40 percent angular coarse fragments. Below the subsoil to a depth of about 87 cm are weathered and broken fragments of rocks. The fragments are the size of gravel, cobblestones, and stones, and many of them crush easily to fine sandy loam.

3.3. *Burton series*

The Burton series consists of well-drained or moderately drained, steep to very steep soils, mostly at elevations above 1525 m. Most of these soils formed under spruce and fir forests in residuum from granite and gneiss. Depth to bedrock is 0.6 to 1 m.Depth of the seasonally high water table is 0.6 to 1.5 m for about 6 months of the year. In a typical profile, these soils have a black loam surface layer about 10 cm thick. The subsoil is about 43 cm thick and is very dark brown to brown, weakly cemented sandy loam in the upper part and yellowish-brown friable sandy loam in the lower part. Below this layer to a depth of about 70 cm is fine sandy loam containing many hard gneiss fragments.

3.4. *Chandler series*

The Chandler series consists of micaceous, extremely well drained, moderately steep to very steep soils on narrow ridgetops and side slopes, mostly on southern and western aspects. These soils formed under forest vegetation in residuum from mica gneiss. Depth to bedrock is more than 1.2 m. The seasonally high water table remains below 1.5 m. In a typical profile, these soils have a very dark brown and dark grayish-brown loam surface layer about 10 cm thick. The subsoil is yellowish-brown loam about 48 cm thick. Below this layer to a depth of more than 2 m is loam saprolite that contains many mica flakes.

3.5. *Chester series*

The Chester series consists of well-drained, sloping to steep soils on the broader ridges and smoother parts of the intermountain areas. These soils formed under forest vegetation in residuum from gneiss and granite. Depth to bedrock is more than 1.5 m. The seasonally high water table remains below a depth of 1.5 m. In a typical profile, these soils have a dark grayish-brown and yellowish-brown fine sandy loam surface layer about 10 cm thick. The subsoil is about 68 cm thick and is dominantly yellowish-red. It is clay loam in the upper part and fine sandy loam in the lower part. Below the subsoil is "strong-brown" fine sandy loam. Below this layer, to a depth of about 1.78 m is "strong-brown" fine sandy loam.

3.6. *Haywood series*

The Haywood series consists of well-drained and moderately well-drained, moderately steep to very steep soils in coves and on toe slopes. These soils formed under forest vegetation in local alluvium derived from materials on the adjoining slopes. Depth to bedrock is more than 1.5 m. Depth of seasonally high water table is more than 1.5 m. In a typical profile, these soils have a surface layer of very dark brown and very dark grayish-brown loam, about 76 cm thick, that contains stones. The next layer is yellowish-brown fine sandy loam about 50 cm thick. Below this, to a depth of about 1.4 m, is dark-brown loam.

3.7. *Porters series*

The Porters series consists of well-drained, moderately steep to steep soils on ridgetops and side slopes of the higher mountains, mostly at elevations above 1070 m. These soils formed under forest vegetation in residuum from gneiss. Depth to bedrock ranges from 0.6 to 1.8 m. The seasonally high water table remains at a depth below 1.5 m. In a typical profile, these soils have a dark-brown loam surface layer about 23 cm thick. The subsoil is dominantly brown, very friable clay loam about 50 cm thick. Below this layer, to a depth of 1.14 m is gravelly sandy loam.

5. Climate

Climatology of the study area is not well known. Although precipitation data are available from lower and intermediate elevation stations, air temperature measurements have been taken only at the lowest stations. In addition, the complex physiography and prevailing regional weather patterns combine to make the southern Appalachian region an area of diverse local climates. The reasons for the main weather types in the course of each year for North Carolina are summarized by ROBINSON (1979), this volume.

Prominent physiography of the southern Appalachian is characterized by the Blue Ridge and Great Smoky Mountains, which lie as widely spaced northeast-southwest trending chains, being interconnected by numerous cross ranges (cf. Fig. 1). The complex pattern of cross-ranges, with their associated valley coves, spurs, and gaps provide a variety of microclimatic conditions. Temperature lapse rates and precipitation gradients may vary considerably from one locality to another. The Balsam Range and its Pisgah Ridge spur are among the highest of the cross ranges. Although located near the middle of the cross-range complex, the Balsams rise high above the surrounding mountains. Because of their high orographic position they possess altitudinal

Table 4. Temperature and precipitation records for weather stations in or near study area (Balsam Range/Pisgah Ridge)

Station/localion	Elevation (m)	Mean annual temperature (°C) *	Mean annual precipitation (mm) **
In or contiguous to study area			
Asheville-Airport	652	13.2	1148
Balsam	1015	-	1519
Bent Creek	643	-	1165
Cullowhee	668	13.3	1236
Haywood Gap	1646	-	1996
Blue Ridge-Cowee Cross Range Intersection			
Highlands	1015	12.1	2019
Blue Ridge-Nantahala Cross Range Intersection			
Coweeta	1361	-	2368

* Tennessee Valley Authority (1976). ** U.S. Department of Commerce (1973).

climatic zones similar to the Smoky and Roan Mountains.

Aside from the TENNESSEE VALLEY AUTHORITY'S (1976) precipitation measurements, no detailed climatological studies have been made of the Balsam Mountains. However, altitudinal temperature and precipitation rates can be extrapolated as approximates from nearby stations where both parameters have been recorded for several years. The temperature and precipitation measurements shown in Figure 2 were derived from the station data shown in Table 4, and the temperature lapse rate from the data shown in Table 5.

Temperature lapse rate for the Balsam/Pisgah Ridge area was determined by the following method:

	Mean temp.	Altitude
Mt. Mitchell	6.1°C	2023 m
Asheville Weather Bureau	13.7°C	672 m
Difference	7.6°C (13.7°F)	1351 m (4432 ft.)

Thus the lapse rate is approximately 0.6°C per 100 m.

Extrapolation of precipitation for Richland Balsam was accomplished

Table 5. Comparative climatological data for Asheville (elev. 672 m) and Mt. Mitchell (2023 m). Station Data for 26 years (1931-1956). Data from MARK (1958) and SCHWARZKOPF (1974).

Month		Mean temperature (°C)			
		Asheville		Mt. Mitchell	
		Daily Maximum	Daily Minumum	Daily Maximum	Daily Minimum
January		9.7	-0.6	2.2	-6.3
February		10.4	-0.7	2.0	-7.1
March		14.3	2.2	4.6	-4.9
April		19.7	6.8	9.7	-0.2
May		24.6	11.3	14.8	4.8
June		28.4	15.7	18.4	9.4
July		29.5	17.6	19.3	10.9
August		27.2	17.1	18.8	10.6
September		26.1	13.7	16.8	8.0
October		20.9	7.2	12.6	3.1
November		14.1	1.8	6.1	-3.1
December		9.1	-0.8	2.8	-5.0
	Year	19.7	7.7	10.6	1.7
	(°F)	67.5	45.8	51.1	35.0

in a similar manner. Mean annual precipitation of the lower stations at Cullowhee, Balsam, and Bent Creek were compared with the high elevation station at the rate of 78.6 mm/100 m (= 9.44 inches/1000 ft.).

In contrast to the Mt. Mitchell lapse rate of 0.6°C/100 m, SHANK (1954) found the rate to be 0.4°C/100 m (= 2.23°F/1000 ft.) for the Great Smoky Mountain area. In addition the mean annual precipitation of several nearby cross range stations also revealed anomalous patterns. In Table 4 it is shown that the Highlands station (1015 m), which is located near the intersection of Blue Ridge and Cowee cross range, has a mean annual precipitation of 2019 mm. In contrast, the Balsam station, at the same elevation (1015 m) in the Balsam Range and 45 km away, records only 1519 mm. Also, just 25 km west of the Highland station, the Coweeta station (1361 m), which is on the Nantahala cross range, reports 2368 mm.

The dumping of high precipitation on these nearby, lower elevations is primarily the result of moisture laden southerly winds being forced up and over the mountainous barriers south of the Balsam Range. This region has the highest rainfall in eastern U.S. However, less than 80 km to the north and across the Balsam Range, the French Broad River Valley is the driest point south of Virginia and east of the Mississippi River. The average here is only 940 mm (U.S. DEPT. OF COMMERCE 1976).

Temperature and precipitation gradients along the Balsam Range reveal a variety of climate zones. In Figure 2 one can see the changes from a temperate, humid climate at the lowest elevation, to a moderately cool, humid climate at the mid-elevation, on to a moderately cold, high humid climate at the highest elevations.

There seems to be no distinct wet or dry season on the Balsam Range, although a drop in rainfall occurs during autumn. The precipitation, at least above 1370 m, is evenly distributed throughout the year, and from approximately 1100 m and up the monthly precipitation in over 100 mm.

Winter and spring precipitation results from migratory lows, pressure storms, and cold fronts passing from the northwest. During these times, snow may accumulate to approximately 1300 mm at the highest elevations. Winds prevail throughout the year from the northwest, and flag trees exhibiting this pattern are common on the exposed bluffs and summits.

The various vegetation types of the Balsam Range tend to correlate more closely with the zonal climate than any other ecological factor.

5. Vegetation

In many respects, the brief trip between Asheville and Richland Balsam along the Blue Ridge Parkway over a 61 km distance is equivalent to a trip from piedmont North Carolina to the Maine coast in New England, a distance approaching 1300 km. The piedmont-like Asheville-Hendersonville Basin is low relief hills and broad floodplain valleys. *Betula nigra*, an indicator species of moist soils, disappears quickly as the extensive oak forests of the slopes are encountered, and these oak forests, except for occasional cove forests of valleys and ravines, grade into spruce-fir forests capping these high Appalachian mountains. Several communities were noted during the course

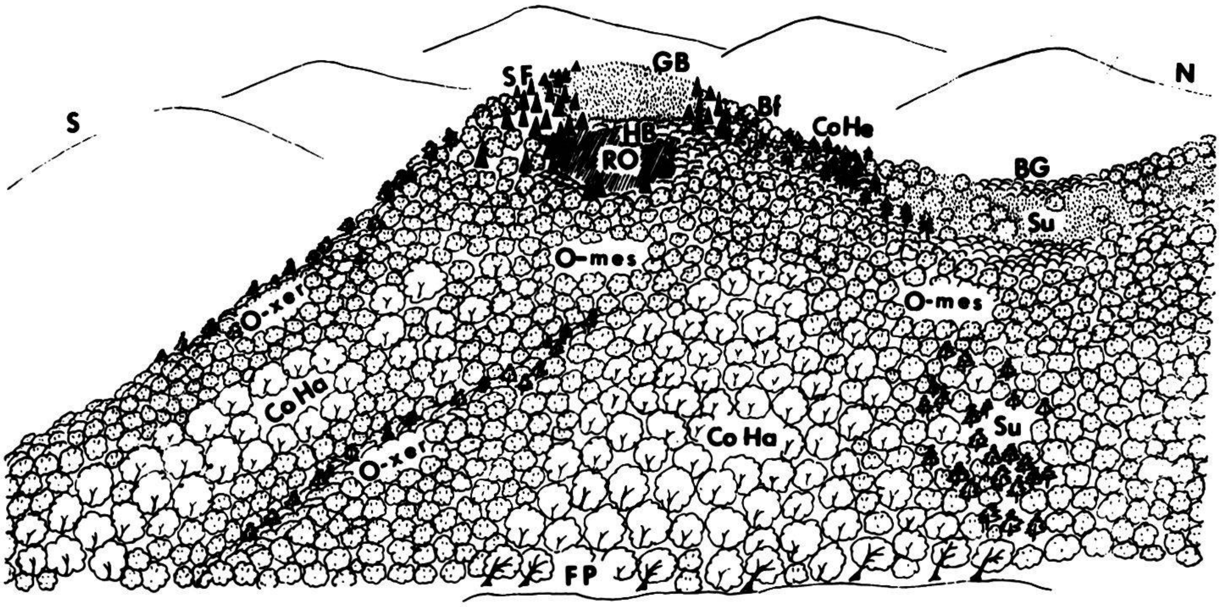

Figure 3. Idealized peak at the junction of the Balsam Mountains and Pisgah Ridge showing the relations of communities with aspect and elevation. Abbreviations are as follows: Bf = boulder field, BG = beech gap, CoHa = cove hardwoods, CoHe = cove hemlock, FP = flood plain, GB = grass bald, HB = heath bald, O-mes = mesic oak, O-xer = xeric oak, RO = rock outcrop, SF = spruce-fir, and Su = successional.

of this study. The following groupings will suffice to help conceptualize the vegetation of the Balsams:1) Floodplain, 2) oak-xeric and mesic, 3)cove-hardwood and hemlock, 4) boulder field, 5) rock outcrop, 6) bald-grass and heath, 7) spruce-fir, 8) beech gap, and 9) successional communities. These are diagrammed in Figure 3 on an imaginary face at the junction of the Balsams and Pisgah Ridge.

5.1. *Methods*

Forest vegetation relevés of the Balsam Mountains were taken at 92.5 m elevational intervals from 10 x 10 m plots. Strata heights were estimated and all species from each level were tallied using Braun-Blanquet coverage values. This allowed a sufficient number of samples (27) to give the basic vegetation description. Along the flatter ridge-tops sampling was not by the elevational interval, but rather in the varied community types. A total of nine sites were classified as mesic oak, five sites as xeric oak, five as spruce-fir, three as cove hardwood, two as boulder field, and one each as floodplain, cove hemlock, or successional sites.

Relative coverage and frequency estimates were determined from the data. Average values for each site were determined from field relevés, using class midpoints similar to values of MUELLER-DOMBOIS and ELLENBERG (1974 p. 63), as follows:

Braun-Blanquet Value	Range of coverage (percent)	Midpoint coverage (percent)
5	75-100	87.5
4	50- 75	62.5
3	25- 50	37.5
2	5- 25	15.0
1,+,r	<5	2.5

The summed values from all strata of the site were divided by the number of strata in which the species would be expected or was observed (dominant trees were divided by all strata from herbs up, for example). The sum of these values were then divided by the total coverage sum of all species for the community type to obtain relative coverage. Relative frequency values were generated for community types with over two samples. Using *Picea rubens* as an example, it occurs in all five plots (number 10 through 14) with relevés as follows:

Plot Number	Stratum 6	5	4	3	2	1	Total No. of strata	Sum/Total No. of strata
10	2	2	+				6	5.41
11	3						4	9.38
12	2						3	5.00
13		2	+				4	4.37
14	2		2	+	+		6	5.83

This example for the spruce-fir community, the sum of all plots (29.9) divided by the sum for all species (106,3) gives the relative coverage 35.5.

Original data are deposited in the Archives at Western Carolina University and can be obtained by request. Nomenclature generally follows RADFORD, AHLES, and BELL (1968). Nomenclature for *Betula alleghaniensis* follows HARDIN (1971).

Table 6. Relative coverage estimates for trees of the Balsam Mountains along the Blue Ridge Parkway

Species	Community*							
		Oak		Cove				
	FP	Xer	Mes	Ha	He	Bf	SF	Su
Abies fraseri							43.2	
Acer pensylvanicum			3.4	0.5		21.5	0.4	
A. rubrum		4.9	8.2	3.4	2.3	1.3	1.0	4.3
A. saccharum				19.4				
A. spicatum						16.6	4.7	
Aesculus octandra				16.2			1.9	
Amelanchier arborea		1.8	3.1			1.3	0.4	
Betula alleghaniensis			7.4		2.3	54.6	4.3	
B. lenta		0.4	0.4	0.5				
B. nigra	8.1							
Carpinus caroliniana	9.5			0.6				
Carya cordiformis				1.0				
C. glabra	8.1	2.9	0.4					1.3
C. ovata				2.9				
C. tomentosa		2.1						
Castanea dentata		1.8	4.7	0.9				
Cornus florida	1.8	3.5		21.1				49.5
C. alternifolia							2.6	
Crataegus flabellata						0.9		
Diospyros virginiana		0.7						
Fagus grandifolia			1.7				2.4	2.5
Fraxinus americana			0.3	0.5		1.3		
Halesia carolina	13.1		1.2					
Hamamelis virginiana			1.0					
Ilex ambigua v. montana	1.8		1.7	2.4			0.6	
I. opaca								2.6
Juglans nigra		2.9						
Liriodendron tulipifera	15.4	0.7		18.7				29.4
Magnolia acuminata	1.8		0.2					
Malus coronaria	1.8							
Morus rubra	1.8							
Nyssa sylvatica		10.4		0.5				1.3
Oxydendrum arboreum		0.4	1.7					
Picea rubens					14.0		35.5	
Pinus rigida		3.3						
P. virginiana		0.4						6.9
Platanus occidentalis	24.4							
Prunus pensylvanica		0.2					1.2	
P. serotina	5.9	0.3	0.7	0.5				1.3
Quercus alba		24.6	2.3	2.4				
Q. alba x prinus			0.3					
Q. coccinea		0.7						
Q. muehlenbergii	1.8							
Q. prinus		12.2	5.1	7.3				
Q. rubra		4.6	48.3	0.5		1.3		
Q. velutina	2.7	7.1						2.0
Robiana pseudo-acacia		1.4	0.8	0.5				
Sassafras albidum	1.8	2.0	1.3	0.5				1.3
Sorbus americana							4.5	
Tilia heterophylla						1.3		
Tsuga canadensis					81.4			

* Bf = boulder field Ha = cove hardwood Mes = mesic oak SF = spruce fir
FP = floodplain He = cove hemlock Xer = xeric oak Su = successional

Table 7. Relative frequency of trees of the Balsam Mountains along the Blue Ridge Parkway

Species	Community*				
	Oak		Cove		
	Xer	Mes	Ha	Bf	SF
Abies fraseri					14.8
Acer pansylvanicum		6.7	3.4	7.1	3.7
A. rubrum	9.8	10.3	7.0	7.1	
A. saccharum			7.0		
A. spicatum				14.3	7.4
Aesculus octandra			3.4		3.9
Amelanchier arborea	2.0	6.7		7.1	3.7
Betula alleghaniensis		6.7		14.3	11.0
B. lenta		3.4	3.4		
Carpinus caroliniana			3.4		
Carya cordiformis			7.0		
C. glabra	5.9	3.4	3.4		
C. ovata			3.4		
C. tomentosa	3.9				
Castanea dentata	2.0	8.6	7.0		
Cornus florida	3.9		7.0		
C. alternifolia					7.4
Crataegus flabellata				7.1	
Diospyros virginiana	3.9				
Fagus grandifolia		3.4			
Fraxinus americana	2.0	1.7	7.4	7.1	
Halesia carolina		5.1			
Ilex ambigua v. montana		3.4	3.4		3.7
Juglans nigra	2.0				
Liriodendron tulipifera	2.0		7.0		
Magnolia acuminata			3.4		
Nyssa sylvatica	2.0		3.4		
Oxydendrum arboreum	7.8	3.4			
Picea rubens					18.5
Pinus rigida	3.9				
P. virginiana	2.0				
Prunus pensylvanica				7.1	11.1
P. serotina	2.0	5.1	3.4		
Quercus alba	5.4	1.7	3.4		
Q. alba x prinus		1.7			
Q. coccinea	3.9				
Q. prinus	7.8	3.4	3.4		
Q. rubra	5.9	15.3	3.4	7.1	
Q. velutina	9.8				
Robinia pseudo-acacia	5.9	5.1	3.4	7.1	
Sassafras albidum	7.8	6.7	3.4	7.1	
Sorbus americana					11.1
Tilia heterophylla				7.1	
Tsuga canadensis			3.4		

* Bf = boulder field Mes = mesic oak SF = spruce-fir
Ha = cove hardwood Xer = xeric oak

Table 8. Relative coverage estimates for shrubs of the Balsam Mountains along the Blue Ridge Parkway

Species	Community*							
		Oak		Cove				
	FP	Xer	Mes	Ha	He	Bf	SF	Su
Calycanthus floridus v. laevigatus				8.4				
Castanea pumila		2.0						100.0
Cornus amomum	26.9							
E onymus americanus	26.9							
Gaylussacia baccata		7.8						
G. ursina			8.6					
Hydrangea arborescens				50.0			2.8	
Kalmia latifolia		83.4	77.0					
Leucothoe recurva			0.02					
Ligustrum sinense	23.1							
Lindera benzoin	23.1							
Menziesia pilosa			0.02					
Rhododendron calendulaceum		2.6	5.4	41.6				
R. maximum					100.0			
Ribes glandulosum						100.0		
Ribes sp.							3.8	
Rubus argutus		2.1						
R. canadensis			2.5				29.6	
Rubus sp.			0.6					
Sambucus pubens							0.8	
Vaccinium constablaei			1.6					
V. erythrocarpum			0.02				15.5	
V. stamineum		0.9						
V. vacillans		1.0						
Viburnum acerifolium			0.8					
V. alnifolium							31.5	
V. cassinoides							8.0	

* Bf = boulder field Mes = mesic oak Ha = cove hardwood SF = spruce fir
FP = floodplain Xer = xeric oak He = cove hemlock Su = successional

Table 9. Relative frequency of shrubs of the Balsam Mountains along the Blue Ridge Parkway

Species	Community				
	Oak		Cove		
	Xer	Mes	Ha	BF	SF
Calycanthus laevigatus v. fertilis			25.0		
Castanea pumila	18.8				
Gaylussacia baccata	6.3				
G. ursina		5.0			
Hydrangea arborescens			25.0		6.7
Kalmia latifolia	25.0	19.9			
Leucothoe recurva		5.0			
Menziesia pilosa		5.0			
Rhododendron calendulaceum	6.3	25.3	25.0		
R. maximum		10.0			
Ribes glandulosum				50.0	
Ribes sp.					6.7
Rubus argutus	6.3				
R. canadensis		5.0			
Rubus sp.		14.9			
Sambucus pubens					6.7
Vaccinium constablaei		5.0			
V. erythrocarpum					20.0
V. stamineum	12.5				
V. vacillans	25.0				
Viburnum acerifolium			25.0		
V. alnifolium					20.0
V. cassinoides					6.7

* Bf = boulder field   Mes = mesic oak   SF = spruce fir
Ha = cove hardwood   Xer = xeric oak

mesic type; note *Cimicifuga* is overwhelmingly dominant in the xeric type. This high diversity was noted for the Balsams in GOVUS' (1976) study of the *Quercus rubra* var. *borealis* "oak orchard" community, a community of dwarfed and widely spaced trees in the high elevations. He suggested the more open character of the community, allowing greater sunlight penetration to the herb layer, permitted the higher diversity he observed.

5.2. *Results*

5.2.1. *Floodplain woodlands* (elevation 610-612 m)

The lowest elevation of the study (610 m) is occupied by a second growth, floodplain woodland. Dominants indicated in Table 6 are *Platanus occidentalis*, *Liriodendron tulipifera*, and *Halesia carolina*. *Betula nigra*, especially indicative of successional floodplains according to OOSTING (1942), is present but is dominated by *Liriodendron* and *Halesia* species that probably seeded into this side from nearby cove forests. The shrub level is occupied by four species (see Table 8) of about equal values, *Cornus amomum* being more indicative of lowlands while *Ligustrum sinense* is introduced. Overwhelming the vines is the introduced *Lonicera japonica*. This species essentially covers the ground surface but surprisingly does not exclude several herbaceous species (Table 12), although their coverage is probably considerably reduced.

5.2.2. *Oak forests* (elevation 610-1600 m)

As BRAUN (1964) and others have indicated as typical for the region, oak forests cover most of the area of the Balsams. On the drier ridges and south slopes where soils are usually shallow, *Quercus alba*, *Q. prinus*, and *Nyssa sylvatica* dominate (Table 6). Additionally *Q. coccinea*, *Q. velutina*, *Carya* ssp., and *Pinus* spp. are present; these are also indicated as components of this community type and might be called the xeric oak forest (similar to Braun's "oak-pine communities"). The mesic oak forest occupying the deeper soiled, upper slopes, and the more northerly aspects is dominated by *Quercus rubra* (Table 6). *Acer rubrum* could be considered as the subdominant here.

Some succinct differences of shrub and herb layers are noted for the respective xeric and mesic oak types. *Kalmia latifolia* is the dominant in both types (Tables 8 and 9), while subdominants for the xeric type include *Gaylussacia baccata* and *Vaccinium vacillans*, the latter most frequent. In the mesic type, *G. ursina*, *Rhododendron calendulaceum*, and *Rubus* spp. show increased subdominant roles. The number of species in the herb layer is higher for the mesic type. Likewise, the dominance is more evenly distributed in the

5.2.3. *Cove forests* (elevation 610-1350 m)

One of the characteristics of the cove forests is their higher number of dominant tree species (BRAUN 1964). This is supported by the data for cove hardwoods here, with (in decreasing dominance values) *Cornus florida, Acer saccharum, Liriodendron tulipifera, Aesculus octandra, Quercus prinus,* and *Acer rubrum.* Other species listed by Braun for the cove hardwoods are also found here: *Acer pensylvanicum, Betula lenta, Carya cordiformis, Castanea dentata, Fagus grandifolia, Fraxinus americana, Quercus alba, Q. prinus,* and *Q. rubra.* Some of the cove hardwoods were practically void of shrubs and considering the three species present, *Hydrangea arborescens, Rhododendron calendulaceum,* and *Calycanthus floridus* var. *laevigatus*, the former two species make up over 90 percent of the shrub layer. Likewise only a few vines contribute to the structure of the cove hardwoods. Second to extensiveness of coverage of the tree layer is the herbs, with many species but none have either an outstanding dominance or frequency (Table 12-17).

The cove hemlock forest, on the other hand, is rather different from the cove hardwoods. Few species make up this forest. *Tsuga canadensis* overwhelmingly dominates the trees, with *Picea rubens, Betula alleghaniensis,* and *Acer rubrum* for the single site (Table 6). Likewise the shrub layer is completely covered with *Rhododendron maximum.* Only one herb was noted in a small area where *Rhododendron* was more widely spaced.

5.2.4. *Boulder fields* (elevation 1300-1500 m)

At the head of some coves in the higher elevations, periglacial boulder fields occur (MICHALEK 1968, KING 1964). These boulders, usually 0.25 to over a meter in diameter, are covered with moss mats, especially *Hylocomium* sp. *Betula alleghaniensis* is well adapted for establishment and maturation in such elevated substrates and thus dominates this site. Dominants of the understory trees here include *Acer pensylvanicum* and *A. spicatum* (Tables 6 and 7). *Ribes glandulosum* represents the dominant straggling shrubs; *Aristolochia macrophylla*, the vine (Tables 10 and 11). Only a few herbaceous species are capable of existing in these very thin humid soil mats (Tables 12-17).

Table 10. Relative coverage estimates for vines of the Balsam Mountains along the Blue Ridge Parkway

Species	Community *					
		Oak		Cove		
	FP	Xer	Mes	Ha	Bf	Su
Apios americana		6.3	6.9	8.3		
Aristolochia macrophylla			12.5	10.o	100.0	
Celàstrus orbiculatus	14.9	5.1				20.0
Convolvulus sp.		5.1				
Cuscuta rostrata			8.3			
Dioscorea villosa		12.7	19.4			
Lonicera japonica	66.3					
Parthenocissus quinquefolia	11.1	5.1				20.0
Rhus radicans						20.0
Rubus flagellaris		26.6				20.0
Smilax glauca	1.9	23.4	11.1			
S. herbacea			13.9			
S. hispida	1.9					
S. rotundifolia	1.9	5.1	27.9	40.8		
Vitis aestivalis v. aestivalis		10.8				20.0
V. aestivalis v. argentifolia				40.8		
V. riparia	1.9					

Table 11. Relative frequency of vines of the Balsam Mountains along the Blue Ridge Parkway

Species	Community *			
	Oak		Cove	
	Xer	Mes	Ha	Bf
Apios americana		6.7	20.0	
Aristolochia macrophylla		13.3	20.0	50.0
Celastrus orbiculatus	10.0			
Convolvulus sp.	10.0			
Cuscuta pentagona		6.7		
Dioscorea villosa	20.0	20.0		
Parthenocissus quinquefolia	10.0		20.0	
Rubus flagellaris	10.0			
Smilax glauca	30.0	13.3		
S. herbacea		20.0		
S. rotundifolia	10.0	20.0	20.0	
Vitis aestivalis v. argentifolia			33.0	

* Bf = boulder field Mes = mesic oak Ha = cove hardwood
FP = floodplain Xer = xeric oak Su = successional

Table 12. Relative coverage estimates of forbs of the Balsam Mountains along the Blue Ridge Parkway

Species	Community *							
		Oak		Cove				
	FP	Xer	Mes	Ha	He	Bf	SF	Su
Achillea millefolium			0.8					
Amianthium muscaetoxicum			1.6					
Angelica triquinata			0.8					
Antennaria solitaria	7.7			1.8				
Arisaema triphyllum						24.3	1.7	
Asarum canadense				1.8				
Aster acuminatus			4.8			12.6	33.0	
A. cordifolius				1.8				
A. curtisii		1.0	0.8					
A. divaricatus		1.0	3.2	3.7			2.5	
A. lateriflorus		2.0						
A. macrophyllus				1.8			0.8	
A. patens		2.0						25.0
A. undulatus			1.6					
Aster sp.			1.6	1.8				
Aureolaria laevigata			0.8	1.8				
Cacalia atriplicifolia		1.0	0.8	1.8				
Campanula divaricata		1.0	1.6	1.8				
Caulophyllum thalictroides				1.8				
Chimaphila maculata		5.0						
Cimicifuga americana				1.8				
C. racemosa		46.3		3.7			13.2	
Circaea alpina							0.8	
Clintonia umbellulata			1.6					
Collinsonia canadensis		1.0	0.8	1.8				
Commelina communis	7.7							
Conopholis americana			0.8					
Corallorhiza wisteriana								25.0
Coreopsis major v. stellata		2.0						
Crepis sp.				1.8				
Cypripedium calceolus		1.0						
Desmodium sp.		1.0		3.7				25.0
D. glutinosum		2.0						
D. paniculatum		2.0						
Disporum lanuginosum				1.8				
Epigaea repens			0.8					
Erigeron pulchellus		1.0		1.8				
Eupatorium purpureum			0.8	1.8			0.8	
E. rugosum		2.0	3.2	1.8		12.6		
Fragaria virginiana			0.8					
Galax aphylla			5.5					
Galium aparine	7.7							
G. latifolium		3.0	2.4	3.7				
Gentiana decora			2.4	1.8				
G. quinquefolia				1.8				
Gillenia trifoliata			0.8					
Goodyera pubescens		2.0	0.8					
Helianthus sp.		2.0		1.8				
Heuchera americana		1.0						
H. villosa						12.6		

* Bf = boulder field Mes = mesic oak Ha = cove hardwood SF = spruce fir
FP = floodplain Xer = xeric oak He = cove hemlock Su = successional

Table 12, cont.

Species	Community*							
		Oak		Cove				
	FP	Xer	Mes	Har	Hem	Bf	SF	Su
Hieracium paniculatum			1.6			12.6		
Houstonia purpurea		1.0	1.6	1.8		12.6		
H. serpyllifolia			1.6					
Hydrophyllum canadense				1.8				
Impatiens pallida				1.8				
Iris cristata			0.8					
Laportea canadensis			4.8	1.8			0.8	
Lobelia puberula		1.0						
Lysimachia quadrifolia		1.0	4.0	1.8				
Medeola virginiana				1.8				
Melampyrum lineare		1.0	1.6					
Monarda sp.			1.6					
Monotropa hypopithys		1.0						
M. uniflora			0.8				0.8	
Oxalis sp.				1.8			0.8	
O. acetosella							41.3	
O. stricta	7.7							
Pedicularis canadensis			2.4	1.8				
Phlox carolina			1.6					
Polygonatum biflorum	7.7	1.0						
P. pubescens				1.8				
Potentilla sp.			2.4					
P. canadensis		1.0						
P. simplex	7.7	2.0						
Prenanthes sp.				3.7				
P. trifoliolata			2.4					
Prunella vulgaris			1.6	1.8				
Pycnanthemum sp.			1.6	1.8				
P. incanum				1.8				
P. montanum		1.0	0.8					
Rudbeckia laciniata	7.7		0.8					
Sanguinaria canadensis				1.8				
Sanicula sp.	7.7			1.8				
Senecio aureus	7.7		0.8					
Silene stellata		1.0	0.8					
Smilacina racemosa		2.0	2.4	3.7				
Solidago sp.		1.0	1.6	3.7				
S. bicolor			1.6	1.8				
S. curtisii		3.0	8.6	1.8				
S. flexicaulis			4.0					
S. glomerata							0.8	
S. uliginosa	7.7							
Stellaria corei							0.8	
S. pubera		1.0	0.8					
Thalictrum sp.				3.7				
Tiarella cordifolia			0.8					
Tovara virginiana	7.7							
Tradescantia subaspera		1.0						
Trillium erectum				1.8				
Uvularia sessilifolia		2.0	2.4	1.8				25.0
Veratrum parviflorum							1.7	
Verbesina alternifolia	7.7							
Viola sp.	7.7		4.0					
V. blanda					100.0	12.6		
V. rotundifolia			0.8	1.8				
Zizia trifoliata								

Table 13. Relative frequency of forbs of the Balsam Mountains along the Blue Ridge Parkway

Species	Community *				
	Oak		Cove		
	Xer	Mes	Ha	Bf	SF
Achillea millefolium		1.1			
Amianthium muscaetoxicum		2.2			
Angelica triquinata		1.1			
Antennaria solitaria			2.0		
Arisaema triphyllum				25.0	9.5
Asarum canadense			2.0	12.5	19.0
Aster acuminatus		2.2			
A. cordifolius					
A. curtisii	3.8				
A. divaricatus		4.4	4.0	12.5	14.3
A. lateriflorus	3.8				
A. macrophyllus		1.1	2.0		
A. patens	3.8				
A. undulatus		2.2			
Aster sp.		1.1	2.0		
Aureolaria laevigata		1.1	2.0		
Cacalia atriplicifolia	1.9	1.1	2.0		
Campanula divaricata	1.9	2.2	2.0		
Caulophyllum thalictroides			2.0		
Chimaphila maculata	5.8	1.1			
Cimicifuga americana			2.0		
C. racemosa	1.9		4.0		9.5
Circaea alpina					4.8
Clintonia umbellulata		2.2			
Collinsonia canadensis	1.9	1.1	2.0		
Conopholis americana		1.1			
Coreopsis major v. stellata	3.8				
Crepis sp.			2.0		
Cypripedium calceolus	1.9				
Desmodium sp.	1.9		4.0		
D. glutinosum	3.8				
D. paniculatum	3.8				
Disporum lanuginosum			2.0		
Epigaea repens		1.1			
Erigeron pulchellus	1.9		2.0		4.8
Eupatorium purpureum		1.1	2.0		
E. rugosum	3.8	4.4	2.0		9.5
Fragaria virginiana					
Galax aphylla			2.0		
Galium latifolium	5.8	3.3	4.0		
Gentiana decora		3.3	4.0		
G. quinquefolia			2.0		
Gillenia trifoliata		1.1			
Goodyera pubescens	3.8	2.2			
Helianthus sp.	3.8	2.0			
Heuchera americana					
H. villosa		1.1			
Hieracium paniculatum	1.9	3.3			
Houstonia purpurea	1.9	2.2	2.0		
H. serpyllifolia		2.2			
Hydrophyllum canadense			2.0		

Species	Community *				
	Oak		Cove		
	Xer	Mes	Ha	Bf	SF
Impatiens pallida			2.0		
Iris cristata		1.1			
Laportea canadensis		1.1	2.0		4.8
Lobelia puberula	1.9				
Lysimachia quadrifolia	1.9	5.6	2.0		
Medeola virginiana			2.0		
Melampyrum lineare	1.9	2.2			
Monarda sp.		2.2			
Monotropa hypopithys	1.9				
M. uniflora		1.1		12.5	
Oxalis sp.		1.1	2.0		4.8
O. acetosella				12.5	9.5
Pedicularis canadensis		3.3	2.0		
Phlox carolina		2.2			
Polygonatum biflorum	1.9				
P. pubescens			2.0		
Potentilla sp.		3.3			
P. canadensis	1.9				
P. simplex	1.9				
Prenanthes sp.			2.0		
P. trifoliolata	1.9	3.3			
Prunella vulgaris		2.2	2.0		
Pycnanthemum sp.		2.2	2.0		
P. incanum			2.0		
P. montanum	1.9	1.1			
Rudbeckia laciniata		1.1			
Sanguinaria canadensis			2.0		
Sanicula sp.			2.0		
Senecio aureus		1.1			
Silene stellata	1.9	1.1			
Smilacina racemosa	3.8	3.3	4.0		
Solidago sp.	1.9	2.2	4.0		
S. bicolor		2.2	2.0		
S. curtisii	5.8	7.8	2.0		
S. flexicaulis		1.1			
S. glomerata					4.8
Stellaria corei					4.8
S. pubera	1.9	1.1			
Thalictrum sp.	1.9		4.0		
Tiarella cordifolia		1.1			
Tradescantia subaspera	1.9				
Trillium erectum			2.0		
Uvularia sessilifolia			1.6		
Veratrum parviflorum			2.2		
Verbesina alternifolia					
Viola sp.		5.1	1.6		
V. blanda				25.0	
V. rotundifolia		1.8	1.6		
Zizia trifoliata	1.6				

* Bf = boulder field Mes = mesic oak Sf = spruce fir
Ha = cove hardwood Xer = xeric oak

Table 14. Relative coverage of grasses, sedges and rushes of the Balsam Mountains along the Blue Ridge Parkway

Species	Community *						
		Oak		Cove			
	FP	Xer	Mes	Ha	Bf	SF	Su
Agrostis sp.		6.7	2.8	33.0			50.0
Andropogon virginicus		13.3					
Brachyelytrum erectum		6.7					
Carex sp.	33.0	13.3	4.2				50.0
C. aestivalis					100.0		
C. brunnescens						50.0	
C. intumescens						50.0	
C. pensylvanica			86.2				
Danthonia sericea		6.7					
D. spicata			1.4				
Luzula acuminata			1.4				
Microstegium vimineum	33.0						
Panicum sp.		13.3		33.0			
P. boscii		20.0	2.8	33.0			
P. dichotomiflorum		13.3					
Poa sp.			1.4				
Unknown grass sp.	33.0	6.7					

Table 15. Relative coverage of ferns and fern allies of the Balsam Mountains along the Blue Ridge Parkway

Species	Community *						
		Oak		Cove			
	FP	Xer	Mes	Ha	Bf	SF	Su
Adiantum pedatum			3.5	11.0		36.4	
Athyrium asplenioides							20.0
Botrychium alabamense							20.0
B. dissectum	50.0						
B. virginianum	50.0						20.0
Cystopteris protrusa					25.5		
Dennstaedtia punctilobula			7.0		25.5	9.1	
Dryopteris campyloptera						9.1	
D. goldiana				11.0			
D. intermedia			3.5	11.0		45.5	
D. marginalis			3.5				
Lycopodium lucidulum							20.0
Polypodium virginianum					49.0		
Polystichum acrostichoides			3.5				
Pteridium aquilinum		100.0	7.0				20.0
Thelypteris hexagonoptera				55.9			
T. novaboracensis			72.1	11.0			

* Bf = boulder field Mes = mesic oak Ha = cove hardwood SF = spruce fir
FP = floodplain Xer = xeric oak Su = successional

Table 16. Relative frequency of grasses,sedges and rushes of the Balsam Mountains along the Blue Ridge Parkway

Species	Community *				
	Oak		Cove		
	Xer	Mes	Ha	Bf	SF
Agrostis sp.	6.3	16.7	33.3		
Andropogon virginicus	12.5				
Brachylytrum erectum	6.3	25.0			
Carex sp.	12.5				
C. aestivalis				100.0	
C. brunnescens					50.0
C. intumescens					50.0
C. pensylvania		16.7			
Danthonia sericea	6.3				
D. spicata		8.3			
Luzula acuminata		8.3			
Panicum sp.	12.5		33.3		
P. boscii	18.8	16.7	33.3		
P. dichotomiflorum	12.5	8.3			
Poa sp.	6.3				
Unknown grass	6.3				

Table 17. Relative frequency of ferns and fern allies of the Balsam Mountains along the Blue Ridge Parkway

Species	Community *				
	Oak		Cove		
	Xer	Mes	Ha	Bf	SF
Adiantum pedatum		11.0	16.7		
Athyrium asplenioides					33.3
Cystopteris protrusa				20.0	
Dennstaedtia punctilobula		11.0		20.0	25.0
Dryopteris campyloptera					25.0
D. goldiana			16.7		
D. intermedia			16.7	20.0	8.3
D. marginalis			16.7		
Polypodium virginianum		11.0		40.0	8.3
Polystichum acrostichoides		11.0			
Pteridium aquilinum	100.0	22.0			
Thelypteris hexagonoptera			16.7		
T. novaboracensis		33.0	16.7		

* Bf = boulder field Mes = mesic oak SF = spruce fir
Ha = cove hardwood Xer = xeric oak

5.2.5. *Spruce-fir forest* (elevations 1600-1830 m)

At the highest elevation (normally above 1600 m) forests are dominated by *Picea rubens* and *Abies fraseri* (see Tables 6 and 7). Subdominants include *Betula alleghaniensis* and *Sorbus americana*. *Acer spicatum* often dominates the understory trees. Shrubs include *Viburnum alnifolium*, *Rubus canadensis*, and *Vaccinium erythrocarpum* predominately with lower contributions from four other species (Tables 8 and 9). Herbs are relatively few in the dark shade of the evergreen conifers. Notable forbs are *Oxalis acetosella* *Aster acuminatus*; notable ferns are *Dryopteris intermedia* and *Athyrium asplenoides*; two common sedges are *Carex brunnescens* and *C. intumescens* (Tables 12-17).

5.2.6. *Successional woodlands* (various elevations)

Most sites sampled along the Parkway were either not disturbed enough to alter their composition or have progressed in succession such that they could be categorized into the above community types. One site (Table 6), however, was not successionally mature enough to be typed and was designated a secondary community. It is dominated by *Cornus florida* and *Liriodendron tulipifera* with the presence of successional *Pinus virginiana*, *Sassafras albidum*, and perhaps *Prunus serotina*. The paucity of shrubs (Table 8) and herbs (Table 12, 13, and 15) is contrasted by the presence of several vines (Table 10).

5.3. *Discussion*

The vegetative groupings in this study are of a broad nature. In this respect they are similar to that of E. Lucy BRAUN'S (1964) listing "types of communities", rather than a somewhat more defined organization as that of Robert WHITTAKER (1956) or the "community class" and "community type" of Al RADFORD (RADFORD and PITTILLO 1977). The more detailed approach with better defined community types (sensu RADFORD) awaits a more complete study of the communities of the Balsams.

5.3.1. *Floodplain woodland*

The presence of successional *Betula nigra* is indicative that this area is likely to have compositional changes over the next few decades. Conspicuously absent for the site is *Salix* spp., especially *S. nigra* and *S. sericea* for our area. *Alnus serrulata* would also be expected here. Probably the floodplain will tend to become cove-like in time (as suggested by the presence of *Liriodendron* and *Halesia*). Washouts and undercut banks and islands are more likely to retain some of the successional species indefinitely.

5.3.2. *Oak Forests*

WHITTAKER (1956) defines many more communities for the Smokies than are indicated here. Along the ridges he indicates dominant pine forests, with *Pinus virginiana* at lower elevations, *P. rigida* and heath at intermediate elevations, and *P. pungens* and heath up to about 1400 m. In the Smokies with more mesic sites at lower elevations, *Quercus prinus-Castanea dentata* and heath are followed by this community minus the heath and *Quercus rubra-Carya glabra* communities. At the upper elevations this same sequence would be *Q. alba-Q. prinus* and *Q. rubra-Castanea* forest. In this study, there were not enough samples to justify this many categories and they were simply divided into drier or xeric oak and mesic oak community types. In some of the sites, the *Quercus rubra-Carya glabra* community was suggested but other oaks were of high dominance also. None of the sites suggested the *Q. alba-Q. pinus* type nor any of the pine-dominated communities. The other communities were present but not differentiated here. Species listed by Whittaker are very similar to those in this study.

5.3.3. *Cove forests*

The Balsams have a few representative remnants of the original cove hardwood communities that existed in the area before pioneer Americans cleared the forests. One of these (Redbank Cove) either has not been timbered or has been very selectively timbered. This site was not sampled in this study and would have added the other species, such as *Tilia heterophylla, Betula alleghaniensis, Magnolia fraseri, M. acuminata, Prunus serotina,* etc. For some reason, the cove hemlock type is almost absent along the Blue Ridge

Parkway and the high elevation site included *Picea* as a subdominant. There are some sites on the lower slopes, however, where this cove type has been observed.

5.3.4. *Boulder field*

This specialized community type is represented in two locations in the Balsams. It is not specified by either BRAUN or WHITTAKER and would probably be assigned to cove hardwoods in their schemes. These periglacial phenomena are present in many locations throughout the southern Appalachians (KING 1964; MICHALEK 1968), some of them extending as far south as Georgia. If the boulders are not too deep (over 1/2 m), species other than *Betula alleghaniensis* are likely to be present in the canopy.

5.3.5. *Beech-gap forest*

In this particular study the beech-gaps were not sampled. BOUFFORD and WOOD (1975) studied three sites in the Balsams and their data is summarized in Table 18. *Fagus grandifolia* is by far most dominant with a smaller contribution being made by *Aesculus octandra*. A few subcanopy trees and shrubs are scattered beneath the *Fagus*, such as *Acer pensylvanicum, Ribes* spp., and *Viburnum alnifolium*, but the herb level is much more prevalent, with either *Carex pensylvanica* or a mixture of many forbs.

5.3.6. *Spruce-fir forest*

Many investigations differentiate the *Abies* forest of the highest peaks from the mixture of *Picea* and *Abies* downslope (see WHITTAKER 1956; BRAUN 1964; and others listed by them). This is apparent in the Balsams, with the dominance of *Abies* on Richland Balsam but generally a mixture elsewhere. Past logging of this area, however, has disrupted the patterns and present infestations of the balsam woolly aphid (*Adelges piceae*) would suggest the area might best be viewed simply as spruce-fir forest. The sites on Richland Balsam are covered with *Abies* presently while the slopes elsewhere have either mixtures or successional species such as *Betula alleghaniensis* or *Sorbus americana*.

Table 18. Beech-gap forest summary of coverage and frequency (BOUFFORD and WOOD 1975)

Tree canopy		
Species	Impt. values Beech Gap	Impt. values Mt. Hardy Gap
Fagus grandifolia	249.5	212.7
Aesculus octandra	50.5	87.3
Also present: *Abies fraseri, Acer saccharum, Betula alleghaniensis, Picea rubens*		

Subcanopy, shrub, and herb layers			
Species	Mean cover value *	Relative coverage	Relative frequency *
Acer pensylvanicum	10.8	6.1	2.1
Anemone quinquefolia	6.7	3.7	6.5
Arisaema triphyllum	7.9	4.4	6.5
Aster acuminatus	0.8	0.5	2.1
A. divaricatus	0.4	0.2	1.0
Athyrium asplenioides	1.3	0.7	3.2
Carex debilis	0.4	0.2	2.1
C. intumescens	0.4	0.2	2.1
C. pensylvanica	52.9	29.8	6.5
C. rosea	0.4	0.2	1.0
Cuscuta rostrata	1.3	0.7	3.2
Dioscorea villosa	0.8	0.5	2.1
Dryopteris x campyloptera	0.4	0.2	1.0
Epifagus virginiana	0.4	0.2	1.0
Eupatorium rugosum	44.2	28.9	6.5
Festuca obtusa	1.3	0.7	3.2
Impatiens sp.	1.7	1.9	4.3
Laportea canadensis	26.3	14.8	6.5
Luzula acuminata	2.0	1.1	5.4
Monarda sp.	0.4	0.5	1.0
Poa alsodes	0.8	0.5	2.1
Polygonatum biflorum	0.8	0.5	2.1
Prenanthes sp.	2.0	1.1	5.4
Rudbeckia laciniata	2.9	1.6	5.4
Smilax herbacea	1.3	0.7	1.0
Solidago curtisii	1.3	0.7	3.2
Thelypteris novaboracensis	0.4	0.2	1.0
Trillium erectum	0.8	0.5	2.1
Viola hastata	6.7	3.7	6.5
V. papilionacea	1.3	0.7	3.2

* Based on 3 samples at Beech Gap plus 3 samples at Mount Hardy Gap.

5.3.7. *Bald Communities*

Perhaps of all communities of the southern Appalachians, none are more intriguing than the grass balds. These occur below the tree line from Virginia south to Georgia at elevations usually in excess of 1600 m. No general explanation has been accepted for all these and it is probable that there are almost as many causes for them as there are theories. MARK (1958) favored the hypothesis that elimination of spruce-fir occured during warmer, drier periods on the intermediate peaks, with subsequent cooling favoring herbaceous growth instead of the deciduous trees of lower elevations. Establishment of spruce-fir in these bald areas has been demonstrated and the lack of the forest here is explained as the result of absence of a seed source here. Other sites have been indicated as clearing by Indians (WELLS 1937), particularly the square Judaculla Fields on Richland Balsam. Still other sites may have been cleared by fires (perhaps induced by humans), windthrows, clearing for pasturage, and the like. BARDEN (1978) presents a recent discussion of the grass bald maintenance in the Balsams.

By far the most important species of grass balds is *Danthonia compressa* (WELLS 1937; MARK 1958). Important herbs include *Achillea millefolium*, *Potentilla canadensis*, and *Rumex acetosella*. At some sites *Poa compressa*, *Deschampsia flexuosa*, *Houstonia serpyllifolia*, *Solidago* sp., and introduced *Phleum pratense* and *Poa pratensis* may be dominant (Table 19). Black Balsam Knob has extensive populations of *Deschampsia* and *Phleum* while Rough Butt Bald has *Poa compressa* and Seniard Ridge, Little Pisgah, and Pisgah are all dominated by *Danthonia*. MARK (1959) listed 453 species for the balds of the southern Appalachian region.

Just as well known as grass balds are the heath balds of the southern Appalachians. These are best developed in the Great Smoky Mountains, usually on shallow-soiled ridgetops, steep slopes, south ridges, etc. They usually form a successional position, with grass balds often being taken over by them before the area is finally climaxed by forest. HORTON and GAINES (1978) studied the heath community at Flat Laurel Gap of Pisgah Ridge and found the heath species accounting for 70 percent of all importance values. *Rhododendron maximum* and *R. catawbiense* accounted for one-third of the total importance values for the site (Table 20). In June these areas become tourist

Table 19. Presence of prominent species in grass balds of the Balsam Mountains (after WELLS, 1937).

Species	Location*					
	T.B.	T.R.	I.G.	R.B.B.	L.P.	B.P.
Danthonia compressa		X	X		X	X
Poa compressa	X			X		
Phleum pratense						X
Juncus tenuis	X					
Potentilla canadensis	X			X	X	X
Houstonia serpyllifolia	X			X		
Pteridium aquilinum var. *latiusculum*					X	
Cirsium discolor					X	
Prunella vulgaris					X	
Solidago patula			X			

* T.B. = Tennessee Bald   I.G. = Indian Graveyard   L.P. = Little Pisgah
T.R. = Tennessee Ridge   R.B.B. = Rough Butt Bald   B.P. = Big Pisgah

attractions during the bloom of *R. catawbiense*. Local people often call them "laurel hells" due to the dense vegetation which can be walked over rather than through at some locations. In time, trees such as *Betula alleghaniensis*, *Amelanchier arborea*, *Sorbus americana*, or *Fagus grandifolia* may succeed the heath. In wetter sites, *Picea* often enters the heath community.

5.3.8. *Rock outcrops*

Several locations near the ridge top of the Balsams have exposed rocks. On ledge or crevice depressions of these outcrops, enough organic material and sand may accumulate to support plants, often rare or endemic species. One notable location for outcrops in the Balsams is along Chestnut Ridge, terminating in the Devils Courthouse. Many species typically more northern in distribution find suitable habitats here: *Leiophyllum buxifolium* var. *prostratum*, *Maianthemum canadense*, *Potentilla tridentata*, *Sanguisorba canadensis*, and *Scirpus cespitosus* var. *callosus*. Among the southern Appalachian endemics of this area are *Abies fraseri*, *Carex misera*, *Diervilla sessilifolia*, *Hypericum buckleyi*, *Krigia montana*, *Paronychia argyrocoma*, *Parnassia asarifolia*, *Pieris floribunda*, *Rhododendron catawbiense*, *R. vaseyi*, *Robinia kelseyi*, *Saxifraga michauxii*, *Vaccinium erythrocarpum*, and others. Thus the

Table 20. Phytosociological parameters for 8 quadrats at Laurel Gap (data from HORTON and GAINES 1978)

Series	No. ind.	Den. no./m^2	Dom. m^2/m^2	Freq. %	Importance value *
Rhododendron maximum	64	0.5000	0.3820	0.875	59
Amelanchier arborea	8	0.0363	0.8274	0.375	56
Rhododendron catawbiense	94	0.7344	0.1660	0.750	53
Kalmia latifolia	60	0.4688	0.1832	1.000	49
Vaccinium vacillans	35	0.2734	0.0308	0.625	25
Lyonia ligustrina	16	0.1250	0.0176	0.500	16
Alnus serrulata	21	0.1641	0.0471	0.125	12
Viburnum nudum	12	0.0938	0.0360	0.250	11
Sorbus arbutifolia	2	0.0156	0.0036	0.250	6
Leucothoe recurva	3	0.0234	0.0154	0.125	4
Sorbus melanocarpa	4	0.0313	0.0049	0.125	4
Vaccinium constablaei	1	0.0078	0.0138	0.125	3
Rhododendron viscosum	1	0.0078	0.0001	0.125	3

Table 21. Phytosociological parameters for 11 quadrats at Graveyard Fields (data from HORTON and GAINES 1978)

Series	No. ind.	Den. no./m^2	Dom. m^2/m^2	Freq. %	Importance value *
Rubus spp.	380	2.159	0.2572	0.818	127
Prunus pensylvanica	45	0.137	0.3097	1.181	80
Vaccinium vacillans	123	0.689	0.0457	0.272	36
Ilex ambigua var. *montana*	12	0.068	0.0489	0.364	19
Vaccinium corymbosum	10	0.057	0.0404	0.182	13
Acer rubrum	4	0.004	0.0236	0.182	9
Rhododendron catawbiense	1	0.006	0.0178	0.090	5
Amelanchier arborea	2	0.002	0.0160	0.091	5
Menziesia pilosa	1	0.006	0.0063	0.090	4
Vaccinium erythrocarpum	1	0.006	0.0007	0.090	3

* Importance values are the sum of relative density, relative dominance, and relative frequency.

variety of the higher elevation plants is increased substantially by species of this habitat.

5.3.9. *Successional communities*

Successional communities occur in several locations in the Balsams. At lower elevations, old fields or pasture land now has become secondary woodlands, usually a mixture of pine and various species of hardwoods. *Pinus virginiana, Prunus serotina,* and *Sassafras albidum* are shade intolerant and are likely to be replaced in the community studied here, probably developing into cove hardwoods as suggested by the presence of *Liriodendron, Fagus,* and *Acer.* At the higher elevations, a study in the Graveyard Fields by HORTON and GAINES (1978) revealed the prominence of *Rubus* ssp., *Prunus pensylvanica,* and *Ilex ambigua* var. *montana* (Table 21). At the present time, there is an almost complete lack of spruce-fir at the site even though spruce and fir occur at lower elevations in the area, and they are moving into the site from the west. This particular site was burned with intense slash fires after timber harvests between 1925 and 1940.

6. Correlation between environmental factors and vegetation

The correlation between environmental factors and vegetational types varies. The closest relationship seems to be between vegetation and altitude, with the spruce-fir forest most prominent at the highest elevations (above 1700 m) while deciduous forests occupy the lower slopes (below 1600 m). Closely allied with this elevational association is climatic regimes, although no particular line of demarcation is known. At Richland Balsam the estimated mean average annual temperature of 5.4^{o}C is about half that at lower stations while precipitation of 2195 mm is nearly double that at the lowest elevation. Topography plays a secondary role, showing its most pronounced role in the coves where hardwood forest reach their best development. Soils show some correlation with vegetation, with Haplumbrepts dominating only the highest elevations in the spruce-fir forest. Few relationships were noted for geology; perhaps the tendency for mica gneiss to underlie the Chandler series is the only positive correlation.

Rather than searching for correlations of vegetation with certain factors, as soil types, rock types, etc., the approach one might take would evaluate how varied factors might be combined with a given community. Reviewing Figure 2 with this in mind, one notes that oak forests, for example, occur over several rock types and several soil series. These forests also occur at several topographic positions and under varied climatic conditions. If one then were to study the diversity of ecosystems that make up the oak forests, this diversity would be quite high. And indeed, this is the impression that botanists have long come to accept for the southern Appalachians. We have just begun to systematically lay out this diversity of systems in any pattern (see RADFORD and PITTILLO 1979) and plant geographers might take this approach in the future.

Summary

The Balsam Mountains occupy a central position in the southern Appalachians and have had a long and complex history, yielding a diverse composition of vegetation covering the varied types of soils, in turn derived from long-term weathering of metamorphic rocks and subjected to the vagaries of climatic elements. Floodplain woodlands of the French Broad River at the lowest elevation quickly give way to the extensive oak forests of the slopes. These forests vary from the mesic type surrounding the coves, north slopes, and high elevation ridges to the xeric type of the exposed south-facing ridges. Cove hardwoods occupy the moist, deep-soiled valley floors, sometimes grading into either cove hemlocks or boulder fields in the upper valleys. Highest elevations are dominated by spruce-fir forests with heath balds fringing rock outcrops or high elevation exposed, shallow-soiled ridges. High elevation gaps are often occupied by beech gap forests. Grass balds are scattered inexplicably throughout the spruce-fir forest. Successional communities occupy many areas where disturbance has been a factor, as the burned over Graveyard Fields. Generally the spruce-fir forests occur over the Burton and Porter soil series of the Haplumbrepts. Several other series are occupied by other vegetational types. Acidic rocks at the region are metamorphic gneisses and schists, these not correlating with other factors except for the tendency of mica gneiss to underlie the Chandler soil series. The climate varies from the cool, moist low elevation with the average annual temperature of 13.2°C and 1165 mm average annual precipitation to the still cooler and more moist high elevational temperature average of 5.4°C and 2195 mm of precipitation. Thus the diversity of vegetation quickly noted by the visitor of the Balsam Mountains is further amplified by the diversity of climate, geology, and soils supporting these interlocking plant communities.

Zusammenfassung

Die Balsam Mountains nehmen in den südlichen Appalachen eine zentrale Stellung ein und weisen eine lange und komplizierte Geschichte auf. Diese führte zu einer vielfältigen Vegetationszusammensetzung auf den verschiedenen Bodentypen, die durch die langfristige Verwitterung der metamorphen Gesteine unter wechselnden Klimafaktoren entstanden sind. Die Ueberschwemmungswälder der Ebene des French Broad River wechseln rasch mit den ausgedehnten Eichenwäldern der Hänge, die von gut mit Wasser versorgten Standorten der Mulden, Nordhängen und höheren Lagen bis zu den trockenen südexponierten Rippen reichen. Mulden-Hartholzwälder besiedeln die feuchten, tiefgründigen Böden der Täler und zeigen gelegentlich Uebergänge zu den Tsuga-Muldenwäldern und den Schuttwäldern der höheren Täler. Die höchsten Lagen werden durch Tannen- und Fichtenwälder dominiert, die auf Felskuppen und flachgründigen Rippen einer offenen Heide weichen. Hochgelegene Sattel sind oft mit charakteristischen Buchenwäldern bedeckt. Im Tannen-Fichtenwald sind offene Grasvegetationen eingestreut, deren Entstehung nicht erklärbar ist. Verschiedene Sukzessionsgesellschaften trifft man dort an, wo ein Störfaktor eingewirkt hat, wie etwa bei den abgebrannten Flächen der Graveyard Fields. Im allgemeinen treten Tannen-Fichtenwälder über den Burton- und Porter-Bodenserien der Haplumbrepts auf. Verschiedene andere Bodenserien werden durch andere Vegetationstypen eingenommen. Metamorphe Gneise und Schiefer sind in der Gegend saure Gesteine, die aber kaum mit anderen Faktoren korreliert sind, abgesehen von der Tendenz des Mica-Gneises, Böden der Chandler-Bodenserie zu entwickeln. Das Klima variiert von den kühlen und feuchten Niederungen mit einer mittleren Jahrestemperatur von 13.2°C und mittleren Jahresniederschlägen von 1165 mm bis zu den noch kühleren und feuchteren Hochlagen mit entsprechenden Werten von 5.4° C und 2195 mm. Die Vielfalt der Vegetation, die dem Besucher der Balsam Mountains sofort auffällt, wird also vor allem bedingt durch die Vielfalt des Klimas, der Gesteinsunterlagen und der Böden, auf denen die Pflanzengesellschaften wachsen.

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