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Vegetation Patterns on the North Slopes of Bluff Mountain, Ashe County, North Carolina

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Abstract

This study of the vegetation on the north slopes of Bluff Mountain indicates that three recognizable associations occur along the altitudinal gradient. These associations correspond to the low-elevation Cove Forest, Northern Hardwoods sub-type of Cove Forest, and Red Oak Association as described for the vegetation of the Great Smoky Mountains. *Acer saccharum* is the dominant of the Cove Forest Association. *Betula lutea* is the dominant of the Northern Hardwoods Association, and *Quercus rubra* var. *borealis* is the dominant of the Red Oak Association of the ridges.

Introduction

Whittaker (1956) described vegetation distribution in the Great Smoky Mountains as a continuous gradation of stands along environmental gradients. He stated that some vegetation associations were discontinuous, with surrounding vegetation types on at least one border. However, these relative discontinuities showed continuous gradations within themselves, and most could be shown to intergrade with other association types in directions other than those in which the discontinuities were observed. The whole pattern was conceived to be a complex continuum of populations. Allowing for discontinuities produced by disturbance and environmental discontinuity, the vegetation pattern could be regarded as a complex mixture of continuity and relative discontinuity. Both continuity and discontinuity are thus to be observed in natural associations.

Tucker (1967) stated that the vegetation types of the Bluff Mountain area, floristically comparable with portions of the Great Smoky Mountain vegetation, are rather typical for the Blue Ridge province within which Bluff Mountain is located. He also stated that the vegetation is a mosaic of vegetation types which intergrade "completely" into one another.

Bluff Mountain is located about two miles west of West Jefferson in southern Ashe County, N. C. It is principally composed of Roan Gneiss (United States Geologic Survey, 1930), and the dominant soil association is the Clifton-Porters Association (Lee, 1955). Average precipitation is slightly over 48 inches, and the mean annual snowfall is over 18 inches. The highest temperature ever recorded at Jefferson, the closest weather station, was 97° F. and the lowest was –20° F. The weather records from the Jefferson station give only an insight into general climatic trends and cannot be applied directly to Bluff Mountain. Precipitation in particular is probably higher on the Bluff than in the nearby valley where the weather station is located.

The purpose of this investigation was to describe the woody vegetation on the north slopes of Bluff Mountain and also to determine whether species distributions along the altitudinal gradient could best be described as a series of discontinuities or whether a continuum exists such that sharp boundaries could not be assigned to species associations.

Thanks go to Dr. J. F. McCormick, who helped design the problem and was a source of encouragement and direction. Dr. A. E. Radford generously shared his knowledge about the flora of that region during several conversations. Dr. H. Lieth also offered guidance both in the laboratory and in the field. Special thanks go to Mr. M. G. Edwards and his family, owners of most of the mountain, for their generous kindness and hospitality to my wife and me during our stay on Bluff Mountain.

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Methods

Three gorges on the northern slopes of Bluff Mountain were studied. The eastern extremity

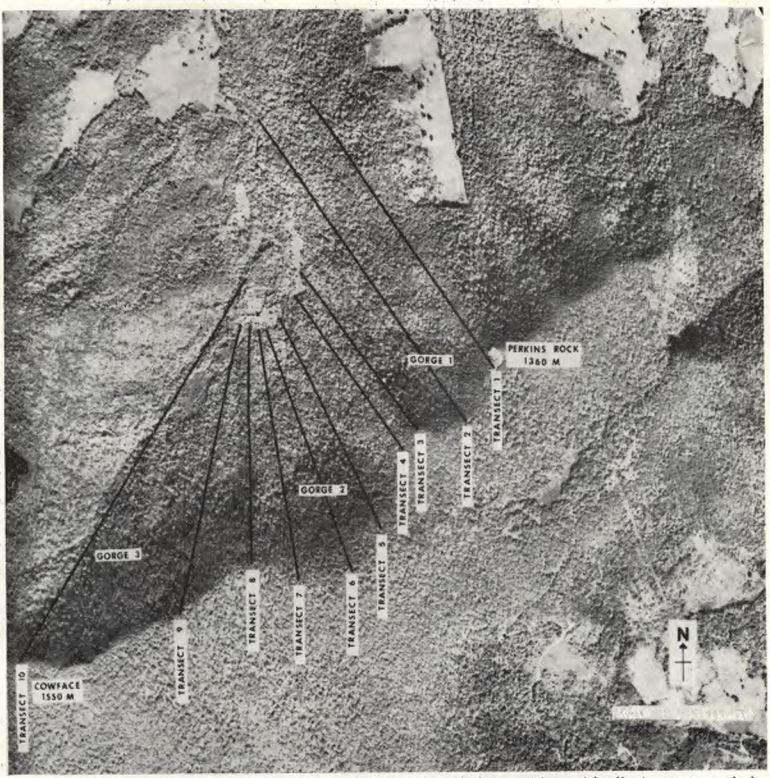


FIG. 1. Aerial photograph of the study area showing the relative position, altitudinal extent, and the topographic exposure of the ten transects studied.

of the study area is landmarked by "Perkins Rock" at an elevation of 1360 meters, and the western boundary by the "Cowface" at 1550 meters (Fig. 1). The ravine portion of each gorge faces north, and there are east-facing and west-facing slopes and ridges. At higher elevations, exposed bedrock is found along the ridges, and large outcroppings of Roan Gneiss are common.

To study distributional patterns of woody species along the altitudinal gradient, compass transects were followed from the ridge crests to lower elevations. The direction of each transect was arbitrarily chosen so that each would lie along one topographic exposure—either the east- or west-facing slopes or the ravine portions of each of the gorges. Once the direction of each transect was determined, a compass sighting was taken and that bearing followed throughout the sampling of vegetation along each transect. Figure 1 shows the positions of the ten transects studied and lists the exposure and altitudinal extent of each. Sampling points included sites between and within homogeneous floristic zones.

The point-quarter sampling method was used to tally trees over one inch in diameter at breast height (Cottam and Curtis, 1956). Diameter of each of the four trees at each sampling point was recorded, and the distance between the point and each of the four trees was measured. All shrubs at each sampling point were recorded.

Relative importance values (Phillips, 1959) were calculated for each species throughout the study area. Relative importance is a composite of relative density, relative frequency, and relative basal area of the species. To determine

the relative importance of each species at various altitudes, relative importance values were calculated for approximately 60-meter intervals of altitude along each transect. Actual altitudinal distributions of all species, for each transect, were plotted to determine whether groups of species had similar distributions (thus forming units) or whether species were distributed independently along the altitudinal gradient.

Results

Species Composition of the North Slopes

Forty-five woody species were recorded.[1] Twenty-five were constituents of the canopy, and twenty were shrubs, including the common liane—*Aristolochia durior*. Table I lists the relative importance values for all species tallied, and Table II lists the shrub and small trees that were observed. Figure 2 shows the relative importance values of the four dominant canopy species and the actual distributions of all species plotted with altitude. *Acer saccharum, Betula lutea,* and *Quercus rubra* var. *borealis* are the dominant species on the north slopes of Bluff Mountain. Each of these species is dominant in one of three distinct species associations found along the altitudinal gradient.

Table I

Relative importance values of all species tallied

Species	Relative Importance Values
Acer saccharum	23.5
Betula lutea	17.2
Quercus rubra var. *borealis*	14.1
Fagus grandifolia	6.8
Betula lenta	5.6
Acer pensylvanicum	4.3
Ostrya virginiana	3.3
Acer spicatum	3.2
Acer rubrum	3.0
Hamamelis virginiana	2.9
Aesculus octandra	2.7
Tilia heterophylla	2.5
Robinia pseudo-acacia	1.7
Prunus pensylvancia	1.7
Quercus prinus	1.4
Carya glabra	1.4
Quercus rubra	1.1
Castanea dentata	.6
Quercus alba	.4
Crataegus flabellata	.3
Prunus serotina	.3
Prunus virginiana	.3
Fraxinus americana	.2
Carya tomentosa	.1

Table II

List of Observed Shrub Species

Aristolochia durior
Clethra acuminata
Cornus alternifolia
Cornus florida
Diervilla lonicera
Kalmia latifolia
Pinus strobus
Rhododendron calendulaceum
Rhododendron catawbiense
Rhododendron maximum
Ribes cynosbati
Ribes rotundifolium
Rubus odoratus
Sorbus americana
Tsuga caroliniana
Vaccinium erythrocarpum
Vaccinium stamineum
Vaccinium vacillans
Viburnum acerifolium
Viburnum alnifolium

Altitudinal Distribution of Species

Quercus rubra var. *borealis* is the dominant canopy constituent of a high-elevation vegetation association (Table III, column 1). Floristically this zone compares with the Red Oak-Chestnut association as described by Braun (1950). Other canopy species recorded within this association were: *Acer rubrum, Fagus grandifolia, Betula lutea, Quercus prinus,* and *Quercus alba*. This association is extensive on the top of the mountain mass and extends down the altitudinal gradient for varying distances, depending on topographic exposure. On the ridges of each gorge and the slopes of Gorge 1 it is found at lower elevations than within the ravines and slopes of the other two gorges (Fig. 3). The chestnut, once a dominant species, is now found only as stump sprouts.

Betula lutea is the dominant member of a Northern Hardwoods forest (Braun, 1950) located between the high-elevation vegetation association and a low-elevation cove forest association dominated by *Acer saccharum* (Table

[1] Nomenclature follows A. E. Radford, H. E. Ahles, and C. R. Bell, *Guide to the Vascular Flora of the Carolinas* (Chapel Hill: Book Exchange, 1964).

Table III

Relative importance values of each species within each association

	Red Oak Association	Northern Hardwoods Association	Cove Forest Association
Rhododendron catawbiense	4.0		
Quercus prinus	3.5		
Quercus alba	2.3		
Castanea dentata	.8		
Crataegus flabellata	.9	.7	
Prunus virginiana	.8	.6	
Acer rubrum	11.0	4.6	
Quercus rubra var. *borealis*	50.0	.9	
Fagus grandifolia	8.0	16.0	3.4
Hamamelis virginiana	5.9	2.3	.7
Ostrya virginiana	2.5	1.7	3.9
Prunus pensylvanica	2.5	3.0	.8
Acer spicatum	1.7	8.0	.4
Acer pensylvanicum	1.8	10.0	4.0
Betula lutea	3.8	52.0	5.0
Tilia heterophylla		7.0	1.3
Aesculus octandra		2.3	4.0
Acer saccharum	2.1	1.9	51.0
Betula lenta			2.3
Quercus rubra			4.7
Robinia pseudo-acacia			3.6
Carya glabra			1.2
Fraxinus americana			1.0
Magnolia fraseri		.7	.7
Prunus serotina			.4
Carya tomentosa			.4

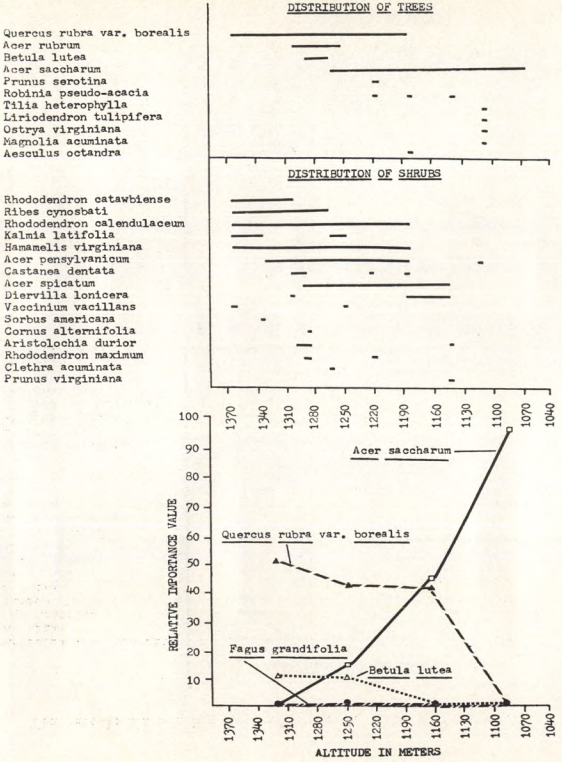
III). The elevational extent of the latter two species associations also varies with topographic exposure.

In the ravine portions of each gorge (Transects 2, 5, 6, and 10) and the west-facing slope of Gorge 3 (Transect 9), the three associations are distinct, and ecotones between each are small in altitudinal extent (Fig. 3). The altitudinal zonation of vegetation on the east-facing slope of Gorge 2 shows another pattern (Transects 7, 8). On this slope the upper limits of the Northern Hardwoods forest extends to the mountain crest, and the association extends downslope to approximately 1320 and 1375 meters, where there occurs a sharp transition into the cove forest (Fig. 3). The vegetation zonation on the west-facing slopes of Gorge 2 (Transect 4) and the west- and east-facing slopes of Gorge 1 (Transects 1, 2) show yet another trend. On those slopes the Red Oak association extends from the mountain crest to approximately 1200 meters, where it intergrades into the cove forest (Fig. 4). The Northern Hardwoods association is not extensive on those slopes, and species common to it are found scattered along the gradient between approximately 1300 and 1200 meters. On those three transects, *Betula lutea* is never the dominant canopy constituent along the gradient (Fig. 3, Transects 2, 4, 5).

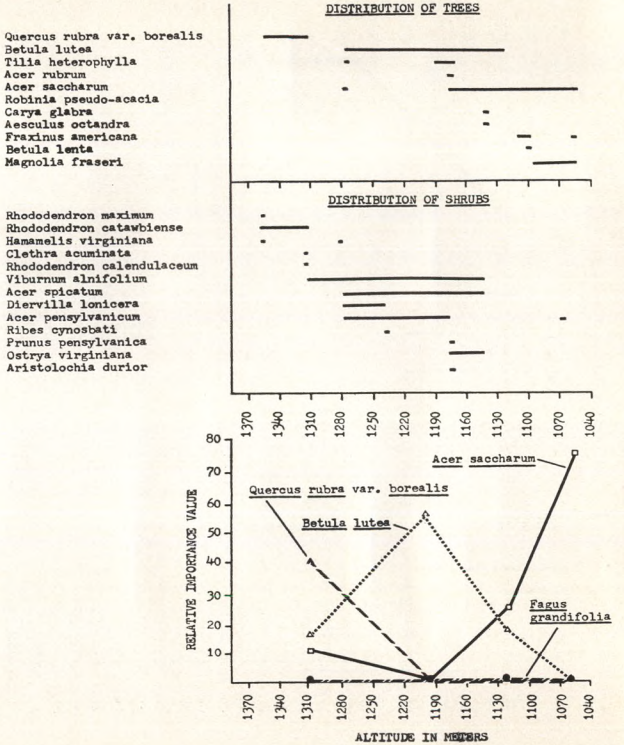
Another distinct feature of two of the species associations is the floristic composition of the understory shrubs. A predominantly ericaceous subcanopy is associated with the Red Oak association. Evergreen ericaceous members of this zone are *Rhododendron calendulaceum, R. catawbiense, R. maximum,* and *Kalmia latifolia.* Deciduous components of this zone are: *Cra-*

FIG. 2. Individual transect data. The upper portion of each of the diagrams that follow on the next five pages shows the actual altitudinal distribution of each tree and shrub species tallied. The graph portion shows the relative dominance of the four dominant canopy species plotted with altitude.

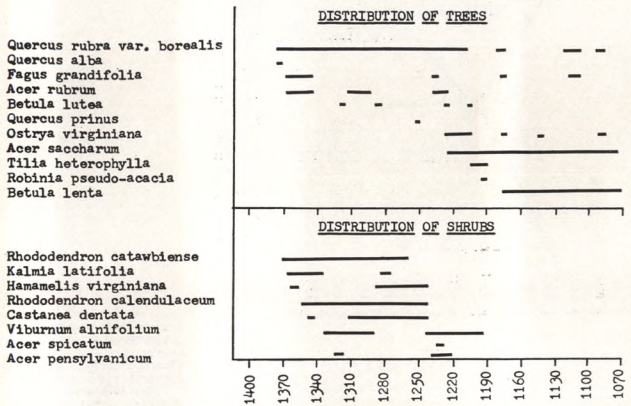
Transect 1: West-facing slope of Gorge 1. 1362–1085 meters.

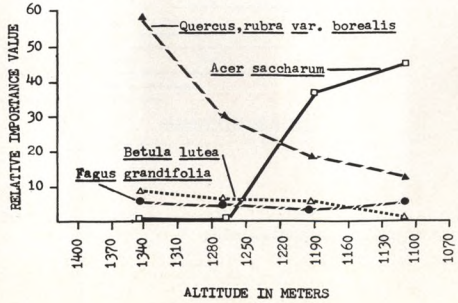


Transect 2: Ravine of Gorge 1. 1359–1067 meters.

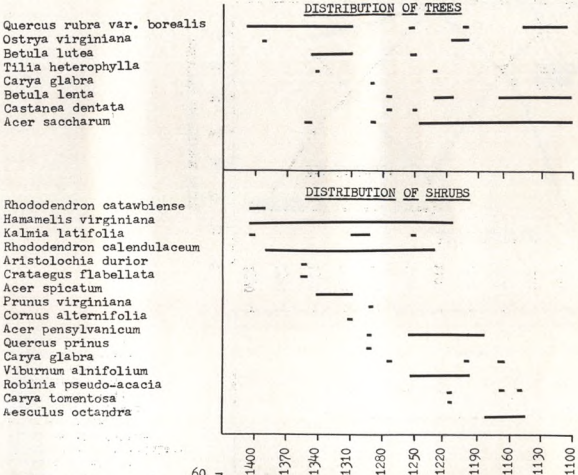


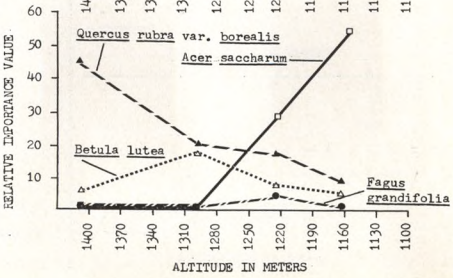
Transect 3: East-facing slope of Gorge 1. 1377–1097 meters.



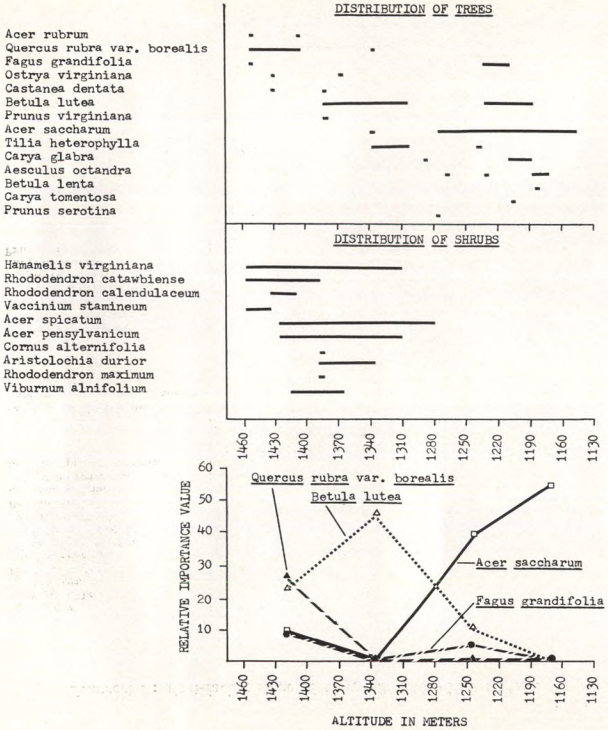


Transect 4: West-facing slope of Gorge 2. 1395–1119 meters.

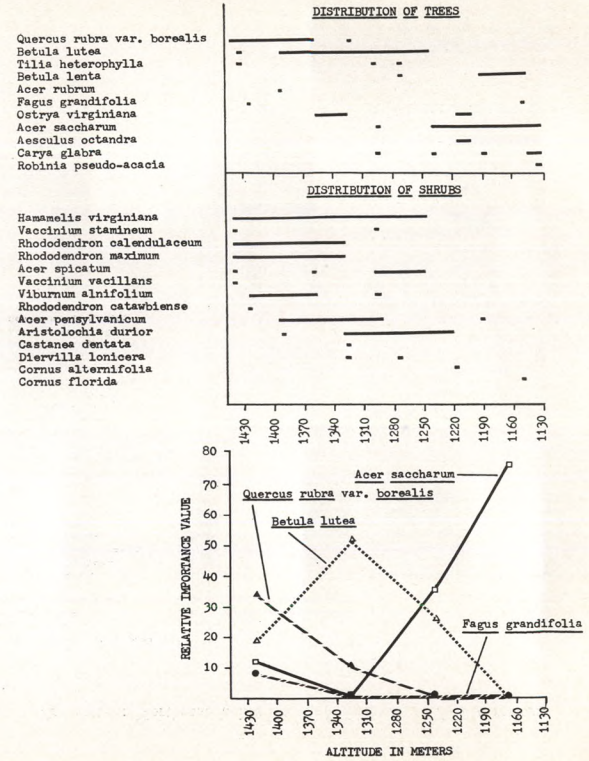




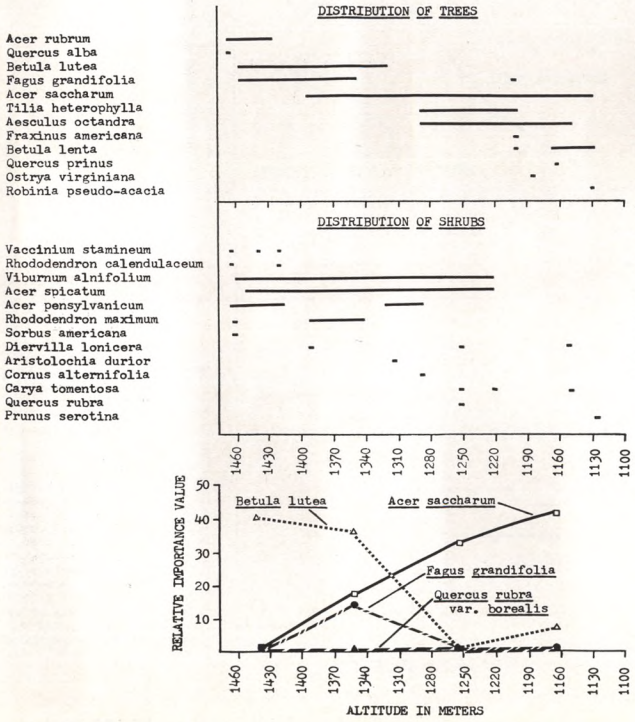
Transect 5: Ravine of Gorge 2. 1453–1161 meters.



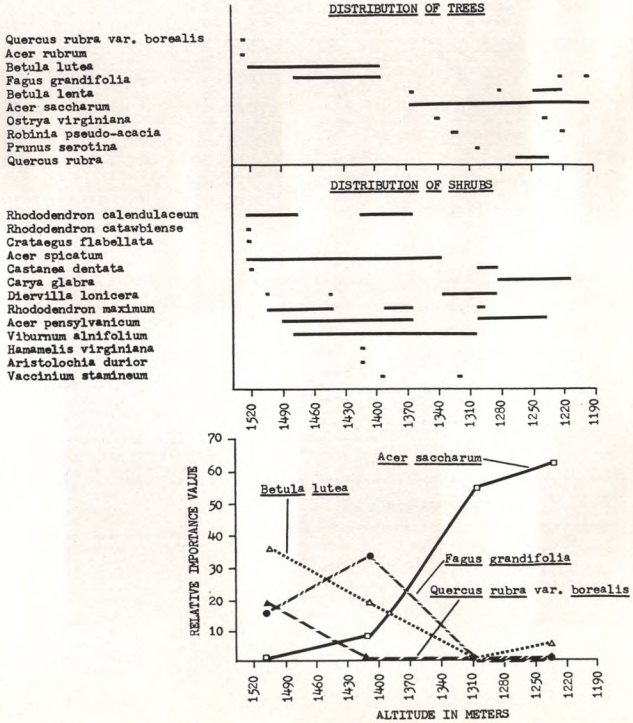
Transect 6: East-facing slope and portion of ravine of Gorge 2. 1447-1150m.



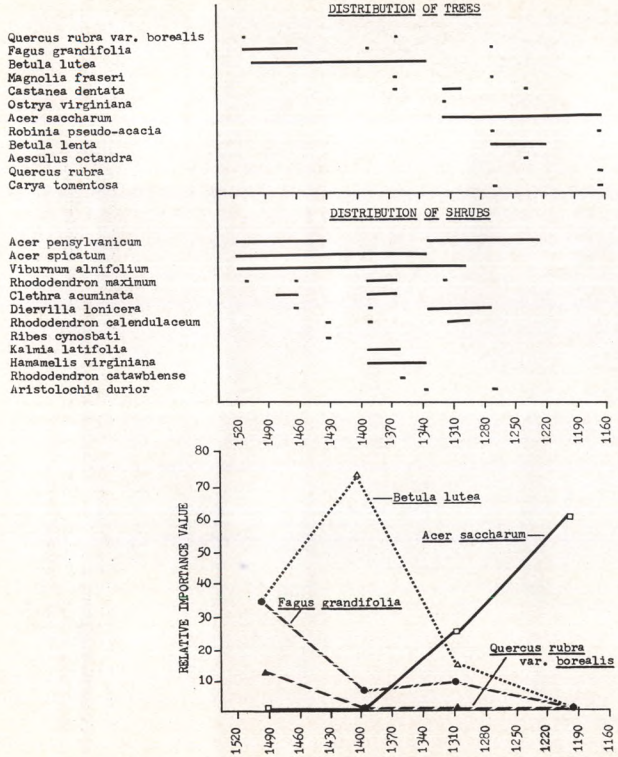
Transect 7: East-facing slope of Gorge 2. 1466–1147 meters.



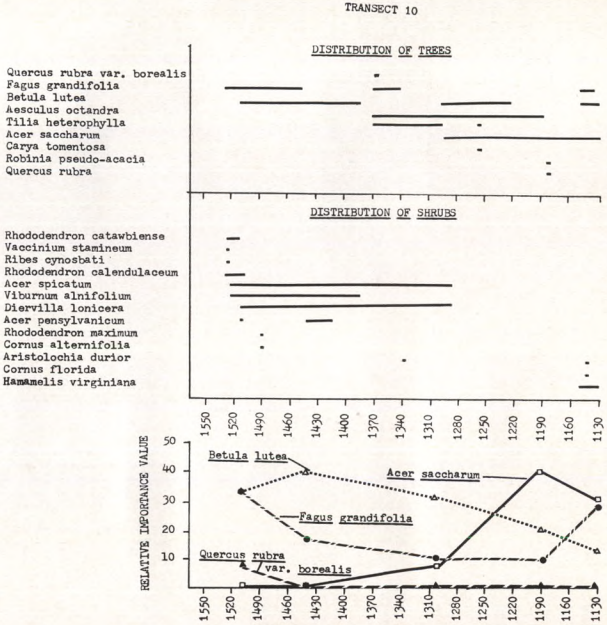
Transect 8: Northeast-facing slope of Gorge 2. 1527–1216 meters.



Transect 9: West-facing slope of Gorge 3. 1508–1161 meters.



Transect 10: Ravine of Gorge 3. 1539–1127 meters.



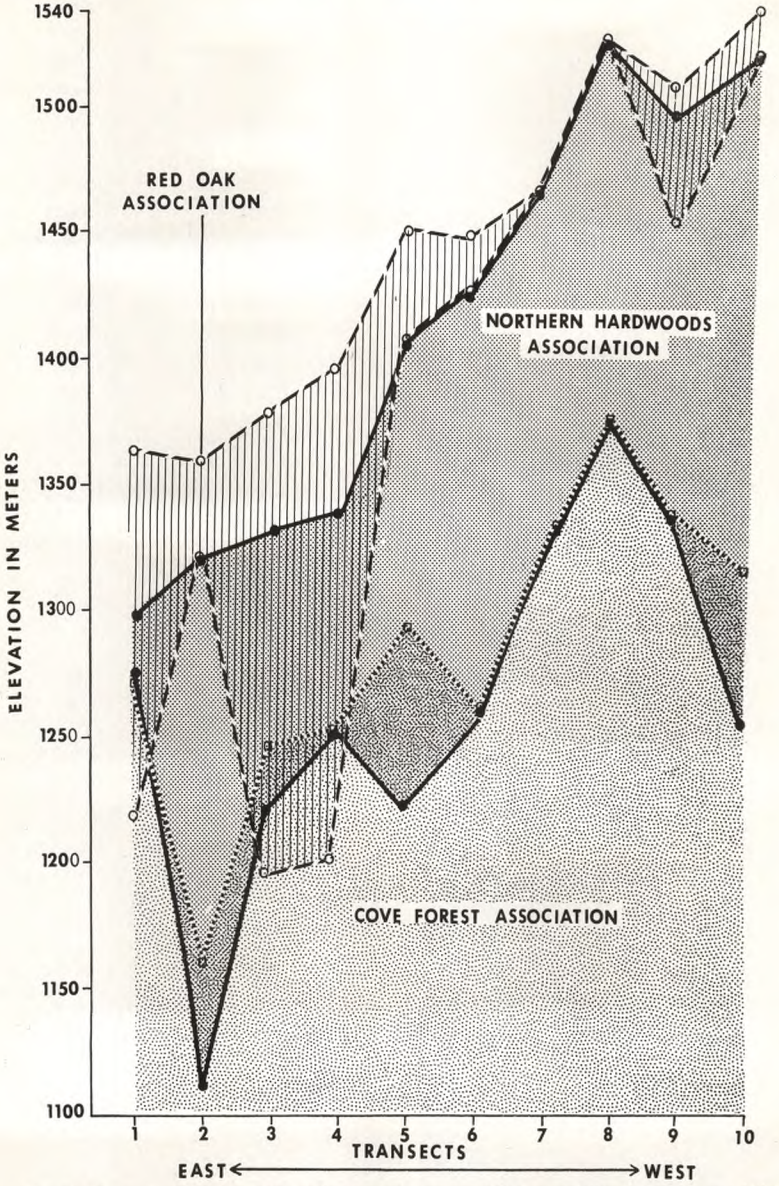


FIG. 3. Diagrammatic profile of the study area showing the altitudinal distribution of each association. Areas of overlap represent the altitudinal extent of ecotones between associations. Refer to information given with Figure 1 for comparison of topographic exposure of each transect.

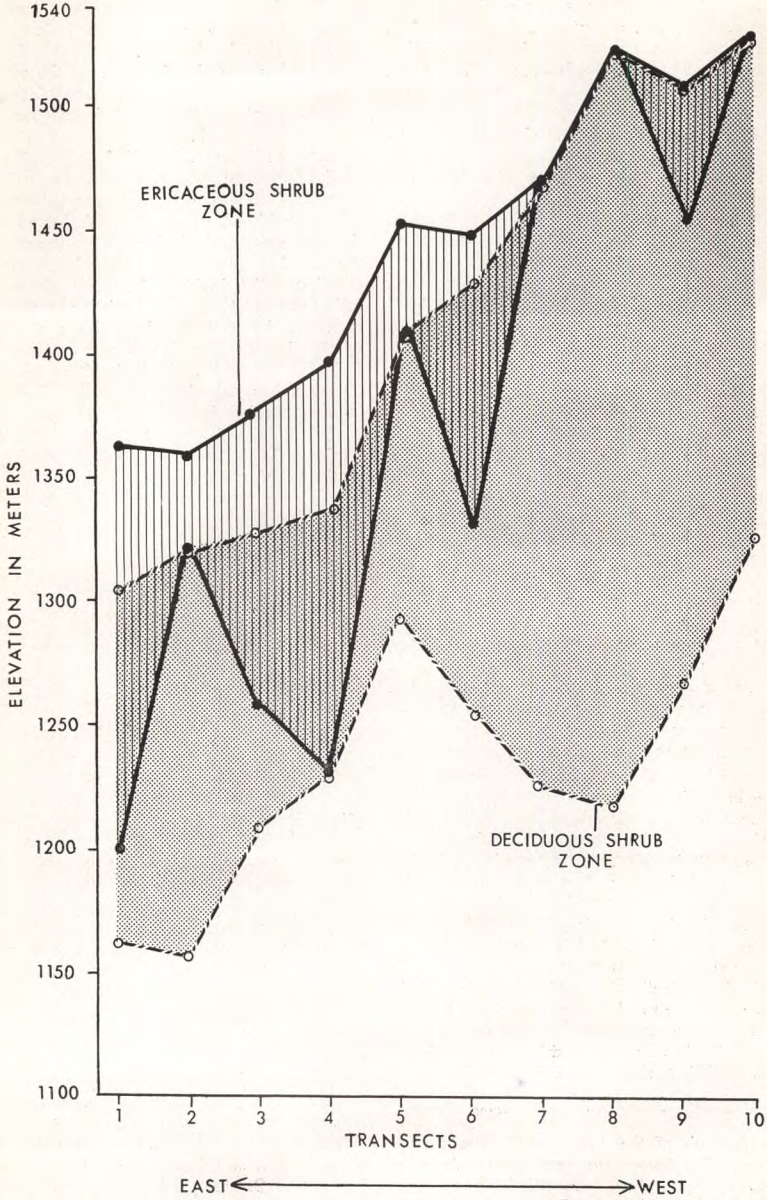


FIG. 4. Diagrammatic profile of the study area showing the altitudinal distribution of the two shrub zones. Areas of overlap represent altitudinal extent of ecotones between the shrub zones. Comparison of this figure with Figure 3 shows the distribution of the shrub zones within the three associations.

taegus flabellata, Hamamelis virginiana, Prunus pensylvanica, P. virginiana, Ribes cynosbati, R. rotundifolium, Sorbus americana, Vaccinium erythrocarpum, V. stamineum, and *V. vacillans.* The ericaceous understory is extensive on the top of the mountain mass and extends down the altitudinal gradient for varying distances, depending on topographic exposure. On the rocky ridges it is found at lower elevations than within the ravines (Fig. 4). On the west-facing slope of Gorge 1 (Transect 1) it occurs as low as 1200 meters, while near the "Cow-face" (Transects 7, 8, 10) it extends down the altitudinal gradient for only 6, 2, and 9 meters of elevation, with the lowest limits at 1460, 1525, and 1530 meters respectively (Fig. 4). The lowest limits of the Red Oak association coincide approximately with the lower limits of this shrub zone in all transects studied (compare Figs. 3 and 4).

The upper limits of the Northern Hardwoods association coincide approximately with the upper limits of another distinct shrub and small tree zone. Principal constituents of this zone are *Viburnum alnifolium, Acer pensylvanicum,* and *Acer spicatum,* while *Diervilla lonicera, Ostrya virginiana,* and *Hamamelis virginiana* are commonly encountered. The lowest limits of this zone usually coincide with either the upper limits of the cove forest or the lower limits of the Northern Hardwood forest (Figs. 3 and 4). No distinct subcanopy zone is associated with the cove forest, and the understory within that association consists of transgressives of canopy species.

The definitive character of the cove forest is the richness of canopy species. Whereas only eight species are commonly encountered within the Red Oak and Northern Hardwoods associations, ten species are present within the cove forest (Table III). Canopy species of the latter association are: *Acer saccharum, Aesculus octandra, Betula lenta, Carya glabra, C. tomentosa, Fraxinus americana, Magnolia fraseri, Prunus serotina, Robinia pseudo-acacia,* and *Quercus rubra.* Because *Acer saccharum* is physiognomically the dominant species within the cove forest and because the ecotone between the cove forest and any other vegetation association is very narrow, this community is the most distinct of the associations studied.

Vegetational Differences Between Gorges

Analysis of the data reveal two additional vegetation changes from east to west along the north slopes. *Fagus grandifolia* increases in importance within the Red Oak association, and there is a concomitant decrease in the importance of *Quercus rubra* var. *borealis.* Second, the elevational extent of the Northern Hardwoods association increases on the western end of the north slopes. Both of these changes occur on the east-facing slopes of Gorge 2—Transect 7.

Quercus rubra var. *borealis* is the dominant species of the Red Oak forest of Gorge 1, and only one individual of *Fagus grandifolia* was recorded within the same area. Similar conditions were observed within most of the area of the second gorge except that beech is more frequently associated with Red Oak. On the east-facing slope of Gorge 2, a floristic change occurs. On that exposure, beech has a greater relative importance value than does *Quercus* (Fig. 5, Transect 7). Continuing in a westerly direction, the relative importance value of *Fagus* increases while that of *Quercus* decreases. Therefore, *Fagus* becomes the dominant canopy species of the high-elevation forest zone on those portions of the north slopes.

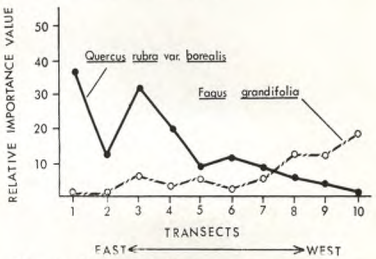


FIG. 5. Shows the decrease in relative importance of *Quercus rubra* var. *borealis* and the concomitant increase in the relative importance of *Fagus grandifolia.* This represents the shift in canopy dominance within the Red Oak Association.

As stated previously, the high-elevation forest association has its lowest limits on the ridges and slopes of each gorge, while it is restricted to higher elevations on ravines. The lower limits of this forest zone occur at increasingly higher elevations, going west from "Perkins Rock" until the association is found only on the mountain crest—Transects 6, 7, 8, 9, and 10 (Fig. 3). On the same slope where *Fagus* becomes dominant over *Quercus,* the slopes leading into the ravines are no longer dominated by high-elevation association vegetation. Instead, these slopes are covered by an extensive Northern Hardwoods association in which *Betula lutea* forms pure stands of very large trees. On that portion of the study area, the high-elevation forest is restricted to the very

tops of the gorge ridges and, as stated, *Fagus grandifolia* is the dominant tree species. It thus appears that, in the ravine slopes, the sub-mesic Red Oak association is replaced by the more mesic Northern Hardwoods association; also, on the rocky ridges the more mesic *Fagus* is occupying the same habitat type as *Quercus* does on more xeric sites.

Discussion

On the north slopes of Bluff Mountain three distinct associations exist, with varying degrees of overlap between them. The distribution of individual species forms a continuum along the altitudinal gradient. However, the response of all species to environmental, substrate, and biological gradients results in the formation of three distinct vegetational associations along the altitudinal gradient. Numerous floristic and ecological studies of vegetation patterns of the Southern Appalachians have been conducted: Cain, 1931; Cain, 1943; Brown, 1941; Braun, 1935; Braun, 1950; Cooper, 1963; Mowbray, 1966; Racine, 1966; Rodgers, 1965; Russell, 1953; Tucker, 1967; Williams and Oosting, 1944; and Whittaker, 1956. Interpretation of over-all patterns and the relationship of these to other vegetation types within the eastern deciduous forest have been thoroughly discussed. Whittaker (1956) and Braun (1950) offer the most thorough descriptions of vegetation patterns of the Southern Appalachians. Vegetation distribution of Bluff Mountain best fits the scheme proposed by Braun.

A. Red Oak Association

This high-elevation association can be segregated into three association segregates: Red Oak, Heath, and Beech with an ericaceous understory. The latter association segregate is found only on the rocky ridge of Gorge 2 and has not been previously described for vegetation of the Southern Appalachians. The presence of the ericaceous understory with a beech canopy seems to be uncommon. The presence of chestnut stump sprouts suggests that that species was once a dominant member of this segregate. The Beech-Chestnut dominance combination is not commonly encountered but Braun (1950) reports this canopy combination for the Knobs of Kentucky area—part of the Western Mesophytic Forest Region. However, *Liriodendron tulipifera*, not found on this portion of Bluff Mountain, is another dominant species within the area described by Braun. Also, there was no ericaceous understory reported by her. It thus seems that the two areas cannot be floristically equated. Radford (personal communication) has stated that this zone may represent a Gray Beech transition that is ecotonal between the cove forest and the Red Oak association segregate. The Heath segregate, composed of ericad heaths and scrubby red oaks, is most extensive on the "Cowface" but also is present near "Perkins Rock." The Red Oak segregate is the most extensive of the three. This segregate is submesic in composition of both canopy and understory strata and is the high-elevation equivalent of the Chestnut Oak-Chestnut forest (Whittaker, 1953). As stated, *Castanea dentata* is no longer a major component of the forest. At this time, no canopy species other than *Quercus rubra* var. *borealis* has a high relative importance value, but *Acer rubrum* is commonly found along with the former at high elevations. At lower elevations, some mesic species such as *Aesculus octandra, Betula lutea, Fraxinus americana, Magnolia fraseri, Prunus serotina,* and *Tilia heterophylla* may be found within the ecotonal regions.

B. Northern Hardwoods Association

Whittaker (1956) considered the portion of the altitudinal gradient dominated by *Betula lutea* to be a segregate of the cove forest. Braun (1950) recognized this zone as a Northern Hardwoods forest, and one of her reasons for doing so was the nature of the understory. To her, *Viburnum alnifolium, Acer pensylvanicum,* and *Acer spicatum* were indicators of the northern relationship of the vegetation. According to Braun, *Acer saccharum, Fagus grandifolia, Aesculus octandra, Fraxinus americana, Prunus serotina, Halesia monticola, Magnolia fraseri, Castanea dentata,* and occasionally *Tilia heterophylla* are accessory species that may be present within this association type. On Bluff Mountain, only *Tilia, Prunus,* and *Magnolia* were recorded within this zone. The other species—except *Halesia,* which was not recorded—were found only within the cove forest. Bluff Mountain vegetation does not conform precisely with the description of Braun (1950) because of the absence of *Betula lutea* in the cove forest, and also because of the sharp transition that exists between the two associations. *Betula lutea* does, only in deep ravines, intergrade into the cove forest but is quickly replaced by *Betula lenta.* Also, the discrete shrub zone associated with that portion of the altitudinal gradient suggests discontinuity between the two associations. The Northern Hardwoods association is here considered to be

a distinct association and not simply a segregate of the cove forest, although they are surely historically related.

C. Cove Forest Association

The cove forests of the Southern Appalachians are closely related to the mixed mesophytic forests of the Cumberland Mountains because of comparable species composition. Species common to the two areas are: *Aesculus octandra, Tilia heterophylla, Acer saccharum, Halesia monticola, Liriodendron tulipifera, Betula lutea, Fagus grandifolia, Tsuga* sp., and occasionally *Castanea dentata.* Other canopy species commonly present are *Fraxinus americana, Prunus serotina, Magnolia acuminata, Acer rubrum, Quercus rubra,* and *Carya cordiformis.* Of the smaller trees, *Magnolia fraseri, Amelanchier laevis,* and *Acer pensylvanicum* are frequent. Only in the absence of *Halesia, Carya,* and *Amelanchier* does this Southern Appalachian cove hardwood association differ from typical mixed mesophytic associations of the Cumberlands. All of the species are seldom found within one area and a number of segregates are distinguishable—all of which may be thought of as mixed mesophytic associations. Within the cove forest examined, there is one recognizable segregate. This occurs in the very moist ravines where *Betula lenta* is the codominant of the canopy with *Acer saccharum.*

In summary, this study shows that vegetation does continuously change along the altitudinal gradient but within the continuum clearly descrete repeatable vegetation units do exist. The author prefers to call these associations and association segregates (Whittaker, 1962).

Conclusions

1. Investigation into the vegetation of Bluff Mountain clearly shows that definable species associations exist within a continuum along the altitudinal gradient.

2. Vegetational changes occur from east to west as well as along altitudinal gradients. *Fagus grandifolia* increases in importance within the Red Oak association and the extent of the Northern Hardwoods association increases on the western end of the north slopes of Bluff Mountain.

3. Vegetation on the north slopes is distributed within three associations:

A. Red Oak association with Heath, Beech with ericaceous understory, and Red Oak association segregates.

B. A Northern Hardwoods association, dominated by *Betula lutea,* located between the high-elevation Red Oak association and a low-elevation cove forest association.

C. Cove forest association composed of a rich assemblage of canopy species within which an *Acer saccharum-Betula lenta* association segregate is discernible.

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