VEGETATION OF ROAN MOUNTAIN: A PHYTOSOCIOLOGICAL AND SUCCESSIONAL STUDY

DALTON MILFORD BROWN
State Teachers College,
Johnson City, Tennessee.

Ecol. Monographs
11: 61-97
1941

TABLE OF CONTENTS

	PAGE
INTRODUCTION	63
THE AREA	63
Location	63
Topography	63
Geological History	63
Soils	64
Climate	64
Vegetational History	65
TERMINOLOGY	67
METHODS	67
VEGETATION	68
Beech-Maple Community	69
Spruce-Fir Community	74
Bald Communities	79
Grassy Bald Community	79
Rhododendron Bald Community	82
Alder Bald Community	85
SUCCESSION	87
Beech-Maple Community	87
Spruce-Fir Community	87
Balds	88
Grassy Bald Community	88
Rhododendron Bald Community	90
Alder Bald Community	91
HISTORICAL VIEWS BEARING UPON BALD SUCCESSION	92
DISCUSSION	94
SUMMARY	96
LITERATURE CITED	97

An area in which three major plant communities of Roan Mountain meet: northern hardwood forest, northern coniferous forest, and "subalpine" grassy bald. Looking eastward from a point immediately northwest of Carvers Gap.

VEGETATION OF ROAN MOUNTAIN: A PHYTOSOCIOLOGICAL AND SUCCESSIONAL STUDY[1]

INTRODUCTION

On cool, moist summits of the higher Southern Appalachians there exists a vegetation more like that of the northeastern United States and Canada than of the surrounding country. Roan Mountain, located in the midst of these southern mountains and rising more than 4,000 feet above the country about it, presents a unique condition to anyone interested in its vegetation. For more than a century it has been considered by many people to be the most beautiful and interesting mountain east of the Rockies, and thus has attracted botanists from both this country and abroad. André Michaux, who was sent to this country by France, was perhaps the first white man to explore the mountain. He was soon followed by such men as Nuttall, the younger Michaux (son of André Michaux), Fraser, Gray, Curtiss, Sargent, Harshberger, Scribner, Lamson, Small, Heller, and others including present-day botanists. Earlier botanists were primarily interested in systematic studies rather than the sociological aspects of the vegetation.

This study represents observations of the vegetation on Roan Mountain which have been made at intervals from 1926 to the present. A detailed survey of the vegetation was begun in 1934 and continued during the summers of 1936 and 1937.

American ecologists have, in the past, been chiefly concerned in determining vegetational changes while Europeans have, in the main, been content merely to present a static picture of the vegetation. No study of the vegetation is complete that does not take into account both its structural and developmental aspects. The aim of this study was twofold. First, it was desired to obtain an adequate description of the present vegetation of Roan Mountain, and second, to consider the dynamics of the vegetation in reference to time and space. The first was accomplished by making a detailed statistical study of the various plant communities within the area, while the second was determined by several lines of evidence relative to successional trends of the communities under consideration.

Since there lie within the area under study the most beautiful and most easily accessible mountain areas of rhododendron in the country, such a study should prove of practical value in formulating a future conservational policy for these natural gardens, whether they be under private or public control. It should also prove of interest to ecologists in that it supplies data from an unusual portion of the Southern Appalachians.

The writer wishes to acknowledge his indebtedness to Dr. H. J. Oosting for advice and criticism throughout the study; to Dr. S. A. Cain for advice pertaining to the statistical surveys; to his wife, Thelma, for help in collection and preservation of plants and for clerical assistance; and to those who helped in taxonomic matters. The writer, however, assumes responsibility for any errors which may be present.

THE AREA

Location

The Southern Appalachians may be divided into two major mountain masses, the Unaka Mountains to the west and the Blue Ridge Mountains to the east, each of which extends northeasterly. Southward from the Unakas, trending toward the Blue Ridge, extend various cross ranges of which Roan is the highest. It is located along the northern portion of the North Carolina-Tennessee state line at latitude 82° west and longitude 36° north. An automobile road extends from the town of Roan Mountain, Tennessee, some 12 miles to the summit. The area of Roan Mountain proper is about 12 square miles, but if the total area represented by the entire mountain mass is considered, the area is approximately 50 square miles.

Topography

The Roan Mountain mass rises from a broad base of about 2,500 feet altitude to a rounded summit of 6,285 feet. The area in Tennessee is drained by the Doe River while the area in North Carolina is drained by the Toe River, both of which flow into the Tennessee River. The summit of Roan forms a broad and rounded divide about 5 miles in extent along the state line, ranging from an altitude of 5,500 feet at Carvers Gap to 6,285 feet at Roan High Knob. Many rounded spurs extend on either side of this divide, alternating with broad "V" shaped valleys. Details of topography are shown in Figure 1.

Geological History

The rock formations are Pre-Cambrian, being igneous and metamorphic rocks of the Archean and consisting of Roan gneiss and Cranberry granite (Keith, 1907). Gneiss caps the mountain and is underlain by granite.

The history of the area may well have begun with the formation of Carolina gneiss, oldest known formation of the Appalachian province. This was followed by uplift and volcanic action in the Archean when the Roan gneiss cut through the Carolina gneiss in great dykes and formed thin sheets over the latter. Base-leveling and submergence in early Cambrian times was followed by four great cycles of sedimentation which ended with the close of the Carboniferous when a great uplift stopped deposition. A long period of erosion followed, which, by the end of the Cretaceous, had reduced the province to nearly a featureless peneplain, the Cumberland or Cretaceous

[1] A thesis submitted in partial fulfillment of requirements for the degree of Doctor of Philosophy in the Graduate School of Arts and Sciences of Duke University, 1938.

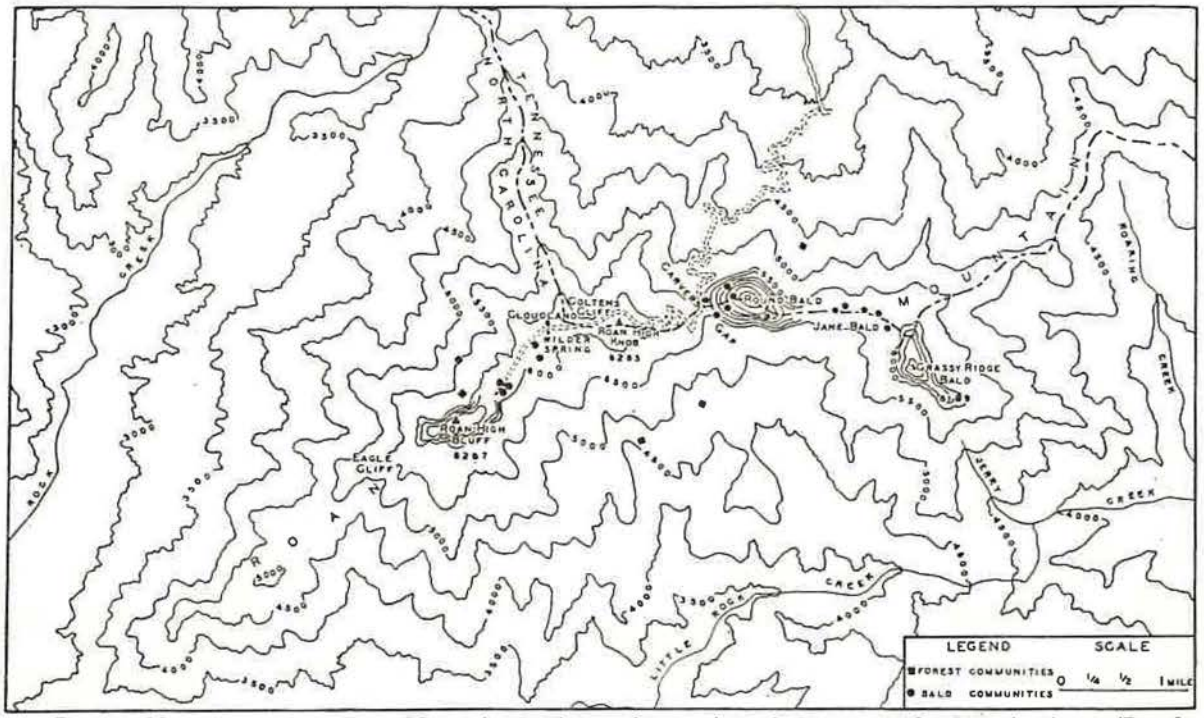

FIG. 1. Map of summit of Roan Mountain showing major portion of the area under investigation. (Based on U. S. Geol. Survey, North Carolina-Tennessee, Bakersville, and Carvers Gap Quadrangles, 1934.)

peneplain. A final uplift of the region resulted in a warped surface and an irregular topography. Since this last uplift, erosion has greatly affected the peaks and ridges, resulting in the rounded present-day appearance.

SOILS

Marbut (1935) has shown the area as belonging to the Gray-Brown Podsolic Soils, but no soil survey has yet been made. Parent material of the summit, and that extending down the slopes to about 4,000 feet, is Roan gneiss composed chiefly of hornblende, gneiss, and schist, with a little diorite. Based on Marbut's soil map (1935) and the writer's limited observation while studying the vegetation, the soils appear to belong to the Chester series which is characterized by a parent material of ancient crystalline origin producing a yellowish or grayish C horizon upon decay.

Soils of forested slopes are fertile, rocky to sandy, loams with medium to high acidity and poorly developed profiles. They vary in depth from a few inches over large bowlders and rock outcrops to several feet in the lower coves. Soils of gently rolling balds vary from a thin, gray, gravelly mineral material an inch or so thick to a black fertile loam 1 to 3 feet deep. More than 95 percent of the soil surface of both forest and balds is covered with vegetation.

CLIMATE

Climate of the Southern Appalachians in general is characterized by a lower temperature, greater precipitation, and higher wind velocity than the surrounding country. Available weather data for the area under study are confined to a three-year precipitation record and to some brief notes kept at camp during the summers of 1934 and 1936 with regard to temperature, showers, and relative amounts of sunshine. Precipitation data were obtained by a self-recording rain gauge established on Cloudland January 3, 1935, by the Tennessee Valley Authority. Data from a 30-year record at Banner Elk, North Carolina, were used since its climate more nearly approaches that of the area under study than any other United States Weather Bureau station in the region. Banner Elk is located about 15 miles eastward on a high rolling plateau at 3,750 feet altitude. Data are also presented from a 23-year record at Johnson City, Tennessee, since it is the second closest station with a continuous record. This station is located about 18 miles northward at an altitude of 1,575 feet. Mean monthly temperature and precipitation for the stations outside the area are presented in Figures 2 and 3, while mean weekly and monthly precipitation for the summit of Roan Mountain is shown in Figure 4.

TEMPERATURE

The annual mean for Johnson City is 57.1° F. while that for Banner Elk is 51.4° F. By interpolation, based on altitudinal differences, the mean annual temperature for Cloudland would be about 44° F. The highest temperature record in 30 years for Banner Elk was 95° F. in July and the lowest temperature was -21° F. in December, an extreme range of 116° F. while the mean monthly range was 33.2° F. Edson (1894) reports -30° F. as the lowest temperature on Roan Mountain for the winters 1892 and 1893. The

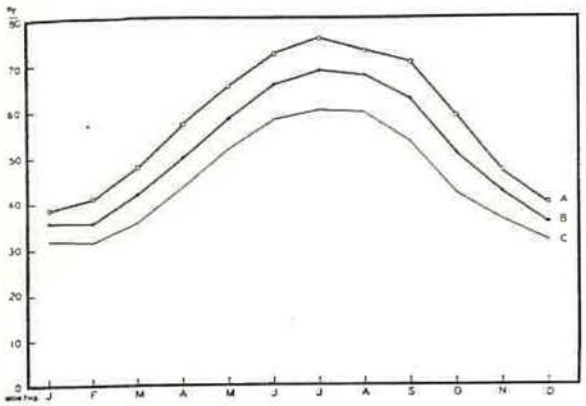

FIGURE 2

FIG. 2. Mean monthly temperatures of two nearby U. S. Weather Bureau stations. The mean monthly temperatures for Johnson City, Tennessee, are based on a 20-year period (1911-1930) while those for Banner Elk are based on a 30-year period (1908-1937).

A. Mean monthly temperatures for Johnson City, Tennessee.

B. Mean monthly temperatures for Banner Elk, North Carolina.

C. Mean monthly temperature predicted for Roan Mountain, North Carolina-Tennessee.

lowest July temperature for Banner Elk was 35° F., an extreme range of 60° F. for July, although the mean range was only 21.9° F. The average frostless season for Banner Elk is 147 days, the shortest reported for North Carolina, but it varies from 87 to 178 days. Since Roan Mountain rises 2,535 feet above the station at Banner Elk it has greater extremes in temperature and a shorter growing season, as would be expected.

PRECIPITATION

Mean annual precipitation for Johnson City is 44.39 inches, for Banner Elk 53.62 inches. Mean annual precipitation for Cloudland during 1935, 1936, and 1937 was 55 inches as compared to 60.49 inches at Banner Elk for the same period, a reversal of

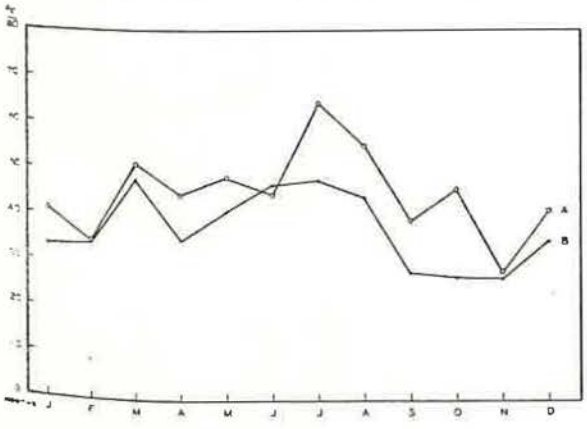

FIGURE 3

FIG. 3. Mean monthly precipitation for Banner Elk (A) and Johnson City (B). Based on a 30-year record (1908-1937) for Banner Elk and a 35-year period (1896-1931) for Johnson City.

what might be expected. Mean annual snowfall at Banner Elk is 39 inches, the second highest in the state of North Carolina. Precipitation for this area is fairly well distributed throughout the year with the lowest monthly mean of 2.78 inches in November and the highest monthly mean of 6.43 inches in July. The highest monthly precipitation on record for Banner Elk was 24.06 inches in July, 1916, and the lowest for the same station was 0.31 inches in August, 1925. Annual precipitation ranges from 36.05 inches in 1925 to 72.95 inches in 1908. For the 3-year period (1935-1937) on Roan Mountain, rain fell each week. The lowest monthly amount was 3.22 inches in June and highest in July, 9.33 inches. There seem to be no dangerously dry periods although there was a nineteen-day period in June, 1936, with only 0.1 inch precipitation which was serious enough to kill as high as 20 percent of the grass clumps in some areas of the grassy bald.

SUNSHINE, CLOUDS, AND FOG

Based on camp records, less than 10 percent of the days of summer have continuous sunshine and less than half of them have as much as 75 percent sunshine. The 3-year record for Cloudland shows that rain fell on about half of the days of summer with July having greatest number of rainy days and June having fewest. Edson (1894), in referring to winter conditions at the summit, says: "The clouds here usually float about level with the summit, though they sometimes rise as much as 500 feet above it, or sink 2,000 feet below; so that it may be said to lie in the track of the clouds." These prevailing conditions gave rise to the name "Cloudland" for the mountain summit.

WIND

In the mountains, the direction of prevailing winds is influenced by general topography of the region. Winds tend to follow courses of the valleys, being deflected by the mountains. The writer's observations for several recent summer seasons indicate that the prevailing winds for most of the area are from the north, coming from the extensive Doe River Valley. Occasionally the wind is from the south, coming from the valley of the Toe. In strongly exposed areas, as in the grassy balds, wind is almost continuous and varies from brisk to strong.

VEGETATIONAL HISTORY

OWNERSHIP

The area has been in private ownership since the region was first settled. The largest single tract, containing about 2,700 acres, extends along the mountain summit for a distance of about 5 miles and includes most of the area under study above 5,000 feet altitude. The tract supports essentially all of the spruce-fir forest and heath-bald vegetation on the mountain, most of the grassy and alder balds, and some of the beech-maple vegetation of the upper slopes. Very little land above 4,000 feet has been cleared for cultivation.

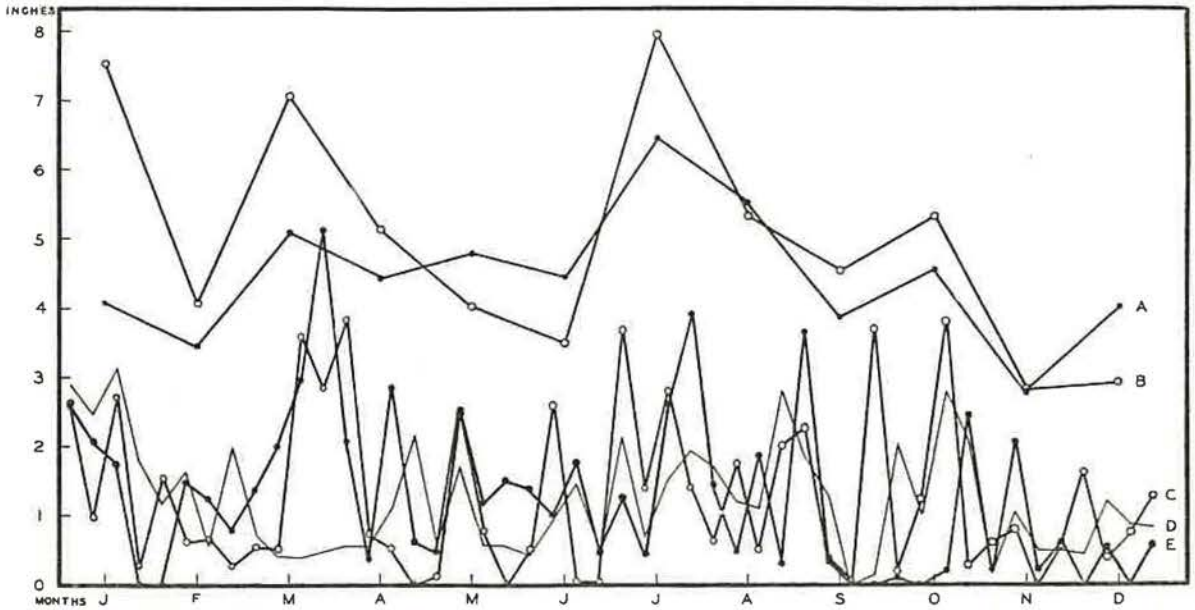

FIG. 4. Mean precipitation on the summit of Roan Mountain by weeks for a three-year period. Based on daily readings as recorded by Tennessee Valley Authority for 1935, 1936, and 1937. Also mean monthly precipitation of Banner Elk and Roan Mountain shown for comparison.

A. Mean monthly precipitation for Banner Elk.
B. Mean monthly precipitation for Roan Mountain.
C. Mean weekly precipitation for Roan Mountain, 1936.
D. Mean weekly precipitation for Roan Mountain, 1937.
E. Mean weekly precipitation for Roan Mountain, 1935.

GRAZING

The grassy balds have doubtless been grazed since the days of the first white settlers. Mitchell (1835) described this mountain meadow more than a century ago as the summer pasture ground for young horses of the whole country about it. No attempt was ever made to restrict grazing until the first hotel was built in 1877. A renewed attempt was made in 1936 by the Roan Mountain Scenic Highway Company but the area has been grazed continuously regardless of restrictions. Most of the grazing in recent years has been by cattle and sheep. There is no evidence of overgrazing at present.

LUMBERING

The first major cutting was done from 1883 to 1886 when the cherry of the upper slopes, principally on the south side, was cut. From observations of old stumps and logs, it is evident that some of the larger birch and maple trees were also cut about the same time. The next major cutting was begun in 1929 and finished in 1937. This cutting was very destructive since it removed all sound spruce and fir trees above 6 inches d.b.h. So far as can be determined from human or vegetational records, this was the first major disturbance of the spruce-fir forest, although there had been light local cuttings when two hotels were built, one in 1877 and another in 1884. Fuel for summer use in these hotels was obtained principally from the near-by coniferous forest but was supplemented by some beech from Carvers Gap. Most of the hardwood belt has been cut over lightly from time to time during the past 50 years. In all except the recent spruce-fir cutting, only the larger trees of the more desirable species were removed.

FIRES

So far as can be learned no forest fires have occurred above 4,000 feet altitude, but the settlers have frequently burned the grassy balds in late fall or early spring to improve grazing. Two mountaineers of the region who are more than 70 years of age told of having seen fires set to the grass periodically for the past 50 years, saying, "mean fo'ks done it." This was confirmed by the presence of ring scars of beech trees at the edge of the grassy balds.

OTHER DISTURBANCES

It is reported that 30 or 40 years ago a train load of rhododendron was shipped north to a botanical garden. Between the years 1927 and 1935 a dozen or more truck loads of this shrub have been removed from the mountain. Many small clumps and canes of rhododendron are removed annually by numerous tourists and natives who visit the rhododendron areas each season. Root and herb collectors have been active in the region for many years, but it appears that they have disturbed the vegetation very little at higher altitudes; however, in 1937 more than a dozen cherry trees were noted which had been cut and stripped of their bark. Early in 1938 many sugar maple saplings on the north slope were also stripped. Least conspicuous but perhaps most significant are effects produced by the local climate. The early

summer drought of 1936 killed about one fourth of the grass clumps on the northern slopes of Round Bald. In spite of minor disturbances, the summit vegetation appears to be in a relatively virgin state except for the recent spruce-fir cutting.

TERMINOLOGY

Terminology used in this study is essentially as defined by Braun-Blanquet (1928). Reference is also made to Cain (1932) who has conveniently summarized fundamental European concepts for American workers. In some instances the original meanings of terms have been slightly modified in order to describe more adequately the points in question. To avoid misunderstanding, the major concepts are here defined in the sense that they are used in this paper.

Community. In spite of the work of the Sixth International Botanical Congress, the "association" concept is not yet standardized. The term "community" is used in this paper primarily in the sense of the "association" as used by Nichols (1929), and Toumey and Korstian (1937). In this study plant communities are characterized by a distinct physiognomy and a definite floristic composition.

Frequency has to do with homogeneity (the uniformity of distribution of species throughout a community) (Braun-Blanquet, 1928, p. 39). It is the ratio of number of quadrats (sample plots) containing a given species to number of quadrats surveyed, expressed as a percentage (frequency index).

The relative homogeneity of stands and communities may be compared graphically by frequency diagrams, provided quadrats of the same size be employed. These diagrams show percentage of species belonging to each frequency class. The five frequency classes here used are as follows:

Class A—species in 0-20 percent of quadrats.
Class B—species in 20-40 percent of quadrats.
Class C—species in 40-60 percent of quadrats.
Class D—species in 60-80 percent of quadrats.
Class E—species in 80-100 percent of quadrats.

Density is the number (abundance) of individuals on a unit area basis. The numbers of individuals recorded from the actual area surveyed were reduced either to a meter or an acre basis.

Cover deals with the surface covered by individuals of each species. The five-point scale of Braun-Blanquet (1928, p. 32) was further subdivided. Class 1 was divided into two classes: Class 0, representing species with less than 1 percent coverage, and Class 1, representing species covering 1 to 5 percent of the surface. This proved very satisfactory since such a large number of species occurred in each community with coverages less than 1 percent. The six-point scale as used in this study follows:

Class 0—species covering less than 1 percent of the ground surface.
Class 1—species covering 1 to 5 percent of the ground surface.
Class 2—species covering 5 to 25 percent of the ground surface.
Class 3—species covering 25 to 50 percent of the ground surface.
Class 4—species covering 50 to 75 percent of the ground surface.
Class 5—species covering 75 to 100 percent of the ground surface.

Basal area is a concept of foresters and is the total cross-sectional area in square feet of the stems of a species based on diameters at 4.5 feet above the ground (d.b.h.). This is a convenient way to show physiological dominance of tree species, since there is probably a close correlation between basal area and the surface or volume of tree crowns.

METHODS

To obtain a clear and accurate picture of the organization of the plant communities of Roan Mountain, reliable analytical data were essential. Such data were obtained by the quadrat method. To obtain adequate data for a quantitative analysis of the vegetation, more than a thousand quadrats were employed. Within individual stands these were randomized somewhat after the Latin square method.

MINIMAL AREA

Since the size of sample plots has been shown by Gleason (1929), Cain (1932, 1934) and others, to affect the concept of frequency, it is desirable to employ a suitable size for each layer of each community. Sizes employed for the forest communities were suggested by Cain (in conference in 1934) based on his experience with similar communities in the Great Smoky Mountains. Due to a marked difference between the physiognomy of the bald communities of Roan Mountain and the Great Smokies, it seemed advisable to determine the minimal area experimentally. This was done according to the method described by Cain (1932). Size of quadrats used in each community and type of data obtained from each are shown in Table 1.

TABLE 1. Sizes of quadrats used for the respective layers of the various communities and kind of data secured from each.

Size (Meters)	Layer	Community	Kind of Data Obtained
1 x 1 ...	Herb and ground	Beach-Maple Spruce-Fir	Coverage by classes; frequency.
1 x 2 ...	Herb and ground	Grassy Bald	Coverage by classes; frequency.
1 x 2 ...	Shrub, herb, and ground	Alder Bald	Density of height classes for woody species; frequency. Coverage by classes for species of each layer; frequency.
2 x 2 ...	Shrub, herb, and ground	Heath Bald	Density by height classes for woody species; frequency. Coverage by classes for species of each layer; frequency.
4 x 4 ...	Shrub	Beach-Maple	Density by height classes; frequency.
5 x 5 ...	Shrub	Spruce-Fir	Density by height classes; frequency.
10 x 10...	Tree	Beech-Maple	Density by d.b.h. classes; frequency; stratification estimated.
10 x 20...	Tree	Spruce-Fir	Density by d.b.h. classes; frequency; stratification estimated.

In laying out quadrats, compass lines were maintained for control. A steel tape was used for tree and shrub quadrats and standard meter sticks for the other quadrats. The d.b.h. classes of trees were determined with a steel diameter tape. Height classes of woody species were determined by measuring, if less than 6 feet tall, and by estimating, if of greater height. Coverages for species of the herb layer and for the ground layer as a whole were recorded according to the six-point scale previously described.

Distribution of Quadrats

As shown in Table 1, three kinds of quadrats (herb and ground, shrub, and tree) were employed in forest communities. A base line was first laid out across one end of a stand. Control lines were established at right angles to the base line. Spacing of quadrats along and between control lines was adjusted to size of the stand in order to insure broad sampling and even distribution. Shrub and tree quadrats were usually spaced at 50-meter intervals, each shrub quadrat being located in the corner of the tree quadrat adjacent to control line and nearest base line. Herb quadrats were spaced along control lines at distances one fifth of intervals between tree and shrub quadrats. Only one size of quadrat was employed for each bald community as shown in Table 1. These quadrats were distributed in the same manner as were the herb quadrats of forest communities. Corners of each stand were marked with wooden stakes or pieces of 0.5 inch painted iron pipe.

Quadrat data concerning the spruce-fir community were obtained during June and July, 1934, and for the beech-maple community in July and August, 1937. Heath balds and alder balds were surveyed during July and August, 1934, and grassy balds in July and August, 1936.

The nomenclature follows Sudworth (1927) for trees, Gray's New Manual of Botany (7th edition) for shrubs and herbs except a few found in Small (1933), and Blomquist (1934) for pteridophytes.

A complete collection representing species involved in this study has been deposited in the Herbarium of Duke University, Durham, North Carolina.

Collection of Successional Data

During the three summers spent on Roan Mountain, observations were made in order to discover successional trends. In 1937 a concentrated attempt was made to discover evidence tending toward an explanation of this problem. Notes were made in the field as a result of such observation and thinking, and numerous photographs along ecotones were made for future study. In addition, certain statistical methods were employed, including *belt transects, strip samples,* and *chart quadrats.* Areas thus investigated were permanently marked for future study.

Belt transects

Three belt transects were established across the ecotone between the grassy bald community and the spruce-fir community. Only individuals of woody species and moss mats were mapped, other species being listed by coverage classes for each square meter of the 1-meter strip and for each 4 square meters of the 2-meter strip. The two 1-meter belt transects were on Cloudland, 6,100 feet altitude, and the 2-meter transect was at Carvers Gap, 5,500 feet altitude.

Strip samples

A set of strip samples was used on Round Bald, largest grassy bald area of the mountain. This set consisted of 355 contiguous 2 by 2 meter quadrats along a north-south line which extends across the crest of the bald and into the beech-maple on either side. Two similar sets of samples were employed on Roan High Knob to determine the relative importance of alder, heath, and conifers. The first set consisted of 37 quadrats 2 by 2 meters spaced along a line extending from the highest point of the mountain to the edge of the spruce-fir forest to the north.[2] The other set consisted of 25 quadrats of the same size and spacing along a line extending from the same point on the knob to a point southward within the grassy bald.

Chart quadrats

Two permanent chart quadrats, 2 by 2 meters each, were established on mineral soil at 6,100 and 6,200 feet altitude, respectively, in order to study establishment of herbs, shrubs, and conifers. Another permanent chart quadrat, 4 by 4 meters, was established in the grassy bald immediately west of Carvers Gap to study invasion of woody species, especially conifers.

A number of other miscellaneous samples were taken across transition lines and in cut-over spruce-fir, but space does not allow their treatment.

VEGETATION

Following Schimper (1903), the vegetation would be divided into forest and grassland, but since certain shrubs are dominant in the grassland area as "thicket communities," it seems preferable to refer to treeless areas as balds.[3] Three forest communities are present on Roan Mountain and they are zoned altitudinally as follows: (1) oak-chestnut community, generally below an altitude of 3,500 feet but extending up some of the ridges to 4,000 feet; (2) beech-maple community between 3,500 and 5,000 feet, by far the most extensive of the area; and (3) spruce-fir community, above 5,000 feet. Most of the original area of the oak-chestnut community has been cleared for cultivation. Practically all trees of any size have been removed for lumber. Most of the chestnut was killed or seriously injured by blight before it was cut. This community is now too poorly represented to justify its analysis or further description.

The balds occur on long, broad ridges above 5,500 feet altitude and, according to most estimates, cover

[2] The beginning point was a marker of the United States Geological Survey embedded in a huge bowlder on the summit.

[3] Early settlers doubtless named these areas "balds" since each is surrounded by forest vegetation and, at a distance, appears like a bald spot on a man's head.

an area of more than 1,000 acres, mostly with a southern exposure. Three major communities are located approximately as follows: (1) rhododendron balds, above 6,000 feet altitude and west of Carvers Gap; (2) alder balds, in moister areas of southern slopes east of Carvers Gap; and (3) grassy balds, occurring throughout the full extent of the bald area but with best development in the vicinity of Carvers Gap.

Beech-Maple Community

Three stands were located in which no fires have been known or cuttings made except half a century ago. Stands A and B are each approximately 5 acres, Stand C, 6.25 acres.

Location of Stands.

Stand A is located on the north slope at an altitude of approximately 4,600 feet, and nearly a mile northeast of Round Bald (Fig. 1). It is approximately 50 yards from a small stream on the east and extends westward over the crest of a gently sloping ridge. The soil surface is rolling with an average slope of about 14 degrees toward the northeast. Stand B is on the south slope, one-half mile south of Carvers Gap at 4,800 feet altitude. It extends over a broad ridge and faces south with an average slope of about 10 degrees. Stand C is located at the same altitude one mile eastward, and faces south with a slope of approximately 8 degrees. In all stands soil is relatively free from surface rocks and outcrops. Stand C is located on what might be termed a "shelf." Soil is more productive in this stand due, perhaps, to its greater depth.

Stratification.

In the beech-maple community, four layers can be recognized: (1) *tree layer,* usually consisting of superior and inferior layers; (2) *shrub layer,* consisting of shrubs and tree saplings (designated by Cain (1932) as "transgressives"); (3) *herb layer,* composed of herbs and seedlings of trees and shrubs; and (4) *moss* or *ground layer,* consisting principally of mosses and lichens. The approximate average vertical location of each of these layers and its coverage class is shown graphically in Figure 5. On the whole, there is no clear-cut separation of layers but rather much overlapping. This is especially true of individuals of tree species which dominate the shrub layer as well as both tree layers.

TREE LAYER

The superior tree layer ranges from 40 to 60 feet in height and from 60 to 90 percent coverage, with an average height of 50 feet and an average coverage of about 70 percent (Figs. 5 and 7). The inferior layer ranges from 10 to 30 feet in height but with more foliage between 20 to 30 feet. In general, the canopy is quite irregular, since it represents an uneven-aged mixed stand of trees. A few of the larger trees, occasionally reaching a height of 70 feet, stand above the superior layer as "dominants," according to the crown classification of foresters.

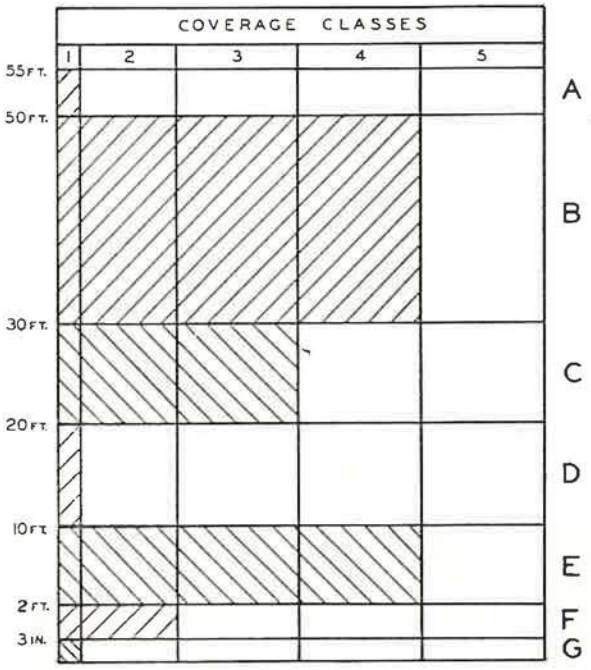

FIG. 5. A combination of coverage class data and stratification for the beech-maple community. (Based on coverage data and recorded from the quadrats and stratification diagrams made in the field at each tree quadrat.)

A. Trees of superior layer overtopping forest canopy. Mostly *Acer saccharum.*

B. Superior tree layer of *Fagus grandifolia, Acer saccharum,* and *Betula lutea.*

C. Upper inferior tree layer of *Fagus grandifolia* and *Acer saccharum.*

D. Lower inferior tree layer of *Fagus grandifolia, Acer saccharum, A. spicatum,* and *A. pennsylvanicum.*

E. Shrub layer of *Fagus grandifolia, Acer saccharum, Viburnum alnifolium,* and *Rubus canadensis.*

F. Herb layer dominated by Dryopteris, Eupatorium, and Impatiens.

G. Moss layer consisting of various mosses and lichens.

Frequency.

In Table 2 is presented a complete list of species occurring in the beech-maple community, as determined by quadrat data. The frequency index (frequency percentage) for each species is shown for separate stands as well as for the community as a whole.

Fagus grandifolia, with a frequency of 95 percent for the stand on north slope and 100 percent for each stand on south slope, is most frequent tree species. The one quadrat of the north slope in which this species did not occur was in an outwash which was very moist and was dominated by *Betula nigra* and *Betula lenta. Acer saccharum* ranks second, with a frequency of 75 percent for north slope, 55 percent and 95 percent, respectively, for south slope stands, and with an average of 75 percent for the community. *Aesculus octandra* and *Betula lutea* each show the same frequency for the community, 11.7 percent, with slight differences as to stands. Each of the remaining 9 species has a frequency below 10 percent, and it may be noted that *Acer pennsylvanicum* occurs

in all three stands, that *Amelanchier laevis* occurs in two stands, and each of the other 7 species occurs in but one stand.

The important trees of this community are *Fagus grandifolia, Acer saccharum, Betula lutea, Aesculus octandra,* and *Amelanchier laevis* as superior or "overstory" species, and *Acer spicatum* and *Acer pennsylvanicum* as inferior or "understory" species. *Picea rubra* is an accidental intruder from the spruce-fir forest above, and *Crataegus* sp. is a rare intruder from the higher ridges and balds.

Density.

Densities of woody species above 1 foot high by stands and for the community as a whole are shown in Table 3. Of the total individuals of tree species, 73 percent belong to *Fagus grandifolia,* 22 percent to *Acer saccharum,* 2.7 percent to *Acer spicatum,* 1 per-

TABLE 2. Frequency and coverage data for species occurring in the beech-maple community. (July and August, 1937.)

Floristic list	Frequency percent				Distribution of coverage classes for the community					
Stand:	A	B	C	Community						
Altitude:	4,600	4,800	4,800	...						
Exposure:	NE	S	S	...						
Slope:	14°	10°	8°	...	0	1	2	3	4	5
Trees[1]										
Acer pennsylvanicum	5	10	5	6.7	..	..	..	..	..	..
Acer saccharum	75	55	95	75.0	..	..	..	..	..	..
Acer spicatum	15	.....	.....	5.0	..	..	..	..	..	..
Aesculus octandra	10	15	10	11.7	..	..	..	..	..	..
Amelanchier laevis	10	15	.....	8.3	..	..	..	..	..	..
Betula lenta	10	.....	.....	3.3	..	..	..	..	..	..
Betula nigra	5	.....	.....	1.7	..	..	..	..	..	..
Betula lutea	15	5	15	11.7	..	..	..	..	..	..
Crataegus sp.	.....	.....	5	1.7	..	..	..	..	..	..
Fagus grandifolia	95	100	100	98.2	..	..	..	..	..	..
Picea rubra	.....	5	.....	1.7	..	..	..	..	..	..
Prunus serotina	.....	5	.....	1.7	..	..	..	..	..	..
Shrubs[2]										
Cornus alternifolia	5	.....	.....	1.7	..	..	..	..	..	..
Ribes rotundifolium	15	.....	.....	5.0	..	..	..	..	..	..
Rubus canadensis	10	10	.....	6.7	..	..	..	..	..	..
Sambucus canadensis	5	.....	.....	1.7	..	..	..	..	..	..
Viburnum alnifolium	30	10	.....	13.3	..	..	..	..	..	..
Pteridophytes[3]										
Athyrium thelypteroides	1	.....	.....	.3	..	..	1	..	..	..
Dryopteris dilatata	46	2	1	17.0	11	25	14	1	..	..
Polypodium virginianum	3	.....	.....	1.0	1	1	..	1	..	..
Polystichum acrostichoides	10	.....	.....	3.3	1	6	3	..	..	..
Lycopodium lucidulum	27	1	.....	9.3	10	13	3	2	..	..
Herbs[3]										
Actaea alba	8	.....	4	4.0	3	5	4	..	..	..
Allium tricoccum	7	.....	.....	2.3	3	3	..	..	..	..
Arisaema triphyllum	20	36	47	31.0	77	19	..	..	..	..
Aster divaricatus	54	29	16	33.0	67	30	2	..	..	..
Aster acuminatus	10	.....	.....	3.3	5	4	1	..	..	..
Carex leptalea	1	.....	.....	.3	1	..	..	..	..	..
Carex lucorum	16	62	5	27.7	15	21	23	18	6	..
Chelone Lyoni	7	.....	.....	2.3	3	3	1	..	..	..
Clematis Viorna	1	.....	.....	.3	..	1	..	..	..	..
Clintonia umbellulata	5	.....	.....	1.7	2	3	..	..	..	..
Cimicifuga racemosa	12	.....	.....	4.0	..	5	4	3	..	..
Circaea alpina	2	.....	.....	.7	1	..	1	..	..	..
Danthonia compressa	1	.....	.....	.3	..	1	..	..	..	..
Dioscorea villosa var. *glabra*	.....	7	2	3.0	7	2	..	..	..	..
Diphylleia cymosa	2	.....	.....	.7	..	2	..	..	..	..
Eupatorium rotundifolium	22	34	32	27.0	37	34	5	5	1	..
Galium triflorum	6	1	1	2.7	4	4	..	..	..	..
Heuchera villosa	4	.....	.....	1.3	4	..	..	..	..	..
Impatiens biflora	40	2	5	15.0	19	20	4	3	1	..
Empatiens pallida	4	.....	3	2.3	5	2	..	..	..	..
Isopyrum biternatum	1	.....	.....	.3	..	1	..	..	..	..
Maianthemum canadense	13	3	.....	5.3	8	8	..	..	..	..
Melanthium parviflorum	11	9	1	7.0	1	20	..	..	..	..
Mitella diphylla	2	.....	.....	.7	1	1	..	..	..	..
Monotropa uniflora	2	.....	.....	.7	1	1	..	..	..	..
Nabalus cylindricus	.....	.....	2	.7	2	2	..	..	..	..
Oxalis acetosella	3	.....	.....	.7	..	2	..	..	..	..
Podophyllum peltatum	.....	.....	2	.7	..	2	..	..	..	..
Prenanthes altissima	2	.....	.....	.7	..	1	1	..	..	..
Saxifraga leucanthemifolia	2	.....	.....	.7	..	1	1	..	..	..
Sedum ternatum	1	.....	.....	.3	..	1	..	..	..	..
Smilacina racemosa	4	4	4	4.0	..	11	1	..	..	..
Solidago squarrosa	1	4	6	3.7	8	2	1	..	..	..
Stellaria pubera	50	8	5	21.0	30	28	5	..	..	..
Streptopus roseus	5	.....	.....	1.7	3	2	..	..	..	..
Trautvetteria carolinensis	2	.....	7	3.0	9	..	..	..	..	..
Urtica dioica	12	2	5	6.3	10	5	3	1	..	..
Veronica officinalis	1	.....	.....	.3	1	..	..	..	..	..
Viola cucullata	9	.....	.....	3.0	7	5	1	..	..	..
Viola canadensis	2	.....	.....	.7	2	..	..	..	..	..
Moss and lichen cover	32	11	10	17.6	11	17	20	3	1	1

[1]Based on 60 quadrats 10 by 10 meters, 20 in each stand.
[2]Based on 60 quadrats 4 by 4 meters, 20 in each stand.
[3]All herbaceous data based on 300 quadrats 1 by 1 meter, 100 in each stand.

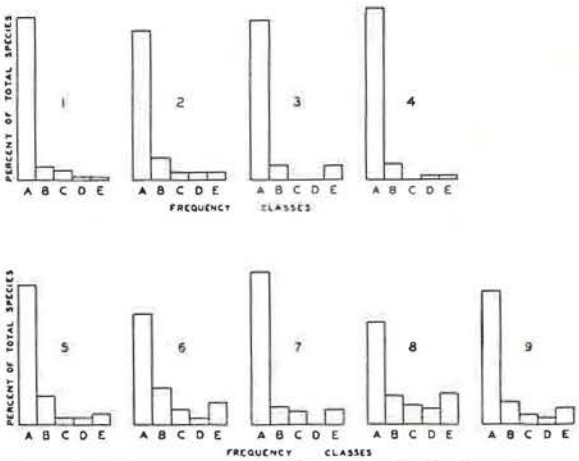

FIG. 6. Frequency class diagrams of the forest communities.
1. Stand A, beech-maple community.
2. Stand B, beech-maple.
3. Stand C, beech-maple.
4. The beech-maple community as a whole.
5. Stand A, spruce-fir community.
6. Stand B, spruce-fir.
7. The spruce-fir community as a whole.
8. Raunkiaer's "normal."
9. Kenoyer's "normal."

FIG. 7. Beech-maple forest of the north slope as viewed from Roan High Bluff, altitude 6,267 feet. Note presence of spruce and fir at the higher altitudes. The cleared fields below are at an altitude of about 3,500 feet.

cent to *Acer pennsylvanicum*, and 1.3 percent to the other 9 species. The north slope supports higher densities than the south slope. This is especially noticeable for *Acer spicatum* and *Acer pennsylvanicum*, 99 percent of which occur on the north slope.

Densities of tree species by five size classes are shown in Table 4. Only two species, *Fagus grandifolia* and *Acer saccharum*, occur in all classes. This indicates that these species are maintaining themselves. The mortality of *Acer saccharum* in the early stages is high as compared to *Fagus grandifolia*, since more than 95 percent of seedlings die before reaching a height of 1 foot. The 67 individuals under 1 foot high recorded for *Fagus grandifolia* represent seedlings and this number does not include the numerous root suckers. *Acer spicatum* and *Acer pennsylvanicum* are not important trees, since they do not reach a d.b.h. of more than 3 inches. About 90 percent of the former and 66 percent of the latter die before they reach a height of 1 foot. *Prunus serotina*, *Fraxinus* sp., and *Quercus velutina* are less than 1 inch

FIG. 8. Winter aspect of beech-maple forest community showing something of density and size classes. North slope at 4,800 feet altitude. Photographed January, 1936.

TABLE 3. Number per acre of woody individuals 1 foot high and over occurring in different stands of the beech-maple community.[1] Stand A is on north slope and stands B and C are on south slope.

Species	Individuals per acre			
	Stand A	Stand B	Stand C	Community
Trees				
Fagus grandifolia	4,688	4,972	3,040	4,233
Acer saccharum	1,906	562	1,316	1,262
Acer spicatum	474	....	....	158
Acer pennsylvanicum	194	4	2	67
Aesculus octandra	6	80	16	34
Betula lutea	22	28	10	20
Betula nigra	30	....	....	10
Prunus serotina	....	14	....	5
Fraxinus sp.	....	12	....	4
Tilia sp.	12	....	....	4
Amelanchier laevis	4	6	....	3
Betula lenta	6	....	....	2
Picea rubra	....	2	....	1
Total trees	7,342	5,680	4,382	5,802
Shrubs				
Viburnum alnifolium	762	50	....	272
Rubus canadensis	488	88	....	192
Ribes rotundifolium	88	....	....	29
Sambucus racemosa	12	....	....	4
Total shrubs	1,350	138	....	496
Total trees and shrubs	8,692	5,818	4,382	6,298

[1]The basic figures for individuals 1 inch d.b.h. or larger were obtained from 20 quadrats 10 by 10 meters for each stand; the basic figures for those under 1 inch d.b.h. were obtained from 20 quadrats 4 by 4 meters for each stand and multiplied by proper factor to make them equivalent to as many 10 by 10 meter quadrats. These values were then combined and their sums multiplied by 2 to change to an acre basis.

TABLE 4. Density per acre of tree species by five size classes as represented in the beech-maple community.[1] (Based on 60 quadrats 10 by 10 meters.)

Species	Up to 1 ft. high	1 ft. to 1 in. d.b.h.	1-3 in. d.b.h.	4-9 in. d.b.h.	10 in. and over	Total
Acer saccharum	18,952	1,096	132	25	8	20,213
Fagus grandifolia	67	3,758	272	147	56	4,300
Acer spicatum	1,387	146	11	1	.....	1,545
Betula lutea	293	13	.....	1	6	313
Prunus serotina	320	4	1	.....	.....	325
Acer pennsylvanicum	186	63	4	.....	.....	253
Betula lenta	80	.....	.....	2	.....	82
Fraxinus americana	67	4	.....	.....	.....	71
Aesculus octandra	.....	25	5	3	1	34
Quercus velutina	27	.....	.....	.....	.....	27
Betula nigra	.....	.....	8	1	1	10
Amelanchier laevis	.....	.....	.....	1	3	4
Picea rubra	.....	.....	1	.....	.....	1
Total	21,379	5,109	434	181	75	27,178

		Number	Percent
Number and percentage of species occurring in	five classes	2	14.3
	four classes	2	14.3
	three classes	4	28.6
	two classes	3	21.4
	one class	3	21.4
Total		14	100.0

[1]Basic figures for sizes under 1 inch d.b.h. were taken from the 4 by 4 meter quadrants and multiplied by the figure necessary to make total density equivalent to 1 acre. Basic figures for sizes above 1 inch d.b.h. were reduced to an acre basis

d.b.h except one Prunus which was 10 inches d.b.h. These occurred on the south slope and indications are that they would never be expected to play an important role in tree layer. Quercus, present in the quadrats only as seedlings, is a tree rarely found on Roan Mountain, although a few large specimens were observed on ridges of south slopes between 4,500 and 5,000 feet altitude.

Basal Area.

Basal area data for trees of the beech-maple community are shown in Table 5. Basal area per acre for all trees by stands varies from 127.64 square feet in Stand A to 174.82 square feet in Stand C. But since

TABLE 5. Basal area and density per acre of trees of the beech-maple community. The upper figure of each pair represents basal area and the lower one, density. (Based on 20 quadrats, 10 by 10 meters, in each stand.)

Stands:	Basal area in square feet				Percent of total basal area	Average basal area per stem (sq. ft.)
	A	B	C	Community		
Fagus grandifolia	87.10	106.94	108.38	100.81	65.99	.212
	400.00	596.00	428.00	474.67		
Acer saccharum	14.82	34.02	27.10	25.31	16.67	.152
	106.00	50.00	340.00	765.34		
Betula lutea	15.64	1.84	33.30	16.93	11.16	2.309
	10.00	2.00	10.00	7.33		
Amelanchier laevis	2.20	6.14	.....	2.78	1.83	.834
	4.00	6.00	.....	3.33		
Aesculus octandra	.12	3.00	4.38	2.50	1.58	.257
	6.00	18.00	4.00	9.33		
Betula nigra	4.08	.....	.....	1.36	.88	.136
	30.00	.....	.....	10.00		
Acer spicatum	2.00	.....	.....	.67	.44	.053
	38.00	.....	.....	12.67		
Crataegus sp.	.....	.....	1.64	.55	.36	.410
	.....	.....	4.00	1.33		
Betula lenta	1.60	.....	.....	.53	.35	.267
	6.00	.....	.....	2.00		
Prunus serotina	.....	1.30	.....	.43	.28	.650
	.....	2.00	.....	.67		
Acer pennsylvanicum	.08	.26	.02	.12	.08	.030
	6.00	4.00	2.00	4.00		
Picea rubra	.....	.02	.....	.01	....	.010
	.....	2.00	.....	.67		
Totals: Basal area:	127.64	153.54	174.82	152.00	100.00	
Density:	606.00	680.00	788.00	691.30		

the density increases in about the same ratio as basal area the sizes of trees average about the same for all stands. The relative importance of each species in the community is best shown by the percentage each represents of total basal area of all species present. *Fagus grandifolia* ranks first with 65.99 percent, followed in order by *Acer saccharum* with 16.67 percent, *Betula lutea* with 11.16 percent, *Amelanchier laevis* with 1.83 percent, *Aesculus octandra* with 1.58 percent, and the remaining 8 species with less than 1 percent each. Average basal area per stem for each of the three important trees is: *Fagus grandifolia*, 0.212 square feet; *Acer saccharum*, 0.152 square feet; and *Betula lutea*, 2.309 square feet. This means that the stems of *Betula lutea* average much larger than any other species.

TABLE 6. A comparison of basal area per acre of trees 1 inch and above, of the beech-maple community by three size classes. (Based on 60 quadrats 10 by 10 meters.)

Species	Basal area per acre			
	1-3 in. d.b.h.	4-9 in. d.b.h.	10 in. and over	Total
Fagus grandifolia	7.15	39.71	53.95	100.81
Acer saccharum	3.51	4.15	17.65	25.31
Betula lutea	.02	.18	16.73	16.93
Amelanchier laevis	....	.29	2.49	2.78
Aesculus octandra	.13	.43	1.84	2.40
Betula nigra	.25	.29	.82	1.36
Acer spicatum	.41	.25	....	.66
Crataegus sp.	....	.11	.44	.55
Betula lenta	....	.53	....	.53
Prunus serotina	....	....	.44	.44
Acer pennsylvanicum	.12	....	....	.12
Picea rubra	.01	....	....	.01
Totals	11.81	45.94	94.36	151.91

[1]Basic figures from 60 quadrats 10 by 10 meters were multiplied by 2/3 to reduce them to an acre basis.

A comparison of basal area by size classes is shown in Table 6. *Acer saccharum* has a higher percentage of its total basal area in the 1- to 3-inch class than does *Fagus grandifolia*, which may indicate a future trend toward more *Acer saccharum*. On the other hand, *Betula lutea* shows essentially all of its basal area in the 10-inch class and above, indicating its deterioration in the community. But the mortality of *Betula lutea* is lowest of any species within the community due to its unusual ability to withstand windfall and heart rot.

Phytographs.

Five of the more important species of trees are presented graphically in Figure 9 by means of phytographs (Lutz, 1930). Four axes of phytographs

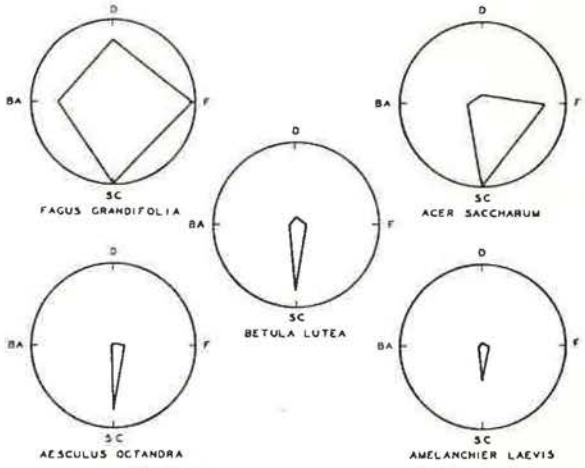

FIG. 9. Phytographs of the more important tree species of the beech-maple community. Constructed from data shown in Table 7.

Legend:
D, percentage of total density, 10 inches d.b.h. and over.
F, frequency percentage, 1 inch d.b.h. and over.
SC, representation in the different size classes.
BA, percentage of total basal area.

herein employed are percentage expressions of (1) abundance of stems 10 inches d.b.h. or over, (2) frequency of stems 1 inch d.b.h. or over, (3) number of size classes in which the species is found, and (4) basal area. Data for construction of the phytographs are shown in Table 7.

TABLE 7. Data for construction of phytographs: 5 species. (Based on data from tables—Values on percentage of total basis.)

Species	Radius 1; Abundance above 10 in. d.b.h.	Radius 2; Frequency above 1 in. d.b.h.	Radius 3; Number of size classes	Radius 4; basal area
Fagus grandifolia	74.7	98.2	100	66.4
Acer saccharum	10.7	75.0	100	16.7
Betula lutea	8.0	11.7	80	11.2
Aesculus octandra	1.3	11.7	80	1.6
Amelanchier laevis	4.0	8.3	40	1.8

Fagus grandifolia is the most important tree of the community, the first dominant, and is followed by *Acer saccharum* as codominant. The more important associates are *Betula lutea, Aesculus octandra,* and *Amelanchier laevis.*

SHRUB LAYER

Frequency.

Only 6 species of shrubs were recorded in the beech-maple community, with 5 appearing in Stand A, 3 in Stand B and none in Stand C (Table 2). *Viburnum alnifolium,* frequency 11.7 percent, ranks first, with *Rubus canadensis,* frequency 6.7 percent, occurring in open places, and *Ribes rotundifolium,* frequency 5 percent, in moist sites. Each of the other three species, *Cornus alternifolia, Sambucus canadensis,* and *Sambucus racemosa,* has a frequency of 1.7 percent.

Density.

Viburnum alnifolium shows the greatest density of any shrub, with 94 percent of the total count appearing on the north slope in Stand A, 6 percent on the south slope in Stand B, and none in Stand C. *Rubus canadensis* ranks second with 85 percent of the plants being on the north slope and 15 percent on the south slope in Stand B. The total density of all shrubs 1 foot high or more is 744 as compared to 5,109 tree stems 1 foot high to 1 inch d.b.h. Basic figures for the above percentages are presented in Table 2.

Densities of woody species of the shrub layer by height classes are shown in Table 8. Shrub species represent only 9 percent of total density of all species 1 to 12 feet high (shrub layer). Thus it is seen that the shrub layer is dominated by transgressives. Of these, 85 percent are *Fagus grandifolia* and *Acer saccharum* and at least three fourths of the total individuals are *Fagus grandifolia.*

HERB LAYER

Pteridophytes and herbs (including grasses and sedges) are included in the herb layer. Seedlings of both trees and shrubs are temporarily present in this layer but are not considered at this point since they belong to superior layers when mature.

TABLE 8. Density per acre of the woody species, up to 12 feet high, by three height classes as represented in the beech-maple community. (Based on 60 quadrats, 4 by 4 meters, 0.24 acre.)[1]

Species	Up to 1 ft.	1 ft.-3 ft.	3 ft.-12 ft.	Total
Trees				
Acer saccharum	18,950	479	617	20,046
Fagus grandifolia	67	2,333	1,425	3,825
Acer spicatum	1,388	121	25	1,534
Prunus serotina	321	4	.....	325
Betula lutea	292	13	.....	305
Acer pennsylvanicum	188	58	4	250
Crataegus sp.	92	.....	.....	92
Betula lenta	79	.....	.....	79
Fraxinus sp.	67	4	.....	71
Aesculus octandra	.....	21	4	25
Tilia sp.	.....	4	.....	4
Shrubs				
Viburnum alnifolium	79	208	63	350
Rubus canadensis	67	154	38	259
Ribes rotundifolium	92	29	.....	121
Sambucus canadensis	.....	4	.....	4
Sambucus racemosa	.....	4	.....	4
Cornus alternifolia	.....	4	.....	4
Total	21,682	3,440	2,176	27,298

[1]Basic figures for reproduction under 6 inches were taken from 300 quadrats 1 by 1 meter and changed to an acre basis. Trees 1 inch d.b.h. and over were not included.

Frequency.

The only fern of importance is *Dryopteris dilatata,* which is confined almost exclusively to the north slope and has a frequency of 17 percent for the community. The other three species encountered, namely, *Polystichum acrostichoides, Polypodium virginianum,* and *Asplenium acrostichoides* are confined exclusively to the north slope where they show frequencies of 10 percent, 3 percent, and 1 percent, respectively, for the stands. *Lycopodium lucidulum* is confined essentially to the north slope where it shows a frequency of 27 percent as compared to 0.5 percent for the south slope.

Of the 40 species of herbs, only 11 species occur in all these stands, and 6 of these show a frequency above 10 percent for the community. These are: *Aster divaricatus,* 33 percent, *Arisaema triphyllum,* 31 percent, *Carex lucorum,* 27.7 percent, *Eupatorium roanensis,* 27 percent, *Stellaria pubera,* 21 percent, and *Impatiens biflora,* 15 percent. The others are: *Galium triflorum,* 2.7 percent, *Melanthium parviflorum,* 7 percent; *Smilacina racemosa,* 4 percent, *Solidago squarrosa,* 3.7 percent, and *Urtica dioica,* 6.3 percent. These 11 species are reasonably well distributed in all three stands of the community, with the exception of *Carex lucorum,* which occurs with a frequency of 5 percent and 62 percent, respectively, for stands of the southern slope, as compared to 16 percent for the stand on northern slope. *Impatiens biflora* and *Stellaria pubera* are 6 to 8 times more frequent on the north slope than on the south slope. Forty-two of the 45 species of the herb layer occur on north slope, while only 20 species are found on

south slope with 15 species in Stand B and 18 species in Stand C. The most characteristic species of the herb layer are: *Actaea alba, Lycopodium lucidulum, Cimicifuga racemosa, Eupatorium roanensis, Maianthemum canadense, Smilacina racemosa, Urtica dioica, Arisaema triphyllum, Melanthium parviflorum, Impatiens biflora, Carex lucorum,* and *Stellaria pubera.*

Coverage.

Coverage classes for all species present in the herb layer are shown in Table 2. *Carex lucorum,* with an average coverage of class 2 for the community, is highest for any species in the herb layer and its highest coverage is in Stand B of south slope. This species covers approximately 15 percent of total quadrat area although a variation of from 1 to 75 percent occurs among individual quadrats. It is most abundant where canopy is relatively open, as along the broad ridges of upper slopes. Only three species show a coverage of class 1, namely, *Dryopteris dilatata, Eupatorium roanensis,* and *Impatiens biflora.* The other 41 species of the community are present with a coverage less than 1 percent; however, a few of them, as *Cimicifuga racemosa* and *Urtica dioica,* show a coverage of class 1 in Stand A. Total coverage of all herbs is only class 2 for the community, which means that less than 25 percent of total ground surface is shaded by plants of herb layer.

Woody seedlings.

Quadrat data show 19,452 seedlings (under 1 foot high) per acre for the community. Of these, 18,027 belong to *Acer saccharum* which shows a frequency of 90 percent, while only 67 belong to *Fagus grandifolia* which shows a frequency of 1.3 percent. But it must be remembered that Acer reproduces mostly seedlings while Fagus commonly reproduces by root suckers. *Prunus serotina, Betula lutea,* and *Acer pennsylvanicum* show a combined total of 786 individuals per acre and are the only other woody species with more than 100 seedlings each per acre. The shrubs, *Ribes rotundifolium* and *Viburnum alnifolium* show 93 individuals each per acre. The north slope supports practically all the shrub seedlings recorded for the community, indicating that the north slope is more mesic than the south slope.

MOSS LAYER

No attempt was made to consider the different species of mosses and lichens, but they were recorded as a layer and coverage indicated if the layer was present. In general, when moss occurred lichens were present also. Frequencies for this layer were as follows: Stand A, 32 percent; Stand B, 11 percent; and Stand C, 10 percent. The average for the community was 17.6 percent. Coverage for the community was class 1, and was much higher on the north slope than on the south slope.

BEECH-MAPLE COMMUNITY AS A WHOLE

The following four layers were recognized: tree layer, shrub layer, herb layer, and ground layer. The tree layer consists of 12 species and is dominated by beech and maple but yellow birch becomes more important with increased altitude until it forms "consociations" at upper limits of this hardwood zone. The shrub layer consists of 6 species only and these represent only 9 percent of woody individuals from 1 to 12 feet high. The remaining 91 percent is represented by tree transgressives which dominate the shrub layer. Hobble bush *(Viburnum alnifolium)* is most important shrub present. Of 41 species present in the herb layer, only four (*Carex lucorum, Dryopteris dilatata, Eupatorium roanensis,* and *Impatiens biflora*) cover as much as class 1 (1 to 5 percent of the surface). One species, *Carex lucorum,* covers class 2 (5 to 25 percent of the surface). A light ground cover of mosses and lichens covered less than 5 percent of the surface.

FIG. 10. Interior view of beech-maple forest as it occurs in Stand A of the north slope. Note unevened age condition of trees. Dryopteris, Smilacina, Cimicifuga, and Allium may be seen in the herb layer.

As indicated by basal area data, this forest community shows a better development of trees on southern slopes than on northern slopes of Roan Mountain. Frequency and coverage data show a better development of shrubs, herbs, and mosses on northern slopes, except for *Carex lucorum,* which shows its best development on southern slopes. As evidenced by the vigorous distribution of trees of all sizes and ages, it appears that the dominants of this community are being maintained.

SPRUCE-FIR COMMUNITY

Location of Stands.

Fortunately a virgin area was located and two stands studied before cutting began.[4] Stand A was sampled by laying out 20 tree and 20 shrub quadrats distributed at 50-meter intervals according to the Latin square method and by 100 herb quadrats located at 10-meter intervals along control lines. Stand B was sampled by laying out 12 tree and 12 shrub quadrats accompanied by 60 herb quadrats distributed at 10-meter intervals along control lines. Stand A was located about one-half mile north of the United

[4] This community was studied early in the summer of 1934. By the time quadrat work was completed, more than half the area had been cut. Trees were cut from a few quadrat areas in less than an hour after they had been studied.

FIG. 11. Upper limit of hardwood forest as seen from Jane Bald, 6,000 feet altitude, looking west toward Roan High Knob (distant center). Note sharp margin of Fagus bordering grassy bald on the south slope (left) and orchard condition of Aesculus on the north slope (right). Alnus thicket appears in the foreground.

States Geological Survey marker on Roan High Bluff (6,267 feet altitude) at an altitude of 5,400 feet. Stand B was located about half way between Stand A and the geological marker at 5,800 feet altitude. Topography of the area immediately north and west of Roan High Bluff in which these stands were located is the most rugged part of the mountain. The slope ranges from 10 degrees to vertical cliffs 10 to 50 feet high. Topography is also quite irregular, with slopes facing all points of compass except south, but the main exposure is northwest. Soil is moist and fertile and usually shallow, except in small depressions and "shelves" at heads of coves. About 10 percent of area is exposed rock, mostly outcrop, which is usually covered with mosses, lichens, and ferns.

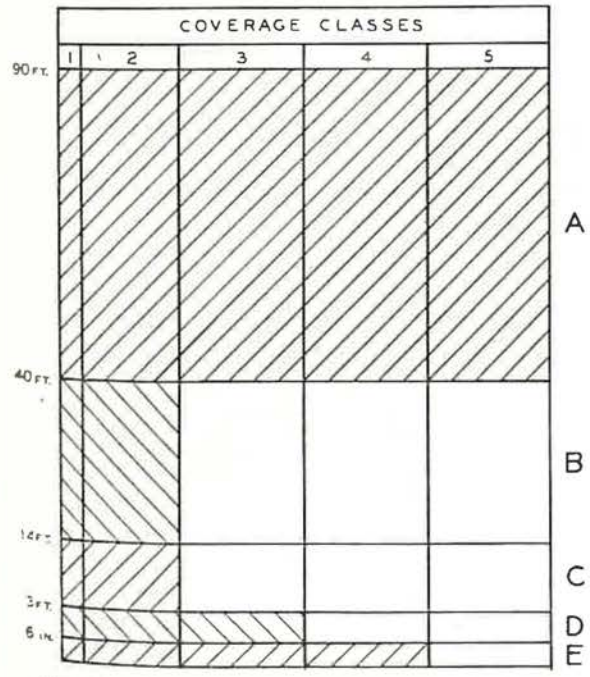

FIG. 12. Stratification-coverage diagram for Stand A of the spruce-fir community.
A. Superior tree layer of Picea and Abies.
B. Inferior tree layer of Betula with Picea and Abies.
C. Shrub layer of Rhododendron, Vaccinium, and Viburnum.
D. Herb layer dominated by Dryopteris.
E. Moss or ground layer of mosses interwoven with Oxalis.

Windfall seems to have been a most important single natural factor affecting vegetation, and has been more severe on heavily exposed ridges. In one small area, 13 trees above 10 inches d.b.h. were counted which had been blown down at different times. Near the summit on the north slope, a landslide had occurred which left about 200 square meters of exposed rock. A few fir trees on the higher spurs had been killed by lightning. So far as could be learned no disturbance had been caused by man or his domestic animals within the area sampled.

Stratification.

In this community four major layers occur which are better differentiated than those of the beech-

TABLE 9. Frequency and coverage data for species occurring in the spruce-fir community. (June and July, 1934.)

Floristic list	Frequency percent			Distribution of coverage classes for the community					
Stand:	A	B	Community						
Altitude:	5,400	5,800	....						
Exposure:	NW	NW	NW						
Slope:	20°	30°	....	0	1	2	3	4	5
Trees[1]									
Abies Fraseri	95	100	97.5	..	..	..	..	..	..
Acer spicatum	25	75	50	..	..	..	..	..	..
Aesculus octandra	5	8.3	6.7	..	..	..	..	..	..
Betula lutea	80	91.7	85.8	..	..	..	..	..	..
Fagus grandifolia	10	.....	5	..	..	..	..	..	..
Picea rubra	100	100	100.	..	..	..	..	..	..
Prunus pennsylvanica	5	.....	2.5	..	..	..	..	..	..
Sorbus americana	15	25	20	..	..	..	..	..	..
Shrubs[2]									
Cornus alternifolia	20	8.3	14.2	..	..	..	..	..	..
Hydrangea arborescens	5	.....	2.5	..	..	..	..	..	..
Lonicera canadensis	5	.....	2.5	..	..	..	..	..	..
Rhododendron catawbiense	20	50	35	..	..	..	..	..	..
Ribes rotundifolium	5	8.3	6.7	..	..	..	..	..	..
Rubus canadensis	.....	16.7	8.4	..	..	..	..	..	..
Sambucus racemosa	5	.....	2.5	..	..	..	..	..	..
Vaccinium erythrocarpum	35	56.7	45.9	..	..	..	..	..	..
Viburnum alnifolium	50	25	37.5	..	..	..	..	..	..
Pteridophytes[3]									
Dryopteris dilatata	80	88.3	84.1	35	..	18	17	2	4
Athyrium asplenioides	.....	30	15	..	6	8	3	1	..
Polystichum acrostichoides	2	.....	1	..	2	..	..	..	..
Polypodium virginianum	25	16.6	20.8	2	17	9	5	..	..
Lycopodium lucidulum	33	30	31.5	2	40	7	2	..	..
Herbs[3]									
Agrostis hyemalis	.....	3.3	1.7	2	..	..	..	..	..
Agrostis perennans	6	.....	3	..	6	..	..	..	..
Angelica Curtisii	1	.....	0.5	..	..	1	..	..	..
Arisaema triphyllum	15	1.6	8.3	1	11	2	2	..	..
Aster acuminatus	19	15	17	20	3	3	1	..	..
Aster divaricatus	32	40	36	7	27	17	4	1	..
Cardamine Clematitis	5	3.3	4.2	2	4	..	..	..	1
Carex gracillima	10	11.6	5.8	..	10	1	..	..	..

TABLE 9 *(Continued)*

Floristic list	Frequency percent			Distribution of coverage classes for the community					
Stand:	A	B	Community						
Altitude:	5,400	5,800	....						
Exposure:	NW	NW	NW						
Slope:	20°	30°	....	0	1	2	3	4	5
Carex trisperma	.....	1.6	0.8	1	..	..	..	..	..
Carex leptalea	1	11.6	6.3	3	5	..	..	..	..
Chelone Lyoni	18	20	19	3	19	8	..	..	..
Cimicifuga racemosa	5	.....	2.5	..	3	2	..	..	..
Circaea alpina	25	10	17.5	4	24	2	1	..	..
Clintonia borealis	9	23.3	16.2	4	13	5	1	..	..
Eupatorium roanensis	.....	1.6	0.8	1	..	1	..	..	..
Galium triflorum	15	.....	7.5	1	15	..	..	..	..
Houstonia serpyllifolia	9	.....	4.5	1	7	1	1	..	..
Hypericum graveolens	1	.....	0.5	..	..	1	..	..	..
Impatiens pallida	9	6.6	7.8	1	..	9	1	..	..
Isopyrum biternatum	8	1.6	4.8	1	..	8	..	..	..
Juncoides echinatum	5	.....	2.5	3	..	..	..	..	..
Maianthemum canadense	2	1.6	1.8	..	3	..	..	..	..
Oxalis acetosella	89	96.6	92.8	1	49	46	27	15	2
Prenanthes altissima	9	.....	4.5	..	6	1	2	..	..
Saxifraga leucanthemifolia	8	1.6	4.8	..	8	1	..	..	..
Solidago glomerata	3	23.3	13.2	1	3	6	5	2	..
Streptopus roseus	2	16.6	9.3	4	5	2	..	..	..
Tiarella cordifolia	47	46.6	46.8	2	50	18	3	..	2
Trautvetteria carolinensis	3	.....	1.5	..	..	..	3	..	..
Urtica dioica	3	.....	1.5	..	2	1	..	..	..
Veratrum viride	1	.....	0.5	..	1	..	..	..	..
Veronica officinalis	1	.....	0.5	..	1	..	..	..	..
Viola spp.	3	3.3	3.2	..	5	..	..	..	..
Zizia Bebbii	1	.....	0.5	..	..	1	..	..	..
Moss and lichen cover	94	96.6	94.8	..	20	26	37	14	16

[1]Based on 32 quadrats 10 by 20 meters, 20 in Stand A and 12 in Stand B.
[2]Based on 32 quadrats 5 by 5 meters, 20 in Stand A and 12 in Stand B.
[3]Pteridophytes and herb data based on 160 quadrats 1 by 1 meter, 100 in Stand A and 60 in Stand B.

maple. The stratification-coverage diagrams (Fig. 12) show the approximate vertical extent of each layer as well as surface extent (coverage). The understory and shrub layers show less coverage in Stand A than in Stand B, while the herb and ground layers are similar in both stands.

TREE LAYER

As shown in the stratification-coverage diagrams for the spruce-fir community (Fig. 12) the superior tree layer reaches a height of 90 feet in Stand A and only 60 feet in Stand B with about equal coverage for each stand. The superior layer is dominated by *Picea rubra* and *Abies Fraseri* at lower altitudes and by *Picea rubra, Abies Fraseri,* and *Betula lutea* at higher altitudes. In Stand A the inferior tree layer reaches a height of about 40 feet and covers about one fourth of the area. In Stand B this layer reaches a height of about 20 feet but covers approximately half the area.

Frequency.

Of the 8 tree species composing the spruce-fir community, *Picea rubra, Abies Fraseri,* and *Betula lutea* show frequencies of 80 percent or above for either stand, the first two running above 95 percent for the community (Table 9). *Acer spicatum,* frequency 50 percent, and *Sorbus americana, frequency* 20 percent, are more frequent at the upper altitudes. *Aesculus octandra,* frequency 6.2 percent, belongs to the beech-maple community, while *Prunus pennsylvanica,* frequency 2.5 percent, is a secondary successional species. Six of the 8 species occur in both stands.

Species characteristic of the tree layer, in order of frequency, are *Picea rubra, Abies Fraseri, Betula lutea, Acer spicatum,* and *Sorbus americana.* The first three are overstory species while the last two are understory species, although *Betula lutea* may occur in either layer.

TABLE 10. Comparison of basal area and density of trees in two stands of the spruce-fir community. The upper number represents basal area and the lower represents number of trees per acre above 1 inch d.b.h. (Based on 32 quadrats 10 by 10 meters, 20 in Stand A and 12 in Stand B. Both stands on the north slope but Stand A is approximately 400 feet higher than Stand B.)

Stands:	Basal area per acre: Density			Percent of total	Average basal area per stem
	A	B	Community		
Picea rubra	181.94	100.58	141.26	57.5	.63
	303.00	155.00	229.00	26.9	
Abies Fraseri	50.84	64.37	57.62	23.5	.11
	549.00	525.00	537.00	62.3	
Betula lutea	22.4	63.31	42.68	17.4	.81
	51.00	55.00	53.00	6.2	
Acer spicatum	1.78	2.40	2.09	.0	.07
	21.00	38.00	29.00	3.1	
Fagus grandifolia	1.51	.....	.76	.3	.38
	3.00	.....	2.00	.2	
Sorbus americana	.28	.87	.58	.2	.07
	4.00	13.00	8.00	1.0	
Aesculus octandra	.01	.92	.46	.2	.23
	1.00	2.00	2.00	.2	
Prunus pennsylvanica	.03	.....	.01	.0	.01
	1.00	.....	1.00	.1	
Totals	258.46	232.45	245.45	100.00	
	933.00	789.00	961.00	100.00	

Density.

Stand A shows a total density per acre of 933 as compared to 789 trees in Stand B (Table 10). The species showing higher densities at the higher altitudes are *Betula lutea, Acer spicatum* and *Sorbus americana,* while those with higher densities at the lower altitudes are *Picea rubra* and *Abies Fraseri.* Of the total individuals in the community, 62.3 percent belong to Abies and 26.9 percent belong to Picea. All other species compose only 10.8 percent of individuals, *Betula lutea* being highest with 6.2 percent.

Four of the species, *Abies Fraseri, Picea rubra, Betula lutea,* and *Acer spicatum,* are represented in all five size classes as shown in Table 11. *Sorbus americana* occurs in four classes while each of the other three species occurs in only one or two size classes. As *Sorbus americana* is usually a small tree, it would not be expected to appear in the large class of 10 inches d.b.h. or over. Since it appears in all other size classes, it is included as one of the four species which maintain themselves in the community.

TABLE 11. Density per acre of tree species by five size classes as represented in the spruce-fir community. (Trees above 1 inch d.b.h. based on 32 quadrats 10 by 20 meters; trees below 1 inch d.b.h. based on 32 quadrats 5 by 5 meters.)

Species	Number of individuals per acre					
	Up to 1 ft. high	1 ft. high-1 in. d.b.h.	1-3 in. d.b.h.	4-9 in. d.b.h.	10 in. and over	Total density
Abies Fraseri	832	1,040	399	112	24	2,407
Picea rubra	464	375	101	56	71	1,067
Betula lutea	384	230	18	8	26	666
Acer spicatum	136	240	24	4	1	405
Sorbus americana	40	155	6	2	.....	203
Fagus grandifolia	.....	.....	1	.....	1	2
Aesculus octandra	.....	.....	1	.....	1	2
Prunus pennsylvanica	.....	.....	1	.....	.....	1
Totals	1,856	2,040	551	182	124	4,753

Tables 11 and 12 show clearly that most of the large trees belong to *Picea rubra* but *Abies Fraseri* is more important than *Picea rubra* in the 4 to 9 inch d.b.h. class. It is quite common to find Abies appearing in almost pure "pole" stands less than 4 inches d.b.h. which accounts for its relatively high basal area in this size class. Due to heavy density of these stands, they may better withstand high wind velocities. *Betula lutea* is most important as a larger tree, often reaching a d.b.h. of more than 24 inches.

TABLE 12. A comparison of basal area per acre of trees (1 inch d.b.h. and above) of the spruce-fir community by three size classes. (Based on 32 quadrats 10 by 20 meters.)[1]

Species	Basal area per acre			
	1-3 in. d.b.h.	4-9 in. d.b.h.	10 in. and over	Total
Picea rubra	3.22	14.66	123.38	141.26
Abies Fraseri	13.86	20.69	23.07	57.62
Betula lutea	.42	2.82	39.44	42.68
Acer spicatum	.80	.96	.33	2.09
Fagus grandifolia	.....	.14	.62	.76
Sorbus americana	.32	.26	.....	.58
Aesculus octandra	.....	.....	.46	.46
Prunus pennsylvanica	.01	.....	.....	.01
Totals	18.63	39.53	187.30	245.46
Percentage of total basal area	7.6	12.0	80.4	100.

[1] Basic figures from 32 quadrats 10 by 20 meters were used to determine actual basal areas for each size class. These numbers were reduced to an acre basis.

Basal Area.

A much better idea of degree of dominance may be gained by referring to the first set of figures in Table 10, which represents basal area. Stand A has a basal area of 258.46 square feet per acre while Stand B has 232.45 square feet per acre. It appears to be a better site than Stand B for *Picea rubra*, but apparently not as good for *Abies Fraseri* as Stand B. *Betula lutea* shows about three times as great a basal area in Stand B as in Stand A. Tolerance of Picea to strong winds is one important explanation since wind action is more severe on the higher slopes. Of the total basal area, *Picea rubra* represents 57.5 percent, *Abies Fraseri*, 23.5 percent, *Betula lutea*, 17.4 percent, and all other species less than 1 percent each. *Betula lutea* shows the largest average stem size with a mean basal area of 0.81 square feet. *Picea rubra* ranks second with 0.63 square feet per stem while *Abies Fraseri* ranks third with only 0.11 square feet per stem.

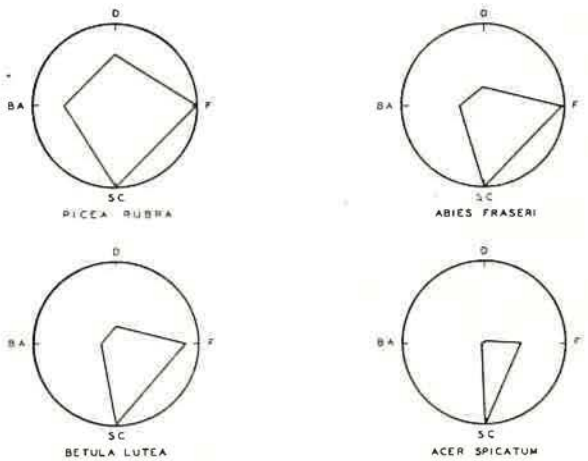

FIG. 13. Phytographs of the important tree species of the spruce-fir community. Constructed from data presented in Table 14. Legend is the same as for Fig. 8.

Phytographs.

Phytographs (Fig. 13) show graphically relative value of the four most important trees of this community. *Picea rubra* ranks highest in the number of large trees, in frequency percentage of trees, and in basal area. *Abies Fraseri* ranks second but has fewer trees above 10 inches d.b.h. than *Betula lutea*, which occupies third place. *Acer spicatum* ranks lowest, representing only 0.9 percent of the trees 10 inches d.b.h. or over and has an insignificant basal area. However, since it shows high frequency and is present in all size classes, it is an important species in the community.

TABLE 13. Data upon which phytographs in Figure 13 are based. (All values are on a percentage basis and are taken from Tables 10, 11, and 12.)

Species	Radius 1: Density 10 in. d.b.h. and over	Radius 2: Frequency 1 in. d.b.h. and over	Radius 3: Number of size classes	Radius 4: Basal area
Picea rubra	57.3	100	100	57.5
Abies Fraseri	19.4	96.8	100	23.5
Betula lutea	21.0	84.3	100	17.4
Acer spicatum	.9	43.7	100	.9

SHRUB LAYER

Frequency.

As shown in Table 9 the three shrubs with highest frequencies are *Vaccinium erythrocarpum*, 45.9 per-

cent; *Viburnum alnifolium,* 37.5 percent, and *Rhododendron catawbiense,* 35 percent. Viburnum is more frequent at lower altitudes while the other two are more frequent at higher altitudes.

All other species have a frequency below 10 percent except *Cornus alternifolia,* 14.2 percent. All species occurred in Stand A except *Rubus canadensis* which is usually confined to openings. *Hydrangea arborescens, Sambucus racemosa,* and *Lonicera canadensis* are rare shrubs of this area and are confined to upper altitudes.

TABLE 14. Density of woody species under 12 feet high by three height classes as found in the spruce-fir community. (Based on 32 quadrats 5 by 5 meters each.)[1]

Species	Number per acre				Coverage Class
	0-1 ft.	1-3 ft.	3-12 ft.	Total	
Trees					
Abies Fraseri	832	500	540	1,872	1
Picea rubra	464	195	80	739	1
Betula lutea	384	50	180	614	1
Acer spicatum	136	65	175	376	1
Sorbus americana	40	25	15	80	1
Shrubs					
Rhododendron catawbiense	145	145	145	435	1
Vaccinium erythrocarpum	100	120	45	265	1
Viburnum alnifolium	10	70	100	180	1
Rubus canadensis	25	40	.....	65	0
Cornus alternifolia	10	35	.....	45	0
Ribes rotundifolium	.....	35	.....	35	0
Lonicera canadensis	10	15	.....	25	0
Hydrangea arborescens	.....	10	.....	10	0
Total tree individuals	1,856	835	990	3,681	
Total shrub individuals	300	470	290	1,060	
Total woody individuals	2,156	1,305	1,280	4,741	

[1]The basic figures for seedlings under 6 inches were taken from 160 quadrats 1 by 1 meter and reduced to acre basis.

Density.

Of 4,741 woody individuals less than 12 feet high (Table 14), occurring in the shrub layer, 3,681 or 77.6 percent are individuals of tree species. These transgressives include 1,872 *Abies Fraseri,* 739 *Picea rubra,* and 614 *Betula lutea.* The density per acre for each of the more common shrub species is as follows: *Rhododendron catawbiense,* 435; *Vaccinium erythrocarpum,* 265; and *Viburnum alnifolium,* 180. The other 5 shrub species are represented by a total of only 180 individuals.

Frequency, coverage, and density data show that *Rhododendron catawbiense, Vaccinium erythrocarpum, Viburnum alnifolium, Cornus alternifolia* and *Ribes rotundifolium* are the more important species occurring in the shrub layer of the spruce-fir community.

HERB LAYER

Frequency.

Of the 5 pteridophytes present in the herb layer, only 3 may be considered characteristic. They are *Dryopteris dilatata,* frequency 84.1 percent, *Lycopodium lucidulum,* frequency 31.5 percent, and *Polypodium virginianum,* frequency 20.8 percent. *Athyrium asplenoides* is confined to moister sites of the upper slopes while *Polystichum acrostichoides,* an accidental species, belongs to the beech-maple and oak-chestnut communities of lower altitudes.

Of the 39 species occurring in the herb layer, *Oxalis acetosella* is the most frequent herb and is present in 92.8 percent of the quadrats. Other of the more frequent species are: *Tiarella cordifolia,* 46.8 percent; *Aster divaricatus,* 36 percent; *Chelone Lyoni,* 19 percent; *Circaea alpina,* 17.5 percent; *Aster acuminatus,* 17 percent; *Clintonia borealis,* 16.2 percent; and *Solidago glomerata,* 13.2 percent. These occur in each stand and are the most characteristic herb species of the community. All of the other 26 species have frequency indices below 10, and 7 are below 1.

Coverage.

The distribution of coverage classes for each species of the herb layer is shown in Table 9. *Dryopteris dilatata* and *Oxalis acetosella* belong to coverage class 2. They cover about 50 percent of the stand which is a greater coverage than that of all other species of the herb layer combined. No other species shows more than 6 percent coverage. *Aster acuminatus* and *Aster divaricatus* occur with coverages up to class 3 and 4, respectively, but more frequently occur with coverages of class 1 or 0. As might be expected, species with high frequency indices show greater distribution in the coverage classes. There also appears a positive correlation between frequency index and total coverage of species which emphasizes the value of frequency data in describing the organization and structure of a community.

Woody Seedlings.

All seedlings of woody species taken together cover about 3 percent of the total area sampled. *Abies Fraseri* and *Picea rubra* were more frequent than all other species combined but neither species covered more than 25 percent of any quadrat. *Viburnum alnifolium* and *Sorbus americana* were each recorded once for class 3; however, seedlings of either were rarely seen. As would be expected, no coniferous seedlings were observed in heavy shade. Seedlings of the two dominants, Abies and Picea, are most frequent, showing 18.7 percent and 15 percent, respectively.

MOSS LAYER

Table 9 shows that mosses and lichens occur in 94.8 percent of the herb plots under the coniferous forest and cover about 65 percent of total ground area. Moss often covers tree trunks to a height of a yard or two and *Usnea* sp. is commonly seen hanging from the limbs of trees.

COMMUNITY AS A WHOLE

This forest community, which commonly occurs in the Southern Appalachians above 4,500 feet, is classified by the Society of American Foresters (1932) as Forest Cover Type 19, red spruce-southern balsam fir. It is further described as commonly having yellow

FIG. 14. Interior view of spruce-fir forest as represented by Stand B. Note large spruce trees with long straight boles and abundant reproduction of both spruce and fir. Viburnum and Dryopteris are seen in foreground.

birch and hemlock associated with the dominants, especially at the lower portions of its range. No hemlock was observed on Roan Mountain above 4,000 feet, spruce and fir being the only conifers present in the area under study. From basal area studies yellow birch is about three times as important at 4,500-5,900 feet as at an altitude 500 feet lower.

Frequency class diagrams (Fig. 6) show the spruce-fir community to be more homogeneous than the beech-maple community, since the former has more of its species in the higher frequency classes. The upper portion of the spruce-fir community (Stand B) shows greater homogeneity than the lower portion (Stand A). Both frequency class curves (histograms) compare favorably with the "normals" of Raunkiaer and Kenoyer (Cain, 1932). When the two stands are combined, there appears less homogeneity than when they are viewed separately. Only 38 species occur in Stand B as compared to 50 species for Stand A. Most of the extra species in Stand A are accidental species from other communities, as *Fagus grandifolia, Polystichum acrostichoides,* and *Cimicifuga racemosa* from the beech-maple forest below and *Veronica officinalis* and *Houstonia serpyllifolia* from the grassy balds above. *Prunus pennsylvanica, Sambucus racemosa* and *Hypericum graveolens* are secondary successional species. This variation in floristic composition is reflected in the frequency class diagrams.

The spruce-fir community is characterized by four layers, a tree layer, a shrub layer, an herb layer, and a ground layer. The tree layer may be further divided into superior and inferior layers. The tree layer, consisting of 8 species, is dominated by *Picea rubra* and *Abies Fraseri* in the superior layer, and by *Betula lutea* and *Acer spicatum* in the inferior layer, birch appearing as one of the dominants at higher altitudes. The superior tree layer covers about 0.6 of the stand and the inferior layer covers about 0.4. The tree layer as a whole covers about 0.9. The shrub layer, consisting of 9 species, is dominated by *Rhododendron catawbiense, Vaccinium erythrocarpum,* and *Viburnum alnifolium* and covers about one half of the ground area. The herb layer, which covers about three fourths of the ground surface, consists of 39 species. It is dominated by *Dryopteris dilatata* in the upper stratum and by *Oxalis acetosella* nearest the ground. Important associated species in order of frequency are: *Tiarella cordifolia, Aster divaricatus, Aster acuminatus, Clintonia borealis, Solidago glomerata, Lycopodium lucidulum,* and *Polypodium virginianum.* The ground layer is carpeted with mosses and closely associated with them is Oxalis of the herb layer. Usnea which hangs from limbs of many trees throughout the community gives evidence of a constantly humid atmosphere under the spruce-fir canopy.

BALD COMMUNITIES

More or less extensive bald areas are characteristic of higher summits of the Southern Appalachians. They have been mentioned or briefly described by botanists since the days of Michaux and Gray. In more recent years plant ecologists have become much interested in these "sub-alpine" areas as indicated by the writings of Harshberger (1903), Cain (1930), Davis (1930), Camp (1931) and Wells (1932, 1937). Most of the recent interest, however, has been shown in an attempt to explain the origin rather than to determine the structure and composition of such communities. The present study deals with both interests, since each helps to explain the other.

In order to present an adequate picture of the structure and composition of the high bald communities of Roan Mountain, data were recorded from 450 quadrats located in 16 different stands. The stands were well distributed throughout the full extent of the areas occupied by these communities. The dynamics of the communities will later be discussed under "Succession."

A grassy bald community occupies about one half of the total bald area on Roan Mountain, and is considered by Wells (1937) to be perhaps the largest high mountain grassy bald of the Southern Appalachians. On the remaining portion, the rhododendron bald community is somewhat more extensive than the alder bald community. In certain protected areas of the Round Bald, dwarfed trees appear in the grass area in an "orchard" condition, Crataegus and Aesculus appearing on the southwest slope and Aesculus on the northeast slope. A dense stand of browsed beech often borders the lower margin of this community on Round Bald, while rhododendron thicket or spruce-fir forest border the grassy stretches on the mountain summit.

GRASSY BALD COMMUNITY

Location and Description of Stands.

By far the best development of the grassy bald community is on Round Bald, a dome-shaped summit immediately east of Carvers Gap. This community is often referred to as "mountain meadow" or "sub-

FIG. 15. Round Bald (grass) as it appears from west side. Carvers Gap is seen in front center. Stands A, B, and C were located on this exposure. Note dwarfed Crataegus above and to the south (right) of Carvers Gap and the patch of Alnus to the upper right immediately above the Fagus.

alpine meadow." Stands A, B, C, D, and E were located on this bald between 5,500 and 5,700 feet altitude. The exposures of these stands were as follows: Stand A, northwest; Stand B, southwest; Stand C, west; Stand D, north; and Stand E, southeast. Stand F was about 1.25 miles east of Carvers Gap on the northeast slope of Jane Bald at an altitude of about 5,700 feet. Stand G was approximately 2

FIG. 16. Looking east across Stand E which is located on the southeast slope of Round Bald. This represents best development of Danthonia on Roan Mountain. August, 1936.

miles west of Carvers Gap and 250 yards southwest of Cloudland Lodge at 6,150 feet. These stands were located on areas varying from almost level in Stand G to as much as a 30 degree slope in the steeper portion of Stand E. The average slope for the community is about 10 degrees.

Wind velocities are medium to strong in all stands, being strongest in Stand D, which is fully exposed to the prevailing northerly winds, and lightest in Stand G, which is best protected.

HERB LAYER

Frequency.

The frequency percentage and mean coverage class for each species recorded from the quadrats are shown in Table 15. The three species belonging to Class E (8 to 100 percent) for the community are *Danthonia compressa, Rumex acetosella,* and *Agrostis hyemalis.* Danthonia occurred in every quadrat of every stand except in Stand D of the north slope where it was absent from 2 quadrats. The mean community frequency for this species is 99.4 percent. *Rumex acetosella* varies from 72 percent frequency in Stand F to 98 percent frequency in Stand C and shows a mean frequency of 90.3 percent. *Agrostis hyemalis* ranges from 60 percent in Stand E to 100 percent in Stand D, averaging 87.4 percent frequency for the community. *Fragaria virginiana,* frequency 65.1 percent, is the only species in Class D, and ranges from 10 percent in Stand C to 100 percent in Stand E. The mean community frequency percentages for species of Class C are: *Houstonia serpyllifolia,* 44.8 percent, and *Carex flexuosa,* 41.1 percent. Class B is represented by 4 species: *Juncus tenuis,* 40 percent; *Viola blanda,* 33.8 percent; *Potentilla canadensis,* 26.3 percent; and *Carex glaucodea,* 22.9 percent. Of the 20 species in Class A, only two are above 10 percent, *Poa pratensis,* 11.6 percent, and *Veronica officinalis,* 14 percent.

The 7 species present in all 7 stands are: *Danthonia compressa, Rumex acetosella, Agrostis hyemalis, Fragaria virginiana, Carex flexuosa, Carex glaucodea,* and *Veronica officinalis.* The 4 species occurring in 6 of the 7 stands are: *Agrostis alba, Houstonia serpyllifolia, Poa pratensis,* and *Potentilla canadensis.*

Coverage.

The distribution of coverage classes for each species is shown in Table 15. There is only one dominant species in the herb layer, *Danthonia compressa,* which covers from 50 to 75 percent of the total area. It rarely covers less than 25 percent of the surface of any quadrat and frequently covers more than 75 percent of the surface of some quadrats, especially in areas of better development where it often attains a height of 2 feet. Of the other 29 species present in the herb layer, only 5 cover as much as 5 percent of the surface. These are *Rumex acetosella, Fragaria virginiana, Carex flexuosa, C. lucorum,* and *Agrostis hyemalis.*

Woody Seedlings.

As previously indicated, there are no trees or shrubs present in typical grassy bald areas. None taller than a foot were seen within the boundaries of the 7 stands studied. Seedlings recorded from the 250 quadrats are as follows: 8 *Rhododendron catawbiense,* 2 to 4 inches high; 6 *Picea rubra,* 2 to 10 inches high; and 1 *Vaccinium erythrocarpum,* 4 inches high. Of these 15 seedlings, 12 were present in Stand G which is bounded on either end by *Rhododendron catawbiense* and is within 100 meters of the coniferous forest which serves as a wind-break to the area.

TABLE 15. Frequency and coverage data for species of the grassy bald community. Where two numbers occur opposite a species, the upper number represents frequency percentage and the lower number represents coverage class. (Based on 250 quadrats, 1 by 2 meters. August, 1936.)

Floristic list	Frequency percent and coverage class								Distribution of coverage classes for the community					
Stand:	A	B	C	D	E	F	G	Community						
No. of samples:	50	25	50	50	25	25	25	250						
Altitude:	5,500	5,500	5,600	5,650	5,700	5,700	6,150	...						
Exposure:	NW	SW	W	N	SE	NE	S	...						
Slope:	7°	7°	8°	10°	15°	7°	5°	...	0	1	2	3	4	5
Pteridophytes														
Dryopteris	4	.....	.....	6	.....	4	.....	2.0	6	..	..	..	..	..
dilatata	0	.....	.....	0	.....	0	.....	0						
Herbs														
Achillea	.....	4	.....	.....	.....	.....	.....	.6	1	..	..	..	..	..
millefolium	.....	0	.....	.....	.....	.....	.....	0						
Agrostis alba	4	.....	10	8	32	12	8	10.6	30	2	..	..	..	..
	0	.....	0	0	1	0	0	0						
Agrostis	98	88	98	100	60	96	72	87.4	154	68	5	..	..	..
hyemalis	0	0	0	1	0	1	0	1						
Carex	2	.....	.....	.....	.....	.....	.....	.3	...	1	..	..	..	..
brunnescens	0	.....	.....	.....	.....	.....	.....	0						
Carex flexuosa	2	4	66	64	24	32	96	41.1	35	62	13	3	..	..
	0	0	1	1	0	0	1	1						
Carex	2	4	22	20	76	28	8	22.9	45	4	..	..	..	..
glaucodea	0	0	0	0	0	0	0	0						
Carex lucorum	2	4	10	.....	20	.....	.....	5.1	5	2	3	5	1	..
	0	0	1	.....	2	.....	.....	1						
Cerastium	.....	.....	.....	4	.....	8	.....	1.7	4	..	..	..	..	..
semidecandrum	.....	.....	.....	0	.....	0	.....	0						
Danthonia	100	100	100	96	100	100	100	99.4	...	4	22	85	67	70
compressa	4	4	4	3	4	3	5	4						
Fragaria	74	100	10	24	100	88	60	65.1	71	41	21	7	1	..
virginiana	1	2	0	0	1	1	0	1						
Hieracium	.....	4	2	.....	.....	.....	.....	.9	2	..	..	..	..	..
gronovii	.....	0	0	.....	.....	.....	.....	0						
Holcus lanatus	.....	.....	.....	.....	4	.....	.....	.6	1	..	..	..	..	..
	.....	.....	.....	.....	0	.....	.....	0						
Houstonia	86	.....	22	20	16	80	88	44.8	85	22	4	..	..	..
serpyllifolia	0	.....	0	0	0	0	1	0						
Juncoides	.....	.....	.....	.....	.....	4	12	2.3	4	..	..	..	..	..
echinatum	.....	.....	.....	.....	.....	0	0	0						
Juncus tenuis	38	96	74	44	4	20	4	40	101	7	2	..	..	..
	0	0	0	0	0	0	0	0						
Phleum	.....	.....	.....	.....	.....	.....	4	.6	1	..	..	..	..	..
pratense	.....	.....	.....	.....	.....	.....	0	1						
Phytolacca	.....	.....	4	.....	.....	.....	.....	.6	2	..	..	..	..	..
decandra	.....	.....	0	.....	.....	.....	.....	0						
Poa pratensis	2	32	4	.....	32	36	4	15.7	27	1	1	..	..	..
	0	0	0	.....	0	0	0	0						
Potentilla	16	36	.....	2	84	20	36	26.3	27	26	..	..	..	..
canadensis	0	0	.....	0	0	0	0	0						
Potentilla	.....	.....	.....	.....	8	4	.....	1.7	1	2	..	..	..	..
monspeliensis	.....	.....	.....	.....	0	0	.....	0						
Potentilla	.....	.....	.....	.....	.....	.....	16	2.3	...	1	1	2	..	..
tridentata	.....	.....	.....	.....	.....	.....	1	0						
Rumex	96	96	98	90	92	72	88	90.3	148	77	3	1	..	..
acetosella	1	0	1	1	0	0	0	1						
Trautvetteria	.....	.....	.....	.....	4	4	.....	1.1	3	..	..	..	..	..
carolinensis	.....	.....	.....	.....	0	0	.....	0						
Trifolium	.....	.....	.....	.....	4	.....	.....	.6	2	..	..	..	..	..
hybridum	.....	.....	.....	.....	0	.....	.....	0						
Trifolium	.....	.....	8	.....	.....	28	4	5.4	11	1	..	..	..	..
saxicola	.....	.....	0	.....	.....	0	0	0						
Veronica	20	12	10	20	4	12	12	12.9	29	4	..	..	..	..
officinalis	0	0	0	0	0	0	0	0						
Veronica	.....	.....	.....	.....	4	.....	.....	.6	...	1	..	..	..	..
serpyllifolia	.....	.....	.....	.....	0	.....	0	0						
Viola blanda	38	48	.....	38	44	60	40	33.8	94	1	..	..	..	..
	0	0	.....	0	0	0	0	0						
Viola cucullata	4	8	.....	.....	.....	.....	.....	1.7	4	..	..	..	..	..
	1	0	.....	.....	.....	.....	.....	0						
Miscellaneous														
Polytrichium	98	100	98	100	40	96	96	92.4	63	46	40	50	27	5
commune	3	0	2	2	0	2	1	2						
Mosses and lichens (other than *P. commune*)	20	8	2	2	.....	.....	.....	4.6	13	..	1	..	..	..
	.....	0	0	0	.....	.....	.....	0						

Heavy migration of seeds from nearby parent plants and protection against high wind velocities best explain presence of woody seedlings in this stand.

GROUND LAYER

The ground layer is composed of several mosses and lichens, but is dominated by *Polytrichum commune* which covers more than ten times the combined areas shaded by all other species present in this layer.

Moss is not conspicuous in the area except as occasional "hummocks," but the study shows that *Polytrichum commune* is present in every stand and shows a frequency of 92.4 percent for the community. The frequency is above 80 percent for all stands except Stand E, on the southeast slope, which shows only 40 percent frequency but has the best development of *Danthonia compressa* of any stand. This better development of Danthonia may indicate a drier site, which is less favorable to the mesic Polytrichum. It is closely interwoven between bases of grass and sedge culms, and is so uniform in its distribution that high frequencies would result even though quadrats were very small.

The highest coverage for Polytrichum is in Stand A where it covers 25 to 50 percent of the surface (class 3). The average for the community is about 10 percent (class 2).

Lichens and mosses other than Polytrichum occurred in 4 of the 7 stands with a mean frequency of 4.6 percent. Average coverage for all such plants is less than 1 percent for the community, and did not exceed 3 percent for any quadrat.

COMMUNITY AS A WHOLE

An examination of the Frequency Class Diagrams (Fig. 17) shows that the grassy bald community is much more homogeneous floristically than either of the forest communities studied (Fig. 6). The individual stands show even greater homogeneity. There are 30 species listed for the herb layer of this community, but not more than 18 occur in any one of the 7 stands. The species with high frequencies also tend to be present in all stands while the species with low frequencies tend to be present in few of the stands. About half of the floristic list represents species which have been introduced into the area, principally by grazing animals. These species become locally established and usually show low frequencies and coverages. (Rumex, of high frequency, is a notable exception.) On the other hand, the native species tend to show

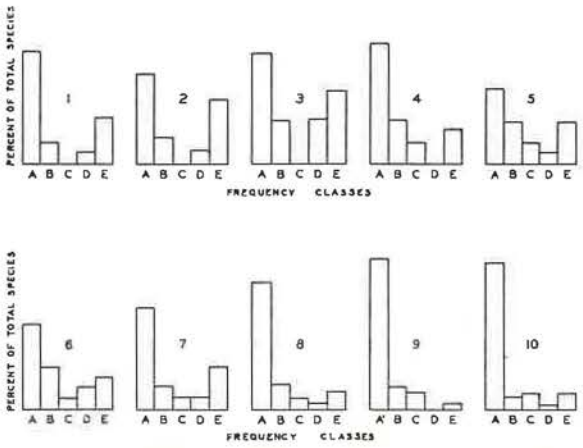

FIG. 17. Frequency class diagram for bald communities of Roan Mountain.
1. Stand A of grassy bald.
2. Stand B, same.
3. Stand C, same.
4. Stand D, same.
5. Stand E, same.
6. Stand F, same.
7. Stand G, same.
8. Community as a whole.
9. Rhododendron bald community.
10. Alder bald community.

uniformity of distribution throughout the community. A rather uniform physiognomy results, except for occasional small areas dominated by moss hummocks.

Characteristic species are *Houstonia serpyllifolia, Carex flexuosa, Carex glaucodea, Potentilla tridentata,* and *Viola blanda.*

Conspicuous introduced species present in the community are: *Achillea millefolium, Agrostis alba, Carex brunnescens, Cerastium semidecandrum, Hieracium Gronovii, Holcus lanatus, Phleum pratensis, Phytolacca decandra, Poa pratensis, Trifolium hybridum, Veronica serphyllifolia,* and *Veronica officinalis.*

RHODODENDRON BALD COMMUNITY

The rhododendron bald community of Roan Mountain, known to the general public as the "Rhododendron Gardens," has been reported as covering about 600 acres—a probable overestimate.[5] The best development of this community occurs along the flattened summit between Cloudland and Roan High Bluff at 6,000 to 6,150 feet altitude. Most of the area occupied by the community is on the southeast side of the divide (Fig. 19). This community is almost surrounded by the spruce-fir forest and is interrupted by patches of grassland of varying extent.

Location of Stands.

Four areas were selected as stands located as follows: Stands A and B at the northwest end of area immediately south of the divide and with a southeastern exposure (Fig. 19); Stand C about 400 meters northeast of Stand A and about 300 meters south of the divide, with a southern exposure; Stand D immediately across the divide from Stand B and with a northwest exposure. Each of these stands was at approximately 6,100 feet altitude and on land that varied in slope from 2 to 10 degrees. Wind velocities were medium to strong in Stand D but mild to brisk in other stands, being lowest in Stand B.

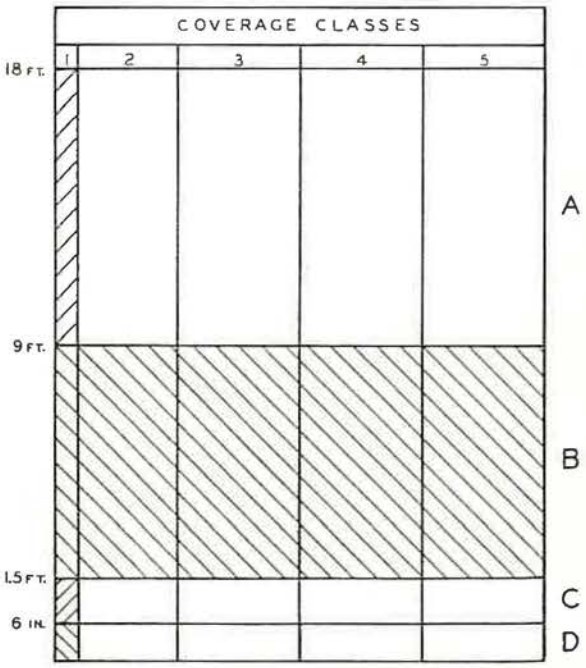

FIG. 18. Cover-stratification diagram for heath bald community.
A. Tree layer of Picea, Abies, and Sorbus.
B. Shrub layer, an almost pure stand of *Rhododendron catawbiense.*
C. Herb layer, suppressed Dryopteris, Houstonia, Viola, and Carex.
D. Ground layer of mosses and lichens.

LAYERS

Shrub, herb, and ground layers are represented in the rhododendron bald community (Fig. 18), but only the shrub layer shows more than 5 percent coverage. A few individuals of *Picea rubra* and *Sorbus americana* overtop the shrub canopy, suggesting a tree layer (Fig. 18). Due to the heavy opaque nature and arrangement of rhododendron leaves which shade more than 95 percent of the surface, very little light reaches the ground. This factor, added to the fact that *Rhododendron catawbiense* produces a network of feeder roots in the upper 2 inches of soil, excludes many individuals which might otherwise be present in the herb layer. A layer of dead leaves not yet decayed covers the ground and retards development of moss. For practical purposes, and upon superficial examination, one might say that there is no herb layer and only a very weak ground layer. Thus the rhododendron bald is essentially a one-layered community.

[5] No attempt has been made to determine the exact area covered by this community, but based on general estimates, there appears to be less than 200 acres. The 600-acre estimate was made for advertising purposes. If the total area in which rhododendron occurs is considered, including the spruce-fir forest, the 600-acre estimate is not too high.

SHRUB LAYER

Frequency.

Frequency and coverage data are presented in Table 16. *Rhododendron catawbiense* shows a frequency of 100 percent in each stand. *Alnus alnobetula* ranks second, showing a frequency of 13 percent for the community and was present in 3 of the 4 stands. *Picea rubra,* usually a "transgressive," ranks next with 8 percent frequency and was present in all stands. *Ribes rotundifolium* was in 3 stands and shows 3 percent frequency. *Leiophyllum Lyoni, Sambucus racemosa,* and *Vaccinium erythrocarpum* were present in half the stands and each shows a frequency of 5 percent or less. Each of the remaining 5 species was present in only one quadrat of one stand, thus showing a frequency of 1 percent each.

TABLE 16. Frequency and coverage data for species present in the rhododendron bald community. Where two numbers occur opposite a species, the upper number represents frequency percentage and the lower number represents coverage class. (August, 1934.)

Floristic list	Frequency percent and coverage					Distribution of coverage classes for the community					
Stand:	A	B	C	D	Community						
No. of samples:	25	25	25	25	100						
Altitude:	6,050	6,100	6,150	6,100	...						
Exposure:	SE	SE	S	NW	...						
Slope:	6°	8°	5°	7°	...	0	1	2	3	4	5
Trees											
Abies Fraseri	.....	.....	4	.....	1	..	..	..	1	..	..
	.....	.....	0	.....	0						
Picea rubra	4	8	4	16	8	..	2	2	1	2	1
	0	1	0	1	1						
Sorbus americana	.....	4	.....	.....	1	..	1	..	..	..	..
	.....	0	.....	.....	0						
Shrubs											
Alnus alnobetula	1	24	8	20	13	..	7	5	..	..	..
	.....	1	0	1	1						
Leiophyllum lyoni	4	4	.....	.....	2	1	1	..	..	..	..
	0	0	.....	.....	0						
Menziesia pilosa	4	.....	.....	.....	1	1	..	..	..	..	..
	0	.....	.....	.....	0						
Pyrus melanocarpa	.....	4	.....	.....	1	..	..	1	..	..	..
	.....	0	.....	.....	0						
Rhododendron	100	100	100	100	100	..	..	..	1	1	96
catawbiense	5	5	5	5	5						
Ribes	4	.....	4	4	3	..	1	1	1	..	..
rotundifolium	0	.....	0	0	0						
Sambucus	8	12	.....	.....	5	..	3	2	..	..	..
racemosa	0	0	.....	.....	0						
Vaccinium	.....	4	.....	.....	1	..	..	1	..	..	..
corymbosum	.....	0	.....	.....	1						
Vaccinium	.....	4	8	.....	3	1	2	..	..	..	..
erythrocarpum	.....	0	0	.....	0						
Pteridophytes											
Dryopteris	84	44	.....	48	44	42	2	..	..	..	..
dilatata	0	0	.....	0	0						
Lycopodium	.....	.....	.....	8	2	2	..	..	..	..	..
lucidulum	.....	.....	.....	0	0						
Lycopodium	.....	.....	.....	4	1	1	..	..	..	..	..
obscurum	.....	.....	.....	0	0						
Herbs											
Agrostis	.....	8	12	.....	5	5	..	..	..	..	..
perennans	.....	0	0	0	0						
Aster acuminatus	.....	4	.....	.....	1	1	..	..	..	..	..
	.....	0	.....	.....	0						
Carex flexuosa	52	64	72	28	54	51	..	..	..	..	..
	0	0	0	0	0						

TABLE 16 *(Continued)*

Floristic list	Frequency percent and coverage					Distribution of coverage classes for the community					
Stand:	A	B	C	D	Community						
No. of samples:	25	25	25	25	100						
Altitude:	6,050	6,100	6,150	6,100	...						
Exposure:	SE	SE	S	NW	...						
Slope:	6°	8°	5°	7°	...	0	1	2	3	4	5
Carex laxiflora	4	8	.....	.....	3	3	..	..	..	..	..
	0	0	.....	.....	0						
Carex leptalea	.....	16	.....	.....	4	4	..	..	..	..	..
	.....	0	.....	.....	0						
Circaea alpina	24	16	4	.....	11	9	2	..	..	..	..
	0	0	0	.....	1						
Danthonia	4	.....	8	4	4	4	..	..	..	..	..
compressa	0	.....	0	0	0						
Deschampsia	28	8	24	24	21	21	..	..	..	..	..
flexuosa	0	0	0	0	0						
Erechtites	4	.....	.....	.....	1	1	..	..	..	..	..
hieracifolia	0	.....	.....	.....	0						
Eupatorium	.....	.....	.....	4	1	1	..	..	..	..	..
roanensis	.....	.....	.....	0	0						
Galium triflorum	4	.....	.....	.....	1	..	1	..	..	..	..
	0	.....	.....	.....	0						
Houstonia	4	.....	.....	.....	1	1	..	..	..	..	..
purpurea	0	.....	.....	.....	0						
Houstonia	60	44	52	24	45	41	4	..	..	..	..
serpyllifolia	0	0	0	0	0						
Juncoides	28	24	28	8	22	21	1	..	..	..	..
echinatum	0	0	0	0	0						
Maianthemum	12	4	24	52	23	23	..	..	..	..	..
canadense	0	0	0	0	0						
Phytolacca	16	4	4	.....	6	6	..	..	..	..	..
decandra	0	0	0	.....	0						
Rumex acetosella	.....	8	12	.....	5	5	..	..	..	..	..
	.....	0	0	.....	0						
Steironema sp.	.....	.....	.....	4	1	..	1	..	..	..	..
	.....	.....	.....	0	0						
Trautvetteria	52	.....	.....	12	16	15	1	..	..	..	..
carolinensis	0	.....	.....	0	0						
Veronica	.....	8	.....	.....	2	2	..	..	..	..	..
officinalis	.....	0	.....	.....	0						
Viola sp.	28	60	32	28	37	33	2	1	1	..	..
	0	0	0	0	0						
Miscellaneous											
Moss and lichen	96	80	84	84	86	63	21	1	1	..	..
cover	1	1	1	1	1						

Coverage.

Rhododendron catawbiense shows a mean coverage of class 5 for the community. Except for occasional small openings between clumps, this species completely shades the ground. Picea and Alnus are the only other species that cover more than 1 percent of the surface, these two species covering about 2 percent of the surface, respectively (class 1).

Density.

Of the 314 woody plants on 400 square meters actually sampled, 242, or 77.1 percent, were Rhododendron. More than half of the remaining individuals were Alnus, Ribes, and Picea (Table 17). Of the 5,142 canes present, 5,021, or 97.6 percent, were Rhododendron canes. The spacing between canes of this species averaged 28 centimeters (11 inches). The average diameter of the canes at 1 foot above ground was slightly less than 1 inch. So dense is the thicket produced by these canes that it is possible to move through a typical stand only with difficulty. There were 17 times as many clumps of Rhododendron as

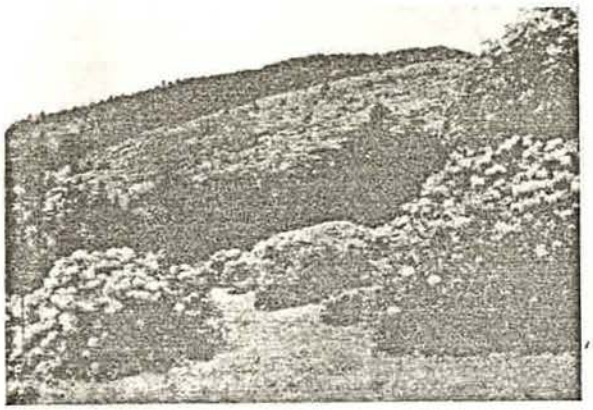

FIG. 19. A portion of "rhododendron garden," looking westward. Stands A and B were located in area beyond first group of conifers. Note that conifers pierce shrub canopy. A *Sorbus americana* appears to the right. Altitude, 6,100 feet. June 25, 1935.

of Alnus and 80 times as many canes of the former as of the latter. The average distance between Alnus clumps was approximately 5 meters (14 feet). Ribes clumps showed about the same spacing as Alnus. The other 6 shrub species show very low densities.

Woody Seedlings.

Table 17 shows 617 Rhododendron seedlings under 6 inches high present on the 400 square meters sampled. It is interesting to note that no Alnus seedlings were recorded from the same area. Ribes seedlings were more numerous than all other shrub seedlings. Of the tree seedlings, *Sorbus americana* was most abundant, showing an average spacing of 1.8 meters (7.3 feet). Twelve Picea seedlings were recorded as compared to 7 individuals of this species which had pushed through the shrub canopy. This most significant dynamic indication will be discussed later.

HERB LAYER

Frequency.

The herb layer is represented by 3 pteridophytes and 21 herbs. The one fern present, *Dryopteris dilatata,* frequency 44 percent, occurred in 3 of the 4 stands. The 2 club mosses, *Lycopodium lucidulum* and *L. selago,* were present only on the north slope (Stand D), with a frequency of 8 percent and 4 percent, respectively.

Of the 21 herbs, *Carex flexuosa* and *Houstonia serpyllifolia* were the most frequent, showing 54 percent and 45 percent, respectively, being the only 2 species in Class C. Class B is represented by 4 species as follows: *Viola blanda,* 37 percent; *Maianthemum canadense,* 23 percent; *Juncoides echinatum,* 22 percent; and *Deschampsia flexuosa,* 21 percent. These 6 herb species are rather uniformly distributed within the different stands. It is an interesting coincidence that these 6 species are the only herb species present in all 4 stands. The species which occurred in only 3 stands were *Trautvetteria carolinensis,* frequency 16 percent; *Circaea alpina,* frequency 11 percent; *Phytolacca decandra,* frequency 6 percent; *Rumex acetosella,* frequency 5 percent; and *Danthonia compressa,* frequency 4 percent. Each of the remaining 11 species occurred in only 1 or 2 stands and show less than 5 percent frequency.

TABLE 17. Density by height classes of woody species present in the rhododendron bald community. (Based on 100 quadrats, 2 by 2 meters. August, 1934.)

	Clump	Canes per clump	Height in feet: number of canes										Total above ½ foot
			0–½	½–1	1–2	2–3	3–4	4–5	5–6	6–7	7–8	8–9	9–10	
Shrub species														
Rhododendron catawbiense	242	21	617	1692	802	531	357	330	660	357	86	6	...	5021
Alnus alnobetula	14	5	...	...	18	4	14	7	7	...	13	...	...	63
Ribes rotundifolium	16	....	74	....	1	...	...	...	15	...	...	...	...	16
Pyrus melanocarpa	9	....	...	...	...	9	...	...	...	...	...	...	...	9
Sambucus racemosa	5	....	11	3	...	...	...	...	1	1	...	...	...	5
Vaccinium corymbosum	4	....	...	...	4	...	...	...	...	...	...	...	...	4
Vaccinium erythrocarpum	3	....	...	3	...	...	...	...	...	...	...	...	...	3
Leiophyllum Lyoni	2	....	...	2	...	...	...	...	...	...	...	...	...	2
Menziesia pilosa	1	....	...	1	...	...	...	...	...	...	...	...	...	1
Tree species														
Picea rubra	13	....	12	2	4	...	...	...	...	...	...	...	7	13
Sorbus americana	4	....	139	2	...	1	...	...	...	...	...	...	1	4
Acer saccharum	...	....	4	...	...	...	...	...	...	...	...	...	...	....
Abies Fraseri	...	....	13	...	...	...	...	...	...	...	...	...	...	....
Betula lutea	1	....	1	...	...	...	...	...	...	...	...	...	1	1
Totals	314	....	871	1905	829	545	371	337	683	358	99	6	9	5142

Coverage.

No species of the herb layer showed as much as class 1 coverage for any single stand or for the community (Table 16). There is a very poor distribution of species among the coverage classes. Only 8 species showed more than 1 percent coverage each in any quadrat (Table 16). Only 1 species, *Viola blanda,* showed more than 5 percent coverage in any quadrat, showing as high as class 3 (25 to 50 percent coverage) in one quadrat. No species showed as much as 1 percent coverage, unless it was present in an open area or at the edge of an opening.

GROUND LAYER

Mosses and lichens, principally mosses, show a frequency of 86 percent for the community. *Polytrichum commune,* characteristic of grassy balds, is common in the small openings and at the edge of openings while mosses characteristic of the spruce-fir forest are common on the bases of Rhododendron clumps and on the lower trunks of the few trees present. The distribution of coverage classes ranges up to class 3, but more quadrats show class 0. The

highest coverages are for quadrats located under the shade of conifers.

COMMUNITY AS A WHOLE

Since the rhododendron bald community consists of a practically pure stand of *Rhododendron catawbiense*, it shows an extremely uniform physiognomy (Fig. 19). Based on data presented in Tables 16 and 17, there is only one dominant for this community, *Rhododendron catawbiense*, which shows 100 percent frequency, presence in all stands, class 5 (75 to 100 percent) coverage, and 97.8 percent of the total density. There are a number of associated species in the herb layer which show low frequency, coverage, and density.

The community appears to be somewhat unstable, since the heavy and almost pure stand of Rhododendron shades a rather suppressed and depauperate herb layer and since the community is susceptible to invasion by conifers which break through the shrub layer and survive as a potential tree layer. There seem to be no strictly characteristic species of the herb layer in the sense of "exclusive" species. No species except *Viola blanda* shows sufficient vitality to reproduce itself under the shrub layer. Species of the herb layer thus appear to be ephemeral invaders from the grassy bald or from the spruce-fir forest.

So far as could be determined, this community represents the most interesting, unique, and extensive stand of *Rhododendron catawbiense* in existence. The species was discovered on Roan Mountain near the end of the eighteenth century by Fraser, who at that time was working for the Russian government (Gray, 1842). The presence of this profusely flowering shrub is perhaps the principal reason why Redfield (1879) wrote the following: "Dr. Gray has well said that it is the most beautiful mountain east of the Rockies."

ALDER BALD COMMUNITY

The alder bald community extends along the summit of Roan Mountain for a distance of about 5 miles, interrupted at intervals by stretches of mountain meadow. It is much less extensive westward, occurring in disconnected patches where soil moisture seems to be above average. Although alder is distributed throughout the bald area, it occurs in pure stands only to the east of Carvers Gap.

Location of Stands.

Since the best development of the alder bald community appeared in the region of Jane Bald, 4 of the 5 stands were located in this vicinity: Stand A on the northeast slope of Jane Bald at 5,800 feet; Stand B immediately eastward on a northwest slope of Elkhorn Bald at 5,800 feet; Stand C on the south slope of Grassy Bald Ridge at 5,900 feet; Stand D on the southwest slope of Grassy Bald Ridge at 5,800 feet; and Stand E on the southwestern exposure of Round Bald at 5,750 feet. The degree of slope for these stands varied from about 8 degrees in Stand A to about 15 degrees in Stands D and E.

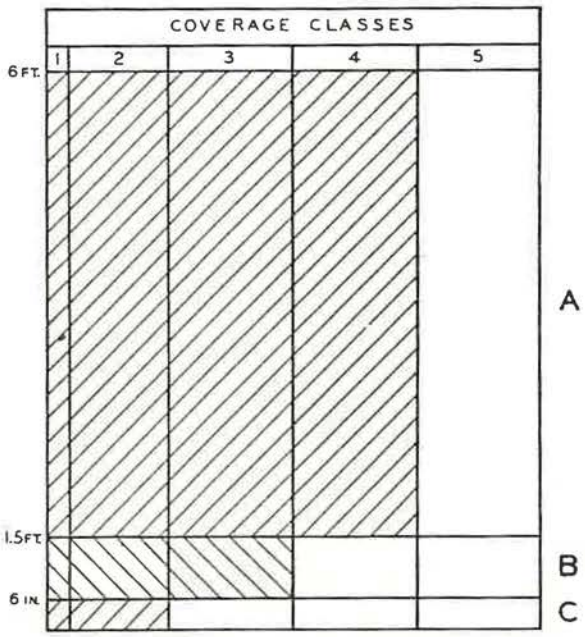

FIG. 20. Cover-stratification diagram for alder bald community.
A. Shrub layer of *Alnus alnobetula* in pure stand.
B. Herb layer of Carex, Danthonia, and Rumex.
C. Moss layer of Polytrichum.

Wind velocity ranges from medium to strong, being strongest in Stand A and lightest in Stand D. Certain areas in Stand D were characterized by a high soil moisture as indicated by the presence of *Sphagnum* sp. which was not present in any other stands of the area.[6] The largest and tallest clumps of Alnus occurred in this stand.

Stratification.

This shrub or "thicket" community is characterized by three layers: (1) a shrub layer, reaching a maximum height of 6 feet; (2) an herb layer, 0.5 to 1.5 feet high; and (3) a ground or moss layer, less than 6 inches high (Fig. 20). Only one tree species was recorded from the 100 quadrats, it being a *Sorbus americana* seedling 6 inches high; however, 3 more were seen outside the quadrats, a *Picea rubra* 6 feet high in Stand B and 2 *Sorbus americana* about 10 feet high in Stand D.

SHRUB LAYER

Frequency.

The floristic list for the alder bald community is presented in Table 18 with frequency and coverage data for each species. Since *Alnus alnobetula* was present in every quadrat analyzed except one in Stand E, its frequency is 99 percent. *Ribes rotundifolium* occurred only once in each of the 3 stands, showing a community frequency of 3 percent. The other woody species, *Menziesia pilosa*, *Rhododendron catawbiense*, and *Smilax glauca* occurred only in Stand A, each being present in only one quadrat. The stand frequency for each is 5 percent while the community

[6] Sphagnum does occur, however, in wet places in the immediate vicinity of the Wilder Spring at 6,100 feet.

frequency is only 1 percent. Thus the shrub layer has only one species, *Alnus alnobetula,* which shows high frequency.

Density.

In Table 19 note that of the 149 plants present, 143 or 95.9 percent are Alnus, and of the 2,305 canes present, 2,288 or 99.3 percent are Alnus canes. There is an average of 16 canes per clump. These canes vary in height from 6 inches to 8 feet, averaging approximately 3.5 feet for the community. The clumps are uniformly spaced at an average of 1.3 meters (4.4 feet) apart. In areas of better development where clumps are taller and more dense, it becomes difficult to force one's way through this thicket community. Rhododendron ranks second with only two plants present on the 200 square meters surveyed.

TABLE 18. Frequency and coverage data for species of the alder bald community. Where two numbers occur opposite a species, the upper number represents frequency percent and the lower number represents coverage class. (August, 1936.)

Floristic list	Frequency percent and coverage						Distribution of coverage classes for the community					
Stand:	A	B	C	D	E	Community						
No. of samples:	20	20	20	20	20	100						
Altitude:	5,800	5,800	5,900	5,800	5,750	...						
Exposure:	NE	NW	S	SW	SW	...						
Slope:	8°	10°	12°	15°	15°	...	0	1	2	3	4	5
Woody species[1]												
Alnus alnobetula	100	100	100	100	100	100		2	3	26	44	24
	3	4	4	4	4	4						
Menziesia pilosa	5	....	....	....	....	1	....	....	1	....	....	....
	0	....	....	....	....	0						
Rhodlodendron	5	....	....	....	....	1	....	....	....	1	....	....
catawbiense	0	....	....	....	....	0						
Ribes	5	....	....	5	5	3	....	3	....	....	....	....
rotundifolium	0	....	....	0	0	0						
Smilax glauca	5	....	....	....	....	1	....	1	....	....	....	....
	0	....	....	....	....	0						
Sorbus americana	5	....	....	....	....	1	....	1	....	....	....	....
	0	....	....	....	....	0						
Pteridophytes												
Dryopteris dilatata	75	50	75	45	20	53	39	13	3	....	....	....
	0	0	0	0	0	0						
Polypodium	20	....	....	....	....	4	3	1	....	....	....	....
virginianum	0	....	....	....	....	0						
Herbs												
Agrostis hyemalis	45	45	40	80	80	58	53	4	1	....	....	....
	0	0	0	0	0	0						
Arisaema	....	....	....	5	....	1	1	....	....	....	....	....
triphyllum	....	....	....	0	....	0						
Aster acuminatus	....	5	10	....	....	3	2	1	....	....	....	....
	....	0	0	....	....	0						
Aster divaricatus	5	....	....	....	....	1	1	....	....	....	....	....
	0	....	....	....	....	0						
Carex aestivalis	....	....	....	15	....	3	1	1	1	....	....	....
	....	....	....	0	....	0						
Carex flexuosa	5	20	30	65	....	23	6	15	2	....	....	....
	0	0	0	0	....	0						
Carex glaucodea	....	....	....	5	5	2	2	....	....	....	....	....
	....	....	....	0	0	0						
Carex	....	10	15	50	....	15	9	4	2	....	....	....
intumescens	....	0	0	0	....	0						
Carex lucorum	90	65	85	65	95	80	13	15	15	19	16	2
	3	2	3	2	2	2						
Danthonia	5	40	75	85	60	53	19	19	8	5	2	....
compressa	0	1	2	1	1	1						
Erechtites	....	....	5	....	....	1	1	....	....	....	....	....
hieracifolia	....	....	0	....	....	0						

TABLE 18 *(Continued)*

Floristic list	Frequency percent and coverage						Distribution of coverage classes for the community					
Stand:	A	B	C	D	E	Community						
No. of samples:	20	20	20	20	20	100						
Altitude:	5,800	5,800	5,900	5,800	5,750	...						
Exposure:	NE	NW	S	SW	SW	...						
Slope:	8°	10°	12°	15°	15°	...	0	1	2	3	4	5
Heuchera villosa	....	....	5	....	....	1	1	....	....	....	....	....
	....	....	0	....	....	0						
Houstonia	50	25	40	65	20	40	35	5	....	....	....	....
serpyllifolia	0	0	0	0	0	0						
Isopyrum	....	....	....	....	5	1	....	1	....	....	....	....
biternatum	....	....	....	....	0	0						
Juncoides	....	....	5	25	5	7	1	3	1	....	....	....
echinatum	....	....	0	0	0	0						
Juncus effusus	....	....	....	15	10	5	1	3	1	....	....	....
	....	....	....	0	0	0						
Juncus tenuis	....	....	....	15	15	5	6	....	....	....	....	....
	....	....	....	0	0	0						
Lilium	....	....	....	5	....	1	1	....	....	....	....	....
philadelphicum	....	....	....	0	....	0						
Maianthemum	....	....	5	....	....	1	1	....	....	....	....	....
canadense	....	....	0	....	....	0						
Polygonum	....	....	....	5	....	1	1	....	....	....	....	....
hydropiperoides	....	....	....	0	....	0						
Potentilla	....	....	....	5	....	1	1	....	....	....	....	....
canadensis	....	....	....	C	....	0						
Potentilla	....	....	....	....	5	1	1	....	....	....	....	....
monspeliensis	....	....	....	....	0	0						
Rumex acetosella	95	95	95	85	75	89	52	27	8	2	....	....
	1	1	0	0	0	1						
Saxifraga leucan-	10	10	....	5	20	9	8	1	....	....	....	....
themifolia	0	0	....	0	0	0						
Trautvetteria	25	....	....	....	....	5	4	....	....	1	....	....
carolinensis	0	....	....	....	....	0						
Trifolium	....	....	....	....	5	1	1	....	....	....	....	....
saxicola	....	....	....	....	0	0						
Veratrum viride	5	....	10	10	....	1	1	....	....	....	....	....
	0	....	0	0	....	0						
Veronica	....	....	....	5	....	1	1	....	....	....	....	....
officinalis	....	....	....	0	....	0						
Viola blanda	80	90	95	100	90	91	81	9	1	....	....	....
Miscellaneous												
Moss and lichen												
cover[2]	70	90	80	70	95	81	18	15	18	17	9	4

[1] Seedlings included.
[2] *Sphagnum* sp. was present in 3 quadrats in Stand D, coverage 2 in each quadrat.

A few Rhododendron clumps were seen outside the quadrats within the area of the stands, and, since all appeared to be in a most vigorous condition, their presence brings up the question of dynamic trends which will be treated later.

Coverage.

There is only one dominant in the shrub layer, *Alnus alnobetula,* which covers about 65 percent of the total area (class 4). Rarely do Alnus clumps produce a closed canopy. There are numerous small openings which constitute about one third of the total area.

HERB LAYER

Frequency.

Only two species of the herb layer belong to Frequency Class E, *Viola blanda,* 91 percent frequency, and *Rumex acetosella,* 89 percent frequency. There is only one species in Class D, *Carex lucorum,* fre-

TABLE 19. Density by height classes of woody species present in the alder bald community. (Based on 100 quadrats 1 by 2 meters.)

Species	Clumps (plants)	Canes per clump	Height in feet: number of canes								
			0–1	1–2	2–3	3–4	4–5	5–6	6–7	7–8	Total canes
Alnus alnobetula	143	16	7	174	784	893	265	140	...	9	2,288
Rhododendron catawbiense	2	..	...	3	4	...	...	...	...	...	7
Menziesia pilosa	1	..	1	4	...	...	...	...	...	...	5
Ribes rotundifolium	1	..	...	...	1	2	...	...	...	...	3
Smilax glauca	1	..	...	...	...	1	...	...	...	...	1
Sorbus americana seedlings	1	..	...	1	...	...	...	...	...	...	1
Totals	149	16	8	182	789	896	265	140	...	9	2,305

quency 80 percent. Three species belong to Class C: *Agrostis hyemalis,* 58 percent; *Danthonia compressa,* 53 percent; and *Dryopteris dilatata,* 53 percent. Class B is represented by two species, *Houstonia serpyllifolia,* 40 percent, and *Carex flexuosa,* 23 percent. Of the 23 species in Class A, *Carex intumescens* ranks first with a frequency of 15 percent, followed by *Saxifraga leucanthemifolia,* 9 percent; *Juncoides echinatum,* 7 percent, and *Juncus tenuis,* 6 percent. Each of the remaining 18 species shows 5 percent frequency or less.

Species of the herb layer present in all 5 stands are: *Carex lucorum, Dryopteris dilatata, Agrostis hyemalis, Danthonia compressa, Houstonia serpyllifolia, Rumex acetosella,* and *Viola blanda. Carex flexuosa* and *Saxifraga leucanthemifolia* were present in 4 stands. Of the remaining 22 species, only 8 occurred in more than one stand. Thus it is seen that about one fourth of the species of the herb layer are widely distributed throughout the community while the remaining species tend to be present locally only. Of these widely distributed species, *Viola blanda, Rumex acetosella,* and *Carex lucorum* are most frequent, while such species as *Carex aestivalis, Aster acuminatus, Juncus effusus,* and *J. tenuis* best represent locally established species.

Coverage.

The 3 species which cover more than 1 percent of the surface sampled are: *Carex lucorum,* class 2; *Danthonia compressa,* class 1; and *Rumex acetosella,* class 1. The combined coverage of all the other species of this layer is less than 5 percent of the total surface. Thus *Carex lucorum* is dominant in the herb layer with *Danthonia compressa* and *Rumex acetosella* as sub-dominants. All species of the herb layer cover about one half of total surface and show their best development in the open areas between alder clumps.

GROUND LAYER

Mosses and lichens occurred in every stand with an average frequency of 81 percent for the community, ranging from 70 to 90 percent in each of the stands. *Polytrichum commune* is the dominant ground species. There is a uniform distribution of the moss and lichen cover throughout the community as indicated by its high frequency. Degree of cover varies from less than 1 percent in some quadrats to more than 75 percent in others as shown by its distribution in all the coverage classes (Table 18) while the average coverage for the community is approximately 15 percent (class 2). *Sphagnum* sp. was present in 3 quadrats in Stand D and covered about 15 percent of the area of each quadrat.

COMMUNITY AS A WHOLE

This shrub community is dominated by only one species, *Alnus alnobetula,* a species with a limited distribution in this country, probably showing its best development on Roan Mountain. This shrub grows in almost pure stands 3 to 4 feet high and covers about 65 percent of the total surface (Fig. 23). In a few places the coverage is almost complete, but throughout the greater extent of the community small openings of 2 or 3 square meters between clumps are common. These openings are usually dominated by *Carex flexuosa, Danthonia compressa,* and *Rumex acetosella, Carex flexuosa* being most important. The moss layer covers less than one fourth of the surface and is dominated by *Polytrichum commune.*

SUCCESSION

BEECH-MAPLE COMMUNITY

The beech-maple community is climax for the altitudinal zone (3,500-5,000 feet) in which it occurs. In general, as indicated by reproduction and survival of dominants, the community appears to be maintaining itself within the deciduous zone. In the extreme upper limits of this zone, yellow birch is dominant and in places gives way to conifers. A good example of such invasion is in Carvers Gap where there are several large relic birches, some of which are dead. Hataya (1933) found a similar condition to be true on Mt. Fuji and says that its birch forest is being replaced by conifers.

SPRUCE-FIR COMMUNITY

The spruce-fir forest is climax at the higher altitudes (5,500 feet to the summit). There is no sign of natural decadence of this community within the area under study, but there is most convincing evidence that it is a vigorous, aggressive community. This is supported by statistical data recorded in the phytographs (Fig. 13) which show that the important trees are represented in the five different size classes. No area was found in which conifers were giving way to any other species.

Secondary succession in the spruce-fir community was determined by repeated observations made each summer within the cut-over areas. All stages were observed from immediate cutting to those nine years old, and in a few instances to some half a century old. These observations were supplemented by statistical data recorded from 25 quadrats 2 by 2

meters located at the head of a cove on the southwestern slope immediately below Wilder Spring. In this area, which in general is representative of the higher cut-over conifer lands, sedges, especially *Carex flexuosa*, became established rapidly and soon covered 10 to 15 percent of the ground surface. *Rumex acetosella* soon appeared with a cover as great as the sedges. The first shrubs were mountain blackberry *(Rubus canadensis)* and red berried elder *(Sambucus racemosa)* with a cover of 10 to 25 percent. Pin cherry *(Prunus pennsylvanica)* was usually associated with these shrubs in varying proportions but was less important in the area sampled than in most cut-over areas on the mountain. The thicket stage was replaced by conifers which became established in the shade. They finally push through the thicket canopy and become the climax dominants. In some places conifers appear directly without the usual intermediate herb and shrub stages.

Korstian (1937) describes in detail secondary succession for the spruce lands of the Southern Appalachians. Some of the data were taken from Unaka Mountain, Unicoi, Tennessee, which is within twenty-five miles of Roan Mountain. His studies show that yellow birch *(Betula lutea)* and shrubs for a time often dominate an area from which conifers have been removed by logging. This is in accord with conditions in the lower portion of the cut-over conifer zone of Roan Mountain.

BALDS

Careful observations have been made throughout the full extent of the balds to determine successional trends. Along ecotones, a number of detailed statistical samples were taken, including 5 belt transects, 3 sets of "intermittent strip samples," and 3 permanent chart quadrats. In addition, a total of 100 quadrats was tallied in four widely different situations of the grassy bald community. In this discussion, it seems desirable to present only the significant results of these studies, supplemented by certain diagrams and photographs. Tension lines between communities are definitely changing. This shifting of tension lines between any two communities is always in the same direction and signifies that succession is now taking place at such points.

GRASSY BALD COMMUNITY

The grassy bald is being invaded by rhododendron, conifers, and alder. The best examples of invasion of the grassy bald by rhododendron are found along the summit west of Roan High Knob. Good examples of grassy bald invasion by conifers are found along the margin of the balds from 5,500 to 6,200 feet altitude (Figs. 21 and 25). Invasion of these balds by alder is less conspicuous and is best seen on the eastern end of Grassy Bald Ridge.

FIG. 21. Invasion of grassy bald by conifers. Conifers in background have invaded the area they now occupy within the past half century. Immediately west of Carvers Gap, looking westward. Altitude, 5,500 feet. August, 1937.

INVASION BY RHODODENDRON

By mass invasion rhododendron *(Rhododendron catawbiense)* appears to be replacing the grassy bald community. An example of such invasion is to be found along the southern margin of the grassy bald immediately southwest of Roan High Knob (Fig. 24). A belt transect study (2 by 100 meters) made in this area shows an abundant supply of rhododendron seedlings, even as many as 20 per square meter in some areas. The greatest density occurs in partial shade of older clumps, but it was not uncommon to find seedlings in an open grassy bald several meters from a rhododendron clump. Seeds either germinate directly in the grass or in moss clumps, there being a slightly higher percentage of germination in moss clumps. Survival of seedlings seems to be high, since very few dead ones were observed in the transect or elsewhere within the grassy bald. That this invasion is positive and of a permanent nature is evidenced by a vigorous representation of rhododendron across the ecotone, ranging from seedlings in the open area, to plants 75 years of age within the rhododendron bald community. It is most unusual to see a dead clump of rhododendron anywhere in the treeless area.

Detailed observation of other areas reveals the same general condition described above. More rapid invasion is usually along depressions while slower invasion is along the more elevated portions of the grassy bald, a condition which might be explained by an adequate soil moisture study. The rate of invasion, since it varied for each particular location, was not determined; but it is safe to say that, in some places, rhododendron advances into the grassy bald as much as a meter a year.

INVASION BY CONIFERS

In certain areas, as along the ecotone between the grassy bald community and the spruce-fir forest, conifers (*Abies Fraseri* and *Picea rubra*) invade the grassy bald directly. Such invasion is more rapid along the northern margin of the grassy balds than elsewhere on the mountain. A splendid example of this condition may be seen on the northeast slope of the ridge immediately west of Carvers Gap (Fig. 21). A transect (2 by 114 meters) was run across the ecotone at this station and the general condition is shown in Figure 25. Seedling conifers usually establish themselves in small moss clumps or by the edge of rocks, but they very often become established directly in the grass. An examination of seedlings that survive in grass showed that some moss was usually present where they became established. The statistical study of the grassy balds shows that moss plants occur throughout the whole area and, when

not in "hummocks," are closely associated with grass culms.

Between the edge of the grassy bald and the advancing coniferous forest there is often a zone of moss *(Polytrichum commune)* 1 to 5 meters wide appearing as a solid "moss carpet" 6 to 12 inches deep (Fig. 26). Such growth also occurs in certain openings just back of the forest margin. The mountain oat grass *(Danthonia compressa)* does not thrive in this dense carpet of moss as evidenced by many dead bunches found within it. The moss carpet advances slightly ahead of the coniferous forest, maintaining about the same width as it encroaches upon the grassy bald. Its appearance may be due to the rapid growth and development of moss plants which, previously suppressed in the slightly xeric grassy bald, become dominant when a more mesic condition occurs. Since such a moss carpet does not occur except in areas within a few feet of conifers, it appears that the forest is either producing a more mesic condition or that it is invading areas becoming more mesic due to other causes. As Toumey and Korstian (1937) have shown, site affects vegetation, and vegetation affects site which in turn is reflected in vegetation. This reaction concept helps explain the above situation.

The conifers produce a more mesic condition by shading and reducing wind velocity. The moss carpet then develops and affords a better condition for the germination of seedlings than exists in grass. Observations revealed that coniferous seedlings become freely established in this moss carpet and show high survival value. Seeds which had lodged between moss plants germinated far more readily than those which lodged between grass culms. Upon germination, the radicle grows downward rapidly between the moss plants to regions of greater moisture. Examination of seedlings 2 to 5 years of age revealed that in most cases the tap root turns at a depth of 3 to 6 inches and grows in a horizontal position. When the conifer canopy shades the area, the moss is suppressed and the heavy carpet disappears.

The effect of trampling is indicated in certain areas grazed by cattle and sheep where many small coniferous seedlings die. The numerous dead seedlings examined revealed a scar at ground level such as might be made by the hoof of an animal.

Examination of spruce and fir trees growing in the grassy bald and within the spruce-fir forest showed a sharp contrast between growth forms. Trees growing in the open develop pyramidal crowns extending to the ground and short, knotty, tapering boles with branches throughout their length (Fig. 28A), while trees growing under forest canopy develop short terminal crowns and clear boles 20 to 60 feet in length (Fig. 28C). In the upper portion of the coniferous forest area, several trees of the former type were found among a forest of the latter type. Since such trees were too knotty to have been split for pulp wood, they were left in the cut-over area, and are now conspicuous objects on the landscape, standing alone as they once did in a one-time treeless area (Fig. 34). Some of them are located as far as 100 meters back of the forest margin. Evidently such trees became established in the grassy bald directly. One finds very few dead coniferous logs near the upper limit of the forest zone as compared to lower portions of this zone, indicating that the upper marginal portion of the forest is little if any older than the oldest trees now within it. Many coniferous stumps with 300 to 350 annual rings occur near the middle of the spruce-fir zone while very few stumps with more than 150 annual rings occur within 50 meters of its upper margin. Upon this basis, an area of more than 100 acres now supports a forest which is apparently less than a century old. Thus the spruce-fir forest of Roan Mountain is relatively young, especially along the upper and eastern limits, and has not reached a maximum development in more than half of the area occupied by it. Neither has it yet covered its total potential area as evidenced by its present advance into the balds.

A 72-year-old native of the southern slope of Roan Mountain, Cane Freeman, remembers the time when a spring, located on the north slope about 100 meters within the forest, was at the margin of what was then a grassy bald along this ridge. The present-day vegetation supports his statement. Evidently the balds were once more extensive than they are now and, from present indications, they are and have been slowly giving way to northern coniferous forest.

INVASION BY ALDER

In a few places along Roan Mountain, as in the vicinity of Jane Bald (Fig. 22), a vigorous growth of alder *(Alnus alnobetula)* appears to be slowly encroaching upon the grassy bald. Cane Freeman, previously cited, says there is more alder in this vicinity than when he was a boy. Jane Bald was so named because an old gray mare, once owned by a woman named Jane, preferred to graze on this spot. At present this area is not suitable for grazing.

FIG. 22. Looking east from the east slope of Round Bald towards Grassy Ridge Bald. The alder bald community has its best development near the crest of the ridge which appears at the horizon. The first rounded peak (center) is Jane Bald. Note the physiognomy of the grassy bald community in the foreground. A small island of conifers appears at the southeastern end (right) of Grassy Ridge Bald. September, 1937.

FIG. 23. A good development of the alder bald as it appears on the extreme western end of Grassy Ridge Bald. Mountain alder *(Alnus alnobetula)* rarely occurs this densely on Roan Mountain and appears to be uncommon elsewhere. August, 1937.

RHODODENDRON BALD COMMUNITY

Rhododendron occurs in almost pure stands on the western summit of the mountain. The quadrat data (Table 6) reveal that conifer seedlings frequently occur under the shade of rhododendron, and that in places they break through the shrub canopy and survive.

There are abundant examples of such invasion of the rhododendron bald. Figure 24 shows a condition

FIG. 24. Diagram showing double invasion. Rhododendron invades the grassy bald and conifers invade the rhododendron bald. R, Rhododendron; A, Abies; P, Picea. The dots represent rhododendron seedlings and the shaded pyramids represent coniferous seedlings. (Based on a transect, 2 by 100 meters located immediately southwest of Roan High Knob.)

existing immediately southwest of Roan High Knob which is typical of rhododendron balds of the area under study. Coniferous seedlings become established both in the open and under the shade of rhododendron plants. The number of conifers that germinate and survive in the rhododendron bald seems to depend primarily upon two factors, the amount of soil moisture and a suitable seed supply. Good survival is

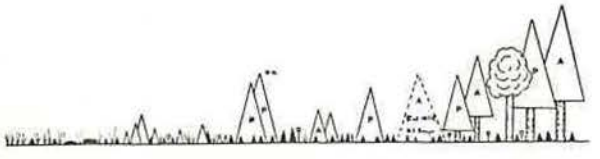

FIG. 25. Diagram showing invasion of the grassy bald by conifers. A, Abies; P, Picea. The shaded pyramids represent conifer seedlings under 1 foot high. Betula seedlings under 1 foot high are represented by the small open circles.

evidenced by the presence of seedlings and trees of different sizes and ages. Conifers frequently become established in scattered rhododendron clumps where they soon overtop the clump and eventually "choke" it out. These conifers often serve as parent trees for another wave of invasion, either directly into the grassy bald area (Fig. 29) or into other rhododendron clumps.

Additional evidence explaining the dynamics of this community was obtained by making a comparative study of the growth forms of rhododendron plants present in shade and in the open. Many different stages of invasion were studied, ranging from establishment of seedlings under rhododendron to elimination of rhododendron by a dense canopy of conifers.

FIG. 26. View of moss carpet which is being invaded by conifers. Immediately west of Carvers Gap. August, 1937.

Rhododendron plants growing in the open become hemispherical in shape, much resembling shocks of hay or wheat (Figs. 20 and 27A). This is obviously an adaptation which permits a maximum exposure of leaf surface with a minimum rate of transpiration. The height of a plant growing in the open rarely exceeds 4 feet, which is usually less than the diameter of its crown. As the clumps within an area become more closely spaced, following invasion, the height increases with a corresponding decrease in diameter. Since light is now received chiefly from above, the clumps assume an ob-conical or corymbose shape (Fig. 27B), a condition typical of clumps in better developed areas of the rhododendron bald community. The maximum height of clumps observed in such areas was 9 feet. By this time invading conifers have pushed through the canopy in certain more favorable places (Fig. 27C). The rhododendron canes under dense shade of conifers begin to die while the canes in partial shade grow rapidly in length, resulting in plants less branched and more slender than those of the open area (Figs. 27D and 27E). Before this time the rhododendron under which the first conifer became established has long since been dead, but its canes, not yet decayed, definitely show that its growth form was determined in the open. Other clumps not so close to the first co-

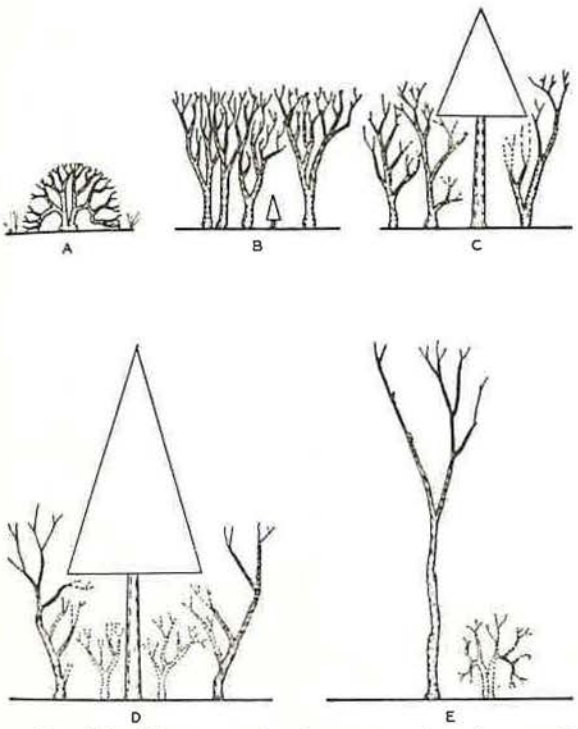

FIG. 27. Diagrams showing successive changes in growth form of *Rhododendron catawbiense* as it becomes invaded by conifers.

A. Conical shape of plants growing in open.

B. Corymbose shape assumed by plants in a normal stand of rhododendron. Conifers establish themselves under the shrub canopy.

C. Heavily shaded branches die (dotted lines) while lightly shaded ones lengthen.

D. Two dead plants which once grew without shading from above and two other plants in which all recent growth has been toward light with dying of heavily shaded branches.

E. Typical rhododendron plant as it occurs under forest canopy.

nifers that invaded, survive by an adaptation in which the plant branches less than in the open and grows very tall, often exceeding 12 feet in height. Finally these are eliminated by the increased crown density of the invading forest (Fig. 30).

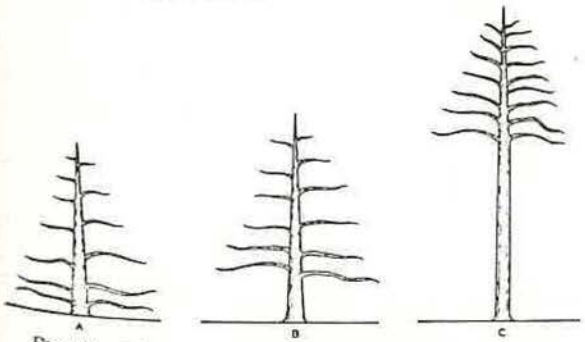

FIG. 28. Diagrams showing growth forms of conifers as determined by light. A, growing in the open with light from above and all sides to the ground level. B, growing in shrub bald with light from above and sides to within 6 to 10 feet of ground. C, growing within the spruce-fir forest with light principally from above.

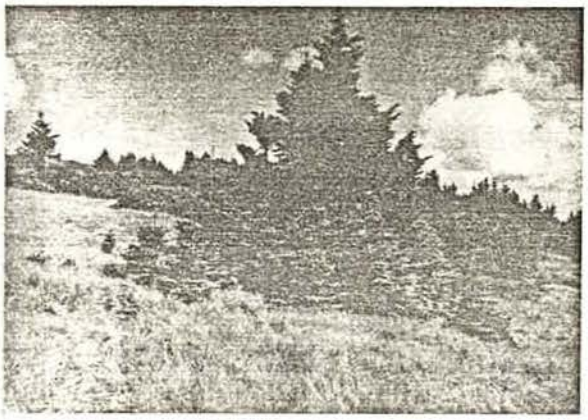

FIG. 29. A late stage of invasion by conifers in which rhododendron has been almost completely smothered out. Note numerous seedlings which have established themselves in the grassy bald near the parent tree. August, 1937.

An excellent example of invasion of rhododendron bald on a large scale is to be found at the southwestern limit of what is now known as the rhododendron garden. The forest along the western border of this area has recently replaced 25 to 50 acres of rhododendron and is still advancing, not only from the west, but also from the north and the south (Fig. 30). Most of the trees of this forest area have short, tapering and knotty boles with but few branches below 6 feet (Figs. 28B and 33), showing that they became established under rhododendron. Ring counts show the average age to be less than 40 years and the maximum age less than 65 years.

The growth forms of rhododendron plants and coniferous trees, the presence of large, dead rhododendron stems, the absence of dead tree trunks, and the abundance of coniferous reproduction provide striking evidence of the youthful and aggressive condition of that portion of the spruce-fir forest described above.

From the foregoing it becomes clear that the rhododendron bald community in the area under study is sub-climax, giving way to the spruce-fir climax forest community.

ALDER BALD COMMUNITY

Successional trends are less conspicuous in the alder bald community than in the other bald communities of the area but alder is invading in some places and is being invaded in others. In areas of better development, as on the northwest slope immediately east of Jane Bald (Fig. 23), the growth of alder is quite vigorous and is apparently maintaining itself. In areas of weaker development, as along the western and extreme eastern limits, alder appears to give way to rhododendron and conifers.

Two sites were observed where rhododendron appears to be invading the alder. The first example is within a small sedge bald about one fourth of a mile west of Carvers Gap along the main divide. Here alder and rhododendron were found growing with canes intertwined. Ring counts of a number of canes

of each species showed that alder invaded the area many years ahead of rhododendron. The other site is on the southwest end of Grassy Bald Ridge where several dozen small, vigorous clumps of rhododendron were present. By counting 50 clumps of alder at random, it was found that 12 of them were dead. No dead clumps of rhododendron were observed here. Thus, it seems that rhododendron succeeds where alder fails. This condition is typical of many acres on this end of the mountain. The cause is unknown, but since fire has occurred within the balds, it has probably been the chief factor in elimination of alder. Damage to alder has also been caused by defoliating insects. Rhododendron seems to be more tolerant of fire and insects than alder.

Based on data from 37 quadrats 2 by 2 meters which were taken along a line extending from Roan High Knob northeastward to the margin of the coniferous forest, rhododendron appears three times as important as alder, the two species forming a very dense and tangled thicket. A comparison of the two species as to ring counts, dead wood, reproduction, relative tolerance under conifers, and sociological dominance, shows that alder is slowly giving way to rhododendron. Harshberger (1903) in describing the vegetation of the summit of Roan (evidently the area described above) says, "*Alnus alnobetula* clings to the north slopes, here forming a pure growth on the steeper inclines (Alnus Association), with *Sorbus americana* below it, but associated with *Rhododendron catawbiense* on the upper slopes of the dome." At present there is no pure growth of alder in this vicinity, but as just revealed there is more rhododendron than alder. Evidently there has been a definite change in the floristic composition of this particular area immediately north of Roan High Knob within the past 35 years.

FIG. 30. Young spruce-fir forest which has recently invaded and replaced what was once a rhododendron bald. Many trees had reached sufficient size to have been cut for pulpwood. This area extends to Roan High Bluff and contains more than 50 acres. From southwest end of rhododendron garden, looking southwest. May, 1938.

The presence of conifers (Fig. 31) which show high survival value, indicates that at this station alder will eventually give way to the coniferous forest climax.

FIG. 31. Looking west from Roan High Knob. Invasion of the mixed alder-rhododendron thicket community by conifers shown in foreground. August, 1937.

A few advanced stages of invasion of alder by conifers were observed on the extreme eastern end of Grassy Bald Ridge where conifers have formed a young closed stand. Thus, alder appears to be subclimax and may be replaced by conifers directly or by rhododendron and then by conifers.

HISTORICAL VIEWS BEARING UPON BALD SUCCESSION

Mitchell (1835) perhaps first mentioned the treeless condition on the summit of Roan Mountain. He wrote, "With the exception of a body of rocks looking like the ruins of an old castle, near the southwestern extremity, the top of Roan may be described as a vast meadow, without a tree to obstruct the prospect; where a person may gallop his horse for a mile or two, with Carolina at his feet on one side and Tennessee on the other." This statement appears significant since it emphasizes the existence, at that time, of large stretches of grassy bald. Evidently this author was describing the area extending from Roan High Knob to Roan High Bluff, all of which now supports too many shrubs and trees to allow one to gallop a horse for more than a quarter of a mile in any direction.

Gray (1842), in a letter to Sir William Hooker, described a collecting trip to Roan Mountain in 1841 and quoted Mitchell's description given above. This indicates that Gray was also impressed by the great expanse of mountain meadow. In describing his collecting on the rounded bald of the southwestern summit, he says, "The only tree is *Abies Fraseri*, a few dwarfed specimens of which extend into the open ground of the summit." He did not commit himself as to the origin or trends; but apparently what he then described as a grassy bald being invaded by *Abies Fraseri* is now a forested area (Fig. 30).

Redfield (1879), in describing the last trip of Asa Gray and party to Roan Mountain, mentioned the balds of the mountain. He says, "Much of the summit prairie flora has been doubtless destroyed by the large herds of cattle, horses, and sheep, which every summer are sent to the mountain for pasture." This

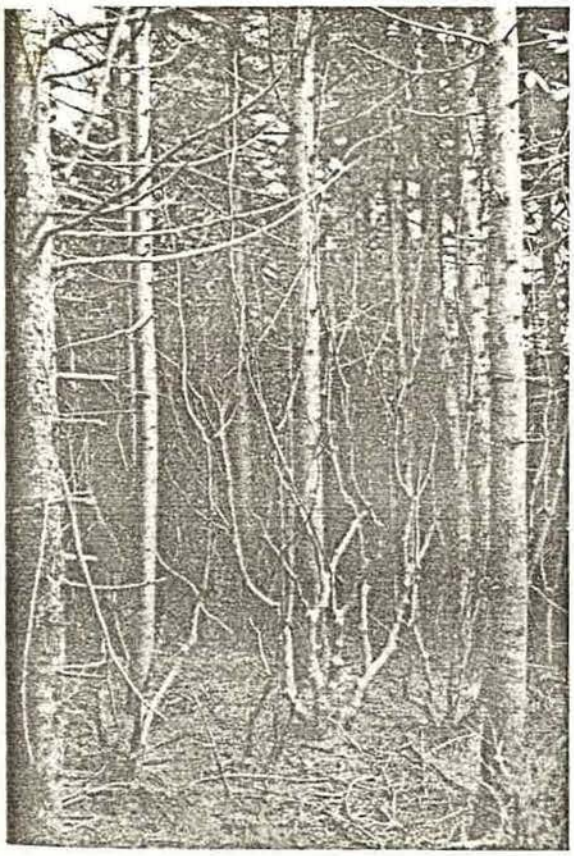

FIG. 32. Growth forms of rhododendron plants as found under spruce-fir canopy. Knots at base of the clump near the center indicate that this plant became established and lived for some time in an open area. Most of the dead twigs on the ground are those which dropped from the lower portion of this clump and other similar clumps. The tall slender dead canes of this clump show that they developed in shade after the area became invaded by conifers. May, 1938.

statement indicates that he considered the native species of the grassy balds to have once been more important than at the time of his visit. Another statement of his in which he says, "There is some reason to believe that the forest of spruce-fir has been encroaching upon the bald portion of the summit, but as it is now being cut for firewood and fencing, any such encroachment is likely to be checked, perhaps too effectually," shows that he believed the area was passing from a "mountain meadow" to a spruce-fir climax.

Harshberger (1903) described the balds of Roan Mountain as a "sub-alpine treeless formation" and made the first attempt to explain the cause of the balds by saying that they were the result of ice-storm injury. He assumed that frozen twigs were snapped off and trees thus eliminated to be replaced by vegetation of another type. His conclusion was based principally upon Edson's study (1894) in which she described frost forms on Roan Mountain. She did not, however, discuss the effect of snow and ice on trees or suggest the cause of the balds.

Davis (1930) considers the grassy balds of the Mount Mitchell region as of natural origin. He says there is no legend of Indian occupancy or of fire. Relative to the heath balds he states: "These heath *balds* seem to be encroaching upon the grassy *balds* but there is no indication of the development toward a forest type. Neither fire nor cut-over seems to explain their origin. They are best considered as physiographic-edaphic climaxes."

Cain (1930), who made a statistical study of the heath balds of the Great Smokies, describes them as having been derived from forested types by the elimination of tree species and considers them as "post-climax 'islands' in the contiguous coniferous and broad-leaf formations." In describing the grassy balds in the following year (1931) he says, ". . . in all probability these balds are natural phenomena. . . . It is sufficient to mention that soil profiles show from a few inches to a foot or more of homogeneous black soil of grassland type, which is far too deep to have developed since the advent of the white man. . . ."

Camp (1931) says, "The grassy balds were originally meadows containing numerous clumps of low shrubs, predominantly ericaceous, with higher shrubs at the margin." He holds that the grassy balds of the southwestern portion of Gregory Bald, located in the Great Smokies, are natural phenomena, probably

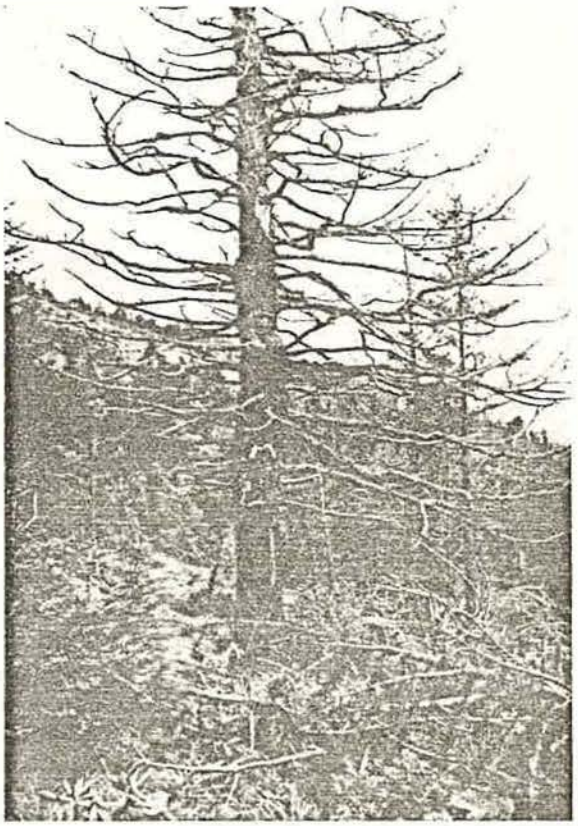

FIG. 33. A parent spruce which evidently became established under shade of rhododendron as indicated by absence of branches lower than 5 feet. This tree is located at the present southern margin of grassy bald immediately west of Cloudland Lodge. May, 1938.

FIG. 34. A parent tree which probably became established in the grassy bald. This tree was far too knotty to have been used for pulp wood. May, 1938.

produced by occasional desiccating southwesterly winds. "In midsummer," he says, "there are occasional periods of excessive drought, and it is this extreme that limits the character of the bald rather than the general climatic mean."

Fink (1931) does not believe these balds to be of Indian origin because it would have been too great a task for the early Indians to have cleared the balds since they lacked both tools and energy.

The foregoing authors have either assumed a theory of natural origin of balds or else have suggested no explanation. Wells (1932, 1936, 1937) has recently proposed a theory of Indian origin to explain the presence of the grassy balds of the Southern Appalachians. Based on a study of 23 grassy balds, he concludes that these balds were initiated by human interference at soil level which destroyed forest vegetation and resulted in the development of grassy balds. His assumption is that this disturbance was due principally to tramping of Indian feet, perhaps supplemented by tramping of their horses and cutting of trees for firewood. He imagines that the Cherokees spent much time on the summits of our higher mountains, congregating there in large numbers during the warmer months for hunting, camping, or perhaps warfare. "A grass bald," he says, "is in a sense an expanded trail." Wells (1937) describes the summit of Round Bald as having been the original Indian bald on Roan Mountain.

DISCUSSION

PROBABLE ORIGIN OF BALDS

These writers have suggested only three causal factors to explain the presence of the balds. Harshberger's ice-storm theory and Camp's theory of desiccating summer winds both suggest the factor of local climate. The "physiographic-edaphic" factor of Davis is a concept of the Cowles school.

The Indian theory of Wells is one of mechanical disturbance of the vegetation at soil level. This theory is not in accord with the facts revealed by the vegetation itself within the area under study. In the first place, the writer can find no evidence that Indians ever spent enough time on this mountain to have produced even slight changes in the vegetation. Artifacts have been searched for throughout the whole area, especially on the summit of Round Bald and in the vicinity of the two large springs at Carvers Gap, but nothing has yet been found. Inquiries have been made of older citizens, but none have heard of Indians having lived or camped on Roan Mountain. Judge S. C. Williams, historian for the State of Tennessee, and a resident of Johnson City, Tennessee, has devoted much time to study and writings concerning

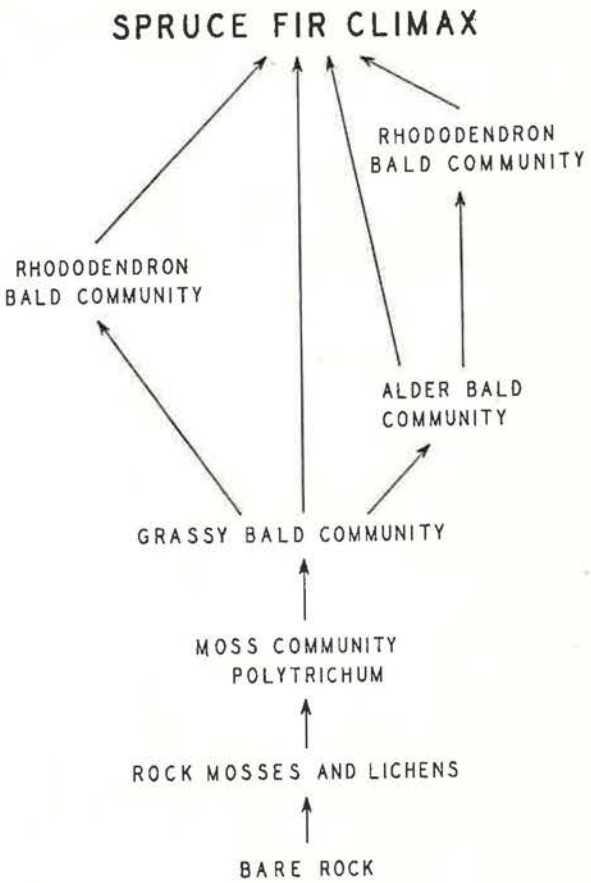

FIG. 35. Probable course of succession on the summit of Roan Mountain.

this East Tennessee country. Recently he said that it was not the custom of the Cherokees to frequent high mountains except to cross them in moving to a new location. He does not believe the Indians had anything to do with the origin of the balds and considers such an idea absurd.

The following excerpts from a letter received from M. W. Stirling, Chief, Bureau of American Ethnology, Smithsonian Institution, further discounts the theory of Indian origin of grassy balds: ". . . the historic sites of the Cherokee are southwest of Roan Mountain. At an earlier date they probably lived in the neighborhood, but we do not know what their customs may have been at this early time. . . . It seems unlikely that a mountain summit would be cleared for any purpose, unless under very exceptional conditions."

Even though one does assume that Indians camped along mountain summits, it would appear more logical that they did so because attracted by pre-existing balds rather than that their presence initiated the development of the balds. Even if Indians had made extensive trails, there is no evidence from this study that such trails would have become expanded into balds. On the other hand, there is abundant evidence that trails on Roan Mountain tend to close up rather than to expand. The present day sheep trails on Alder Bald are usually less than a foot wide and are worn down to a depth of more than 6 inches in places. Alder canes overlap the trail and after more than a century of use these trails, more than a mile in extent, have not expanded. Another old trail is the one leading from the southwestern end of the present rhododendron garden to Roan High Bluff. This trail has been used extensively by both man and beast for more than a century, and even though it leads through grass, shrub, and forest communities, there is no sign of expansion.

The locations of old horse and cattle trails, abandoned more than half a century ago, were determined within the present pure stand of rhododendron. This observation indicates that the trails were made within grassy areas which have since been replaced by rhododendron. Rather than trails producing grassy balds by their expansion, grassy balds may even contract and eliminate previous trails within their area by an invasion of shrubs or trees or both.

On the northeast slope of Round Bald there is a community of buckeye *(Aesculus octandra)* existing in an orchard condition. The growth forms of the trees indicate that they were not produced within a forest but rather in open areas. Since dead trees were frequent and reproduction weak, it appears that these trees are on the decline. Fire, grazing and browsing, and some cutting to improve grazing have been apparently responsible for this decline. No trees exist on the very summit of this bald. Perhaps windfall has been an important factor in the elimination of trees from this summit. Increased transpiration and decreased soil moisture of the heavily exposed dome-shaped summit may have been factors of greater significance.

An excellent example showing the effect of windfall in the elimination of trees and their subsequent replacement by grass, is a grassy bald area about 15 by 40 meters extending as a "peninsula" into the hardwoods of the southwest slope of Round Bald. Many old logs with long, straight boles are located in this grassy spot which is bordered by trees with clear boles 30 to 40 feet, showing that the area was once forested.

Another example of grassy bald having replaced hardwoods is at Carvers Gap where a forest "isthmus" once connected the hardwood forest area of the south slope with that of the north slope. Natives who have known the area for more than half a century told the writer that a cabin once stood in the gap and that hardwoods were cut to supply firewood for this cabin as well as for the hotel at Cloudland. Several small buckeye, hawthorne, beech and a few birch trees still stand as relics. A number of large, dead trees, evidently uprooted by wind, show the dangers of windthrow subsequent to opening this forest by cutting.

In both cases, the grassy bald has replaced the trees and appears to be maintaining itself. Whether or not hardwoods will eventually invade this area remains to be seen. There is no indication at any place along the ecotone between grassy bald and hardwoods that, under *natural conditions,* either community is giving way to the other, save the tornado case cited above.

Spruce-Fir Advances Between Grassland and Hardwood

It appears significant that the spruce-fir forest has been slowly advancing eastward from an original center of distribution in the vicinity of the southwestern summit. Parallel invasions have occurred on the two slopes of the divide, north and south, in which the coniferous forest advances as a "wedge" along the ecotone between the grassy bald and the hardwoods. This forest spreads by mass invasion into the bald areas, there being very little advance into the hardwoods. A small "island" of conifers occurs on the southeastern end of Grassy Bald Ridge. Below, these conifers are bordered by hardwoods (birch, beech, and maple) and above, by alder and rhododendron which they invade. There are no conifers or rhododendrons within many miles of this area except on Roan Mountain to the west of Carvers Gap, a distance of 2 miles or more. Since migration of rhododendron and conifers is essentially by wind, and since the prevailing winds are from the north (sometimes from the south but rarely from the east or from the west), this "island" of conifers and rhododendron appears to be a new or secondary center of distribution for these species on that portion of Roan east of Jane Bald. It is probable that this "island" originated by rhododendron having become established in what was once a grassy or alder bald and which subsequently became invaded by conifers.

Griggs (1934), in a careful study of the timber line in Alaska, has shown that forest there has been continuously advancing northward into new territory. He

obtained most reliable evidence from the growth forms of old parent trees located some distance back from the forest edge. He explains that old trees with large branches all along the boles indicate that they developed in the open before a closed forest condition had yet been reached. The picture presented by the growth forms of rhododendron and conifers in the area under study, as previously described, is in accord with Griggs' findings.

IS OUR CLIMATE CHANGING?

The only adequate explanation of the dynamic trends in the vegetation on Roan Mountain seems to lie in the concept of climatic change. Unless it is agreed that for the first time in the vegetational history of this area, the grassy balds have come to the end of their long sustained sub-climax stage and are gradually giving way to a forest, the first to occupy the area in question, it must be assumed that climate has changed recently or is now changing, and that such changes are being reflected in the vegetation.

May not climatic change and plant migration be in progress at the present time? The common generalization that any factor which has operated throughout the vast ages of the past has had sufficient time to have long since produced stabilization, needs rethinking. Griggs (1937) has pointed out that vast changes, due to changes in climate, have taken place within the past 1,000 years or so. Among them he cites the following examples: (1) Syria is becoming too arid for agriculture; (2) the old Norse colonies in Greenland which once thrived on dairying, now lie buried in the ground perpetually frozen; and (3) plant migrations are now in progress as in the past. He also concludes that the recent advance of forest in Alaska is due to climatic change.

As a result of this phase of the study dealing with succession, it appears to the writer that insufficient soil moisture, at times critical to woody seedlings, best explains the long period during which the balds have apparently maintained themselves as a subclimax. As Cox (1933) has stated, it is not the average but the extreme conditions which happen only occasionally that are most important in determining vegetational changes. The mild drought of June, 1936, was responsible for the death of some conifers that had become established in the grassy bald in the vicinity of Carvers Gap. Should such a condition recur only once every few years, invasion of the grassy bald by coniferous forest would be retarded or perhaps stopped completely. Thus, it appears that the present and recent advance of shrubs and conifers into the grassy area has been due primarily to a shortening of dry periods at critical times. The precipitation mean need not have changed since there is an abundance of rainfall within the area if properly distributed as to time. The balance between precipitation and vegetational change at extremely critical times is most delicate, even so sensitive that the appearance of a shower or even a cloudy or foggy day just before the crucial period is reached, may result in the survival of seedlings which otherwise would have perished. The factor of grazing, and subsequent occasional fires set to improve grazing, have served merely to check normal trends in succession rather than to have caused them. Such factors tend to maintain the grassy balds for a slightly longer period than would have been expected under natural conditions.

The problem of "bald origin" is not yet solved, but it is felt that this study represents a closer approach to the true explanation than has appeared hitherto. Before a solution is finally reached, further study of certain edaphic factors, particularly soil moisture, seems advisable.

SUMMARY

1. A statistical study was made of the plant communities of Roan Mountain during the growing seasons of 1934, 1936, and 1937.

2. The area under study is the major portion of Roan Mountain, altitude 6,285 feet, located along the northern portion of the Tennessee-North Carolina state line. As compared to the surrounding country, the climate of this area is characterized by lower temperatures, higher precipitation, higher wind velocities, less sunshine, and a shorter growing season.

3. The vegetation is considered to belong to either a forest or grassland type. Altitudinal zonations of the forest communities are: (1) beech-maple, 3,500 to 5,500 feet; and (2) spruce-fir, above 5,500 feet. Grassland communities (including shrub balds) occur from 5,500 feet to the summit.

4. The beech-maple community is composed of a superior tree layer consisting of beech, maple, and birch with some buckeye and service berry; an inferior tree layer of mountain maple and striped maple; a shrub layer dominated by hobble bush, gooseberry, and blackberry; an herb layer dominated by *Eupatorium roanensis, Impatiens biflora,* and *Dryopteris dilatata;* and a ground layer represented by a light cover of certain species of mosses and lichens.

5. The spruce-fir community contains a tree layer dominated by spruce and fir with an addition of yellow birch at higher altitudes; a shrub layer dominated by purple rhododendron, blueberry, and hobble bush; an herb layer dominated by *Dryopteris dilatata* and *Oxalis acetosella;* and a ground layer heavily carpeted by mosses.

6. The balds, located along the linear summits of the mountain, cover approximately 1,000 acres. They are represented by three communities: (1) grassy balds, most extensive and found throughout the full extent of the bald area; (2) alder balds, confined essentially to the eastern end; and (3) rhododendron balds, confined principally to the western end of the summit.

7. The grassy bald represents the most homogeneous community, floristically, within the area studied. It is dominated by only one species, *Danthonia compressa* (mountain oat grass). Other frequent species are *Rumex acetosella, Agrostis hyemalis, Fragaria virginiana, Houstonia serpyllifolia,* and *Carex flexuosa.*

8. In the rhododendron bald, the shrub layer is dominated by an almost pure closed stand of purple rhododendron with only a light expression of species in herb and ground layers.

9. The alder bald consists of a shrub layer dominated by mountain alder and an herb layer of *Carex lucorum, Danthonia compressa,* and *Rumex acetosella.* These herbs find their best expression in the small openings between alder clumps.

10. The beech-maple community appears as an old and well stabilized climax for the zone it occupies, except in certain portions at the upper margin of its range where the spruce-fir appears to be gradually replacing yellow birch.

11. The theory of Indian origin of the grassy balds is discounted and the theory of natural origin sustained.

12. The grassy balds were once more extensive along the summit of Roan Mountain than at present, having given way to shrub and forest communities.

13. The spruce-fir forest community is climax for most of the area above 5,500 feet. It appears that under natural conditions the balds will eventually give way to this forest climax.

14. The recent advance of the coniferous forest into the grassy bald areas may possibly be caused by a change in climate, resulting in a less xeric condition for seedlings at critical times. Such climatic change is assumed to have been recent or is now in progress.

LITERATURE CITED

Blomquist, H. L. 1934. Ferns of North Carolina. 131 pp. Duke University Press, Durham, N. C.

Braun-Blanquet, J. 1932. Plant Sociology: the study of plant communities. Trans., rev., and ed. by G. D. Fuller and H. S. Conrad. 439 pp. McGraw-Hill Book Co., New York.

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

——— 1931. Ecological studies of the vegetation of the Great Smoky Mountains of North Carolina and Tennessee. I. Soil reaction and plant distribution. Bot. Gaz. **91:** 22-41.

——— 1932. Concerning certain phytosociological concepts. Ecol. Monog. **2:** 475-505.

——— 1934. Studies of virgin hardwood forests: II. A comparison of quadrat sizes in quantitative phytosociological study of Nash's Woods, Posey County, Indiana. Amer. Mid. Nat. **15:** 529-560.

Camp, W. H. 1931. The grass balds of the Great Smoky Mountains of Tennessee and North Carolina. Ohio Jour. Sci. **31:** 157-165.

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

Edson, Mrs. H. R. 1894. Frost forms on Roan Mountain. Pop. Sci. Monthly **45:** 30-39.

Fink, P. M. 1931. A forest enigma. Amer. Forests **37:** 538; 556.

Gleason, H. A. 1924. The structure of the beech-maple association in northern Michigan. Mich. Acad. Sci., Arts, and Letters. **4:** 285-296.

Gray, A. 1842. "Notes of a botanical excursion to the mountains of North Carolina," in a letter to Sir William Hooker. Amer. Sci. and Arts **42:** 1-49.

Griggs, R. F. 1934. The edge of the forest in Alaska. Ecology **15:** 80-96.

Harshberger, J. W. 1903. An ecological study of mountainous North Carolina. Bot. Gaz. **36:** 241-258; 368-383.

Hataya, B. 1933. The phytogeography of conifers in Japan, and successional changes in the conifer forests on Mount Fuji. Proc. 5th Pacific Sci. Congress (Canada) **4:** 3,289-3,293. Univ. of Toronto Press. 1934. n.v. Biol. Abstr., **11** (8): 18,030.

Keith, A. 1907. Roan Mountain Folio No. 151. U. S. Geological Survey.

Korstian, C. F. 1937. Perpetuation of spruce on cutover and burned lands in the higher Southern Appalachian Mountains. Ecol. Monog. **7:** 125-167.

Lutz, H. J. 1930. The vegetation of Heart's Content: a virgin forest in northwestern Pennsylvania. Ecology **11:** 1-29.

Marbut, C. F. 1935. Atlas of American Agriculture. Part 3. Soils of the United States. U. S. Dept. Agr.

Mitchell, Elisha. 1835. Notice of the height of mountains in North Carolina. Raleigh Register, Nov. 3, 1835, and in Amer. Jour. Sci. and Arts **35:** 378.

Redfield, J. H. 1879. Notes of a botanical excursion into North Carolina. Torr. Bot. Club **6:** 331-339.

Robinson, B. J., and M. L. Fernald. 1908. Gray's new manual of botany, 7th ed. American Book Co., New York.

Schimper, A. F. W. 1903. Plant-geography upon a physiological basis. 839 pp. Clarendon Press, Oxford.

Small, J. K. 1933. Manual of the southeastern flora. The Science Press, Lancaster, Pa.

Sudworth, G. B. 1927. Check list of the forest trees of the United States, their names and ranges. U. S. Dept. Agr. Misc. Circ. **92.**

Toumey, J. W., and C. F. Korstian. 1937. Foundations of silviculture upon an ecological basis. 2nd. ed. 456 pp. John Wiley and Sons, New York.

U. S. Dept. Agr., Weather Bureau. Monthly meterological summary for Johnson City, Tenn., and Banner Elk, N. C.

Wells, B. W. 1936. Origin of the Southern Appalachians grass balds. Science **83:** 283.

——— 1936. Andrews Bald: the problem of its origin. Jour. So. Appal. Bot. Club. **1:** 59-62.

——— 1937. Southern Appalachians grass balds. Elisha Mitchell Sci. Soc. **53:** 1-26.