Written To Aunt Jessie
by Philip Castro

A QUANTITATIVE STUDY OF THE SUBALPINE FOREST OF ROAN AND BALD MOUNTAINS IN THE SOUTHERN APPALACHIANS

An Abstract

Presented to

the Graduate Faculty

East Tennessee State University

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

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by

Philip K. Castro

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A QUANTITATIVE STUDY OF THE SUBALPINE FOREST OF ROAN AND BALD MOUNTAINS IN THE SOUTHERN APPALACHIANS

Purpose. The subalpine forests surrounding the grassy balds on Roan Mountain and Bald Mountain were studied to make a quantitative record of their present condition and to determine whether forest vegetation is presently invading the balds.

Method. The canopy trees were sampled by the Bitterlich method to determine the composition of the forest. Density and average tree diameter were determined by modification of the point quarter method. Increment borings and tree heights were taken for representative canopy trees. 1/20 acre circular plots were used to measure tree reproduction and shrub density.

Summary. The forest is dominated by beech, northern red oak, yellow birch, hawthorn, and buckeye occurring in distinct communities. If the present reproduction continues, the forest will lose its orchard-like appearance. As the canopy closes and the leaf litter builds up, the sedge-grass herbaceous layer will probably be replaced by forest herbs. The shrub layer seems to be of minor importance and may become less important if the forest canopy closes.

Conclusion. Balds are an early stage of a very long term succession. The subalpine forest is an invasion of the bald and is composed of several successional communities. The most extensive community is beech. Beech or a mixture of beech, sugar maple, or buckeye seems to represent the most important climatic climax community of the two mountains.

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Thesis prepared under the guidance of Mr. John C. Warden, Dr. Frank H. Barclay, and Wallace A. Tarpley.

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INTRODUCTION

The subalpine forest that surrounds the grassy balds on Roan Mountain and Bald Mountain were studied at elevations between 5,120 and 5,930 feet in the winter and spring of 1969 in order to make a quantitative record of their present condition and to determine whether forest vegetation is presently invading the balds.

Previous studies of this type of vegetation include Davis (1930), Cain (1931), Camp (1931 and 1950), Brown (1941 and 1953), Wells (1936a, 1936b, 1937, 1946, and 1956), Russell (1953), Whittaker (1956), Mark (1958 and 1959), Billings and Mark (1957), and Ramseur (1959). According to Billings and Mark, balds occur where there had been some disturbance at elevations near the tolerance limits of forest species, either at the lower limits of the spruce-fir forest or the upper limits of the northern hardwood forest. They concluded that balds are early stages in long term successions ultimately leading back to forest. Similar conclusions were reached by Cain (1931), Brown (1941), and Whittaker (1956). The present study was designed to provide additional quantitative data bearing upon this hypothesis.

In all, 15 stands were studied, representing every forest type avialable on the two mountains. Most of the stands included in the present study may be called "orchards" in the sense used by Cain (1931), Brown (1941), Whittaker (1956),

and others. Whittaker (1956) describes the orchard vegetation type as being composed of stunted, widely spaced beech (Fagus grandifolia), northern red oak (Quercus rubra var. borealis), and hawthorn (Crataegus spp.) growing singly or in combination. Davis (1930) used the name, "subalpine orchard association" for this type of vegetation. Trees found in this forest are species from the northern hardwood forest formation found between the elevation of 4,500 and 5,500 feet. Usually the stands include a herbaceous layer of sedge and grass remarkably similar to that seen in the treeless balds, but as the forest canopy closes and the leaf litter becomes continuous, the bald species are replaced by forest herbs such as Claytonia caroliniana and Erythronium americanum.

Roan Mountain is located at N lat. 36° 06' and W long. 82° 06'. Bald Mountain is located at N lat. 35° 59' and W long. 82° 30'. Both occur on the North Carolina-Tennessee state line and are part of the Unaka mountain range of the Southern Appalachian Mountains. The locations of the stands included in this study are shown by Figures 1 and 2. All but one of the study areas on Roan Mountain were located on U. S. Forest Service land. There is no indication that any of these will be seriously disturbed in the near future. However, stands on Bald Mountain are located on property recently acquired by the Bald Mountain Development Corporation and the Wolf Laurel Properties, Inc. (Route 3, Mars Hill, North Carolina).

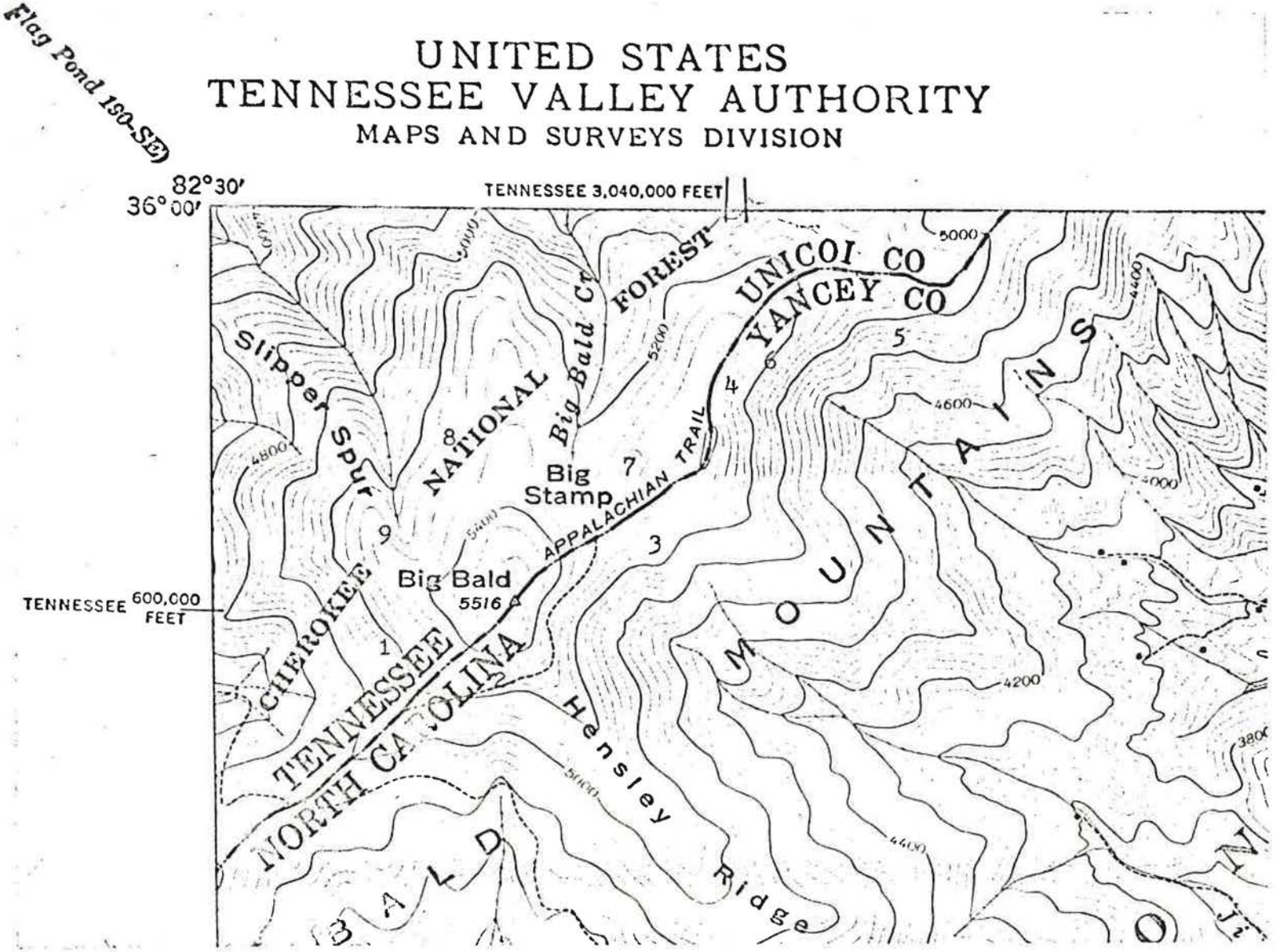

Figure 1. The location of sample stands on Bald Mountain.

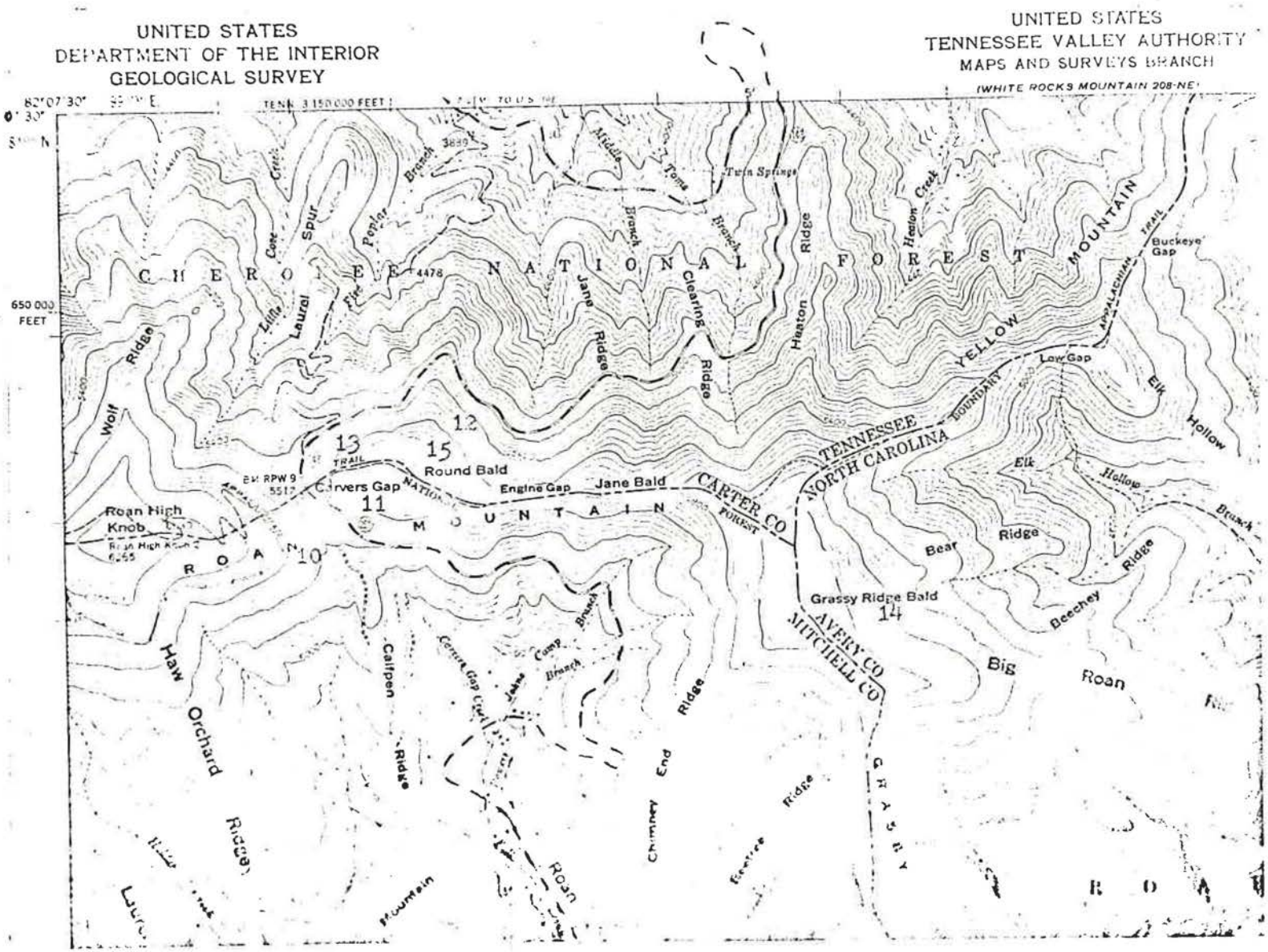

Figure 2. The location of sample stands on Roan Mountain.

This property is being developed into a tourist resort with a golf course, ski slope, shopping center, and building lots. While the lower slopes and parts of the bald are now considerably disturbed, the high elevation orchard stands had not been disturbed by this development in the spring of 1969.

The geology of Roan Mountain and Bald Mountain consists of precambrian granite and granitic gneiss (Conrad, 1966). The surface rock is Roan gneiss or hornblende gneiss with lesser amounts of hornblende schist. Along with Roan gneiss, some mica gneiss and schist may be found (Stuckey, 1965).

The soils of the study areas on Roan Mountain are described in the Soil Survey-Mitchell County, North Carolina (1952). The soils of Bald Mountain are described in the Soil Survey-Yancey County, North Carolina (1952). Nine of the study areas occur on Burton stony loam (see Table XV), one on Porters loam steep phase, and one on Porters stony loam very steep phase. For a detailed description of these soil types refer to the above reports and to Lee (1955).

There is a need for weather information on the mountains where balds occur. There are no official records for Roan Mountain or Bald Mountain. Data from stations located in the vicinity of these mountains are summarized in Table I. The weather information for Mt. Mitchell would compare best with that expected on Roan and Bald Mountains, having a growing season less than that of Transou, North Carolina. Mark (1958)

reported that records from Asheville showed that the prevailing winds of the region are from the northwest with southwesterly winds rare except during winter and spring, but southeasterly and westerly winds frequent during spring, summer, and fall. Local topography, however, often alters wind patterns, with gaps acting as wind funnels. In the absence of instrument records, it was necessary to rely upon such indicators as the direction of windswept grasses and sedges as well as flag trees. Russell (1953) considered wind to be an important factor in the establishment and persistence of beech in these gaps. Brown (1941) suggested that windfall may have been a cause of the balds on Roan Mountain. Camp (1931) suggested that hot southwesterly winds may have been a cause of the balds in the Great Smoky Mountains, with grazing and fire in recent times adding to their grassland character. Snow drifting observed in the course of the present study indicates a prevailing northwest wind. The directions, given in Table III, show that stands 7 and 13 of the present study face the prevailing wind. Stands 10, 11, and 14 on Roan Mountain are protected from wind and accumulated snow drifts. These drifts had bent some of the small trees in stand 11. On Bald Mountain stands 3, 4, 5, and 6 are on the protected side. One snow drift in stand 3 lasted until the middle of April. While there was no bending damage to the trees of Bald Mountain, snow cover had caused rabbits to clip northern red oak, sugar maple (Acer saccharum), and

TABLE I

TEMPERATURE, PRECIPITATION, AND GROWING SEASON DATE SUMMARIZED FROM CARNEY (1955) AND HARDY, CARNEY, AND MARSHALL (1967) AT METEROLOGICAL STATIONS NEAREST TO THE STUDY AREAS

	Mount Mitchell	Crossnore	Marshall	Waynesville	Fletcher	Transou
Elevation (ft.)	6,635	3,362	1,646	2,658	2,070	3,200
Temperature (^{o}F)						
January ave.	27.60	34.20	37.70	38.90	36.40	34.50
July ave.	59.10	67.00	73.40	71.30	72.20	67.80
Maximum (annual)	87.00	91.00	102.00	98.00	-----	-----
Minimum (annual)	-23.00	-9.00	-10.00			
Precipitation (inches)						
Annual ave.	73.53	53.18	38.22	45.92	50.25	52.98
Growing season (days)			173	165	180	150
Ave. date of last 32^{o}F min.			4/24	4/30	4/17	5/11
Ave. date of first fall 32^{o}F min.			10/17	10/12	10/14	10/8

yellow birch (Betula lutea) two feet above the ground.

Brown (1941) states that the forests have not been burned above 4,000 ft. on Roan Mountain, but that the settlers frequently burned the grassy balds. Mark (1958) considered fire in the past 50 years to be of no importance in the maintenance of the balds. The present author observed some evidence of fire damage to the old yellow birch found on the northwest slope of Round Bald. This damage occurred many years ago. To the writers own knowledge the southwest slope of Grassy Ridge Bald on Roan was burned in 1956 and again in 1962. These fires were not severe but killed some beech trees as well as most of the beech reproduction. At this date, beech reproduction is sparse with a continuous sedge-grass ground cover in the burned areas. This year a fire burned an area of 1-2 acres of grass-heath bald on the north slope of Grassy Ridge Bald. Some Rhododendron catawbiense was killed but this 1969 fire did not damage Alnus crispa. The fire history of Bald Mountain seems to be similar to that of Roan Mountain. Some fire damage was noticed in stand 9 on Bald Mountain.

Brown (1941) stated that Roan Mountain has been grazed since the first settlers came. He said that attempts were made in 1877 and 1936 to restrict grazing, with no success. At the writing of his paper in 1941, the mountain was still being grazed. Sheep belonging to the family of the present author were among the last sheep to graze Roan Mountain. They

seldom grazed farther than Jane Bald, staying for the most part on Grassy Ridge Bald. We discontinued our grazing of the balds in the mid-50's. However, other people allowed their cattle to graze for several more years. There has been no important grazing of Roan Mountain for the past 10 or 12 years.

The fence around Bald Mountain has not been repaired for 8 or 9 years, but its condition suggests that Bald Mountain has had a more recent grazing history. According to a representative of the Bald Mountain Development Corporation, several cattle were allowed to graze the bald three years ago to keep the grass picked down. The bald has not been grazed for the past two years.

MATERIALS AND METHODS

Fifteen stands were selected according to their location around the balds so that all avialable slopes and recognizable forest types in the subalpine orchard forest situated next to the balds could be sampled. Stands 1-9 were located on Bald Mountain. Stands 10-15 were on Roan Mountain. The upper edge of all stands except stand 10 comes in contact with examples of the grassy bald. The east side of stand 10 joins the bald while the upper edge joins a young spruce-fir forest that was orginally a grass bald, according to Brown (1941) and Mr. Herby Gouge, a native of Roan Valley. Where possible, only stands large enough to permit 30 or 40 sample points were used. However, some stands, the only examples of their type available, were included regardless of size. Table II gives the number of sample points taken for each stand.

The tree layer was sampled by the Bitterlich method, discussed in detail by Grosenbaugh (1952) and by Phillips (1959). This method was especially suitable for this study because of the uniform "even aged" character of the orchard forest. The method is also useful because large areas can be sampled rapidly. Bitterlich sampling was done with a fixed basal area angle gauge having a basal area factor of 10. (All equipment, unless otherwise indicated was obtained from Forestry Suppliers, Inc., Jackson, Mississippi). The basal area

factor was corrected for slope by a clinometer which gave the corrected factor along with the per cent. slope. Sample lines consisted of 10 sample points and, except in stands 5, 9, and 6 followed contour lines. Stands 5 and 9 were sampled by running sample lines at right angles to the contours from the bald into the forest. Random sampling was done in stand 6 to obtain as many sample points as possible in this small area. The sample points were spaced either 75 of 100 feet apart, depending upon the distance required to avoid sampling the same tree twice. The upper sample line of first sample point was always 75 feet from the bald edge (except in stand 6). Table II shows the distance between sample points used in each stand.

Frequency and presence values were computed for trees and tree reproduction. Frequency was considered to be the number of samples in which a species occurred divided by the total number of samples examined. Presence is defined as the number of stands in which a species occurred divided by the total number of stands examined. Bald Mountain and Roan Mountain were considered separately in computing these values.

In addition to the basal area data taken at each sample point, the two trees closest to each sample point were measured for DBH. The distance from each of the two closest trees to the sample point was measured. These data were then used to compute the average tree diameter and density of trees. Density

TABLE II

THE LOCATION OF SAMPLE POINTS AND SAMPLE PLOTS,

THEIR POSITION, NUMBER, AND SPECING

Stands	No. of sample pts.		Elevation (ft.) of the sample lines 1	2	3	4	Distance Between pts. (ft.)
1	40		5,274	5,225	5,175	5,115	100
2	30		5,250	5,240	5,140		100
3	40		5,250	5,190			100
4	20		5,275	5,225			100
5 Vertical lines	40	Top	5,175	5,225	5,225	5,200	100
		Bottom	5,075	5,090	5,100	5,090	
6 Random sampling	10		5,275				100
7	30		5,325	5,310	5,290		75
8	30		5,320	5,275	5,235		75
9 Vertical lines	20	Top	5,360	5,350			75
		Bottom	5,260	5,245			
10	40		5,475	5,430	5,400	5,350	75
11	30		5,590	5,575	5,510		75
12	30		5,675	5,600	5,550		75
13	30		5,630	5,550	5,475		100
14	30		5,955	5,930	5,910		75
15	20		5,737	5,725			75

was computed according to the formula $D=43560/d^2$ where d is the average distance between trees established by the point quarter method (Phillips, 1959).

The canopy height along each sample line was estimated by measuring selected trees with a field range finder.

Increment borings were taken from selected dominant trees to estimate the age of each stand.

Tree reproduction was sampled within a 1/20 acre circular plot established around each sample point. The plot radius of 26.33 ft. was determined by use of the field range finder. Table II shows the number of plots sampled per stand. All tree stems over one foot tall but less than one inch in diameter were counted in the tree reproduction size class. Stems from one to four inches in DBH were distinguished as saplings.

Shrubs were counted in each of the same 1/20 acre plots.

The herbaceous layer was considered more subjectively since the primary aims of this study were directed toward the woody vegetation. Estimates of species importance were made after cruising the stands. Each species was assigned to an abundance class, following Phillips (1959). The estimated abundance of herbs, given as the average distance between individuals, are shown in Table XIV. The herb layer was examined three times during the spring (April 25-26, May 8-9,

and May 22-23, 1969). Any species not in condition to be identified on these dates was omitted from the list of the spring flora.

Soil was sampled with a three foot screw type auger. Random samples were taken throughout the stand to determine soil depth. A composite sample of topsoil was taken from each stand and tested with pHydrion Vivid 1-11 paper for pH (Micro Essential Laboratory; Brooklyn, New York).

Elevation was determined by an Everest Pocket Altimeter and recorded for each sample line.

Scientific names and common names follow the Manual of the Vascular Flora of the Carolinas by Radford, Ahles, and Bell (1968).

RESULTS

The Canopy Layer

Total basal areas of the forest stands and the estimated contribution of each species to the totals are shown in Table III. The total basal area is expressed in square feet per acre. The relative basal area of each species is given as a per cent. of the total basal area.

For the subalpine forest as a whole the total basal area varied from 112.67 ft.^{2}/acre (stand 12) to a low of 31.54 ft.^{2}/acre (stand 15). For Bald Mountain the range in total basal area was 106.53-53.08 ft.^{2}/acre. Northern red oak did not appear in any of the samples from Roan Mountain, even though it does occur at lower elevations there. Buckeye (*Aesculus octandra*) did not occur in the samples taken on Bald Mountain although it does occur at lower elevations in the hollows near the base of that mountain. Spruce (*Picea rubens*) and Frasier's fir (*Abies fraseri*) were both absent from Bald Mountain. The absence of spruce, fir, and buckeye from this mountain, which is lower than Roan Mountain, is noteworthy.

In interpreting the relative basal areas values given in Table III, a species was considered to be a dominant member of the forest if its relative basal area was 15 per cent. or more of the total. On this basis, beech was the most important tree, being dominant in eight of the stands. As can be seen

in Table III, beech expressed stronger dominance in gaps and on north slopes, but occurs all around Roan Mountain. Stand 11 on Roan and stand 9 on Bald Mountain are typical beech stands. Yellow birch was a dominant in five stands. It is an important species in all the forests around the balds. Typically, yellow birch was found as an old tree, but young trees were found in stands 5, 13, and 14. Northern red oak was dominant in five stands, but was more restricted in range of habitat than yellow birch. Its best development was in stands 2 and 3 on the south slope of Bald Mountain, where it occurred in nearly pure stands. Hawthorn dominated three stands. Its importance, estimated by relative basal area, seems to be greater on Bald Mountain, but it has a high presence value on both mountains. Buckeye, while a dominant tree only in stands 12 and 15 on the north slope of Round Bald, appears in every stand of Roan. Its absence from the higher areas of Bald Mountain has already been mentioned as a peculiar feature. All other tree species are represented by low basal area.

At high elevations dominance is confined to a few species. Sugar maple, black cherry (Prunus serotina), serviceberry (Amelanchier arborea var. laevis), moosewood (Acer pensylvanicum) and mountain maple (Acer spicatum) occur on both mountains but did not achieve dominance in any of the stands. Black cherry may have been more important on Roan in the past than it is now. There was selective logging of black

cherry in the 1880's (Brown, 1941). Records of selective cutting in other species are not known. The appearance of the stands, however, suggests that only cherry has been removed from them in significant quantity. They may be considered "nearly virgin".

Basal area varied with elevation in 61.5 per cent. of the stands. The data of stand 12, presented in Table IV is used to illustrate the pattern. The basal area is lowest along the upper sample line, reaches a maximum along the middle sample line, and is intermediate in the lower sample zone. Visual inspection suggests that the forest along the upper part of the stand, adjacent to the grassy bald established most recently. Low basal area here is due partly to small size, but also to the wide spacing of trees. In the middle sampling zone the forest appears older and at a later stage of succession, consisting of an old age group of widely spaced trees with younger trees that now occupy the spaces between the older trees. The lower sampling zone represents a forest that is still older, and seems further along in succession, the basal area now reduced by natural thinning.

Table V gives the average diameter of two trees at each Bitterlich sample point by stands and by species. Table V also shows the average distance between trees in the different stands. From the latter data the average density of trees in each stand was calculated. Comparative density values are

given in Table III. In general the average diameters are higher, and the trees farther apart, on Bald Mountain. On Bald Mountain the west, south, and east slopes have an average diameter per tree of 15.86 inches, while on the north slopes the average diameter is 11.65 inches. The difference is partly due to the change of dominance from northern red oak to beech. A similar difference is noticed in the two yellow birch stands, 13 and 14, on Roan Mountain. Both yellow birch and northern red oak grow larger than beech in the orchard condition. Beech shows more evident deterioration with age. As an example of a comparison that can be made, the dominants of stand 8 on Bald Mountain and those of stand 12 on Roan Mountain are considered. The average diameter of beech in stand 8 is 10.9 inches, while the beech of stand 12 have an average of 9.15 inches. Both stands are located on north slopes. These stands are comparable with regard to the diameter of beech. However, the diameters of the second dominant, yellow birch, are considerably different, 13.14 on Bald Mountain and 19.1 on Roan. Stand 7 on Bald Mountain has old yellow birch of an open grown character scattered widely throughout the stand, with beech filling in the area between. The open grown form of yellow birch suggests that it appears early and is older. The earlier appearance of yellow birch is evidenced also by average diameter. Beech had

an average diameter of 11.36 inches while yellow birch had an average of 18.89 inches. Representative beech trees were 222 years old while representative yellow birch trees were 264 years old.

Table VI shows the canopy height in the upper, middle, and lower parts of each stand. The severity of the growing conditions along the upper edge, next to the grassy bald, is indicated by the height of the canopy there. Variations in height are dependent upon canopy age (ages are given in Table VIII), changing species composition (composition is given in Table III), differences in exposure to sun and wind (see Table VII), and other factors. Table VII shows the relation of elevation to canopy height. In general, an increase in elevation is accompanied by a decrease in canopy height, but elevation is considered to be only one factor in the complex of variables influencing height.

Increment borings were taken to estimate the age of the stands and the diameters of representative canopy sized trees of dominant species were measured. These results are shown in Table VIII. The sampled trees of Bald Mountain averaged 156 years old; the trees sampled on Roan Mountain averaged 247 years old. The trees sampled in stand 15 on Roan Mountain had obviously grown as root sprouts from previous trees, so it is impossible to determine the date of the first establishment from seed. Initial invasion of the pioneer trees occurred one

or more generations before the present sprout trees. This problem is encountered in every stand since vegetative reproduction is important in all of the dominant species at these elevations, especially in the initial orchard condition. Thus the ages presented in this study should be considered as stem ages only. A method of determining the age of root systems would be useful, but there is no assurance that any one root, or even the entire root system would be as old as the tree itself, since there is a replacement of parts that have decayed. Growth is slow in all stands, as can be seen in Table VIII. The oldest tree found in any sample, was a 385 year old yellow birch. This tree was 26 inches DBH. Another interesting tree was a buckeye (stand 14). It was 4 inches in diameter, only 17 feet tall, but 195 years old. Northern red oak has the best growth rate of the dominant trees in the subalpine forest. Red spruce in stand 10 had the fastest growth rate of any species studied. The spruce sampled was 62 years old and 17 inches DBH.

The dominant canopy trees are evenly spread throughout the stands where they occur, as shown by the frequency values in Table IX. This table also gives presence values. Yellow birch and hawthorn are shown to occur in every stand on Bald Mouuntain; beech and buckeye are in every stand on Roan Mountain.

Tree Reproduction

Because of vegetative reproduction, a high count for reproduction-sized beech may be less significant than a lower count for yellow birch or sugar maple. While beech commonly forms clumps of sprouts around the parent trees, yellow birch and sugar maple do not. Their reproduction is mainly from seed. The latter species are more randomly distributed. The aggressiveness of beech in this forest type indicated that it would increase in stands where it does not already dominate. Although yellow birch, buckeye, and northern red oak may reproduce vegetatively, they are usually confined to replacing the old stem rather than producing new trees.

Two sets of data are given for tree reproduction. Table X shows the number of stems per acre in the reproduction size class. Some reproduction was found in all stands, but higher reproduction is evident on Bald Mountain. Bald Mountain had a high of 1,171 stems per acre (stand 1) and a low of 306 in the hawthorn orchard (stand 6). The high on Roan was 787 stems per acre (stand 11) with a low of 243 per acre (stand 15). Table XI gives frequency and presence values of tree reproduction. Frequency values show that the dominants are reproducing in every stand, but in some stands (as in stand 4) a change in dominance is occurring with different species dominating the overstory and understory layers. On Bald Mountain, hawthorn, beech, and yellow birch have 100 per cent.

presence values. In general, beech is reproducing importantly in all stands since their release from grazing pressure. The effects of fire on tree reproduction could not be evaluated. Sugar maple, with a presence of 77.8 per cent. in the reproduction layer is less important in the canopy at present in the forest on Bald Mountain. Old seed trees are present in this forest indicating that an earlier generation of sugar maple was able to enter this forest. Sugar maple at similar elevations on Roan Mountain is an important forest dominant. Moosewood and mountain maple are reproducing significantly enough to remain in the stands that they now occupy. Black cherry, red maple (Acer rubrum), and white pine (Pinus strobus) are reproducing in a significant number of stands. Vigorous white pine seedlings are entering the grass balds and some of the stands on Bald Mountain, although no seed trees could be found at this elevation. On Roan, where spruce and fir occur within a stand, they are about five feet above the hardwood canopy. Evidently they successfully invade some of the stands of high elevations. Fraser's fir is being heavily damaged by the balsam woolly aphid (Chermes piceae) (Rauschenberger and Lambert, 1969).

The total number of saplings, and the number of saplings of each species per acre, is shown in Table XII. The number of saplings is well below that of tree reproduction, as expected. Hawthorn, although important in every stand, has fewer

saplings and seedlings in stands where the canopy is closing. In the stands dominated by northern red oak, there are few oak but many beech saplings. This is especially well shown in the data for stand 4 (Table XII), where there are no oak saplings but 63 beech saplings per acre. Stand 13 on Roan Mountain was unusual, with more sapling than seedling reproduction. The density of saplings was, in general, lower on Bald Mountain than on Roan. For example, the density of beech saplings in stand 12 on Roan is more than twice the density of beech saplings in stand 8 on Bald Mountain, even though both are typical beech dominated stands.

Shrubs

Although the shrub layer is not a prominent feature of the orchard forest type, shrub density was measured and these measurements are shown in Table XIII. An oustanding feature of this forest type is the limited shrub flora and the visible discontinuity of the shrub layer. All species except Rhododendron catawbiense and Alnus crispa are shared by the the two mountains, since R. calendulaceum and R. maximum are present although they did not enter any sample areas on Roan. On Bald Mountain R. maximum appears to be increasing in importance in some locations, notably on rock outcrops in the northwest corner of stand 1. On Bald Mountain the most important shrubs are R. maximum, R. calendulaceum, and Vaccinium spp. (mostly V. corymbosum). On Roan Mountain these species are

replaced in importance by Sambucus pubens and, in stand 14, by Rhododendron catawbiense and Alnus crispa. Shrubs are sparse on both mountains. Even at their greatest density, 156 shrubs per acre (stand 3), they do not provide continuous coverage except for a few local spots along a dry ridge within the stand.

The Herbaceous Layer

Table XIV lists the flowering plants and ferns of the herbaceous layer. In open stands and where stands joined balds, a continuous sedge-grass layer was found, with sedges appearing to be more prevalent. Where leaf litter had accumulated sufficiently to form a continuous cover, the sedge-grass cover was disappearing. It is here that forest species such as Erythronium americanum, Claytonia caroliniana, Phacelia fimbriata, Viola spp., Anemone quinquefolia and other forest herbs are most prevalent. More complete treatments of the herbaceous layer in the bald and adjacent forest types are found in papers by Brown (1941), Russell (1953), Mark (1959), and Ramseur (1959). Brown (1941) lists the flora of Roan Mountain. Russell (1953) lists the flora of beech gaps of the Great Smoky Mountains. Mark (1959) lists the flora of the southern Appalachian grass balds. Ramseur (1959) worked with the vascular flora of high elevation communities of the southern Appalachian Mountains. Two other papers, Wells (1937) and Davis (1930), are also applicable to this study.

Soils

Table XV shows information gathered concerning the thickness of topsoil and subsoil, depth of accumulated leaf litter, amount of stoniness, and pH. The topsoils were dark and fairly constant in depth, ranging from 12-16 inches. However, in stand 12 the topsoil was only 2 inches in depth near the lower edge, but was 12 inches deep near the bald. In the birch stands (13 and 14) the soils were immature, consisting of a varying layer of peat on rock. The subsoil was absent in many of the cores examined. Absence of subsoil, together with thin topsoil, suggests some disturbance and erosion there. In general, yellow birch can be observed today pioneering in eroded areas as well as on the rock outcrops found on balds. Some change in topsoil color, from black to dark brown, was noticed going from bald areas into the forest. Mark (1958) considers this a result, rather than a cause, of succession. All of the soils examined were high in peat content and retained water well.

Slope Exposure

The data, in Table XVI, for stand 5 on Bald Mountain shows the influence of slope exposure on the relation of dominant species measured in terms of basal area. Stand 5 is located on a broad smooth ridge sloping down the east side of Bald Mountain. Sampling of the ridge was accomplished by running sample lines down into the forest at right angles to

the contour lines rather than parallel to the contour as in other samples. Line 1 was on the south slope of the ridge and was dominated by northern red oak. Lines 2 and 3 were on top of the ridge, facing east, and were dominated by northern red oak and hawthorn. Hawthorn remained constant between the two, occurring in a grown up field or bald on top of the ridge. There was a decrease of northern red oak from line 2 to 3. Line 4 was on a north facing slope. Here northern red oak decreased, losing its role as dominant to yellow birch. On Bald Mountain the west, south, and east slopes have red oak as a dominant, while north slopes are dominated by beech and yellow birch.

Pioneer Species

Primary invasion of the balds involves mainly hawthorn, serviceberry, and mountain ash, whose seedlings are able to come up through the grass. White pine is a significient invader of the grassy bald on Bald Mountain. The invaders are scattered over the balds with serviceberry having an affinity with, but not restricted to moss hummocks. The size of this present group of bald invaders shows that they have come in since the release from grazing. Mark (1958) states that protected areas such as Round Bald on Roan Mountain are doing better in seedling reproduction than those which were being grazed.

On both mountains the forest flora is limited to species

found in the "northern hardwood forest formation" and the "spruce-fir forest formation" (Davis, 1930). On both mountains the large dominant hawthorn trees are mostly Crataegus punctata. On Bald Mountain, where there is high hawthorn reproduction beneath the forest canopy, most of the seedlings are C. flabellata, a species that seems more confined to forest, not entering the grass bald as easily as C. punctata. A few sweet birch (Betula lenta) were noticed below stand 3, but none were sampled. Beech is the northern "Gray Beech" which occurs above 4,500 ft. in the southern Appalachians (Camp, 1950).

TABLE III

TOTAL BASAL AREA, BASAL AREA OF EACH SPECIES AS PER CENT OF TOTAL BASAL AREA, AND DENSITY OF CANOPY SPECIES IN THE SUBALPINE FOREST OF BALD AND ROAN MOUNTAINS

Elevation (ft.)	5,200	5,240	5,220	5,250	5,120	5,275	5,310	5,275	5,310
Azimuth (degrees)	250°	175°	140°	120°	75°	75°	330°	325°	320°
				Stands (Bald Mountain)					
Species	1	2	3	4	5	6	7	8	9
Northern red oak	78.22	97.00	89.40	42.90	53.20	10.00		.50	.92
Yellow birch	19.59	1.30	1.35	8.55	19.06	13.00	19.58	9.46	1.56
Beech	.50		2.43	39.45	3.47		65.40	80.40	83.70
Hawthorn		1.66	.28	1.69	14.06	77.00	10.03	5.49	15.63
Sugar maple	1.64		1.75	2.80	3.09		3.80	1.54	
Serviceberry			2.94	.56	.25		2.00	2.46	1.47
Black cherry			1.86	.69	5.33			.50	.55
Mooswood					.29				
Mountain maple					.29				
Total basal area (sq. ft. per acre)	103.10	75.24	80.52	94.54	85.49	71.07	53.08	68.65	106.53
Density (trees per acre)	384	268	322	384	286	125	123	224	380

TABLE III (continued)

Elevation	5,415	5,575	5,625	5,550	5,930	5,730
Azimuth	115°	200°	40°	250°	130°	40°
			Otter's (Bear Mountain)			
Species	10	11	12	13	14	15
Beech	71.69	79.71	75.06	24.60	12.09	7.35
Buckeye	2.63	9.73	15.15	5.96	.90	76.05
Yellow birch	12.44	5.67	5.03	57.50	81.40	
Hawthorn	.28	3.75	1.54	.71		16.60
Red spruce	2.89	.41	.93	6.93		
Sugar maple	6.70	.69	1.36	.81		
Fraser's fir	.29			.71	4.40	
Black cherry	1.74			.37		
Mountain ash				.30	1.09	
Serviceberry			.93			
Fire cherry	.34					
Total basal area (sq. ft. per acre)	98.52	98.24	112.67	90.91	74.18	31.54
Density (trees per acre)	750	480	626	230	266	474

TABLE IV

A COMPARISON OF ELEVATION TO BASAL AREA (DATA FROM STAND 12)

Species	Stand 12 5,675 ft. sample line	5,600 ft. sample line	5,500 ft. sample line
Beech	52.25	118.08	89.25
Buckeye	13.58	22.99	13.65
Yellow birch	4.18	2.09	9.45
Hawthorn	1.05	2.09	1.70
Sugar maple	1.05		3.15
Red spruce	2.09		
Serviceberry	1.05		
Total basal area sq. feet per acre	75.25	145.25	117.60

TABLE V

THE AVERAGE DIAMETER OF SPECIES, TOTAL AVERAGE DIAMETER, AND DISTANCE BETWEEN TREES ARE GIVEN FOR EACH STAND

Elevation (ft.)	5,200	5,240	5,220	5,250	5,120	5,275	5,310	5,275	5,310
Azimuth (degrees)	250	175	140	120	75	75	330	325	320
				Stands (Bald Mountain)					
Species	1	2	3	4	5	6	7	8	9
				Average diameter (inches) by species					
Northern red oak	18.15	16.50	15.65	16.65	20.10	18.49			
Yellow birch	16.28	6.36		13.61	17.12	15.75	18.89	13.14	
Beech			6.90	7.72	14.72		11.36	10.90	11.92
Sugar maple	38.20			14.31	6.37		5.33		
Hawthorn		9.97		9.55	11.55	12.99	9.97	10.00	10.60
Serviceberry			11.61		11.47		8.28	12.58	
Black cherry			27.10		16.80				22.28
				Average[1] diameter (inches) all species					
	17.89	15.95	15.65	11.87	16.30	13.49	11.71	11.10	11.92
				Average distance between trees (ft.)					
	10.69	12.75	11.65	10.70	12.30	18.70	18.85	13.63	10.58

[1] The average of all trees was computed by adding all diameters then dividing by the total number of trees sampled, thus it does not equal the average of the values given on individual species in the above columns.

TABLE V (continued)

Elevation (ft.)	5,615	5,575	5,625	5,550	5,930	5,730
Azimuth (degrees)	115	200	40	350	30	40
			Stands (Roan Mountain			
Species	10	11	12	13	14	15
			Average diameter (inches) by species			
Beech	7.81	8.92	9.15	11.80	7.24	11.50
Yellow birch		15.51	19.10	16.58	12.11	
Buckeye		9.15	8.50	12.71		8.90
Hawthorn		7.33	8.29	8.27		10.25
Sugar maple	12.20			14.63		
Red spruce	8.76	15.30		9.35		
Fraser's fir					4.77	
			Average[1] diameter (inches) all species			
	8.28	9.33	9.20	14.30	11.30	9.30
			Average distance between trees (ft.)			
	7.64	9.53	8.35	13.80	12.00	9.60

TABLE VI

ESTIMATED AVERAGE HEIGHT (ft.) OF THE FOREST CANOPY IN UPPER, MIDDLE, AND LOWER SAMPLING ZONES

Stand no. and forest type	Sample lines		
	Upper	Middle	Lower
1 Northern red oak-yellow birch	45	45	65
2 Northern red oak	37	45	50
3 Northern red oak	43	--	52
4 Northern red oak-beech	30	--	45
5 Northern red oak-yellow birch	40	42	45
6 Hawthorn	25	25	25
7 Beech-yellow birch	20	30	45
8 Beech	25	25	25
(Yellow birch)	30	30	30
9 Beech-hawthorn	25	--	28
10 Beech	27	35	35
11 Beech	25	25	25
12 Beech-buckeye	30	30	30
13 Yellow birch-beech	40	40	40
14 Yellow birch	14	17	23
15 Buckeye-hawthorn	15	15	15

TABLE VII

THE RELATION OF ELEVATION (ft.) AND SLOPE EXPOSURE (AZIMUTH DEGREES) TO AVERAGE CANOPY HEIGHT (ft.)

Stands	Elevation	Azimuth	Height
14	5,930	30	18
15	5,730	40	15
12	5,625	40	30
11	5,575	200	25
13	5,550	350	40
10	5,415	115	32
7	5,310	330	32
9	5,310	320	27
8	5,275	325	29
6	5,275	75	25
4	5,250	120	38
2	5,240	175	44
3	5,220	140	48
1	5,200	250	52
5	5,120	75	42

TABLE VIII

AGE DETERMINATION FOR THE STANDS BY INCREMENT BORINGS FROM SELECTED DOMINANT TREES

Stands	DBH, inches	Age, years
1 Northern red oak-yellow birch		
Northern red oak	18	145
Yellow birch	10	99
2 Northern red oak		
Northern red oak	21	274
3 Northern red oak		
Northern red oak	17	131
4 Northern red oak-beech		
Northern red oak	17	135
5 Northern red oak-yellow birch		
Northern red oak	18	87
6 Hawthorn		
Hawthorn	14	116
7 Beech-yellow birch		
Beech	14	222
Yellow birch	27	264
8 Beech		
Yellow birch	23	128
9 Beech-hawthorn		
Beech	13	129
10 Beech		
Beech	14	169
Beech	4	69
Yellow birch	18	138
Red spruce	17	62
11 Beech		
Beech	12	253
12 Beech-buckeye		
Beech	17	107
13 Yellow birch-beech		
Yellow birch	28	349
14 Yellow birch		
Yellow birch	26	385
Yellow birch	19	368
Yellow birch	11	262
Yellow birch	8	88
Buckeye	9	195
15 Buckeye-hawthorn		
Buckeye	11	159
Buckeye	9	125

TABLE IX

FREQUENCY AND PRESENCE VALUES FOR IMPORTANT CANOPY-SIZE TREE SPECIES ARE SHOWN FOR EACH STAND

Elevation (ft.)	5,200	5,240	5,220	5,250	5,120	5,275	5,310	5,275	5,310	
Azimuth (degrees)	250	175	140	120	75	75	330	325	320	
				%Frequency						%Presence
				Stands (Bald Mountain)						
Species	1	2	3	4	5	6	7	8	9	
Northern red oak	100.00	100.00	100.00	75.00	96.00	20.00		3.33	5.00	88.89
Beech	5.00		15.00	75.00	17.50		96.70	96.66	100.00	77.78
Yellow birch	65.00	6.66	7.50	45.00	55.00	10.00	63.40	30.00	15.00	100.00
Hawthorn	2.50	6.66	2.50	10.00	55.00	100.00	26.60	20.00	75.00	100.00
Sugar maple	12.50		12.50	15.00	25.00		10.00			55.56
Black cherry	2.50		12.50	10.00	35.00			3.33	5.00	66.67
Serviceberry		17.50	10.00				10.00	16.66	15.00	55.56
Mountain maple					2.50					11.11
Mockernut					2.50					11.11

TABLE IX (continued)

Elevation	5,415	5,575	5,625	5,550	5,930	5,730	
Azimuth	115	200	40	40	30	40	
			%Frequency				%Presence
			Stands (Roan Mountain)				
Species	10	11	12	13	14	15	
Beech	100.00	100.00	100.00	40.00	66.66	15.00	100.00
Yellow birch	55.00	20.00	33.33	100.00	100.00		83.33
Buckeye	20.00	36.66	76.70	3.33	40.00	100.00	100.00
Hawthorn	2.50	30.00	16.66		6.66	45.00	83.33
Sugar maple	37.50	6.66	13.33		6.66		66.66
Black cherry	15.00				3.33		33.33
Serviceberry			3.33				20.00
Red spruce	20.00	3.33	6.66		43.40		66.66
Fraser's fir	2.50			26.66	6.66		50.00
Mountain ash				6.66	3.33		33.33
Fire cherry	2.50						20.00

TABLE X

REPRODUCTION OF TREE SPECIES AND TOTAL TREE REPRODUCTION IN STEMS PER ACRE

Elevation (ft.)	5,200	5,240	5,220	5,250	5,120	5,275	5,310	5,275	5,310
Azimuth (degrees)	250	175	140	120	75	75	330	325	320
					Stands (Bald Mountain)				
Species	1	2	3	4	5	6	7	8	9
Northern red oak	288	270	421	22	42	40			
Beech	66	2	191	529	110	6	998	838	785
Yellow birch	578	82	27	13	79	36	62	9	1
Hawthorn	174	362	223	70	123	206	32	30	17
Serviceberry	44	96	27	2	8	6	14	1	
Sugar maple	10	18	25	30	19	6			1
Black cherry		6	5		8			1	
Moosewood	8	2	4	5	4		2		
Hickory (Carya sp.)	1								
Basswood (Tilia sp.)	1								
Red maple	1	2	1						
Chestnut (Castanea dentata)		2	3						
White pine			1				2		
Mountain maple				1		6			
Tree reproduction per acre	1,171	842	928	672	393	306	1,110	879	804

TABLE X (continued)

Elevation (ft.)	5,415	5,575	5,625	5,550	5,930	5,730
Azimuth (degrees)	115	200	40	350	30	40
			Stands (Roan Mountain)			
Species	10	11	12	13	14	15
Beech	521	752	502	126	166	132
Yellow birch	1	14	14	110	177	3
Buckeye		1			4	7
Hawthorn						93
Sugar maple	6	18	58	2	1	1
Serviceberry						4
Black cherry	13	2				2
Mountain maple	1		18	64	20	
Moosewood			2	26	8	
Red maple		1				1
Mountain ash				2	20	1
Fraser's fir	13	1		4	60	
Red spruce	13		2	38		
Tree reproduction per acre	568	787	597	372	456	244

TABLE XI

FREQUENCY AND PRESENCE VALUES FOR IMPORTANT REPRODUCTION SIZE TREE SPECIES

Elevation (ft.)	5,200	5,240	5,220	5,250	5,120	5,275	5,310	5,275	5,310	
Azimuth (degrees)	250	175	140	120	75	75	330	325	320	
				Stands (Bald Mountain) %Frequency						%Presence
Species	1	2	3	4	5	6	7	8	9	
Northern red oak	87.5	100.0	82.5	15.0	35.0	20.0				66.7
Beech	25.0	10.0	50.0	95.0	35.0	20.0	100.0	96.7	100.0	100.0
Yellow birch	62.5	63.3	42.5	20.0	40.0	50.0	63.3	26.7	5.0	100.0
Hawthorn	65.0	100.0	87.5	50.0	82.5	50.0	53.3	43.3	50.0	100.0
Serviceberry	60.0	93.3	50.0	10.0	27.5	20.0	33.3	3.3		88.9
Sugar maple	27.5	26.7	25.0		20.5	20.0			5.0	77.8
Black cherry		26.7	17.5		25.0			6.7		44.4
Moosewood	17.5	6.7	7.5		7.5	15.0	6.7			66.7
Hickory	2.5									11.1
Besswood	2.5									11.1
Red maple	2.5	6.7	2.5							33.3
Chestnut		3.3	10.0							22.2
White pine			2.5				6.7			22.2
Mountain maple				10.0	2.5	30.0				33.3

TABLE XI (continued)

Elevation (ft.)	5,415	5,575	5,625	5,550	5,930	5,730	
Azimuth (degrees)	115	220	40	350	30	40	
			Stands (Roan Mountain) %Frequency				%Presence
Species	10	11	12	13	14	15	
Beech	100.0	100.0	100.0	63.3	80.0	55.0	100.0
Yellow birch	2.5	13.3	13.3	63.3	90.0	30.0	100.0
Buckeye			3.3		16.7	35.0	50.0
Hawthorn						90.0	16.7
Sugar maple	20.0	16.7	23.3		3.3	5.0	83.3
Serviceberry						30.0	16.7
Black cherry	10.0	10.0				15.0	50.0
Mountain maple	2.5		43.3	63.3	36.7		66.7
Moosewood			10.0	33.3	36.7	5.0	66.7
Red maple		3.3				10.0	33.3
Mountain ash				6.7	40.0	5.0	50.0
Fraser's fir	32.5	3.3		10.0	50.0		66.7
Red spruce	17.5		6.7	46.7			50.0

TABLE XII

SAPLING DENSITY BY SPECIES AND BY TOTAL NUMBER OF STEMS PER ACRE

Elevation (ft.)	5,200	5,240	5,220	5,250	5,120	5,275	5,310	5,275	5,210
Azimuth (degrees)	250	175	140	120	75	75	330	325	320
					Stands (Bald Mountain)				
Species	1	2	3	4	5	6	7	8	9
Northern red oak	18	4	7		14				
Beech	6	2	37	63	7		194	190	105
Yellow birch	24		3	1	31		14	10	2
Hawthorn	52	70	33	9	10	2	6	18	14
Serviceberry	1	4	2		14			2	
Sugar maple	1		1		4				
Black cherry		1	2		7				
Moosewood	6				4				
Iron wood (Ostrya virginiana)			1						
Chestnut		2	2						
White pine					1				
Mountain maple					5				
Total saplings per acre	108	83	88	73	97	2	214	220	121

TABLE XII (continued)

Elevation (ft.)	5,415	5,575	5,625	5,550	5,930	5,730
Azimuth (degrees)	115	200	40	350	30	40
			Stands (Roan Mountain)			
Species	10	11	12	13	14	15
Beech	215	361	440	82	72	59
Yellow birch	9	2	36	132	59	4
Hawthorn						1
Buckeye		1		2	2	
Black cherry		1				
Sugar maple	2	1	5	1		
Mountain ash				2	10	
Moosewood	1	4	1	24		
Fraser's fir	8			4	36	
Fire cherry (Prunus pensylvanica)					1	
Red spruce	5		2	26		
Mountain maple	1		12	92	10	
Serviceberry				1		
Total saplings per acre	341	370	496	366	190	64

TABLE XIII

SHRUB DENSITY BY SPECIES AND TOTAL NUMBER OF STEMS PER ACRE

Elevation (ft.)	5,200	5,240	5,220	5,250	5,120	5,275	5,310	5,275	5,310
Azimuth (degrees)	250	175	140	120	75	75	330	325	320
				Stands (Bald Mountain)					
Species	1	2	3	4	5	6	7	8	9
Rhododendron calendulaceum	15	32	72	8					
Vaccinium corymbosum	15	22	52	4	2			2	
Rhododendron maximum	11	2	22	52	2		2	4	
Sambucus canadensis	2				4	16	2		
Cornus alternifolia		2	4	10	2				
Sambucus pubens				4	30		2	4	10
Hydrangea arborescens	1			32	2				
Kalmia latifolia		2	6	2					
Viburnum alnifolium				4					
Ilex ambigua var. montana		2							
Ribes	1								
Total shrubs per acre	45	62	156	116	42	16	6	10	10

TABLE XIII (continued)

Elevation (ft.)	5,415	5,575	5,625	5,550	5,930	5,730
Azimuth (degrees)	115	200	40	350	30	40
			Stands (Roan Mountain)			
Species	10	11	12	13	14	15
Sambucus canadensis						3
Vaccinium spp. (V. corymbosum)		1				
Sambucus pubens	12	3	48	4	4	
Ribes rotundifolium		1	2	6		
Alnus crispa					42	
Rhododendron catawbiense				1	62	
Viburnum alnifolium			4	5	2	
Ilex ambigna var. montana			4	1		
Hydrangea arborescens				1		
Total shrubs per acre	12	5	58	18	110.	3

TABLE XIV

ESTIMATED AVERAGE DISTANCE BETWEEN INDIVIDUAL STEMS IN THE HERBACEOUS LAYER BY SPECIES, ACCORDING TO CLASSES

(Class 1=1'-1', 2=1'-2', 3=2'-12', 4=12'-30', 5=30'-125', 6=125'-300', 7=300' or more, and *=local)

	STANDS															
	Bald									Bean						
SPECIES	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Achillea millifolium	5	7	6				2								
Allium tricoccum				6	7	6	7			7	7		7		
Anemone quinquefolia				5	5	4	4	4	5	5	5	4	5	3	3
Antennaria plantaginifolia			5						6						
Aricaera triphyllum	5	5		6			*5			5	5	5	6		
Aster spp.	5		*5	5	*2		3	2	5	2	3		2	2	
Cardamine clematitis										4	4	5	3	4	
C. concatenata	4		*5	5	6		6	4	5				6		
C. diphylla		7							2						6
C. pensylvanica		*4													
Castilleia coccinea	6	3	3	5	4										
Caulophyllum thalictroides				6	7					5					
Carex spp.	3	5	1	4	3	3	2	6	5	5	5			3	4
C. debilis Michaux var. rudgei										6					
C. latifolia	4	5	5	5		5	5	5	6	6		4		5	
C. pensylvanica	1	1	2	4	3	1	4	4		1	1	3	3	3	1
Chrysanthemum leucanthemum		5													
Cimicifuga racemosa					7				7						
Claytonia caroliniana	1	*1	*1	2	3	3	5	1	1	6		1	4	4	3
Clintonia borealis												6	5		
C. umbellulata												7			
Conopholis americana		6													

TABLE XIV (continued)

SPECIES	STANDS Bald 1	2	3	4	5	6	7	8	9	Roan 10	11	12	13	14	15
Dicentra canadensis	*3		4	3	*4			4	2	5		6	7		
D. cucullaria			*1		2	*1	6	5	2						
Diphylleia cymosa	*4			7											
Dieporum lanuginosum												5	6		
Erigeron strigosus	5	5													
Erythronium americanum					3	5	*1	1	1	*1	1	4		3	2
Eupatorium rugosum	5			5	6				5	5	4				
Fragaria virginiana		6	5		6									5	4
Galium				6											
Helenium autumnale	6						7								
Heuchera sp.	*2	*2	6	*1											
Hieracium sp.		5						*1	6						
Houstonia serpyllifolia											7			4	6
Hypericum graveolens															5
Impatiens sp.				*1	5			*1	6						
Lactuca sp.			7	6											
Lilium sp.	7		6	6	5	6									
Lycopodium acuminata	3	3	4	5	4	4	5							4	4
Maianthemum canadense							7			6		5	5		
Mentha sp.	*2	*6	*1	6	5	5	6	6							
Oxalis sp.								5					5		
Pedicularis canadensis	5	4	5	5	5										
Phlox paniculata						*5									
Poa	3	3	4	4	5	1	2	5						5	1
Poa cuspidata			5		6	6			6	4		6	6	5	

TABLE XIV (continued)

SPECIES	STANDS: Bald 1	2	3	4	5	6	7	8	9	Road 10	11	12	13	14	15
Podophyllum peltatum			7	6	5				7						
Polygonatum biflorum												6			
Potentilla canadensis	3	4	4	5		3	5	4	4					5	2
Prenanthes sp.		3	6	5	4				5		6	6			
Prunella vulgaris		5													
Ranunculus bulbosus	2	5	5	5	5	6		6							
Ribes glandulosum												5	3		
R. rotundifolium												6	6		
Rubus sp.	6				7		7				5			5	5
Rumex acetosella		4			6	3	*1	4	*3						4
R. obtusifolius	6	7	4	3	6	5	6	6	5						
Phaelia fimbriata	*1			4	2	*1			6						
Saxifraga micranthidifolia	*2	*6	*2	*2											
Sedum ternatum	4	*2	3	4	5	4	4	4							
Senecio aureus	4	2	2	4	5	2	5	6	5	*2				4	
S. smallii	4	1	2	5	5			5							
Smilicina racemosa				5	5				5						
Stellaria pubera			5	5	4		3	4	1			4	6		
Streptopus roseus			7									5	5		
Taraxacum officinale		6			6			5	5						
Thalictrum sp.					6										
Tiarella cordifolia L.												6	5		
Tradescantia sp.			7												
Trautvetteria carolinensis										5	5	3	3	3	4
Trillium erectum	5			6	*5	5	6	6	5	5		5	7		

TABLE XIV (continued)

SPECIES	STANDS														
	Bald									Roan					
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
T. grandiflorum	5	4	5												
Veratum viride	*4			*3	6	5		*5	5	5	6	4	3	4	
Viola canadensis L. var. rugulosa									3						
V. rafinesqueyi var. pallens							7				5	7			
V. eriocarpa var. eriocarpa	6			*2		4			6						
V. Papilionacea		5	6	6	4	1	6		6		5				
V. rotundifolia			7	6				6	7		7				
Ferns															
Athyrium acrlenioides	5	5	4	4	5	4	5	3	5			4	4		
Botrychium virginianum	7				7										
Dennstaedtia punctilobula										5	5			5	6
Dryopteris marginalis												7			
D. spinulosa			6	5	5	5	*1	5	5	6		5	6	5	
Osmunda claytoniana	*1				6										
Polypodium virginianum	*6	*6		6	6		6						6	4	
Polystichum acrostichoides	5	5	6	6		6						7	7		
Pteridium aquilinum			5	5	5				5						
Tholypteris noveboracensis	5			5					5	5	5	5	5	5	

TABLE XV

SOIL CHARACTERISTICS IN THE SAMPLE AREAS: DEPTH OF A AND B HORIZONS, THICKNESS OF LITTER, PH, COLOR, STONINESS OF THE A HORIZON, AND SOIL CLASSIFICATION

STANDS	Depth in inches A	B	Litter	Color	Soil Type	Stoniness	pH
BALD							
1 Northern red oak-yellow birch	13	10-20	2	Black	Bu[1]	Slight	5
2 Northern red oak	5.5	7	1	Black	Bu	Slight	5
3 Northern red oak	12	20	2	Black	Bu	Slight	5
4 Northern red oak beech	14	6	3	Dark brown	Bu	Moderate	5
5 Northern red oak-yellow birch	16	16	3	Black	Bu	None	5
6 Hawthorn	12	20	2.5 (grass)	Black	Bu	None	5
7 Beech-yellow birch	13	4	2.5	Dark brown	Bu	Slight	5
8 Beech	11	13	1.5	Dark brown	Bu	None	5
9 Beech-hawthorn	11	10	2	Dark brown	Bu	None	5
ROAN							
10 Beech	14	20	3	Dark brown	Ptu[1]	Moderate	5
11 Beech	15	12	3.5	Black	Pls[1]	Extreme	5
12 Beech-buckeye	3-bottom 12-top	14	2	Dark brown	Bu	Slight	5.5
13 Yellow birch-beech	1-16	0-12	1.5	Black	Bu	Extreme	6
14 Yellow birch	16	0-20	1.5	Black	Bu	Extreme	6
15 Buckeye-hawthorn	16	18	2 (grass)	Dark brown	Bu	Slight	5

[1] The abbreviations are: Bu, Burton stony loam; Ptu, Porters stony loam, very steep phase; and Pls, Porters loam, steep phase.

TABLE XVI

THE RELATION OF SLOPE EXPOSURE ALONG DIFFERENT SAMPLE LINES TO PER CENT BASAL AREA OF TREE SPECIES IN STAND 5 ON BALD MOUNTAIN (Line-1, south facing; lines-2 & 3, east facing, and line-4 north facing)

SPECIES	Per cent basal area			
	Line 1 S	Line 2 E	Line 3 E	Line 4 N
Northern red oak	82.00	60.00	48.00	22.80
Yellow birch	4.83	5.90	12.30	53.20
Hawthorn	3.62	22.40	22.40	7.70
Beech	5.15		1.02	7.70
Sugar maple	1.21	3.53	6.13	5.07
Black cherry	2.41	5.90	9.20	3.80
Moosewood		1.18		
Mountain maple		1.18		
Serviceberry		1.02		

DISCUSSION

For convenience, the subalpine forest is divided by the author into five communities. The communities are named according to the conspicuous dominant species, where dominance is measured by basal area. Table III shows how easily this classification can be done in the subalpine forest type. Presently the northern red oak community is found on ridges and slopes exposed to southerly winds. The yellow birch community occurs as transitions from northern red oak to beech and from beech to balds. The beech community is the most extensive; it is found on north slopes and at the high elevations. The hawthorn and the buckeye communities occur as pioneer invasions into the grassy balds.

The hawthorn type is illustrated by stand 6 and part of stand 5. Typically, it exists as an orchard with widely spaced low trees. Some change in ground cover type occurs beneath the hawthorn trees, with forest species coming in where the hawthorn leaf litter has caused the continuous grass-sedge cover to be broken. Very little tree reproduction was occurring beneath the open canopy of this community at the time of this study.

Stand 15 is dominanted by buckeye and hawthorn and is representative of the buckeye community. In this stand the orchard condition is best seen. Beneath the extremely

stunted, widely spaced, trees there is a continuous sedge-grass herb layer similar to grassy bald. Tree reproduction is limited in this community, but if the present trend continues, this stand will change to a beech community.

The northern red oak community was shown in stands 1, 2, 3, and parts of 4. It is an orchard type, but a developing Crataegus flabellata understory alters the orchard appearance. This community may follow an initial C. punctata invasion, with southerly exposure and lower elevations giving it stability. Tree reproduction data showed that northern red oak is reproducing, but that red oak saplings are outnumbered by beech saplings, suggesting a trend toward eventual beech dominance. Good examples of the yellow birch community are seen in stands 13 and 14. The trees of stand 14 are severely stunted while those of 13, at a lower elevation, are taller. This is probably one of the early communities of bald invasion. Observation of widely spaced yellow birch of open grown character within some of the beech stands suggest that this community precedes beech. Yellow birch seems to be more successful as an invader of balds where erosin or rock outcrops have resulted in a weaker grass cover. Both of the birch stands on Roan were on immature soils consisting of peat on rock with little or no subsoil.

The beech community appears to be the important climax community of both mountains and often loses its orchard appearance

because of canopy closure. Where it invades the balds directly it may exist as an orchard. At high elevations buckeye is an important member of this community. At lower elevations sugar maple becomes important. Yellow birch occurs in this community along drainage lines and on rock outcrops.

Shrubs have little apparent influence upon these communities. Sambucus canadensis is the only important shrub in the hawthorn and buckeye communities. The important shrubs of the northern red oak community are Rhododendron calendulaceum, Vaccinium spp., and Rhododendron maximum. The yellow birch seems to show more variation in its shrub layer. In stand 13, Ribes was the important shrub, while in stand 14 Alnus crispa and Rhododendron catawbiense were found. The extensive beech community is nearly devoid of shrubs with Sambucus pubens as the only important member.

The trends of succession observed in this study are thought to follow the lines shown in Figure 3. The rate of succession appears to be very slow and has apparently been subject to set-backs in the past, as evidenced by dead trees and fallen trees observed especially on Bald Mountain. In general, Bald Mountain seems to present a less favorable environment for trees than does Roan, and successions on Bald are less advanced toward the beech climax.

The evidence gattered within the subalpine forest support the contention that the existing forests now occupy areas

formerly covered by grassy bald vegetation. The present forests are old (Table VIII) and represent invasions that occurred long ago. The existing contact between forest and bald is a sharp one in most places, suggesting some arresting factor operated in the past. It is necessary to distinguish between the earlier arrested wave of forest invasion occurring on the balds several hundred years ago, from a new wave of invasion which has perhaps begun in recent times. The succession currently in progress is not the same as the earlier succession of perhaps 400-500 years ago.

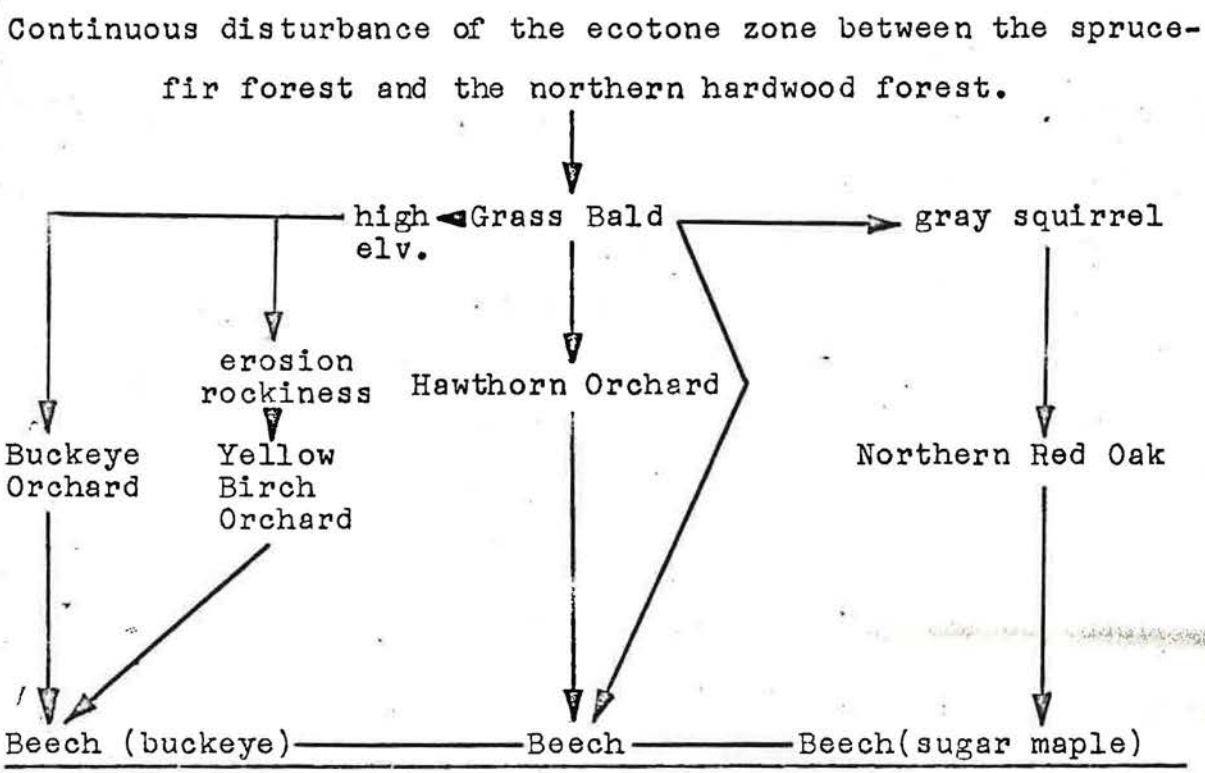

Figure 3. A diagram of forest succession found occurring on Roan Mountain and Bald Mountain.

SUMMARY

The subalpine orchard forests around the balds on Roan Mountain and Bald Mountain were studied in the winter and spring of 1969. The objectives were to record the present vegetation and to determine whether the existing forests had actually invaded the existing balds. The data presented in this paper do not contradict the hypothesis of Billings and Mark (1957) that balds are early stages in long term successions leading to forests. The time and direction of the succession is suggested in this paper.

Data from the canopy layer show that the forest is dominated in different areas by beech, northern red oak, yellow birch, hawthorn, and buckeye. These areas are recognizable as distinct communities. Most of the dominant trees are old and have small diameters and low heights. The trees are reproducing in the forests but invade adjacent grassy balds with difficulty.

The shrub layer is of minor importance in the subalpine forest at present.

The herbaceous layer is dominated by sedges and grasses in the open orchards, but as the canopy closes and leaf litter builds up, these are replaced by more typical forest herbs. The invasion of balds by forest is suggested.

The soils are similar in all stands, except in 13 and

14 where they are essentially peat on rock. These may represent early communities where balds have been eroded.

The communities of hawthorn, buckeye, and yellow birch may have resulted from direct invasion of the bald community or from the destruction of some previous forest by windthrow, fire, grazing, erosion, clearing by man, or some other cause. The northern red oak community may have followed Crataegus punctata and may have been favored by grazing, fire, drought, and slope exposure. Where conditions have been less extreme beech seems to replace red oak. Factors such as grazing, fire, drought, or windthrow all seem to contribute to the orchard condition and have held these forest in subclimax. The subalpine environment has slowed the movement of the subalpine forest, as well as the spruce-fir forest, into the balds. Now that these areas are not under grasing pressure, the balds and orchards, if they are to be maintained, must be maintained by climatic extremes or human disturbance. The evidence, however, does not favor the view that balds and orchards represent climatic climaxes, and indirectly indicates that successions are in progress.

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