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A Study of Plant Distribution Patterns at a Mid-Altitude Location in the Great Smoky Mountains National Park

Everette H. Cooley
University of Tennessee - Knoxville

To the Graduate Council:

I am submitting herewith a thesis written by Everette H. Cooley entitled "A Study of Plant Distribution Patterns at a Mid-Altitude Location in the Great Smoky Mountains National Park." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Botany.

Royal E. Shanks, Major Professor

We have read this thesis and recommend its acceptance:

Fred H. Morris, Sander Eldhurst

Accepted for the Council:
Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

July 14, 1954

To the Graduate Council:

I am submitting herewith a thesis written by Everette H. Cooley entitled "A Study of Plant Distribution Patterns at a Mid-Altitude Location in the Great Smoky Mountains National Park." I recommend that it be accepted for twelve quarter hours of credit in partial fulfillment of the requirements for the degree of Master of Science, with a major in Botany.

Royal E. Shanks
Major Professor

We have read this thesis
and recommend its acceptance:

Fred H. Norris

Andrew E. Hunt

Accepted for the Council:

[illegible]
Dean of the Graduate School

A STUDY OF PLANT DISTRIBUTION PATTERNS

AT A MID-ALTITUDE LOCATION

IN THE GREAT SMOKY MOUNTAINS NATIONAL PARK

A THESIS

Submitted to
The Graduate Council
of
The University of Tennessee
in
Partial Fulfillment of the Requirements
for the degree of
Master of Science

by

Everette H. Cooley

August 1954

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Dr. Aaron J. Sharp identified all of the bryophytes in the study area.

Appreciation is given to Mr. Arthur Stupka, park naturalist at the Great Smoky Mountains National Park, who cooperated in the use of the study area, and to those responsible for the official weather records of the Smoky Mountain Snowfall Study.

Special appreciation is given to Mr. Jarvis B. Hadley of the Geological Survey Staff at the Great Smoky Mountains National Park, who accompanied the author on two reconnaissance trips to study the geologic formations.

Others who aided are Mrs. Luella Cooley and Mr. Robert Wilson as assistant surveyors.

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INTRODUCTION

Travelers in the Great Smoky Mountains are often impressed by the striking contrasts between the evergreen and deciduous vegetation types exposed to view along the mountain slopes. In the springtime one can look across the valley formed by the West Prong of the Little Pigeon River, toward the north-facing slopes of Sugarland Mountain, and see the intricate mosaic pattern of the vegetation as the new leaves of the deciduous trees unfold, spreading out in a wide fan in the lower coves and extending, tongue fashion, up the mountain slopes into the high coves between lead ridges. These deciduous forest patterns extend up the established drainage systems to the ridge top at 4000 feet. Contrasting to these splashes of new green are the dark, somber colors of the hemlock and rhododendron on the ridges and covering the steep slopes within the drainage troughs.

This general picture is duplicated time and again along the mountain road from Park Headquarters to Newfound Gap. At about 3800 feet the hemlocks on the ridges have become interspersed with spruce. Along the North Carolina-Tennessee state line between Newfound Gap and Clingmans Dome, occurring in the gaps between peaks and on the upper slopes of coves, are found stands of northern hardwoods, often of "orchard" type (Cain 1935). These high altitude gaps and coves are of the beech type with spruce and fir on the ridges surrounding them (Russell 1953).

When one walks through these gaps and coves in the spring he finds certain constant species, forming, in places, a mat of ground cover. From 2000 to 4000 feet *Phacelia fimbriata* so completely blankets the sunny floor under the naked deciduous canopy in certain areas that it is impossible to avoid crushing innumerable fragile, white petals. Associated with the *Phacelia* are *Claytonia*, *Caulophyllum*, *Dicentra*, *Erythronium*, *Houstonia*, and various species of *Trillium* and *Dryopteris*.

Most of these plants are not found under the evergreen canopy. It is like stepping into a new world — a world that is sometimes barren, other times a dense tangle of rhododendron and fallen trees. This is true on the steeper slopes of the cove floor as well as on the ridge leads.

Since this pattern seemed to be so consistent, not only in the park but in other places in the Appalachians, such as described by D. M. Brown (1941) on Roan Mountain and by Coile (1938) in Randolph County, West Virginia, an attempt was made by the author to make a comprehensive study of plant distribution patterns at a mid-altitude location near the Alum Cave parking area in the Great Smoky Mountains National Park.

This study began in the spring of 1950 with a general reconnaissance from the Chimneys Camp Ground up one of the valleys to the top of Sugarland Mountain with the idea of using this area for such an investigation.

The region used for the most extensive part of this survey occupies about eleven acres of cove and adjacent ridges south of Tennessee Highway Number 71, one-half mile east of the Alum Cave parking area (Fig. 1). The site was originally chosen because it included an isolated stand of spruce and fir unusual for such a low elevation. A study was made of this spruce-fir "island" to find out if its floristic composition was the same

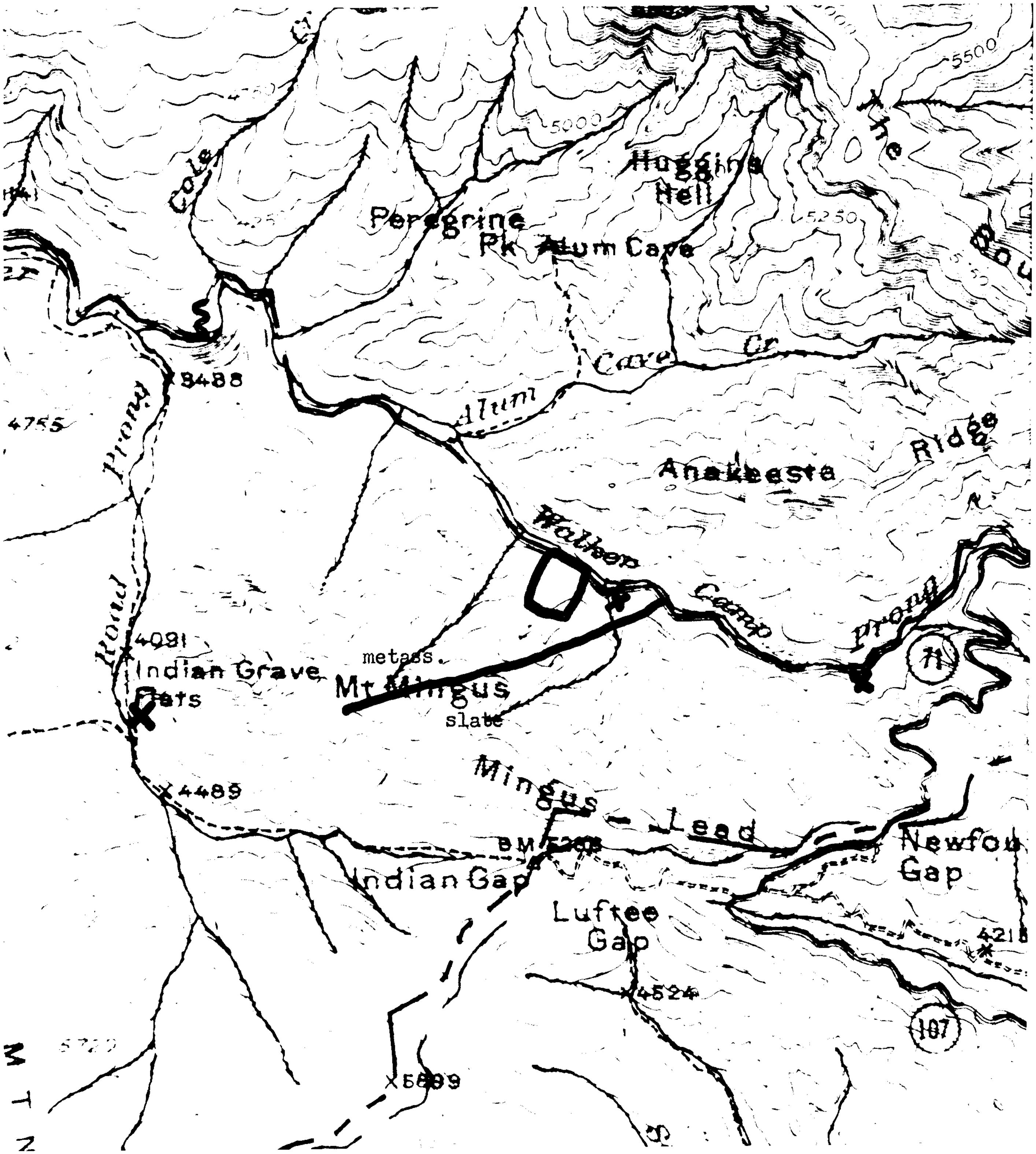


Figure 1. Contour map of north portion of Clingmans Dome $7\frac{1}{2}$" Quadrangle outlining location of study area; location of isolated low altitude <u>Abies fraseri</u>, X; and geologic position of metasandstone and slate formations.

as that of its high altitude counterpart, how it came to be there, and if it would persist. A survey of the relationship of this community to the surrounding vegetation was made, and the problem was expanded to include consideration of the pertinent geologic, edaphic, and climatic factors.

METHODS USED

A detailed contour map of the study area was constructed by using the highway as a base line and a roadside 4000 foot marker as a bench mark. From this line four traverses were run up toward Mt. Mingus ridge. Because of the rough terrain a staff compass, rod, Abney level, and steel tape were the main tools used in this mapping.

One traverse was established up the major drainage depression. Two others bounded the east and west portion of the area to establish the side contour intervals. Another traverse was made up through the rhododendron on the ridge because it was so difficult to see exactly what happened to the topography in such a brushy area. All surveying was hindered by the fact that clearing out of vegetation could not be done along lines of sight because of park regulations. Contour lines were drawn in the field to insure as much accuracy as possible.

Considerable aid was obtained from Mr. Jarvis Hadley of the United States Geological Survey group at the Park Headquarters in the geologic interpretation that follows. Mr. Hadley accompanied the author in the study area on two occasions and helped in classifying the geologic formations of the area.

For sampling of the vegetation twelve 10X10 meter quadrats were established in this area. All of the woody species over one inch DBH were counted and measured in each plot. All woody species under one inch DBH and all other vascular plants in each area were recorded. A soil auger and trowel were used in examining the soil profiles in each quadrat.

To obtain a better picture of transition zones between obviously different vegetation types, two line transects were made, one up the ridge and the other up the cove. Woody species were counted and measured and notes on vascular plants were made. This information was recorded for every 1X10M segment along the transect.

On the basis of these transects the area was divided into six stands designated as A, B, C, D, E, and F (Fig. 2). These stands were used for presence analysis and the 10X10M plots within them were used for stand data. Frequency figures were derived from the 1X10M segments.

It is believed that these sample areas were large enough to provide analytical data on the major species in the area, for species-area curves had indicated that 1X10M plots were of adequate size for use as constancy plots for ground cover species in the types represented.

No systematic attempt was made to analyze the bryophytes of the area. A comprehensive list was made in the field by Dr. Aaron J. Sharp, bryologist at the University of Tennessee. These field identifications were made in four selected areas, stands A, B, C, and F, for comparative purposes.

For climatic data, temperatures of soil and air at each station were determined. The air temperatures were obtained from north-facing plastic mounted Six's maximum-minimum thermometers fastened to crossed boards about one foot above the ground. Soil temperatures were measured using an eight-inch Weston dial type, metallic soil thermometer. Additional climatic data were obtained from the official weather records of the Smoky Mountain Snowfall Study, a joint project of the Tennessee Valley

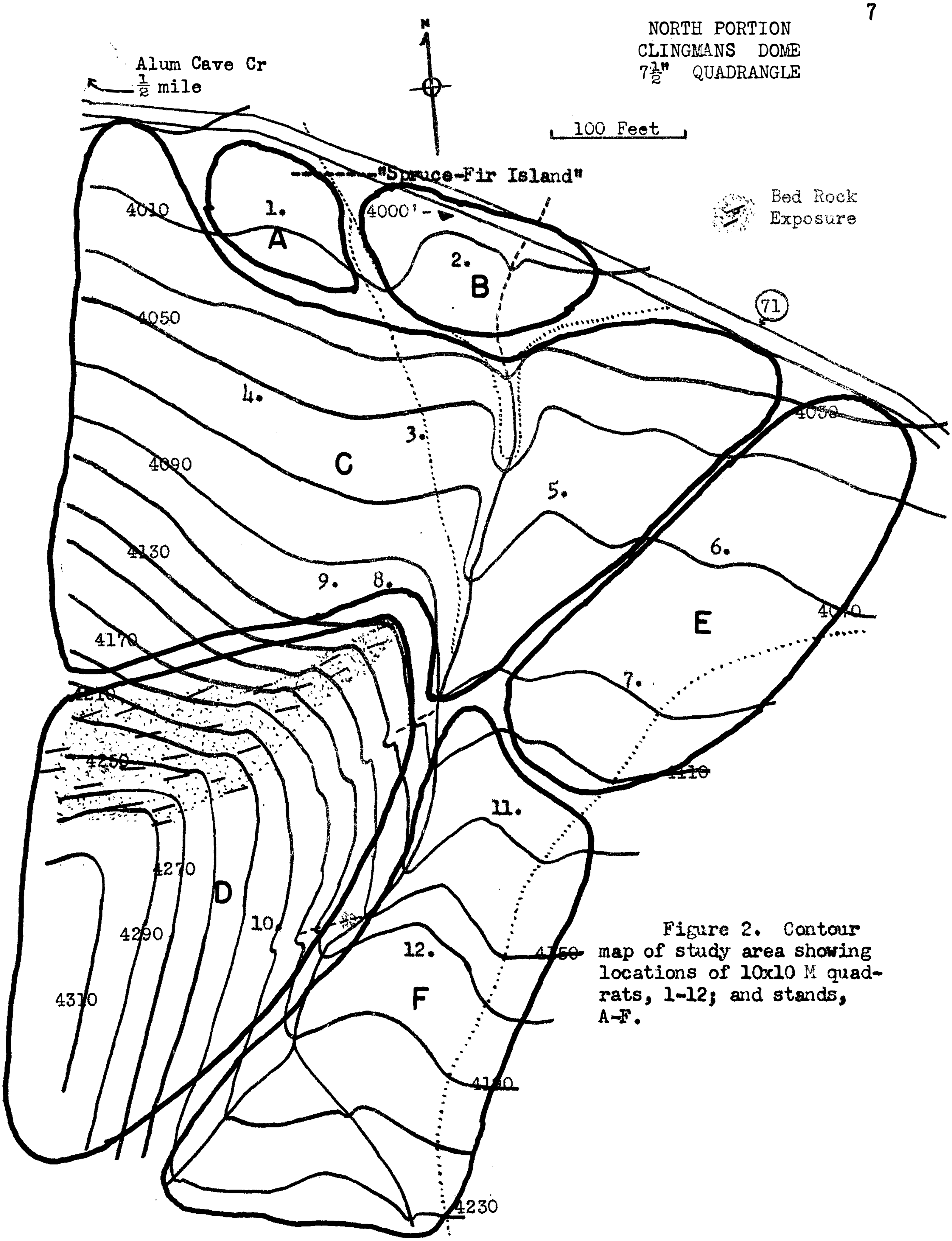


Figure 2. Contour map of study area showing locations of 10x10 M quadrats, 1-12; and stands, A-F.

Authority, National Park Service, and the U. S. Weather Bureau, 1946-1950.

To make a comparison of yearly growth rates of spruce, fir, and hemlock, increment borings were taken with a ten inch Swedish increment borer and growth rings counted and compared with the DBH of each tree sampled.

GEOLOGIC AND EDAPHIC PATTERNS

Geology

The geologic patterns in this limited area were typical of many of the high mountain coves in the Great Smoky Mountains. Two field reconnaissance trips with Mr. Hadley of the U. S. Geological Survey in August 1950 and July 1951 revealed the following information.

From surface accumulations and bedrock exposures it could be seen that this section lay within an area of coarse, gritty conglomerate which is medium to coarse graywacke sandstone and conglomerate, composed of quartz and feldspar grains, in thick beds, with graded bedding (King 1949).

The beds of conglomerate in the study area are a part of the massive quartzite and conglomerate beds that lie just south of the crest of the Great Smoky Mountain range and east of Newfound Gap forming a wedge 2000 feet thick with a base about 1200 feet above the base of the Anakeesta unit. These beds are like the Bullhead unit upon which the Anakeesta unit lies. The Anakeesta unit consists of black pyritic slate and fine grained black dolomite with interbedded coarse graywacke (King 1949, King and Stupka 1950).

It has been postulated by King (King and Stupka 1950) that the mountains were much the same during the ice ages as at present, but during that time they were modified in many details. Denny (1949) reports similar observations of the accumulation of angular boulders on the higher slopes resembling those now forming in alpine and subarctic environments above timber line.

The area under study fitted very well into this over-all pattern. The ridge and steep slope forming the west half of the plot (Fig. 3) have bedrock exposures of the graywacke type before described. These projecting rocks were possibly riven by frost action during the Pleistocene producing boulder fields of the coarse metasandstone. These have been urged forward slowly by the freezing and thawing, and heaving of the clays that enclosed them, resulting in their accumulation below the steep outcroppings.

Precipitation falling on the colluvial material percolates through the debris to bedrock before flowing down to the major valley streams, the water table becoming progressively deeper toward the base of the slope. The clays were partly washed out of the mantle rock causing it to settle, developing shallow depressions leading down the slope as can be noticed in the topographic map (Fig. 3).

Also, during the Pleistocene, perhaps during several glacial and inter-glacial periods, a deep deposit of graywacke and slate filled out in fan-like fashion in the high cove valleys, bounded by the ridges. The base of these deep drifts terminate in the main valley where stream action cuts it off and moves it on downstream. This area has been designated as Alluvium One in this study and consists of a bouldery material in a matrix of pebbles, sand, and clay. The drainage is good in this type of alluvium, which may be twenty feet in depth in places.

Since the Pleistocene, streams have cut into this alluvium forming deep "V" drainage patterns following along the boundary of the bedrock, resulting in a dome shaped cove topography. In recent geologic history

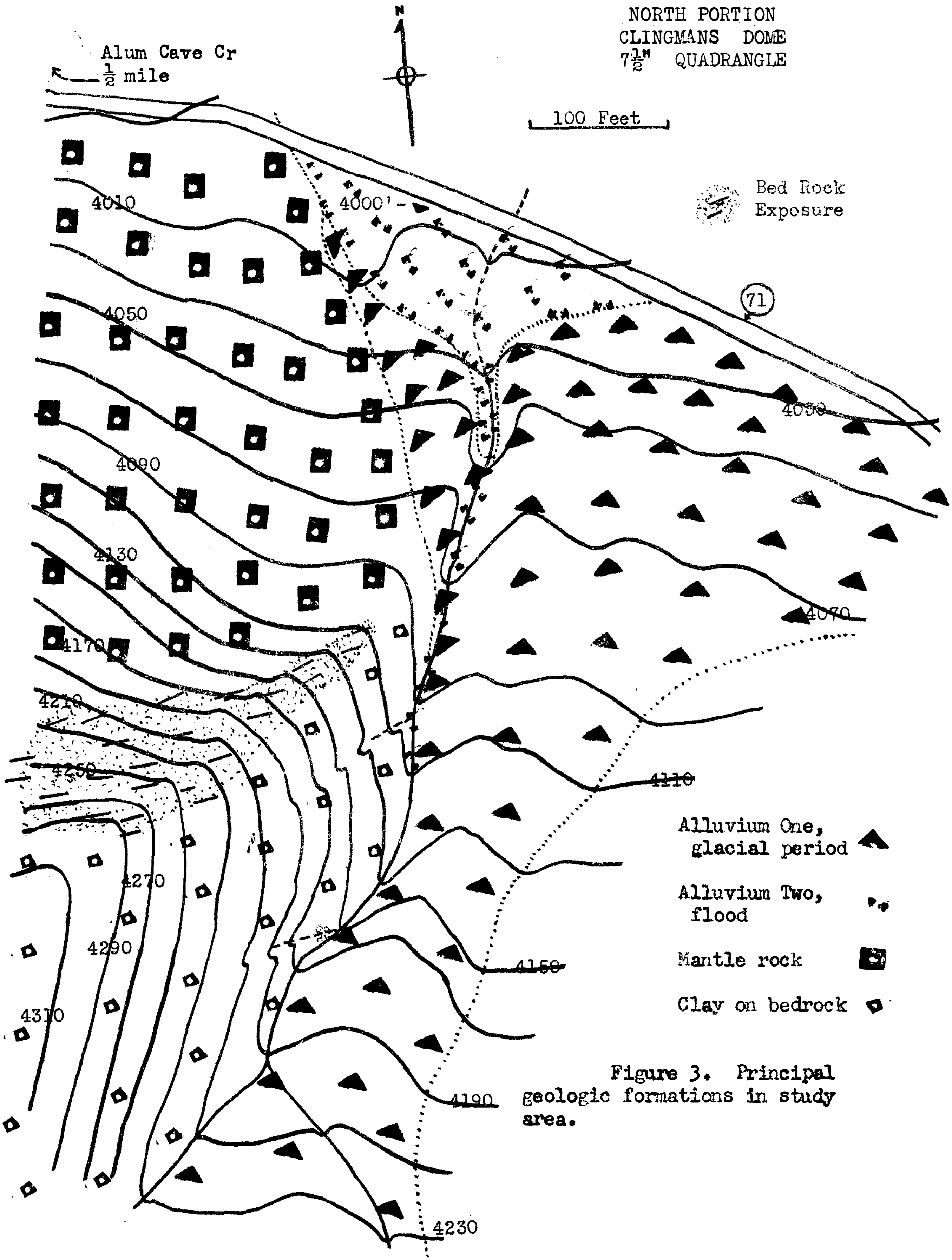


Figure 3. Principal geologic formations in study area.

flash floods have carried down slate from the above Anakeesta unit (Fig. 1) and formed an alluvial zone, here called Alluvium Two, which fanned out from the mouth of the stream forming a small terrace-like fan of small blocks of black, flat slate up to two inches in diameter.

A flash flood in the fall of 1951 added to this alluvial deposit and changed the surface configuration a little in this immediate zone. The same flood probably contributed to a slide in stand D (Fig. 3) which denuded a small valley along the ridge exposing the bedrock under the clay.

Distinct, sharply drawn boundaries of these geologic formations were difficult to ascertain because they were mostly made up of the same type of parent material. Alluvium Two was obvious because of the thick deposition of small particles of slate within it. Alluvium One and mantle rock, however, were of the metamorphosed sandstone and there was some intermingling where their boundaries met.

Soil

Following this period of major profile development there was a period of soil formation with vegetation types, leaching, and erosion serving as the major factors in soil genesis. Clay deposits in area D were formed by weathering in place of the bedrock. For the most part, however, there was so much rough, stony land that the soil auger was of little value in profile determination. Where soil had developed and could be seen it was comparable to the melanized soils or brown forest soils with weak podzolization under the evergreen canopies as described by S. A. Wilde (1946). Podzolization was most pronounced in stand C.

A similar pattern was found by Coile (1938) in the West Virginia mountains where he found a brown forest soil developing under a stand of northern hardwood, yellow birch, beech, sugar maple, with a podzol under a spruce canopy about six chains away. In that region the two contrasting types of soil were believed to have been influenced in their development by the different forest types. In the Tennessee mountains, however, the soils developing under spruce were not so highly podzolized. This may be attributed to the generally higher base content of the metamorphic rock.

There was an obvious lack of B horizon in this area (Table I) which is true in most of these high mountain soils. This is due to the rapid loss of leached material because of the steep slopes involved. Mineral material leaving the A horizon moves down and out too fast to build up a noticeable zone of mineral accumulation.

The area designated as Alluvium Two was not old enough to have developed a true solum as it consisted of a thin layer of litter with about four to ten feet of small shale fragments in a clay matrix. This area was so rocky that the road crew that camped here during construction of the road could not dig a hole deep enough to bury a dead mule.

The ridge surface was sufficiently complicated in structure to make any generalizations difficult. Several definite types can be mentioned.

(1) The least amount of soil formation was observed on a small triangular plot designated as the spruce-fir island (Fig. 2). This area, the terrace-like lower portion of the rock mantle, was cavernous, characterized by large rocks. Most of the boulders were covered on the top surfaces with pads of moss. In places holes as much as three feet in

TABLE I

SOILS

Station	A_{00}	A_0	A_1	A_2	B	C_1
A	0-½ in.	--	--	--	--	Cavernous graywacke 5-15 ft.
B	½-1 in.	--	--	--	--	Alluvial shale and conglomerate 5-10 ft. in clay matrix
C	0-½ in.	0-3 in. greasy black mor	0-12 in. light brown loam	?	--	0-4 in. ashy gray clay on 2-20 ft. of large mantle graywacke
D	0-2 in.	3-12 in. of brown-black humus	6-8 in. gray-brown mineral and organic	10-12 in. brown mineral	--	20-26 in. yellow clay
E	0-1 in.	10-14 in.	?	?	--	Alluvial conglomerate rocks 1 in.-3 ft. in dia.
F	½ in.	1 in.	6-12 in. light brown sandy loam	6 in. yellow-brown sandy loam	--	10-20 ft. deep alluvial conglomerate rocks 1 in.-3 ft. in diameter

depth could be found in this bouldery material, with here and there accumulations of humus in the pockets. The terrace slope exhibited more humus along the east side and a bank of yellow clay toward the north. The drainage from the mantle slope was below this colluvial terrace so there has been a gradual washing out of the clay resulting in this cavernous topography. This could have been hastened by flash floods such as the ones that built up the Alluvium Two fan. The very nature of the three sided exposure of the area would aid in this loss of material.

(2) The mantle rock also showed little soil development but it did have a deeper layer of humus and litter. Mantle rock was exposed in many places, with melanized soil profiles developing in the depressions. Light brown soil which covered the mantle rock at lower elevations represented accumulation of alluvial material from the region above.

(3) In area D on the ridge top above the bedrock exposure a pocket of spongy humus was found. The soil auger showed an accumulation of eighteen inches of humus, five inches of yellow clay, six inches of sandy clay, and five inches of wet clay.

CLIMATE

Equally as important as a consideration of basic soil pattern is a consideration of climatic factors. The region of the Great Smoky Mountains has long been noted for its floristic complexity which is in large part attributable to its range of elevation and the resulting range in climate. Both precipitation and temperature change markedly in the approximate one mile of relief in the Great Smokies.

Statistics on precipitation, humidity, and temperature tabulated from the official records of the Smoky Mountain Snowfall Study, a joint project of the Tennessee Valley Authority, National Park Service, and United States Weather Bureau, have been used to obtain a general picture of the regional altitudinal climatic profile and to see the relationship of the study area in the broad macrothermal picture. It is realized, of course, that local variations and the short three year period used in this summary limit specific conclusions. General trends and patterns do make certain generalizations possible, however.

According to Shanks (1954) the average temperature decrease with altitude is 2.23° Fahrenheit per thousand feet. This can be observed in Figure 4. Temperature data indicated that of the total decrease from Park Headquarters to Clingman's Dome weather station over half of the decrease occurred below the 3800 foot station. Half of the total precipitation had also occurred below the 3800 foot station.

From the weather records an analysis was made of the relative humidity. The per cent of hours of the month that the relative humidity

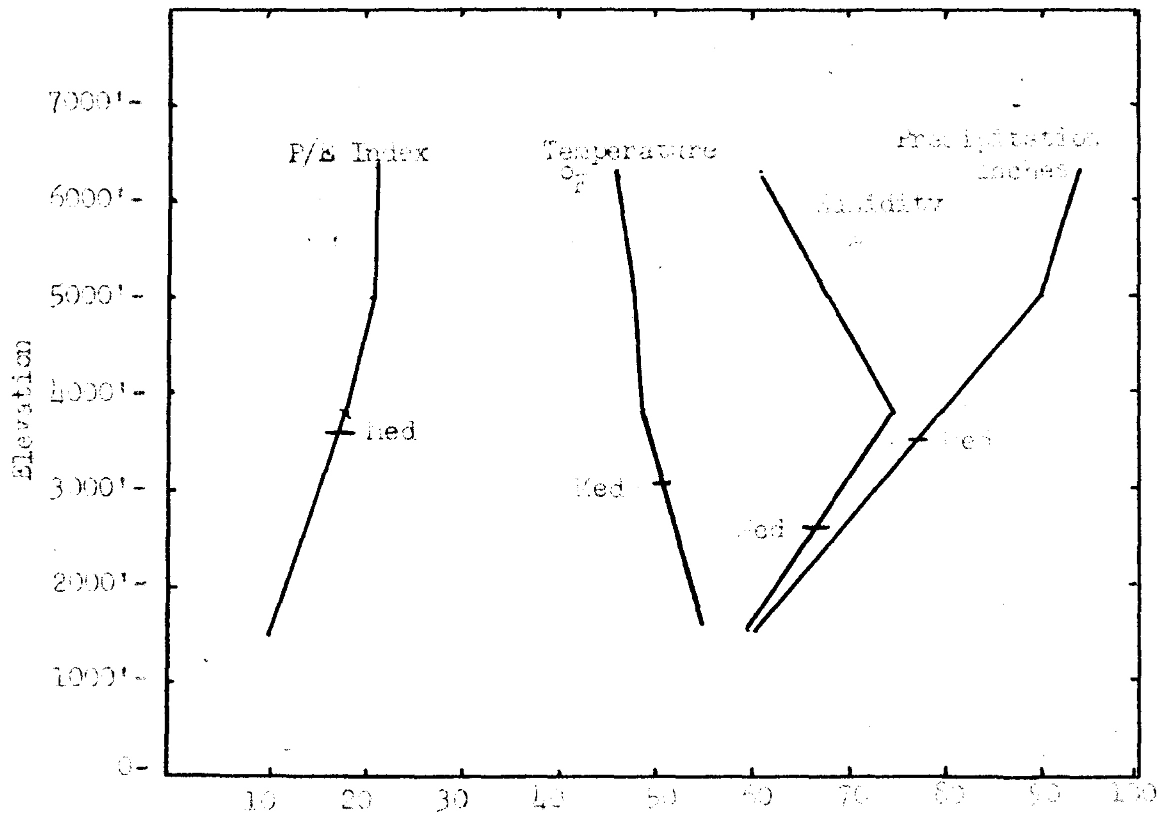


Figure 4. Graph showing average monthly P/E index, temperature, per cent of days humidity was over 90 per cent, and precipitation from January 1948 to June 30, 1950.

was over 90 per cent was computed for each of the four stations. The relative humidity was greatest at the 3800 foot station. The percentages at the next two higher stations were much lower, indicating that many times it was less humid at 6300 feet than at the 1460 foot station.

A knowledge of the location of the weather stations is mandatory for analysis of this data. The 1460 foot station is at the Park Headquarters which is in the level valley of the Little Pigeon River. Here are experienced many of the weather phenomena associated with the area outside of the mountain range. All records indicate that it was hotter and drier than the other stations but still not to the extreme since humidity was still high.

The local situation of the 3800 foot station at Alum Cave parking area as well as its altitude must be taken into account in explaining the major changes in weather that had taken place by the time this elevation had been reached. This station is at the juncture of Alum Cave Creek and Walker Camp Prong and near the study area. It received cold air drainage from Mt. LeConte, the Boulevard, Mt. Mingus, and Mingus Lead. Since it is in a flat cold air tended to pile up in this area. The same explanation could account for the high humidity as cold and warm air meet in this region. This relationship has been recorded by Daubenmire for the western mountains (Daubenmire 1947).

The ridge stations at 5000 and 6300 feet are at Newfound Gap and Forney Ridge parking area respectively. Warm air moving over the gap served to increase rainfall here over that of the 3800 foot point but kept the air stirred up enough to reduce the humidity so that it was less than that of the rather sheltered areas below. There was even a temperature lag in this more exposed position.

Forney Ridge is exposed to the cold and relatively dry winds from the southwest so the humidity fell quite low at times. Records indicated that many times the humidity dropped below 20 per cent, then rose abruptly to 100 per cent as a moist wind blew across the point. This occasional low humidity was made up for by the increased precipitation and decreased temperature at this elevation as indicated in Figure 4, which includes the P/E ratio computed from the temperature and rainfall records.

The weather pattern along the transect described indicated rapid increases in precipitation and humidity and decreasing temperature up to the Alum Cave parking lot area. A more gentle increase from that point indicates that as far as climatic conditions are concerned the 3800, 5000, and 6300 foot points seem to be more comparable and decidedly different from the lower elevations in individual weather elements as well as in P/E ratio.

According to Shanks (1954) the 1460 foot station falls within Thorthwaite's mesothermal forest climate and all of the others are well within the range which is described as a wet microthermal region with adequate precipitation at all seasons.

Besides this broad concept of climatic conditions as affected by altitude microclimatic conditions existing within this pattern deserve special mention because of their influence on vegetation.

There exist within this same transect adjacent habitats of strikingly different temperature variation. This is the ridge vs. cove pattern, in which the ridges are the steeper bedrock and mantlerock projections and the coves are the cupped, shallow depressions of alluvial concentration between. In a one year study of soil and air temperature near the Chimneys parking area, at the Alum Cave parking area and at a beech gap at 5200 feet elevation on the skyline drive to Clingmans Dome, a consistent pattern of cove vs. ridge temperature was noted (Fig. 5), with the soil temperatures on the ridges lower than those in the coves.

Air temperatures showed a greater fluctuation than soil temperatures (Fig. 6). This was particularly noticeable in May when absence of foliage from the deciduous trees in the coves eliminated protective insulation such as that afforded by the evergreens on the ridges. It was concluded that soil temperatures serve as a good indicator of temperature in these regions, fluctuating much less than air temperature and reflecting general temperature conditions over the preceding period of several days.

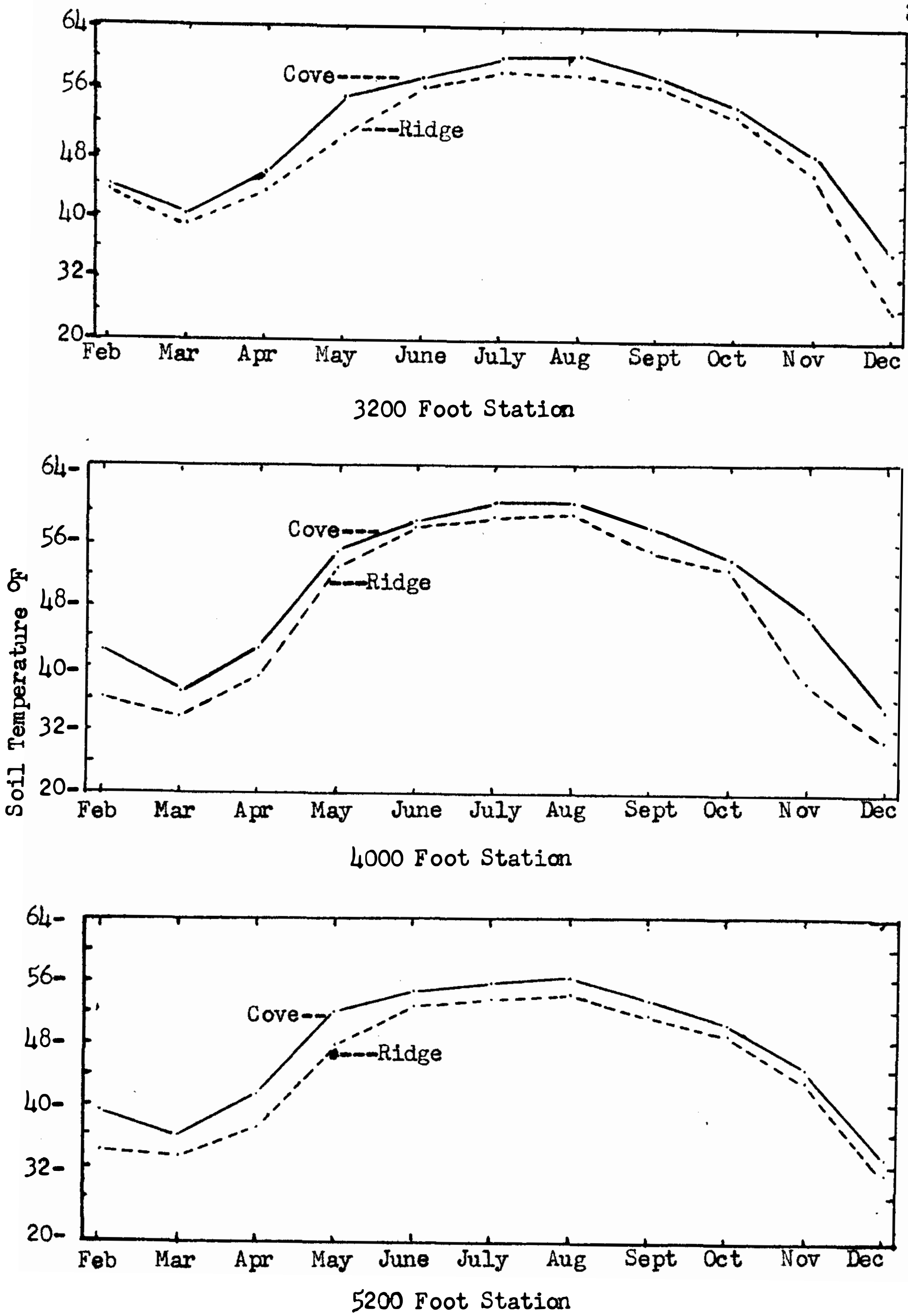


Figure 5. Average soil temperat re in cove and on ridge at three selected stations in the Great Smok Mountains National Park for the year 1950.

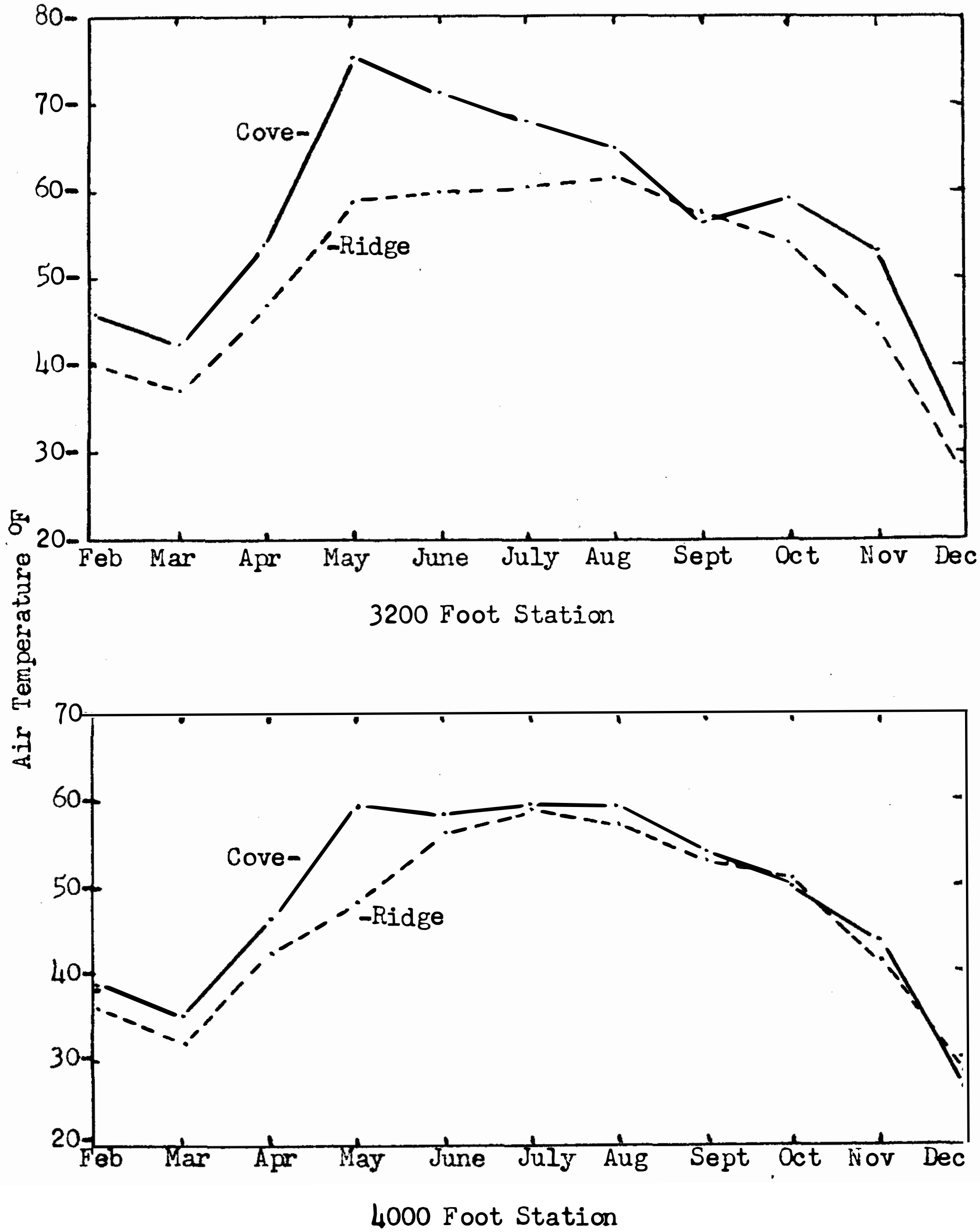


Figure 6. Average air temperatures in cove and on ridge at selected stations in the Great Smoky Mountáns National Park for the year 1950. The 5200 Foot Station was destroyed by bears.

VEGETATION

Analysis of Total Area

Obvious physiognomic differences were noted in reconnaissance of this area. These differences were particularly pronounced as far as ease of walking was concerned as well as in visual observation. The entire study area was first checkered with twelve quadrats. For comparative purposes substantiated by data obtained from the quadrats the area was divided into individual stands. The stands are identified as A, B, C, D, E, and F (Fig. 2).

Presence data for the study area indicate several species that are common to the entire area and have been given a presence value of 5 (Table II). Betula alleghaniensis is especially prevalent through stand C. From a distance this entire stand has a light green cast of yellow birch summer foliage, as if this were a deciduous area, belying the scattered hemlock and dense rhododendron beneath its canopy.

Tsuga canadensis and Picea rubens occupied an important place in presence values for the entire area along with Fagus grandifolia. Shrubs of high presence were Rhododendron maximum, Rubus canadensis and Ilex montana. On the ground level lack of similarity in these stands became very obvious as only one herb, Oxalis montana, and one fern, Dryopteris spinulosa var. intermedia were common to all stands.

It would seem, then, that the plants of lower presence value serve more to accentuate the obvious physiognomic differences in these stands.

Areas A and B were conspicuous because of the presence of Abies fraseri

TABLE II

TABULATION OF PRESENCE, CONSTANCE, FREQUENCY OF SPECIES OF TREES, SHRUBS, HERBS, AND FERNS IN SIX STANDS IN STUDY AREA

Species	Stands						Total Area	
	A	B	C	D	E	F	Presence	Constance
Trees								
Betula alleghaniensis Britton	x	x	4	3	3	3	5	5
Picea rubens Sarg.	x	x	1	3	3	2	5	4
Tsuga canadensis (L.) Carr.	x	x	1	4	5	2	5	5
Abies fraseri (Pursh) Poir.	x	x	x	-	-	-	3	2
Fagus grandifolia Ehrh.	x	x	1	1	5	4	5	4
Acer rubrum L.	x	x	-	-	2	2	4	3
Acer saccharum Marsh.	x	x	x	x	1	5	4	2
Acer pennsylvanicum L.	-	-	-	-	1	4	2	1
Acer spicatum Lam.	x	-	1	-	1	2	4	2
Aesculus octandra Marsh.	-	x	x	-	-	4	3	1
Magnolia fraseri Walt.	-	-	1	-	1	-	2	-
Prunus serotina Ehrh.	-	x	-	-	1	1	2	1
Cornus alternifolia L.	x	-	-	-	1	2	3	1
Fraxinus pennsylvanica var. subintegerrima (Vahl.) Fern.	x	x	-	-	1	-	2	2
Betula lenta L.	-	x	-	-	1	-	2	1
Castanea dentata (Marsh.) Borkh.	-	-	1	-	-	-	1	1
Quercus rubra var. borealis (Michx. f.) Farw.	x	-	-	-	1	-	2	1
Tilia heterophylla Vent.	-	x	-	-	x	-	2	1
Amelanchier laevis Wieg.	-	-	1	1	1	2	4	-
Shrubs								
Rhododendron maximum L.	x	x	5	5	2	1	5	5
Diervilla sessilifolia Buckl.	-	x	-	-	-	-	1	-
Viburnum cassinoides L.	x	-	-	-	-	-	1	-
Kalmia latifolia L.	-	-	1	3	-	-	2	1
Vaccinium erythrocarpum Michx.	x	x	-	-	-	-	2	1
Viburnum alnifolium Marsh.	x	-	-	-	3	-	2	1
Sambucus canadensis L.	x	x	1	-	1	-	2	-
Smilax rotundifolia L.	-	x	1	3	2	-	4	1
Smilax herbacea L.	-	-	-	-	-	1	1	1
Hydrangea arborescens L.	x	x	x	-	-	2	3	2
Ribes rotundifolia Michx.	x	x	-	-	-	2	3	2
Rubus canadensis L.	x	x	1	-	3	2	5	2

x - Present
1-5 - Frequency

TABLE II

TABULATION OF PRESENCE, CONSTANCE, FREQUENCY OF SPECIES OF TREES, SHRUBS, HERBS, AND FERNS IN SIX STANDS IN STUDY AREA (CONTINUED)

Species	Stands						Total Area	
	A	B	C	D	E	F	Presence	Constance
Ilex montana T. & G.	x	-	x	x	3	2	5	1
Evonymus obovatus Nutt.	x	x	-	-	3	5	4	3
Herbs								
Allium tricoccum Ait.	-	-	-	-	-	2	1	-
Carex intumescens Rudge	x	x	-	-	-	-	1	1
Festuca obtusa Biehler	-	-	-	-	-	2	1	-
Clintonia borealis (Ait.) Raf.	x	x	-	-	1	-	3	-
Erythronium americanum Kerr.	-	-	-	-	-	x	1	-
Trillium erectum L.	-	1	-	-	1	2	3	3
Lillium superbum L.	-	-	-	-	x	-	1	-
Streptopus roseus Michx.	x	-	-	-	-	1	1	1
Polygonatum	-	-	-	-	-	1	1	-
Medeola virginiana L.	-	x	-	-	x	-	2	2
Habenaria psycodes (L.) Spreng.	-	x	-	-	-	-	1	1
Arisema quinatum (Nutt.) Schott.	x	x	-	-	3	-	3	3
Mitchella repens L.	x	x	-	-	3	-	3	3
Laportea canadensis (L.) Wedd.	-	x	-	x	2	5	3	2
Stellaria pubera var. silvatica (Beguinot) Weath.	-	x	-	-	-	-	-	-
Claytonia virginica L.	x	x	-	-	x	x	4	-
Ranunculus recurvatus Poir.	-	x	-	-	-	x	1	1
Cimicifuga americana Michx.	-	-	-	-	1	5	2	1
Actea pachypoda Ell.	x	x	-	-	1	3	3	2
Clematis virginiana L.	-	x	-	-	-	-	1	-
Diphylleia cymosa Michx.	-	x	-	-	-	1	2	1
Caulophyllum thalictroides (L.) Michx.	-	-	-	-	-	4	1	1
Dicentra Cucullaria (L.) Bernh.	-	-	-	-	-	x	1	-
Dicentra canadensis (Goldie) Walp.	-	-	-	-	-	x	1	-
Sedum ternatum Michx.	-	x	-	-	1	-	2	1
Tiarella cordifolia L.	x	x	-	-	4	2	4	3
Mitella diphylla L.	-	x	-	-	x	-	2	-
Saxifraga micranthidifolia (Haw.) Britt.	-	-	x	-	-	-	1	-
Oxalis montana Raf.	x	x	x	x	4	1	5	3

TABLE II

TABULATION OF PRESENCE, CONSTANCE, FREQUENCY OF SPECIES OF TREES, SHRUBS, HERBS, AND FERNS IN SIX STANDS IN STUDY AREA (CONTINUED)

Species	Stands						Total Area	
	A	B	C	D	E	F	Presence	Constance
Impatiens pallida Nutt.	-	x	-	-	-	1	2	1
Viola rotundifolia Michx.	x	-	-	-	-	-	1	-
Circaea alpina L.	x	x	-	-	x	-	3	1
Zizia aptera (Gray) Fern.	-	x	-	-	-	-	1	1
Zizia trifoliata (Michx.) Fern.	-	x	-	-	-	-	1	1
Osmorhiza Claytoni (Michx.) E. B. Clarke	-	-	-	-	-	4	1	1
Monotropa uniflora L.	-	-	2	-	x	-	2	-
Chelone lyoni Pursh.	-	-	x	x	-	x	1	-
Epifagus virginiana (L.) Bart.	-	x	-	-	-	-	1	-
Cuscuta gronovii Wildd.	-	-	-	-	-	x	1	-
Phacelia fimbriata Michx.	-	-	-	-	-	x	1	-
Hydrophyllum canadense L.	-	-	-	-	-	3	1	1
Monarda didyma L.	-	x	-	-	x	x	3	2
Blephilia hirsuta (Pursh) Benth.	-	x	-	-	-	-	1	1
Houstonia serpyllifolia Michx.	-	x	-	-	-	-	1	-
Galium triflorum Michx.	-	x	-	-	-	-	1	1
Eupatorium rugosum var. roanense (Small) Fern.	x	x	-	-	-	x	2	-
Solidago glomerata Michx.	x	x	x	-	x	-	2	1
Aster divaricatus L.	x	x	-	-	2	5	4	3
Rudbeckia laciniata L.	-	x	-	-	-	x	2	-
Solidago Curtisii T. & G.	-	x	-	-	2	5	3	3
Aster Lowrieanus Porter	-	x	-	-	-	-	1	1
Chrysanthemum Leucanthemum L.	-	x	-	-	-	-	1	-
Prenanthes altissima L.	x	x	-	-	1	1	3	1
<u>Ferns and Club Mosses</u>								
Lycopodium lucidulum Michx.	-	-	-	-	4	2	2	1
Polypodium virginianum L.	x	-	1	-	-	-	3	1
Dennstaedtia punctilobula (Michx.) Moore	x	x	-	-	-	-	2	2
Dryopteris spinulosa var. intermedia (Muhl.) Underw.	x	x	1	1	5	5	5	5
Athyrium thelypteroides (Michx.) Desv.	-	-	-	-	-	2	1	1

TABLE II

TABULATION OF PRESENCE, CONSTANCE, FREQUENCY OF SPECIES OF TREES, SHRUBS, HERBS, AND FERNS IN SIX STANDS IN STUDY AREA (CONTINUED)

Species	Stands						Total Area	
	A	B	C	D	E	F	Presence	Constance
Polystichum acrostichoides (Michx.) Schott.	x	x	-	-	-	2	3	2
Botrychium virginianum (L.) Sw.	-	-	-	-	-	1	1	-
Dryopteris noveboracensis (L.) Gray	-	x	-	-	-	4	2	1

within them. Area C had within it several large trees of Magnolia fraseri and dead logs and trees of Castanea dentata. Area F in appearance was a cove hardwood stand with Acer rubrum, Acer saccharum, Acer pennsylvanicum, Aesculus octandra, and Tilia heterophylla.

Stands C and D had a dense growth of rhododendron which extended only as scattered plants in the other stands. Again it was in the ground strata that differences became pronounced as stands C and D had only five and one species respectively within them. This was due to the dense growth of rhododendron and its contribution to the shading effect and mor type humus found under it. Area B had a scattered and diverse flora of thirty-eight species. Flash floods of 1951 have probably altered the vegetation and topography of area B. Although twenty-three species of herbs were listed for area E there was not a dense ground cover, the plants being scattered to a considerable extent, attributable to the high presence of evergreen trees in the canopy. Area F had a dense ground cover of thirty-eight herbaceous species under a deciduous canopy. The spruce-fir island, area A, had only thirteen scattered herbaceous species.

Constance diagrams (Fig. 7) indicated even more species in the lower class of infrequents. Only four species were constantly present in the area. They were Betula alleghaniensis and Tsuga canadensis, as canopy, with Rhododendron maximum and Dryopteris spinulosa var. intermedia in the understory. These data were compiled from the twelve scattered 10X10 meter quadrats scattered over the entire area of study. Since these plots were larger than minimum area established by a species-area curve the results implied greater homogeneity than was actually the case.

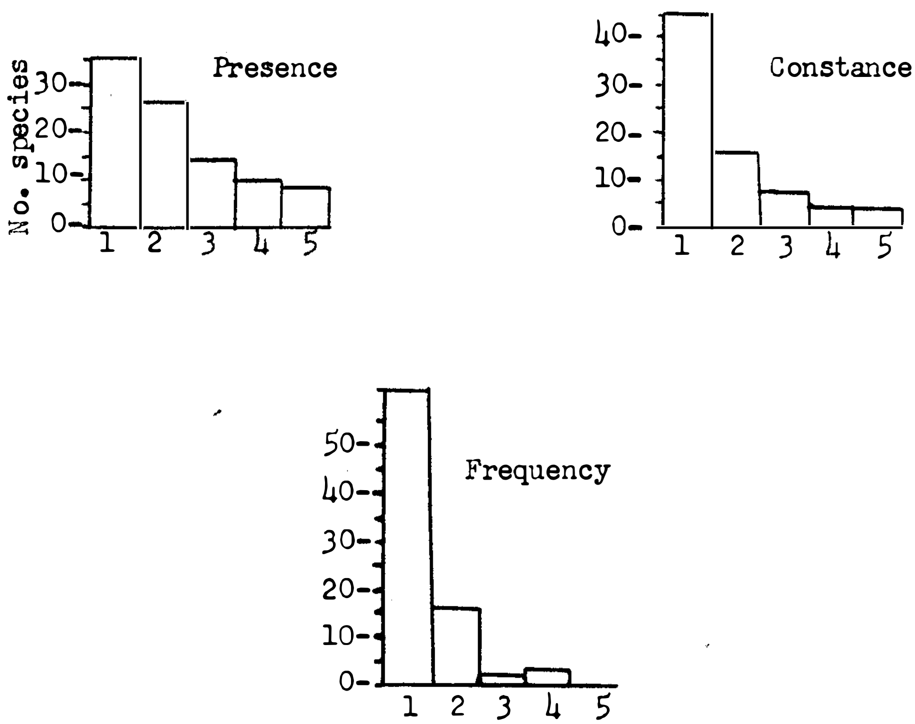


Figure 7. Presence, frequency, and constance diagrams for study area. Frequency based on 1X10M plots and constance based on 10X10M plots. 1-1 to 20 percent, 2-21 to 40 per cent, 3-41 to 60 per cent, 4-61 to 80 per cent, and 5-81 to 100 per cent.

Analysis of the meter-wide ridge and cove transects further showed the heterogenous nature of the study area. Diagrams (Fig. 7) showed no species in the high bracket with over 70 per cent of them as class 1 of infrequents.

Presence data for bryophytes were collected only for areas A, B, C, and F during the brief field reconnaissance with Dr. Aaron J. Sharp. Of the ninety-six identified, sixty-five were found in stand A, thirty in stand B, fifty-one in stand C, and thirty in stand F. Combined data showed that 84 per cent of the bryophytes occurred on the ridge composed of stands A and C. Fifty-five per cent of them appeared in the cove represented by stand F and part of the creek bottom.

The high presence of bryophytes along the ridge was associated with a low herbaceous cover and dense, persistent evergreen canopy. This north facing habitat also was cooler and received more surface water drainage than the deeper-soiled cove. Even so the entire area showed a good bryophyte growth composed of a mixture of plants common on low, mid-altitude, and high altitude sites. A presence list (Table III) has been compiled showing where the different species were found in the four stands.

Presence figures for stand B would have been even lower if the bryophytes along the damp incline leading up to the spruce-fir island were not recorded. In stand F many of the recorded species were found only along the small stream.

TABLE III

LIST OF BRYOPHYTES IN STANDS A, B, C, F IN STUDY AREA

Species[1]	Stands A	B	C	F	Distribution in Great Smoky Mts. Nat'l Park[2]
Anomodon attenuatus	-	x	x	x	CH[3]
Anomodon rostratus	x	x	x	x	CH
Anomodon Rugelii	-	x	-	x	B-CH
Anomodon tristis	-	x	-	x	B-CH
Atrichum undulatum	x	x	-	-	-
Bartramia pomiformis	-	-	x	-	-
Brachythecium plumosum	-	-	-	x	CH
Brachythecium rivulare	-	-	-	x	-
Brachythecium salebrosum	-	-	-	x	-
Brotherella delicatula	x	x	x	-	CH
Brotherella recurvans	x	x	x	x	F-S-CH
Brotherella tenuirostris	x	-	-	-	-
Bryhnia novae-angliae	-	-	x	-	CH
Climacium americanum	-	-	-	x	CH
Dicranella heteromalla	x	-	-	-	F
Dicranodontium denudatum	x	-	x	-	F
Dicranum fulvum	x	x	x	x	F-B-CH
Dicranum montanum	-	-	-	x	CH
Dicranum scoparium	x	x	x	-	F-S-B-CH
Fissidens cristatus	x	x	x	x	CH
Grimmia gracilis	-	-	-	x	CH
Heterophyllium affine	x	-	x	-	S-CH
Homalotheciella subcapillata	x	-	-	-	B-CH
Hygrohypnum eugyrium	x	-	-	-	-
Hylocomium brevirostre	x	x	x	x	F-B-CH
Hylocomium splendens	x	x	x	x	F-S
Hypnum Crista-castrensis	x	-	-	-	F-S
Hypnum curvifolium	x	x	-	-	S-CH
Hypnum fertile	-	-	x	x	S-B-CH
Hypnum imponens	x	-	-	x	S-B-CH
Hypnum molluscum	-	x	-	-	CH
Hypnum reptile	x	-	x	x	F-S

[1]Taxonomic nomenclature according to Sharp 1939.

[2]Cain and Sharp 1938.

[3]CH - Cove Hardwood; F - Fir; S - Spruce; B - Beech.

TABLE III

LIST OF BRYOPHYTES IN STANDS A, B, C, F IN STUDY AREA (CONTINUED)

Species	Stands A	B	C	F	Distribution in Great Smoky Mts. Nat'l Park
Leucobryum glaucum	x	-	-	-	CH
Leucodon brachypus	x	x	-	x	B-CH
Mnium affine	x	x	x	x	CH
Mnium hornum	-	-	-	x	-
Mnium punctatum	x	-	-	x	-
Mnium rostratum	x	-	-	x	-
Neckera pennata	-	-	x	x	B-CH
Plagiothecium denticulatum	x	-	x	x	-
Plagiothecium elegans	x	-	x	-	-
Plagiothecium micans	x	-	x	-	-
Plagiothecium Muellerianum	x	-	-	-	CH
Plagiothecium Roeseanum	-	-	x	-	-
Plagiothecium sylvaticum	-	-	x	-	-
Platygyrium repens	x	-	x	-	B
Polytrichum ohioense	x	-	x	-	F-S
Porotrichum alleghaniense	x	-	-	x	CH
Rhabdoweisia denticulata	-	-	x	-	-
Rhodobryum roseum	x	x	-	x	CH
Rhytidiadelphus triquetrus	x	x	-	x	F
Schwetschkeopsis denticulata	-	x	-	x	B-CH
Sematophyllum carolinianum	x	-	-	-	-
Sematophyllum marylandicum	-	-	-	x	-
Tetraphis pellucida	x	-	x	x	F-CH
Thuidium delicatulum	x	x	x	x	F-S-B-CH
Trichostomum cylindricum	x	-	x	-	CH
Ulota americana var. rufescens	-	-	-	x	B
Acrobolbus rhizophyllus	-	-	x	-	-
Bazzania denudata	x	-	x	-	F-S
Bazzania trilobata	x	-	x	x	F-S
Blepharostoma trichophyllum	x	-	x	-	F-S
Calypogeia Trichomanis	x	-	x	x	-
Cephalozia bicuspidata	x	-	x	-	F-CH
Cephalozia connivens	x	-	-	-	-
Cephalozia curvifolia	x	-	x	x	F-S-CH
Cephalozia media	x	-	x	-	F-S-CH
Chiloscyphus polyanthus	-	-	x	x	-
Diplophyllum apiculatum	-	-	x	-	-

TABLE III

LIST OF BRYOPHYTES IN STANDS A, B, C, F IN STUDY AREA (CONTINUED)

Species	Stands A	B	C	F	Distribution in Great Smoky Mts. Nat'l Park
Frullania Asagrayana	x	x	x	x	F-S-CH
Geocalyx graveolens	x	-	-	-	F
Harpalejeunea ovata	-	x	-	-	CH
Harpanthus scutatus	-	-	x	-	CH
Herberta tenuis	x	-	x	-	F-S
Lejeunea patens	x	x	x	x	-
Lepidozia reptans	x	-	-	-	F-S
Lepidozia sylvatica	x	-	x	-	-
Lophocolea minor	-	-	-	x	-
Lophozia incisa	-	-	x	-	F
Metzgeria conjugata	x	-	-	-	CH
Metzgeria crassipilis	x	x	-	-	S
Metzgeria furcata var. fruticulosa	x	x	x	x	S-CH
Microlejeunea Ruthii	-	x	-	-	-
Microlejeunea ulicina	x	-	-	-	F
Odontoschisma prostratum	x	-	-	-	-
Plagiochila Austini	x	-	-	-	-
Plagiochila Sullivantii	x	-	-	-	-
Porella platyphylloidea	x	x	-	x	S-CH
Radula complanata	x	x	-	x	-
Radula obconica	-	-	x	-	-
Radula tenax	x	-	x	x	-
Scapania nemorosa	x	-	x	-	F-CH
Sphenolobus exsectus	-	-	x	-	F-S
Sphenolobus Michauxii	x	-	-	-	F-S
Trichocolea tomentella	-	-	x	-	-

Stand Analysis

It was on the basis of this information that the entire area was broken down into the stands as before described. Frequency data indicated that stand C was dominated by Betula allegheniensis and Rhododendron maximum with a rich ground cover of bryophytes. Stand D showed Tsuga canadensis increasing in number over that of the C area part of the ridge, Betula alleghaniensis and Picea rubens also contributing to the canopy cover. As in stand C rhododendron had a frequency of 5, with Smilax rotundifolia becoming an important contributor, especially on the top ridges. Kalmia latifolia came into this zone in class 3.

Tsuga canadensis and Fagus grandifolia appeared in frequency class 5 in stand E. Cutting of large hemlocks in the lower parts of this stand probably contributed to the high frequency of beech seedlings. Since there was no dense shrub layer here a ground layer of class 4 frequency composed of Tiarella cordifolia, Oxalis montana, Dryopteris spinulosa var. intermedia, Lycopodium lucidulum, and Michella repens was present.

Above this stand the soil became deeper and steeper. In stand F deciduous trees Acer saccharum, Acer pennsylvanicum, Aesculus octandra, and Fagus grandifolia were frequent. Evonymus obovatus matted the ground in many places. Laportea canadensis made survey work difficult and sometimes painful. Cimicifuga americana, Aster divaricatus, Aster Lowrieanus, and Dryopteris spinulosa var. intermedia with Caulophyllum thalictroides and Osmorhiza Claytoni covered the ground completely, making little room for bryophyte invasion. The spring aspect here as in higher altitude beech gaps (Russell 1953) showed frequent Claytonia virginica, Phacelia fimbriata, Allium tricoccum, Trillium erectum, and Dentaria diphylla.

Phytographs

The woody plants of major importance in the area were taped at breast height and the data have been analyzed in phytographic form expressing per cent of basal area, of stems of all species, of presence, and of reproduction (Fig. 8).

In stands A and B the high presence of Picea rubens contributed greatly to its great basal area. Most of them were about nine inches DBH and were in the canopy at about forty feet. They showed a very small amount of reproduction in comparison with Abies Fraseri which was equal in basal area but lower in presence. This was accounted for by several trees that had reached a diameter of over one foot. Reproduction of fir, particularly around the larger trees, was high, but the small trees, even ten to fifteen years of age, had only reached a height of one to one and one-half feet, with most of them much smaller.

Areas C and D again showed a high value for Rhododendron maximum as to per cent of total stems, presence, and reproduction. Although the basal area seemed small it was remarkably high when the DBH of this shrub was taken into consideration. Although many of these plants spread out from large three to five inch stems the majority of them were in the one inch diameter class, making for a low total basal area. Betula alleghaniensis had a high basal area value because most of the trees measured were large. Tree reproduction throughout stands C and D was limited to small open places. In stand D Tsuga canadensis and Picea rubens

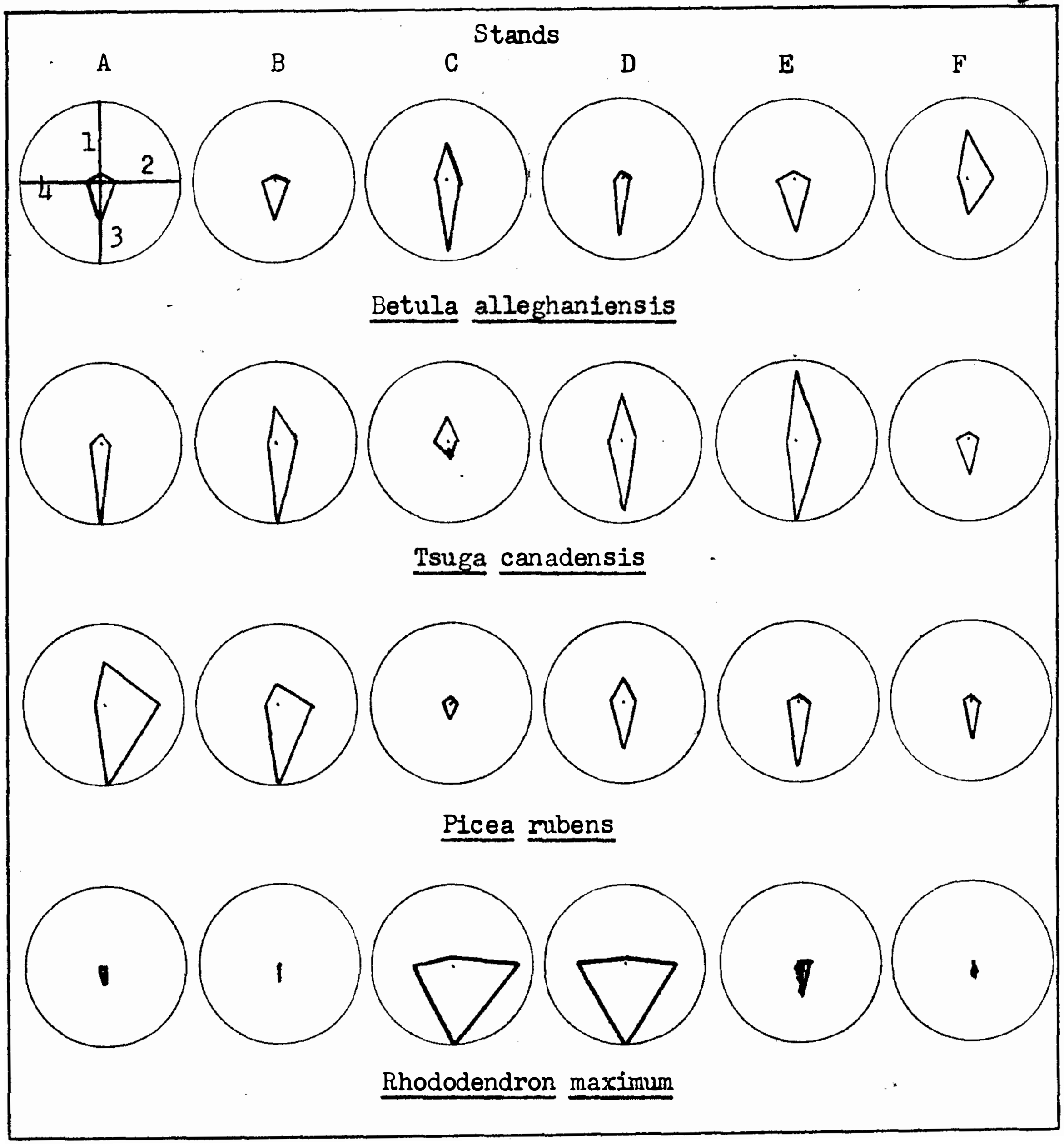


Figure 8. Phytographs showing growth patterns of major woody species in six stands in study area. Radius 1, percentage of total basal area; Radius 2, percentage of total stems; Radius 3, percentage frequency; Radius 4, percentage of total woody stem reproduction.

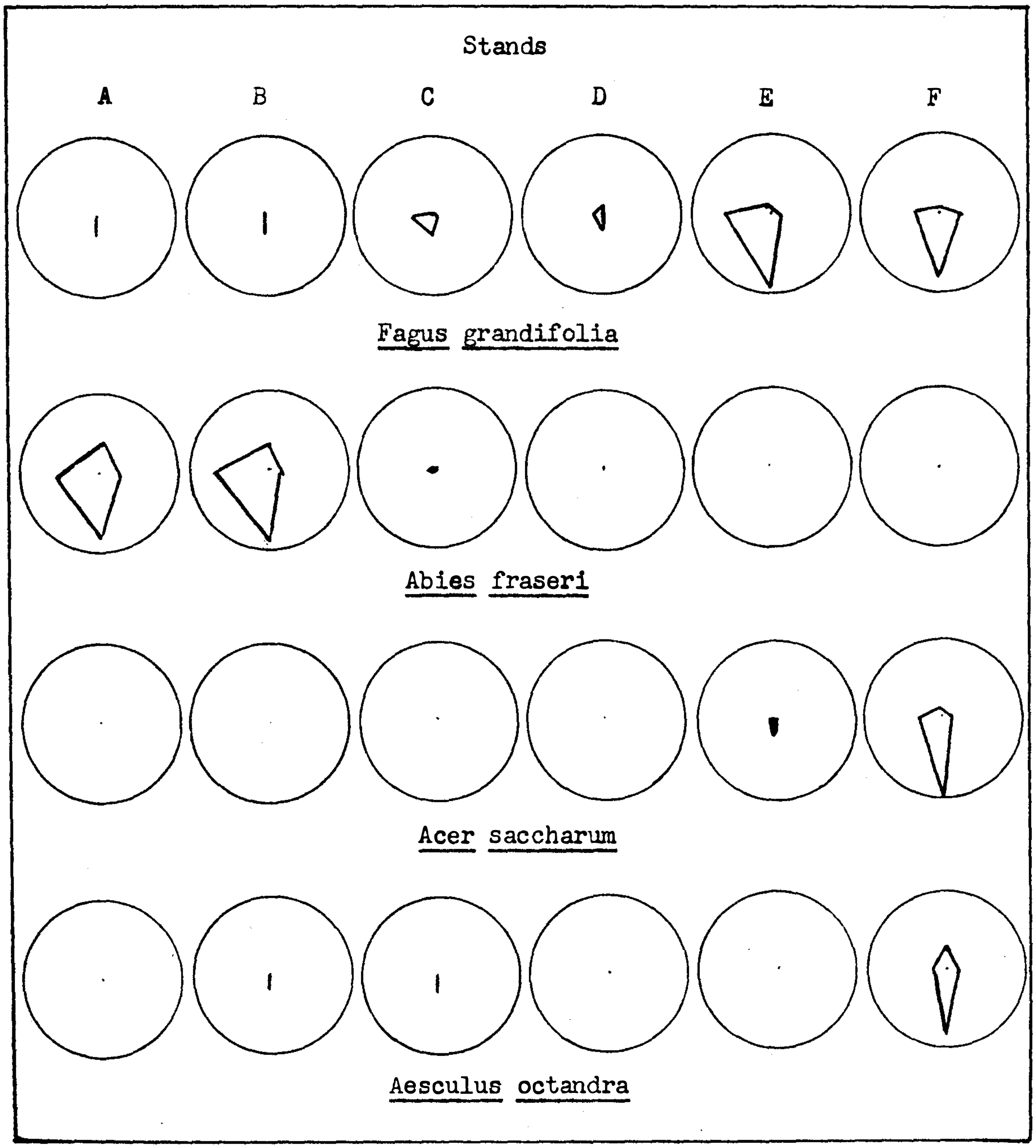


Figure 8. Phytographs showing growth patterns of major woody species in six stands in study area. (Continued)

exceeded other tree species in importance. Many large trees again accounted for the high basal area.

In stand E it was evident that Tsuga canadensis occupied a good part of the area due to the number of large trees. Because of the cut-over and denuded area along the road cut Fagus grandifolia showed a high percentage of reproduction.

Betula alleghaniensis with highest basal area again assumed importance in stand F. It was followed by Acer saccharum and Aesculus octandra. Most of these trees were so large that only a small number of them appeared in the quadrats. High presence value of the latter two can be attributed to seedlings. Beech was also reproducing in this area.

Tree Age Determination

For further comparative purposes an attempt was made to take increment borings from representative trees of hemlock, spruce, and fir in each stand. In analyzing these data there did not seem to be any differences between each of the stands, but in grouping all of the borings from A and B together and comparing them with all of the others a very interesting pattern developed (Fig. 9).

All of the trees from which cores were obtained in stands A and B seemed to be of nearly equal diameter, height, and age. The average age of most of the trees was between thirty-five and fifty years, even with diameters running from five to thirteen inches. The smaller trees seemed to have had a slow start under other faster growing trees of the same species and age. One hemlock, for instance, was one foot in diameter and

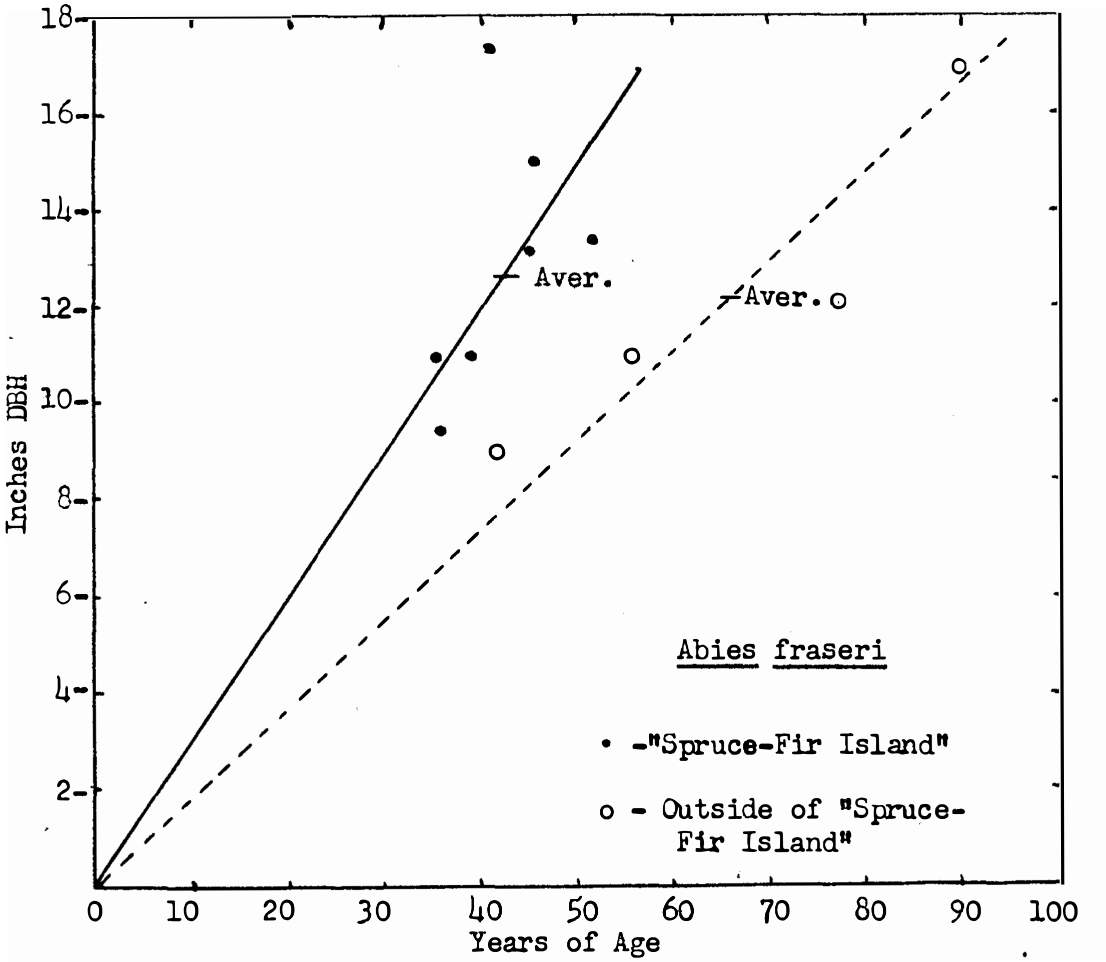
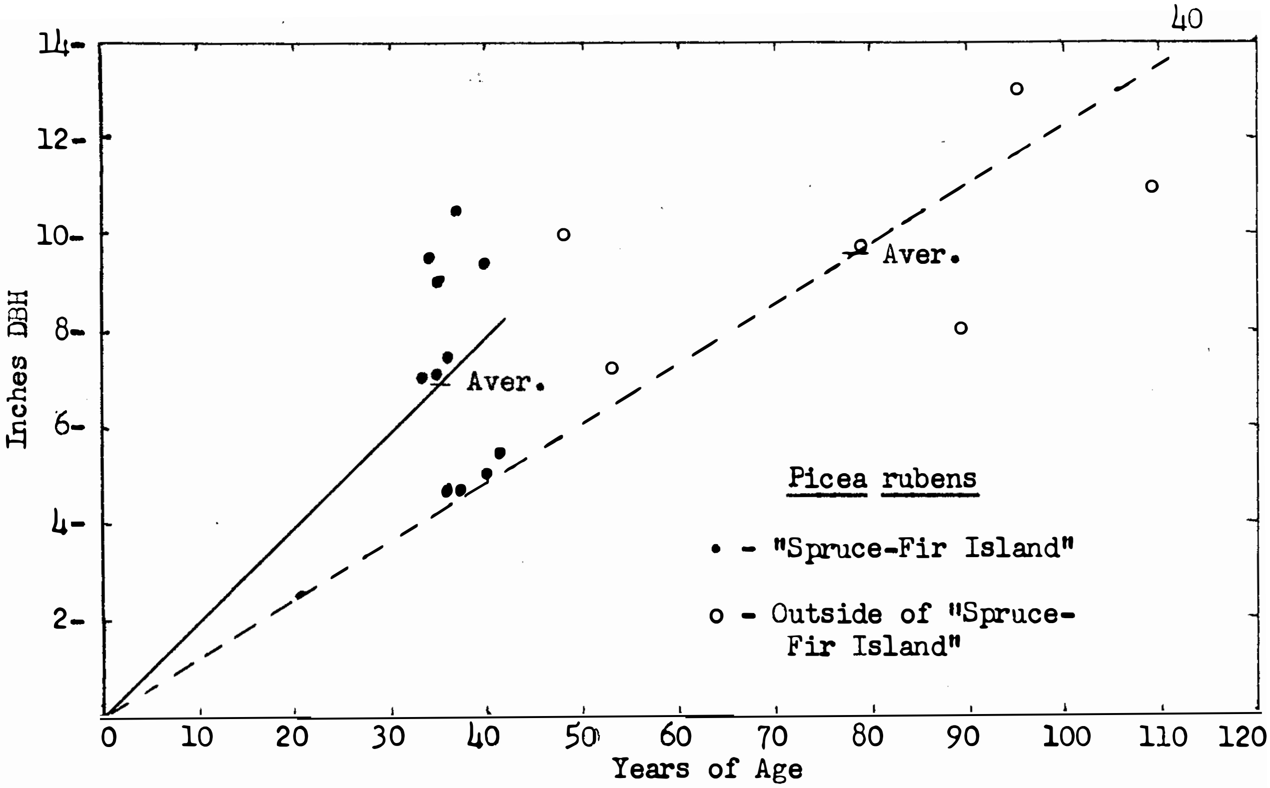


Figure 9. The comparative rate of growth of spruce, fir and hemlock on "Spruce-Fir Island" as found elsewhere in study area. Data from increment cores taken at DBH.



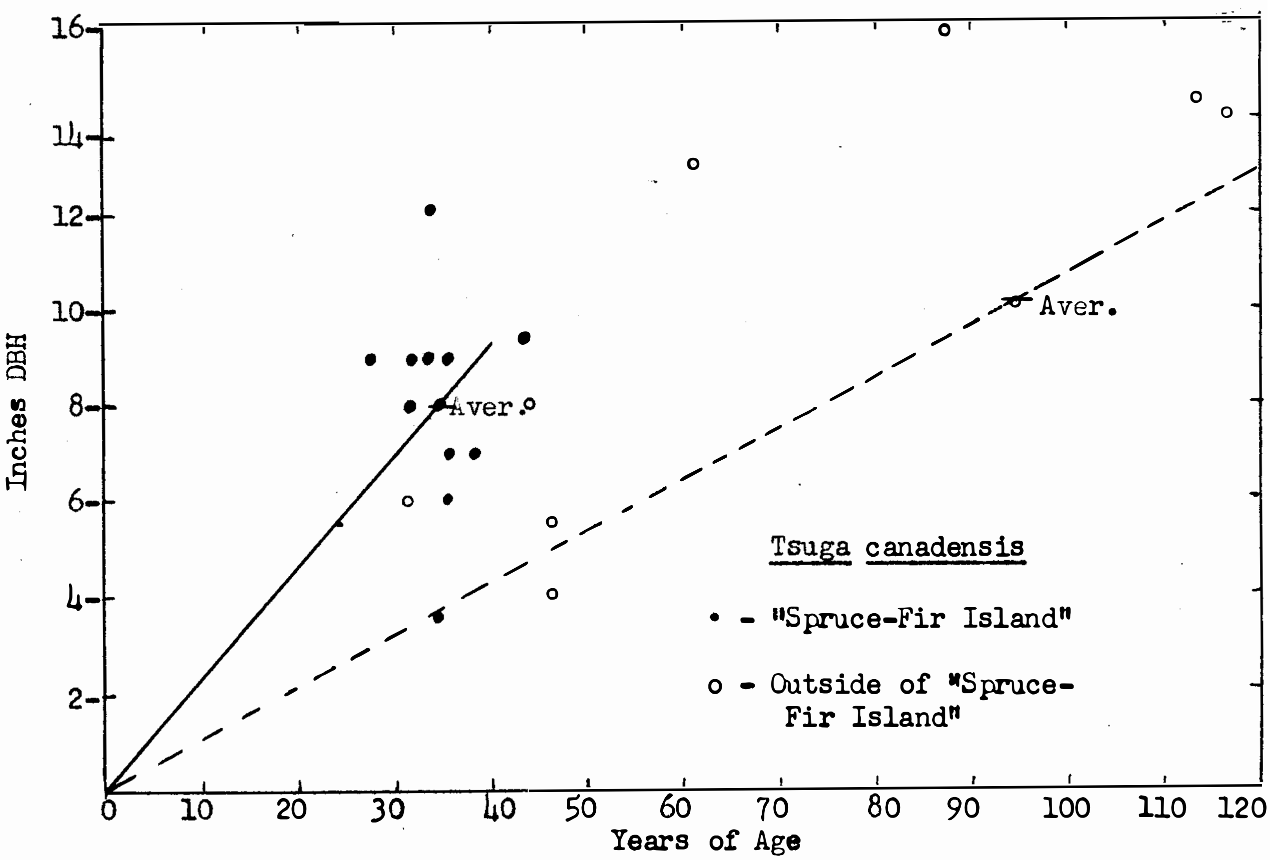


Figure 9. The comparative rate of growth of spruce, fir and hemlock on "Spruce-Fir Island" as found elsewhere in study area. (Continued)

thirty-five years old as compared to another hemlock of the same age less than three inches in diameter. In general the average age and size of the fir was a little greater than that of the spruce and hemlock.

From this it would seem that the trees in areas A and B came in as seedlings at about the same time because of some clearing in this area. Reports from people that fished through this region in the early 1900's substantiated these data. One ranger in the park recalled a little thicket of evergreens at this location during his boyhood fishing days.

Spruce and hemlock outside of this area showed a greater diversity as to height, diameter, and age. The general pattern showed a slower rate of growth. This was especially pronounced for the younger trees growing under established canopy. The pattern was even more obvious on the rhododendron ridge where one hemlock one hundred and thirty-eight years old had only reached a diameter of seven inches.

Only two fir trees were found in the vicinity outside of areas A and B (Fig. 1). Since only two were found after a careful search it is believed that they have reached about their lower altitudinal limit. In a check down Road Prong from Indian Gap the lowest elevation for the appearance of fir was found to be approximately the same as in the study area along Walker Camp Prong (Fig. 1). These trees seemed to be of the same age and diameter as those in the study area. One fir tree near the spruce-fir island had reached an age of ninety-two years and could well have served as a seed tree for this little fir forest.

DISCUSSION

Due to the antiquity, diversity of topography and range of altitude there are great differences in forest vegetation in the Great Smoky Mountains. There exists an Appalachian extension of the northern coniferous forest at higher elevations characterized by red spruce and Fraser fir (Oosting and Billings 1951). In the cove areas are found mixed mesophytic types which have been described as cove hardwood forest (Cain 1943). The composition of the cove types varies with altitude and topography. In general they are composed of various combinations of beech, birch, buckeye, basswood, tulip poplar, sugar maple, and hemlock (Braun 1950).

In the area of this study there is a mingling of the mixed mesophytic and spruce-fir associations, although in close proximity each is found in its own ecological niche. The forest of the study area can be classified into three basic types which appear to be edaphically differentiated. These types are red spruce(-hemlock)-yellow birch, red spruce-Fraser fir, and sugar maple-beech-yellow birch (Society of American Foresters, committee on forest types 1954).

Red Spruce(-Hemlock)-Yellow Birch

Hemlock was a co-dominant in the red spruce-yellow birch type as reported by the committee on forest types. This type represented a low elevation extension of red spruce from Mt. Mingus and Mingus Lead. It was found on the weathered bedrock surfaces and had a rhododendron understory. *Kalmia* and greenbrier entered into the community on southern exposures and outcroppings. This type extended into the Alluvium Two deposit where there was a moist "flat". In the better drained part of this flat where little rhododendron occurred, there was a ground cover of bryophytes interspersed with Clintonia, partridge berry, and Lycopodium.

A variant of the type consisted of almost pure yellow birch with a rhododendron understory. This type was on mantle rock on north facing exposures. Chestnut was at one time a part of this slope community as several standing snags and down logs were found. Many instances of yellow birch growing on logs might lead one to assume that the capacity of this tree to grow in this fashion (Cain 1940) may account for its prevalence as the only openings in the evergreen canopy of shrubs appeared where old trees had fallen.

The appearance of rhododendron in this type, particularly in its appearance at the edges of the alluvium where the stream had cut down close to bedrock, made this species a good indicator of moist outcroppings and bedrock formations.

Red Spruce-Fraser Fir

When openings appeared in favorable sites, such as the spruce-fir island, fir and spruce seeded in and appeared as a distinct segregated community similar to its normal higher altitude counterpart. This community with its understory of characteristic shrubs and herbs was reproducing and had been holding its own for over forty years. Without an abundant seed supply nearby it would probably have never existed.

Sugar Maple-Beech-Yellow Birch

This type was found in the cove where there was a deep deposit of well drained alluvium. There were several deciduous dominants: buckeye, yellow birch, sugar maple and beech. Ground indicator species of this cove hardwood type included such spring blooming species as fringed phacelia, toothwort, purple trillium, doll's-eyes, blue cohosh and foam flower followed in the summer by wood-nettle, bugbane, Curtiss golden-rod, and white wood aster.

This type mingled with the red spruce-yellow birch type along the steep banks of the Alluvium Two where it had been cut by the stream. On these ridges there was found Magnolia Fraseri and beech.

Except for the spruce-fir community all of the types seemed to be mature and all were characterized by different age groups of the dominant species, indicating that each of the types was relatively stable, and evidently constituted a part of the climax pattern (Whittaker 1953).

SUMMARY

1. A comprehensive study of plant distribution patterns was made at a mid-altitude location near the Alum Cave parking area in the Great Smoky Mountains National Park.

2. The study area was divided into four different zones on the basis of their geologic structure. These areas were (a) Alluvium One consisting of bouldery material in a matrix of pebbles, sand and clay built up in the cove valley during the glacial period, (b) Alluvium Two, a small terrace of slate deposited at the mouth of the cove stream by flash floods, (c) zone of weathered bedrock, and (d) mantle rock deposits below outcropping which in one place had been eroded so badly as to be left as an isolated island of large loosely packed boulders.

3. Climatically the 3800 foot station which was near the study area, the 5000 foot station, and the 6300 foot station seemed to be comparable, and different from the lower elevations. The higher area, 3800 to 6300 feet, can be described as a wet microthermal region with adequate precipitation at all seasons.

4. Adjacent microclimatic habitats of cove and ridge existed in the region studied. Air drainage in the "V" shaped coves contributed to the greater extreme of temperature within them. Canopy cover and degree of slope related to amount of radiation and insolation were also reflected in the temperature difference.

5. Presence data showed an intermingling in the study area of

bryophytes and vascular plants common to both the spruce-fir association and the mixed mesophytic associations.

6. Phytosociological data showed three distinct communities: red spruce(-hemlock)-birch, red spruce-fir, and sugar maple-beech-yellow birch. These communities showed a high degree of correlation with local edaphic, topographic, and climatic factors characteristic of the habitats in which they are usually found.

7. Phytographs of major woody plants emphasized the phytosociological data.

8. Increment borings substantiated the belief that the "Spruce-Fir Island" was a local phenomenon of recent origin.

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APPENDIX

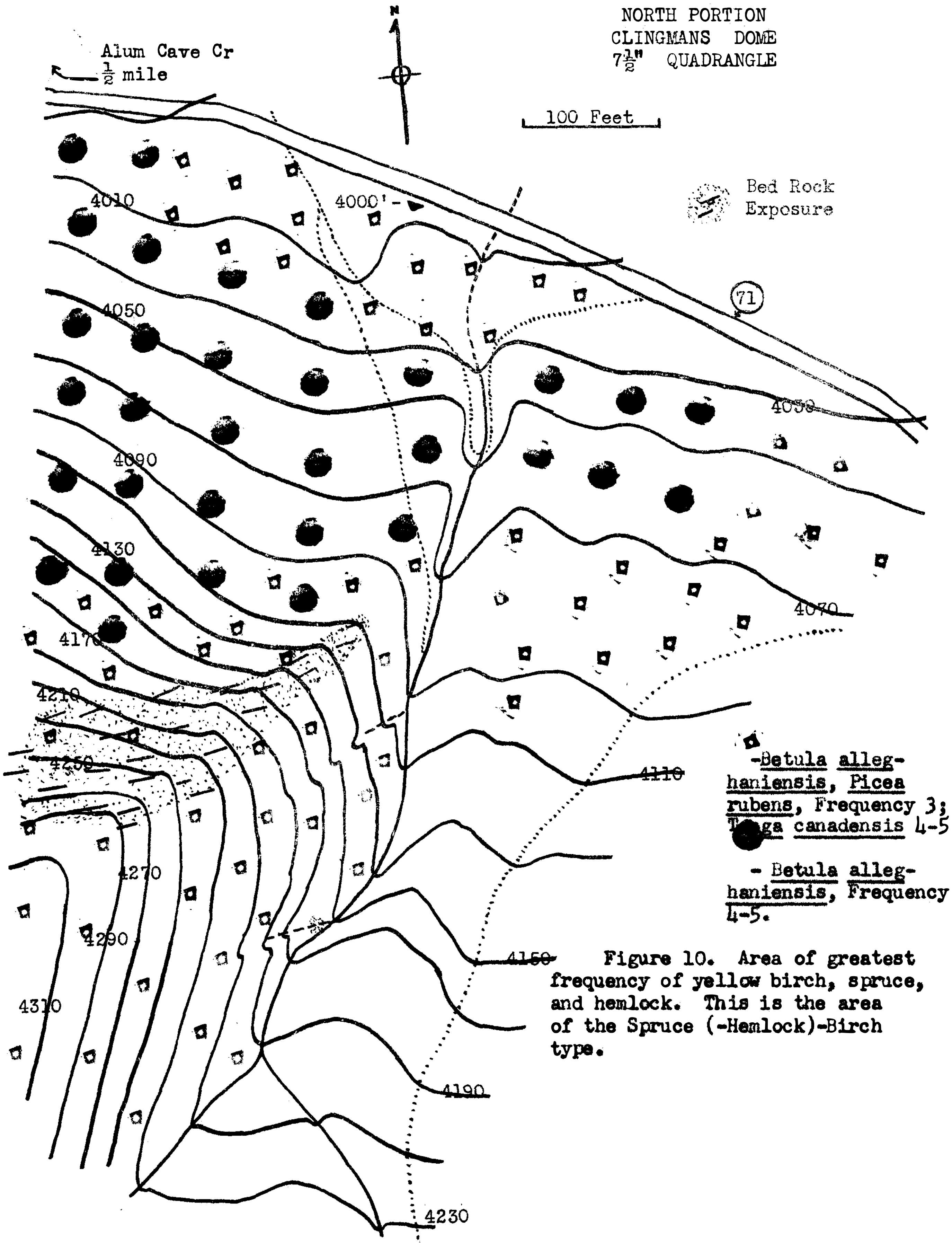

Figure 10. Area of greatest frequency of yellow birch, spruce, and hemlock. This is the area of the Spruce (-Hemlock)-Birch type.

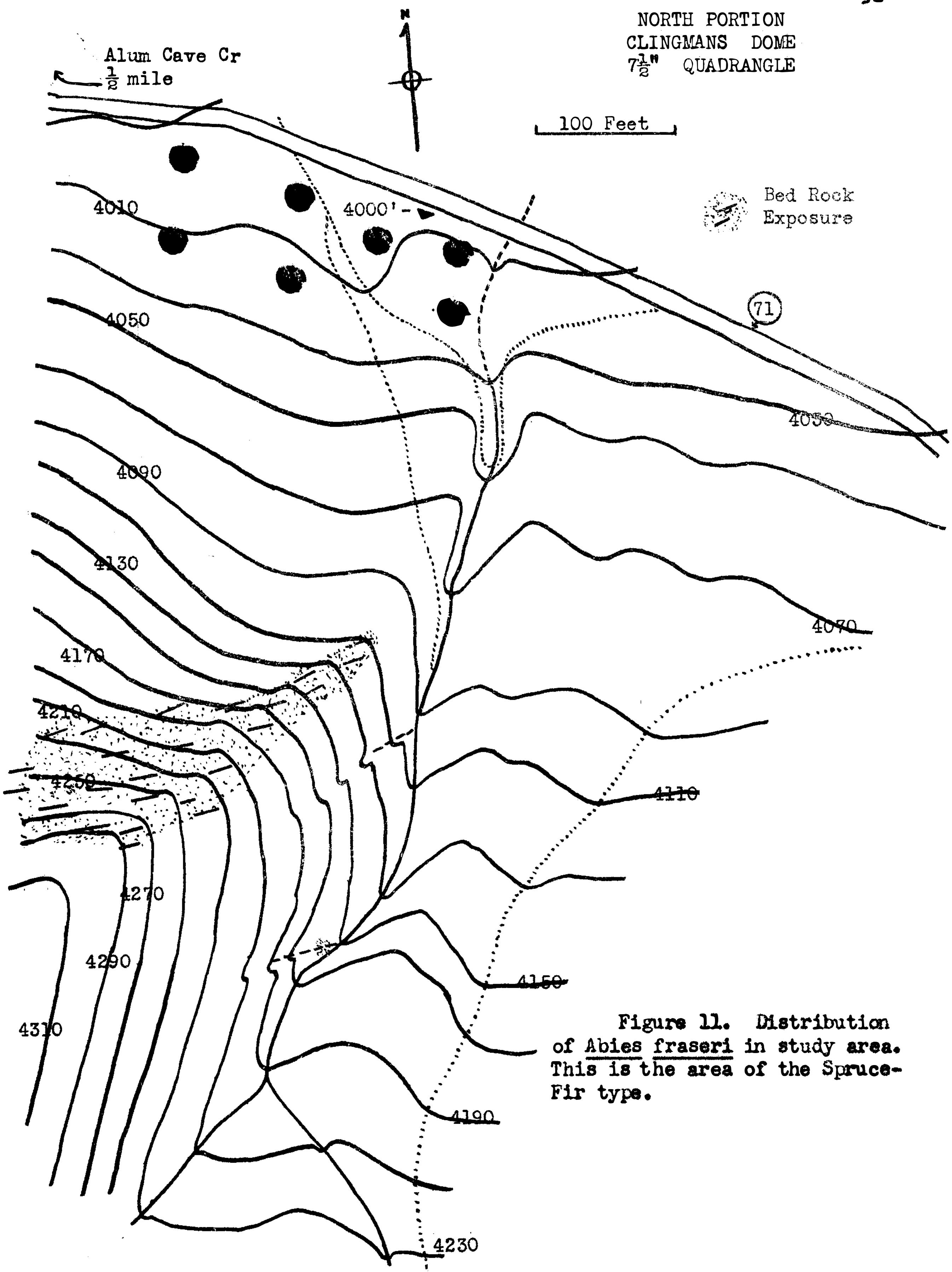

Figure 11. Distribution of Abies fraseri in study area. This is the area of the Spruce-Fir type.

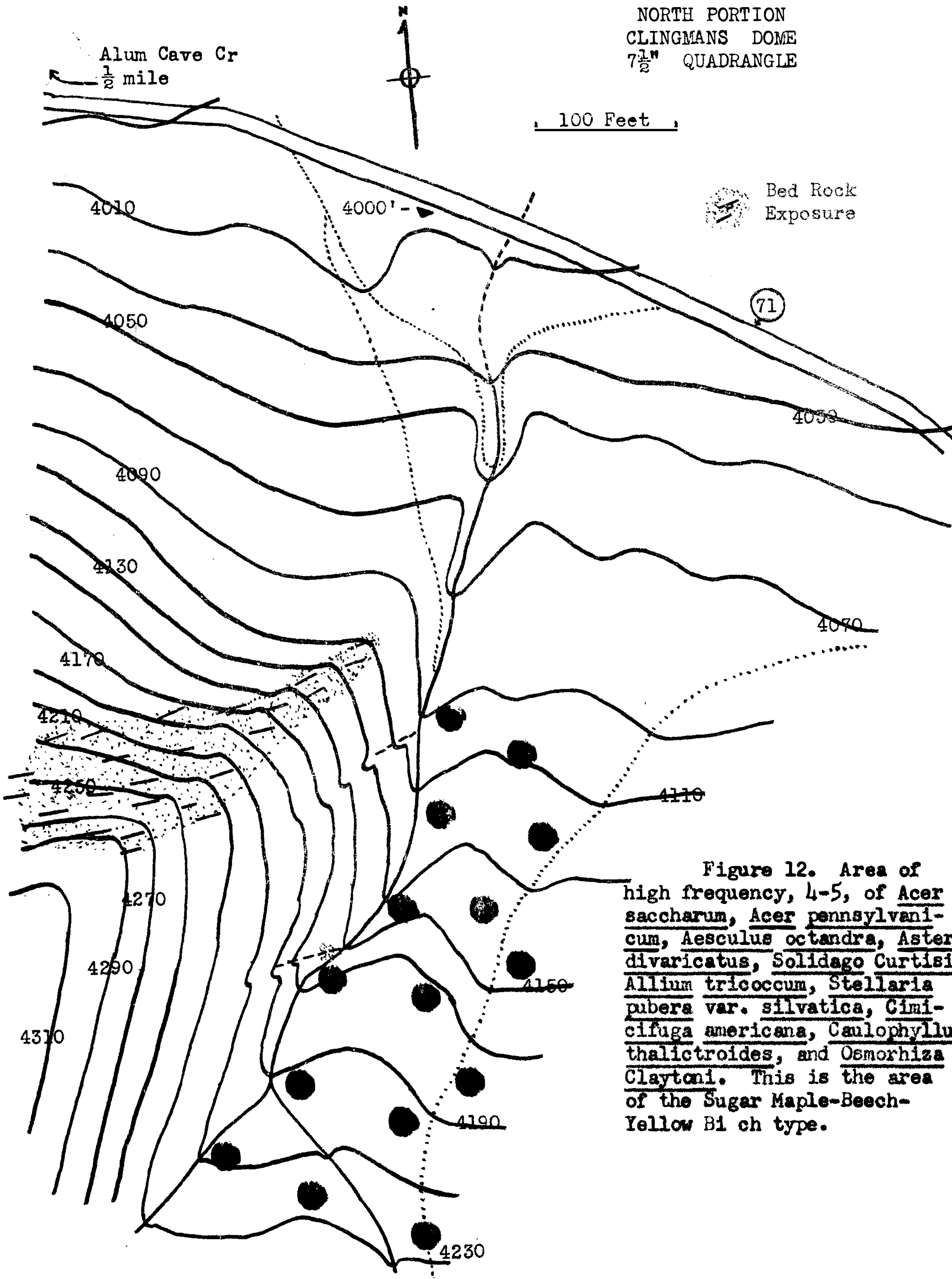

Figure 12. Area of high frequency, 4-5, of *Acer saccharum*, *Acer pennsylvanicum*, *Aesculus octandra*, *Aster divaricatus*, *Solidago Curtisii* *Allium tricoccum*, *Stellaria pubera* var. *silvatica*, *Cimicifuga americana*, *Caulophyllum thalictroides*, and *Osmorhiza Claytoni*. This is the area of the Sugar Maple-Beech-Yellow Bi ch type.

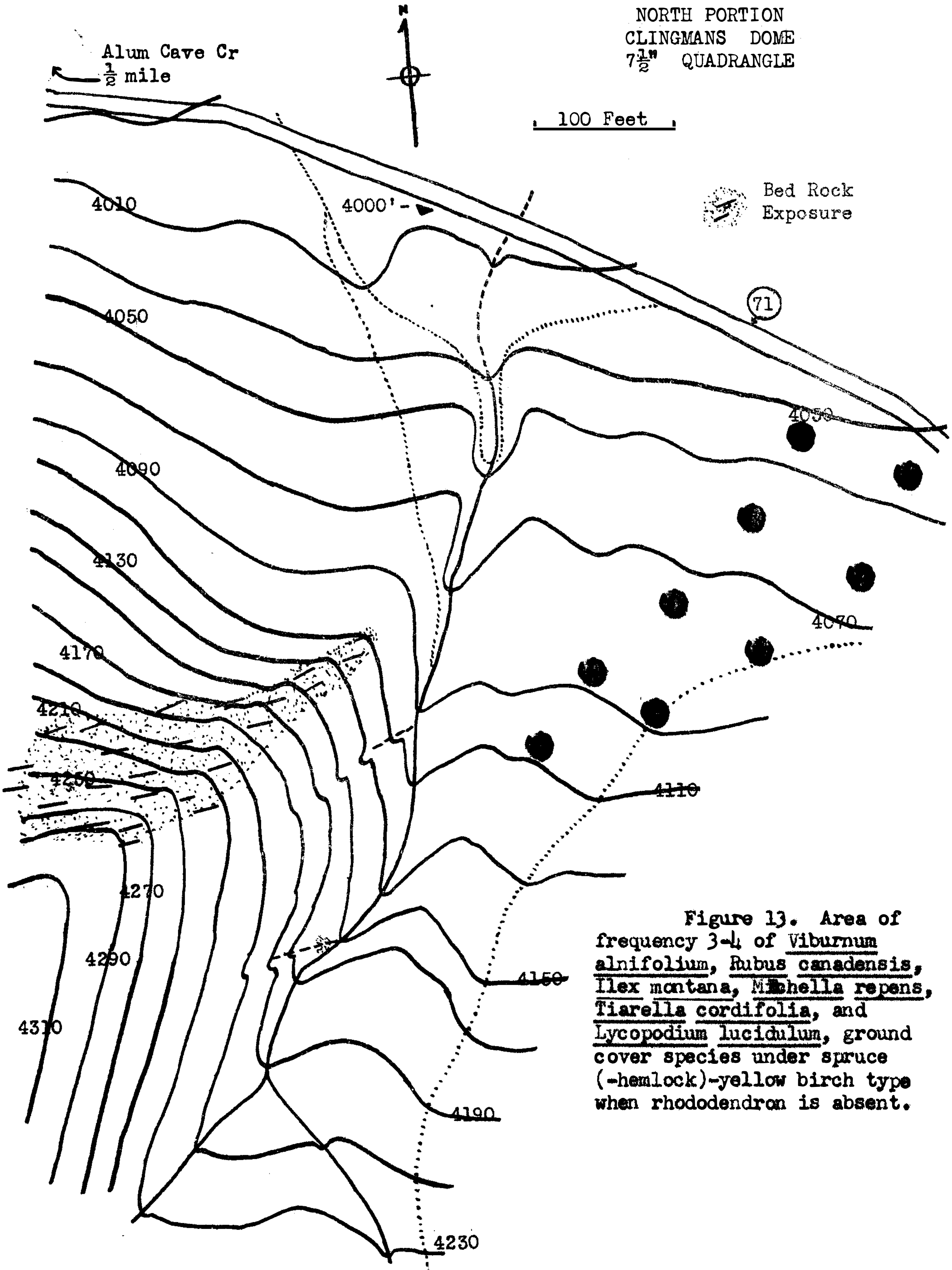

Figure 13. Area of frequency 3-4 of Viburnum alnifolium, Rubus canadensis, Ilex montana, Mitchella repens, Tiarella cordifolia, and Lycopodium lucidulum, ground cover species under spruce (-hemlock)-yellow birch type when rhododendron is absent.

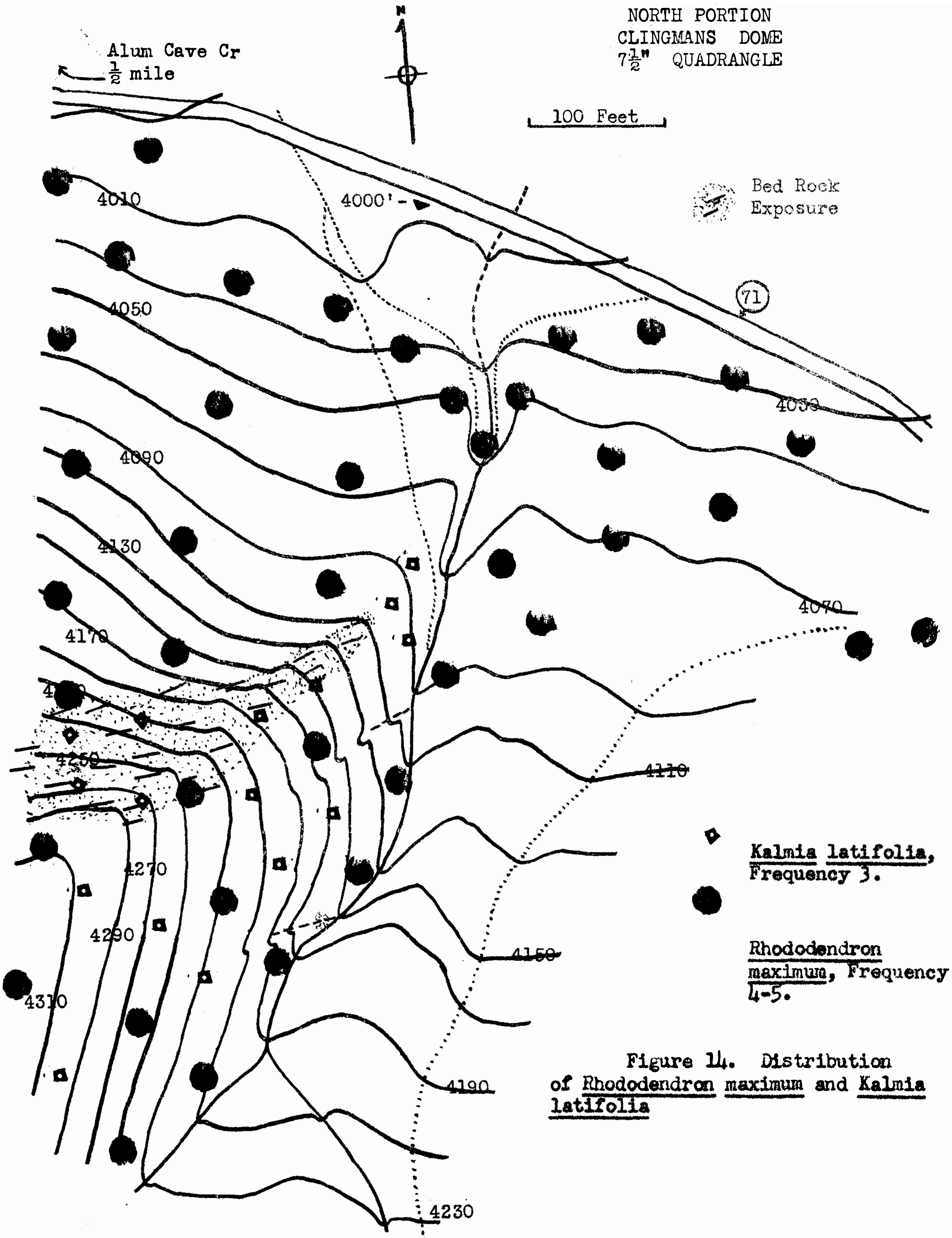

Figure 14. Distribution of *Rhododendron maximum* and *Kalmia latifolia*

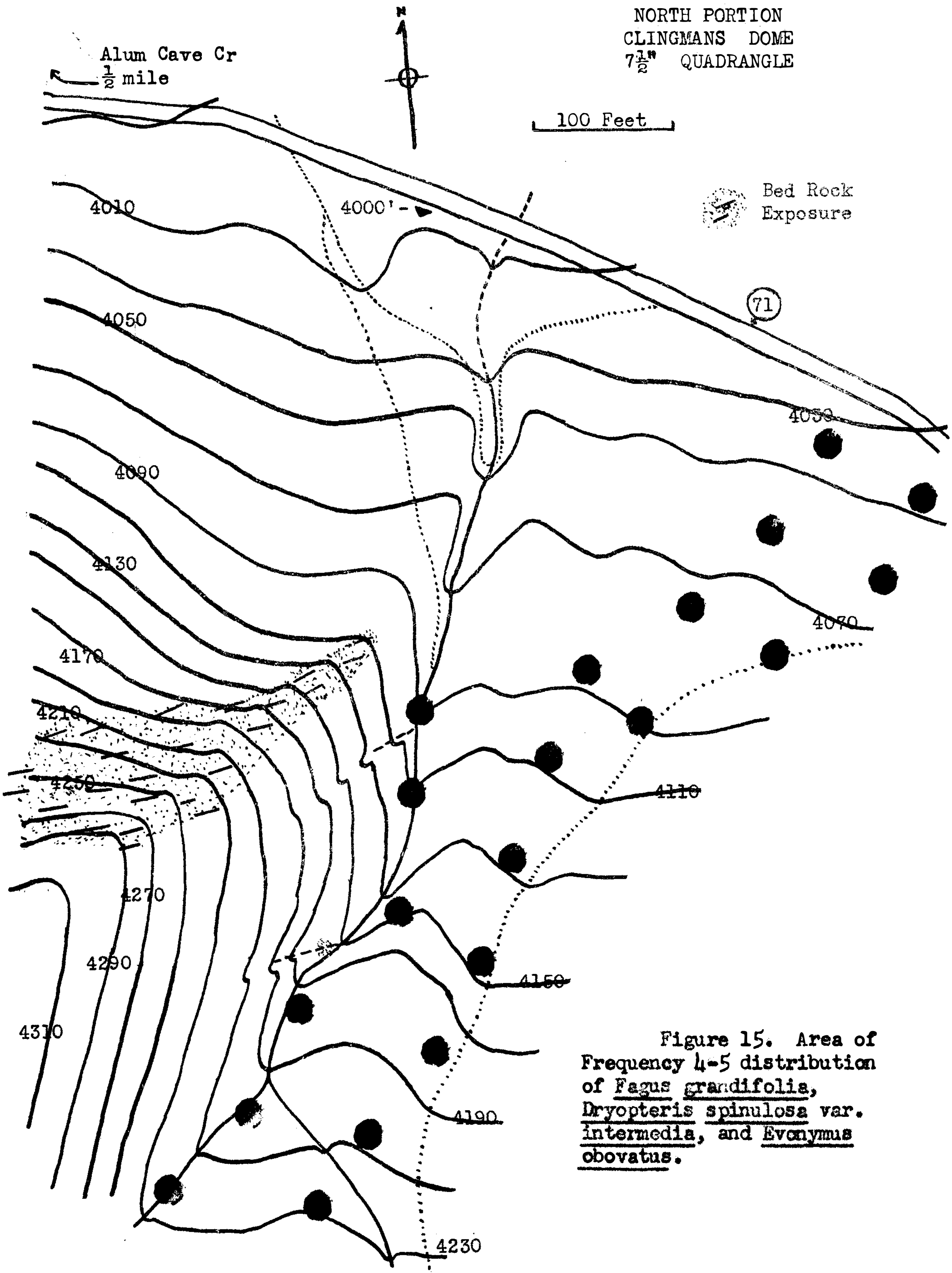

Figure 15. Area of Frequency 4-5 distribution of Fagus grandifolia, Dryopteris spinulosa var. intermedia, and Evonymus obovatus.