1958 No. 24

BLACK ROCK FOREST PAPERS

MICROCLIMATIC AND VEGETATIONAL STUDIES IN A COLD-WET DECIDUOUS FOREST

by

Philip Ross

This work was supported by the U. S. Army Quartermaster Research and Engineering Command under Contract DA 19-129-QM-572. The views and conclusions in this report are those of the authors and do not necessarily reflect the views, nor have the indorsement, of the Department of Defense.

HARVARD BLACK ROCK FOREST

CORNWALL-ON-THE-HUDSON, NEW YORK

LIST OF TABLES

LIST OF APPENDIXES

ABSTRACT

The Harvard Black Rock Forest, situated in Orange County, New York, on the north side of the Hudson Highlands, presents an ideal situation for studying vegetational composition and structure and microclimatic factors. During a period of sixteen months data on temperature and its vertical stratification, relative humidity, precipitation, soil moisture, and soil temperature were gathered from ten field stations and related to topography, soil, and vegetation.

Six plant associations were studied and mapped: mixed hardwood, hemlock-hardwood, Quercus rubra, Quercus Prinus, Quercus ilicifolia, and Quercus alba-Carya glabra.

Precipitation values show a decided rain-shadow effect on the Northern Slopes section where values averaged 40.62 inches for twelve months compared to values for Glycerine Hollow in the Highlands section which averaged 47.96 inches. The bottom of Glycerine Hollow where the monthly mean air temperatures for the summer months averaged 65.9°F was the coolest area; the south slope of Glycerine Hollow recorded the lowest monthly average during the winter at 25.7°F. The lower north slope of Black Rock Hill recorded warmer average temperatures than any other station: 70.8°F during the summer and 28.4°F during the winter months. During the study, average relative humidities were higher and average temperatures were lower at the field stations than at Stewart Field, a nearby Air Force Base where regular, standard weather observations are collected. Soil temperatures followed the trends of the mean air temperatures except during the winter when the soil temperatures averaged 32°F. The soil moisture averaged higher on the north slopes than at Glycerine Hollow; runoff and evaporation are probably responsible. Glaze was found to be an important factor in tree development.

Partial solutions for the causes of the distribution of the vegetation types are suggested. The mixed hardwood and the hemlock-hardwood associations are related to the deep till soils and the high soil moisture on the lower north slopes. Tsuga canadensis (Hemlock) is found predominantly in the cooler ravines. The Quercus Prinus (Chestnut Oak) association is related to low soil moisture in the thin soils on the steep upper slopes. The Quercus rubra (Red Oak) association is related to the more mesic conditions on the lower more level slopes. The Quercus ilicifolia (Scrub Oak) association found on the westerly sides of exposed hilltops is related to the dry conditions of the air and the soils in addition to lower average temperatures. The Quercus alba-Carya glabra (White Oak-Pignut Hickory) association is related to warmer soils, extremes in air temperatures, and low soil moisture.

ACKNOWLEDGMENTS

The study of the microclimates and vegetation of the Harvard Black Rock Forest was made possible by a contract with the United States Army Quartermaster Research and Engineering Command: Contract No. DA19-129-QM-572, Project No. 7-83-01-001A. The writer wishes to express his appreciation to Sigmund J. Falkowski, Project Officer, for his genuine interest and his helpful advice extended during the project.

The writer wishes to express his appreciation to Professor Hugh M. Raup, Director of the Harvard Forest and sponsor of the writer at Harvard University, for his help and encouragement during the research project. The writer acknowledges with appreciation Dr. John C. Goodlett for his helpful criticism of the manuscript. Sincere thanks are due to Benjamin B. Stout, Supervisor of the Harvard Black Rock Forest, for his help and cooperation during the period of the study.

To Lt. Col. G. A. Hoglund and Capt. John F. Disharoon, of the 12th Weather Squadron, Stewart Air Force Base, Newburgh, New York, the writer wishes to express his gratitude for providing meteorological data of the Base.

The writer is indebted to his wife Jane for her encouragement during the project and her advice and help in the preparation of the manuscript.

TABLE OF CONTENTS

Table of Contents (Continued)

LIST OF FIGURES

MICROCLIMATIC AND VEGETATIONAL STUDIES IN A COLD-WET DECIDUOUS FOREST

CHAPTER I

INTRODUCTION

Vegetation is acted upon and influenced by a complex of interacting factors. One approach to an understanding of vegetation is through a determination and description of the general characteristics of the vegetation such as composition and structure and the environmental factors affecting these characteristics.

The study of habitat climates, or microclimates, and their relation to vegetation is relatively new.[1] In Germany Gregor Kraus became the father of microclimatology with the publication of his book, "Boden und Klima auf klienstem Raum."[2] In the United States ecologists were publishing meteorological reports of local areas as early as 1901.[3] Since this time the study of microclimates and vegetation has developed along two lines: (1) the economic line is represented by research and investigation by the Weather Bureau in agricultural meteorology,[4] and by the study of forest fire weather factors;[5] and (2) the ecologic line is represented by research by botanical scientists emphasizing slope exposure,[6] soil environments,[7] meteorological factors,[8] and the nature of environmental responses in plants and vegetation.[9]

Objectives

The present study was organized to determine and to describe the microclimatic factors in the environmental complex of a cold-wet type of deciduous forest, the Harvard Black Rock Forest, and their relationship to the vegetation of the area.

The specific objectives of the study were as follows: (1) to gather data on temperature and its vertical stratification, relative humidity, precipitation, wind direction and velocity, solar radiation, and soil moisture and temperature variations for a period of sixteen months from a network of ten microclimatic stations located in the hilly Harvard Black Rock Forest; (2) to analyze the vegetation of the area; to map the distribution, location, and extent of the vegetation types; and to record the phenological development of the vegetation; (3) to analyze the microclimates of the ten selected sites in the Forest, in relation to topography, slope exposure, soil and vegetation; (4) to study special aspects of the moisture regime, namely, condensation and dew during the warm months and glaze formation during the cold months; (5) to apply the findings of the study to the problem of the distribution of the types, conditions, and locations of the various vegetation types and/or species of the vegetation cover present in the study area; and (6) to document the study with representative maps, diagrams, and photographs to illustrate the area and the conditions being analyzed.

---

[1] The following references have excellent reviews of the microclimatological literature: Bliss, 1956; Cantlon, 1953; Geiger, 1950; Wolfe, 1949.

[2] Geiger, 1950.

[3] Cowles, 1901.

[4] Batchelor, and West, 1915; Cox, 1910, 1923; Smith, 1920; Whitney, 1894.

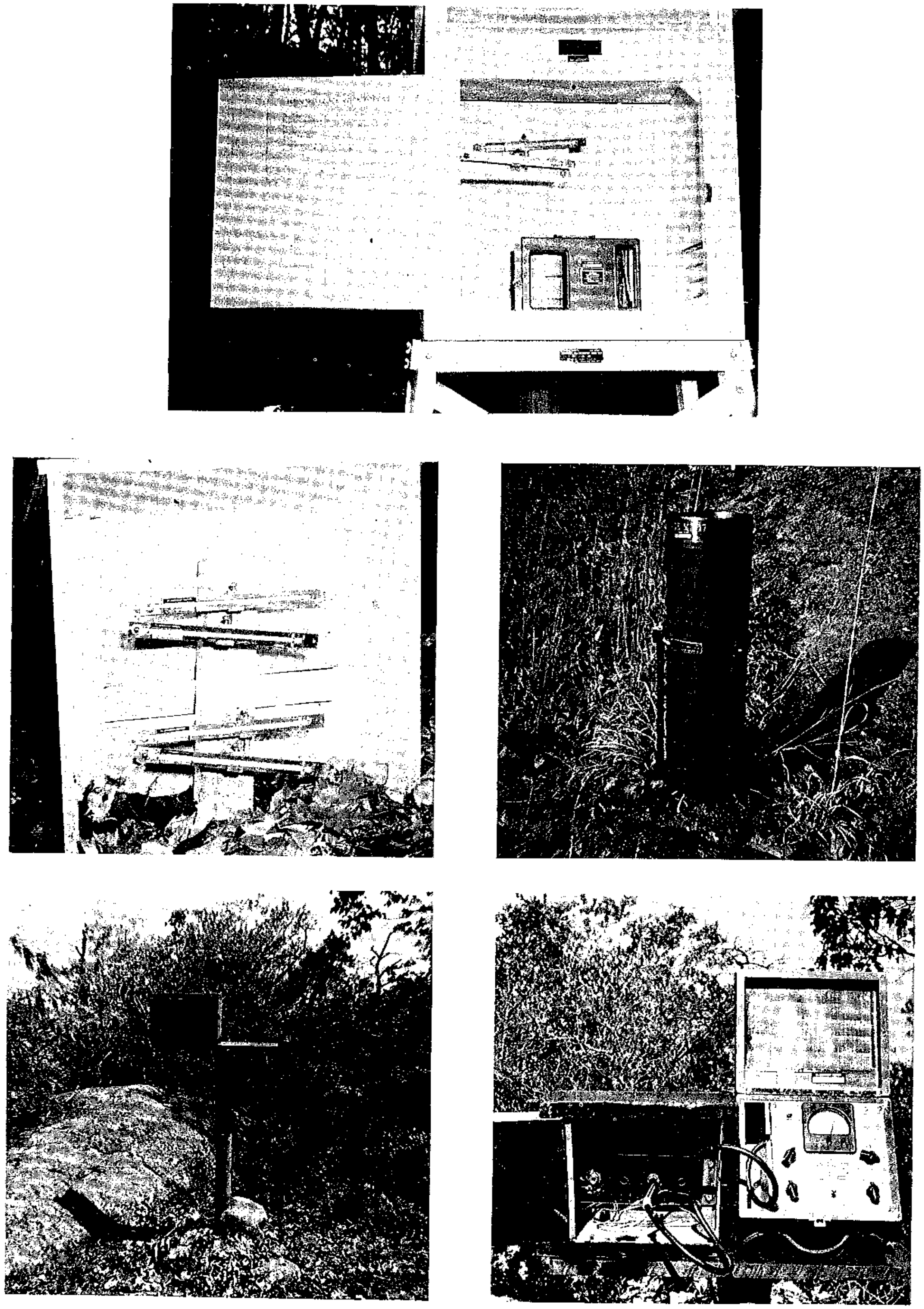
[5] Alexander, 1950; Gast and Stickel, 1929; Hawley, 1926; Hayes, 1941; Mitchell, 1929; Stickel, 1931.

[6] Aikman, 1941; Burns, 1953; Cantlon, 1953; Cottle, 1932; Harshberger, 1919; Pierce, 1934; Potzger, 1939; Young, 1920.

[7] Cain, 1951; Daubenmire, 1936; Graham, 1939; Larson, 1929.

[8] Burns, 1953; Fuller, 1912; Huffaker, 1942; Hough, 1945; Livingston, 1907; Thornthwaite, 1940; Veartaja, 1954.

[9] Cain, 1944; Daubenmire, 1937; Lundegårdh, 1931; Oosting, 1948.



1. Instruments installed at each field station.

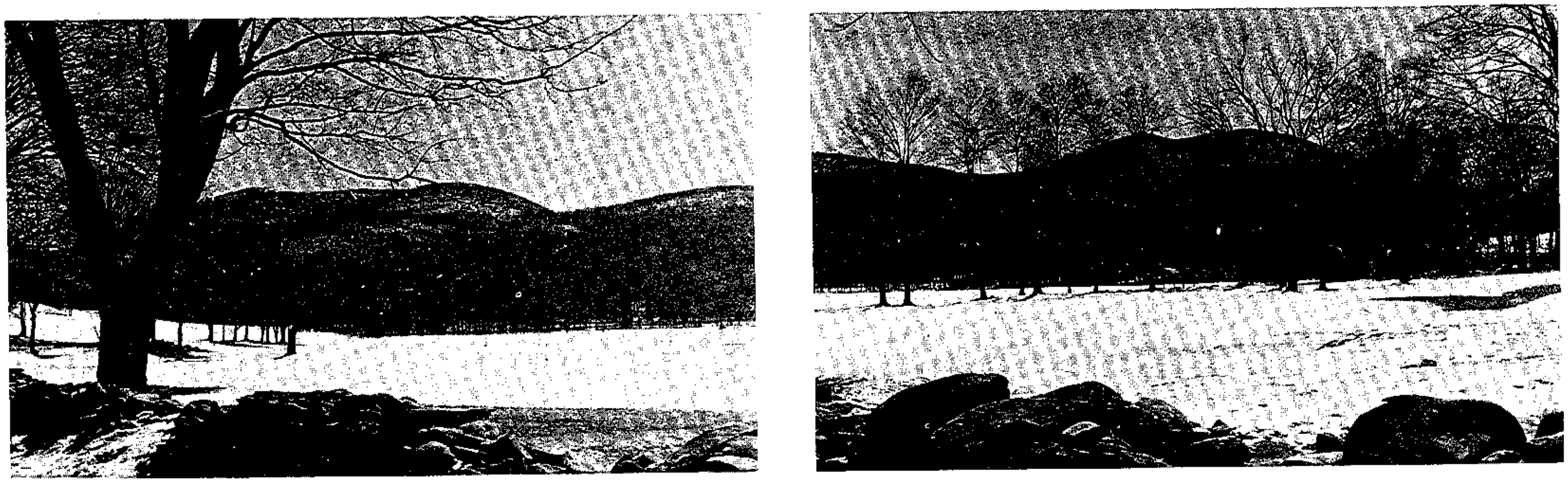
Upper: Instrument shelter with hygrothermograph and maximum-minimum thermometers.

Center left: Shelter with maximum-minimum thermometers.

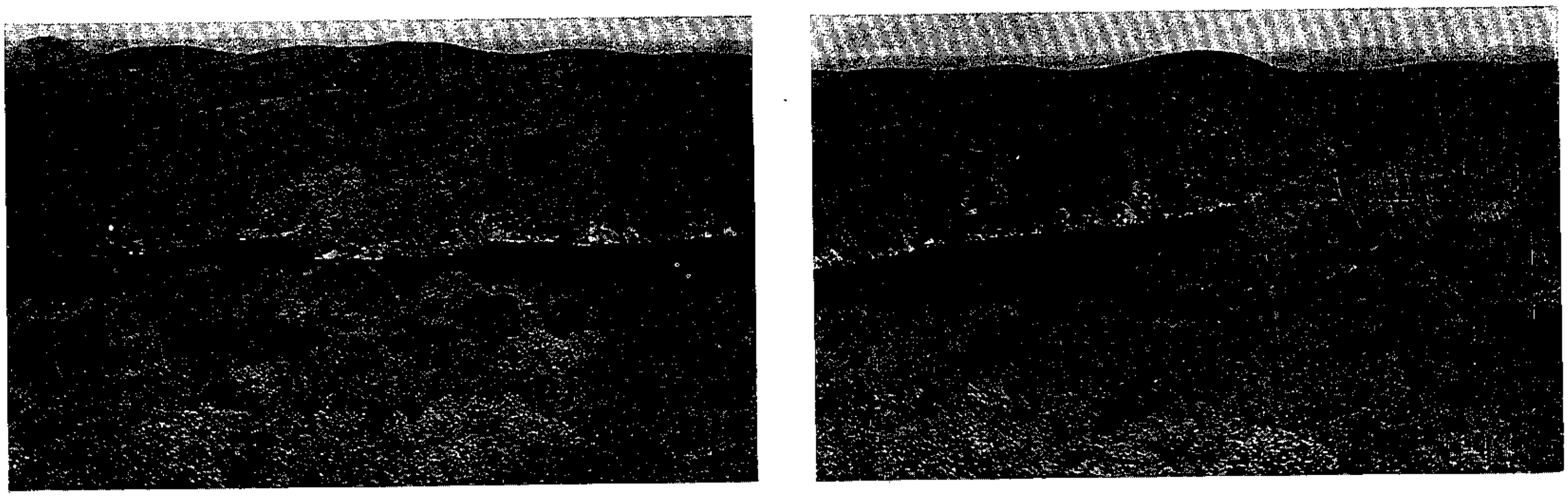
Center right: Precipitation gage.

Lower left: Soil moisture and soil temperature station.

Lower right: Terminal panel and measuring ohmmeter of soil moisture and soil temperature station.



2. Panorama of the Northern Slopes section of the Harvard Black Rock Forest. Viewed from the Cornwall Golf Course. January, 1957.



3. Panorama of the Highlands section of the Harvard Black Rock Forest. Viewed from the fire tower looking southeast. Arthur's Pond is in the center of the picture. July, 1957.

CHAPTER II

REGIONAL SETTING

Physiography

The Harvard Black Rock Forest is located in the towns of Cornwall and Highlands, Orange County, New York. The land in which the Forest is situated has been under single family ownership from the early 1900's. It was organized about 1928 as a "forest laboratory for research in problems of forest management and for the demonstration of successful methods in practice." [1] The Forest came under the direction and management of Harvard University in 1950, under the will of the late Dr. E. G. Stillman.

The Harvard Black Rock Forest is situated on the north side of the Hudson Highlands, part of a belt of rocky hills extending from southern New England across the Hudson River at Cornwall, New York, and southward through New Jersey. The rolling "Hudson Lowland" lies to the north and northwest of the Forest beyond Schunemunk Mountain.

The Forest area can be divided into two physiographic sections: the "Northern Slopes" section and the "Highlands" section. [2] The Northern Slopes section extends from the northern and lowest edge of the Forest, 420 feet above sea level, to about 1200 feet. This section comprises 1/3 of the Forest and is characterized by lower slopes of thick till and upper slopes of bedrock outcrops interspersed with masses of till. Sackett Hill, Frog Hill, Black Rock Hill, Honey Hill, and Mt. Misery are located in this section. Canterbury Brook and its tributary and Black Rock Brook drain this section and half of the Highlands section. The ravines cut by these brooks have steep, rocky slopes and rocky, terrace-like bottoms with small flood plains.

The Highlands section is located south of the Northern Slopes section and includes the remaining 2/3 of the Forest. It is a rolling, plateau-like area of swamps and hills with relief seldom over two hundred feet. The highest elevation in the Forest, Spy Rock, 1463 feet above sea level, is located in this section. The lower levels are the depressions, or "coves," of Cat Hollow, Aleck Meadow, and Glycerine Hollow. Above the general level of the Highlands stand several hills: Hill of Pines, 1400 feet; Rattlesnake Hill, 1400 feet, Black Rock Hill, 1410 feet; Spy Rock, 1463 feet; and Sackett Hill, 1320 feet. Drainage in the Highlands section is by Mineral Spring Brook, the brook in Cat Hollow, and Cascade Brook which flows through Glycerine Hollow. Figure 1, at the end of the report, shows the topography of the Northern Slopes and Highland sections of the Forest. The topographic map, Figure 4, included in this report shows the general features of the Harvard Black Rock Forest in detail.

Climate

The climate of the Harvard Black Rock Forest, a microthermal snow-forest climate, can be placed on the Daf climatic classification of Köppen. [4] The average temperature of the coldest month, January, falls below -3°C (26.6°F) while the average temperature of the warmest month, July, rises above 22°C (71.6°F). There is no regularly occurring dry season; the driest month receives more than 3 cm. (1.18 in.) of rain.

The following climatic data are from West Point, New York, which lies to the south of the Forest. Data were collected for thirty years, but the station was discontinued in 1948. The average January temperature was 28.3°F (warmer than Forest temperatures during the study), while July had an average temperature of 74.6°F. The maximum temperature recorded reached 106°F, and the lowest temperature was recorded at -17°F. The average date of the last killing frost in spring was April 19; the average date of the first killing frost in autumn was October 30. The average growing season was 194 days. The average precipitation was 41.18 inches. February was the only month with an average precipitation under 3 inches. The prevailing winds were westerlies with considerable differences in direction resulting from the topography. The average annual number of clear days for the state of New York was 133, partly cloudy 105, and cloudy 127. [5]

The U. S. Army Quartermaster Corps has described two areas in the United States as cold-wet regions, that is, areas where the greatest frequency of cold-wet conditions exist. The Harvard Black Rock Forest is included in one of these areas. Cold-wet conditions have been characterized by

> . . . temperatures that are often near or below freezing (32°F), especially during the night, but that may be above freezing during the day; abundant precipitation, generally in the form of snow, sleet, or chilling rains; much cloudiness and some wind.[6]

According to Meigs and de Percin the percent frequency of occurrence of cold-wet conditions in southern New York State is above 20 percent from October through May.

Soils

The soils of the Forest are formed upon a parent material of glacial till which was deposited upon a granitic bedrock. The ice in its north to south and southeast movement, deposited a thick till upon the bedrock surface of the Northern Slopes section of the Forest and a thin and discontinuous till on the Highlands section. During the withdrawal of the ice the till was exposed to the rigors of the periglacial climate. Intense frost action disturbed and altered the exposed surface of the till forming a layer of warp, or congeliturbate. Post-glacial weathering has only slightly altered this layer.[7]

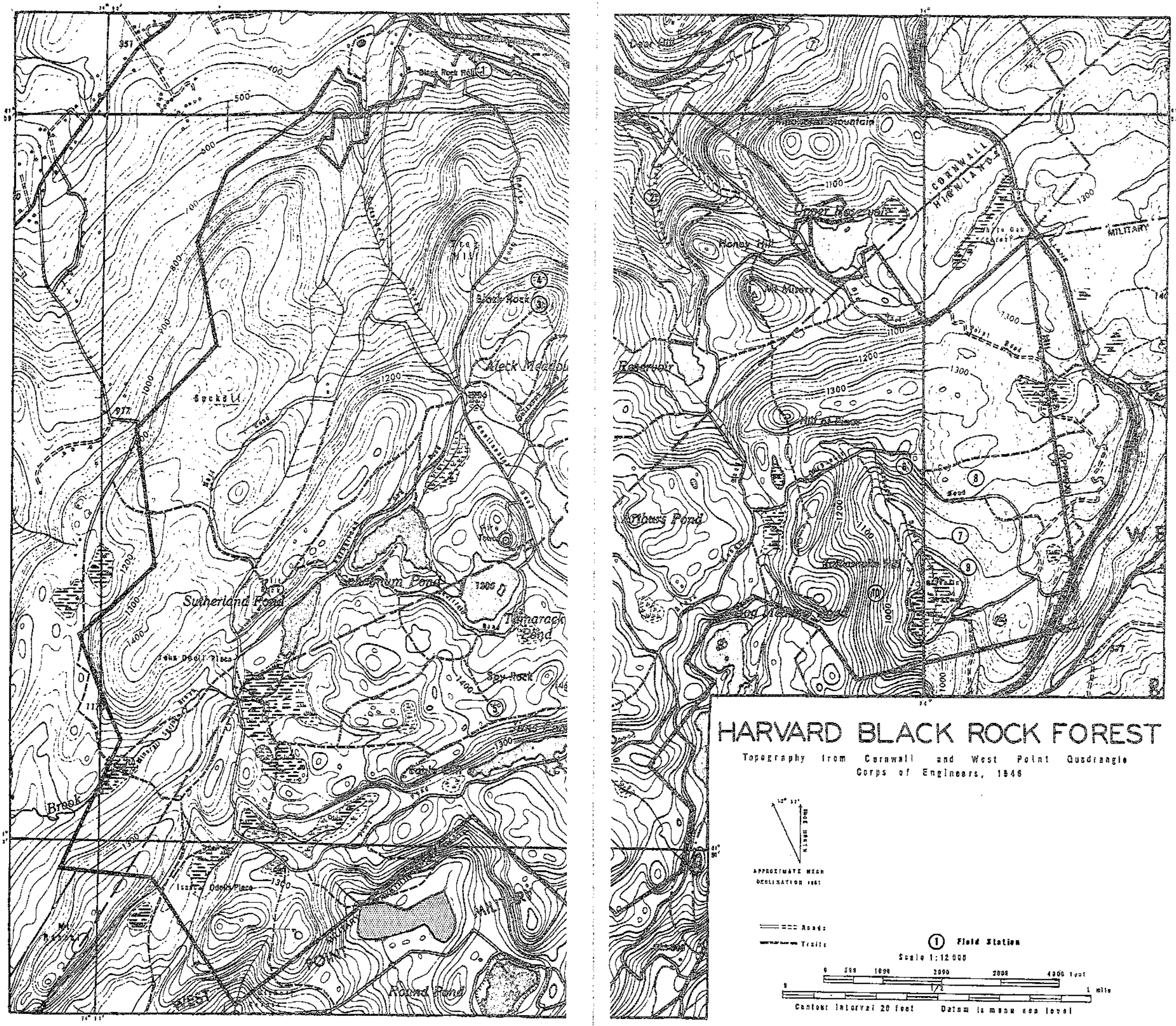
The following account of the glacial till in the Forest is summarized from Denny's paper. The slopes of the Forest are covered by material upon which two kinds of frost action have been operative. In forming the congeliturbate layer the disturbed soil surface layer has moved down slope under the process of solifluction. Cn the steeper northwest and southwest slopes large blocks, congelifractates, have been split off and rolled down slope as talus. Consequently on the steeper lower slopes a mass of pebbles and boulders overlies weathered till and the upper slopes have a rather rounded surface. The entire Forest presents a picture of smooth surfaces brought about by intense periglacial frost action. The boundary between the thick glacial deposits and the thin till is evident and has been mapped by Denny. This boundary, important not only to the developing soils but also to the vegetation, is shown on the soil and vegetation maps.

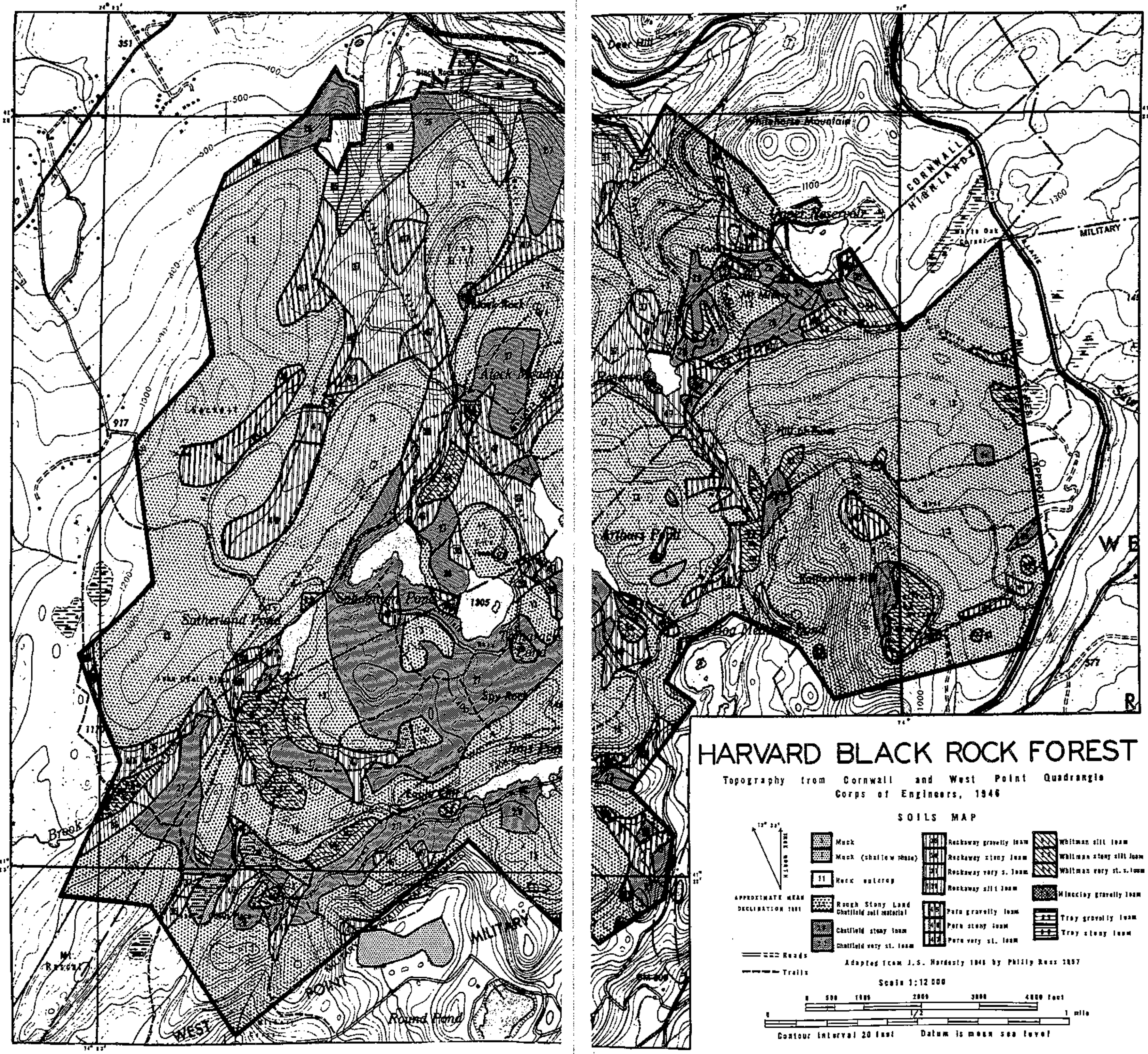
A profile through the thick deposits of the Forest shows a compact, bluish gray till resting on glaciated bedrock. The upper part of the till is stained with limonite and slightly weathered. Above this lies a loose yellowish-brown, slightly weathered congeliturbate. The deposits covering most of the highlands of the Forest consist of a thin, sandy layer of compact and weathered till of yellowish-brown color resting on slightly weathered bedrock. Above the weathered till lies a horizon of loose yellowish-brown weathered congeliturbate. It is upon the congeliturbate layer that the brown forest soils have formed.

The soils of the Harvard Black Rock Forest are classified as brown podzolic soils. Most of the Forest surface is covered by a shallow Mor type of humus. Recent leaf litter covers the surface of the soils and is underlain by a partly decomposed, semi-fibrous mat of felted hardwood debris ranging from 0.5 inches to 2 inches or more in thickness. In a few scattered spots where moisture is sufficient for earthworm activity a shallow granular Mull type of humus has developed. In the coves and especially on the north slopes a deeper layer of humus in all stages of decomposition can be found. Below this humus layer is a dark brown mineral soil from 4 to 6 inches in thickness. The subsoil is yellowish-brown in color grading into lighter colored material at a depth of 2 feet.[8]

Six soil series, 15 soil types, and 4 other soil separations were identified and mapped by J. Stewart Hardesty of the Soil Conservation Service in the spring of 1940.[9] Chatfield soil material, the most common soil series, was mapped on rough stony land and covers some 57 percent of the entire area of the Forest. Ninety-four percent of the Forest lands is classified as having stony to very stony soils. The soils map, Figure 5, shows the distribution of the soil types and other soil separations as mapped by Hardesty.

The following descriptions of the soils are summarized from Hardesty's report. The Chatfield soil series has developed on the thin glacial till derived from gneiss and granite. This series occupies 546 acres of the Forest. The series is characterized by having brown surface soils with brownish-yellow subsoils and being interrupted by numerous rock outcrops. These soils are low in fertility and very strongly acid. The Chatfield soils are found in the Highlands section on the sides and tops of the ridges and hills.


HARVARD BLACK ROCK FOREST
Topography from Cornwall and West Point Quadrangle
Corps of Engineers, 1946
APPROXIMATE MEAN DECLINATION 1951
Roads
Trails
Field Station
Scale 1:12 000
Contour interval 20 feet
Datum is mean sea level
Sutherland Pond
Tamarack Pond
Sphagnum Pond
Aleck Meadow
Black Rock
Round Pond
Upper Reservoir
Honey Hill
Arthurs Pond
CORNWALL
MILITARY
Brook



HARVARD BLACK ROCK FOREST
Topography from Cornwall and West Point Quadrangle
Corps of Engineers, 1946
SOILS MAP
TRUE NORTH
APPROXIMATE MEAN DECLINATION 1951
Muck
Muck (shallow phase)
Rock outcrop
Rough Stony Land Chatfield soil material
Chatfield stony loam
Chatfield very st. loam
Rockaway gravelly loam
Rockaway stony loam
Rockaway very s. loam
Rockaway silt loam
Pura gravelly loam
Pura stony loam
Pura very st. loam
Whitman silt loam
Whitman stony silt loam
Whitman very st. s. loam
Hinckley gravelly loam
Troy gravelly loam
Troy stony loam
Roads
Trails
Scale 1:12 000
0 500 1000 2000 3000 4000 feet
0 1/2 1 mile
Contour interval 20 feet
Datum is mean sea level
Sutherland Pond
Round Pond
Deer Hill
Whitehorse Mountain
CORNWALL HIGHLANDS
MILITARY
WEST
Brook
1305
1000
1100
1300
500

Rockaway soils are similar in texture, fertility, and acidity to the Chatfield soils but have developed on deep glacial till. They have a friable dark-brown surface soil with heavier brownish-yellow, firm but friable, porous subsoils. These soils occupy 221 acres in the Forest mainly on the lower north slopes.

Peru soils have also developed on deep till but with varying amounts of sandstone. They are poorly drained due to an impervious "hardpan" layer in the subsoil. The 304 acres of Peru soils are found in the coves and depression areas.

Whitman soils, closely associated with the Peru series, occupy 129 acres in poorly drained depressions and sources of small streams. They lack the "hardpan" layer and have a dark, grayish-brown loam surface soil and a highly mottled, gray subsoil.

Troy soils have developed on a deep glacial till derived from sandstones, shales, and limestones. The soil is grayish-brown and friable on the surface, yellowish-brown, firm, and compact in the subsoil with calcareous till at depths of 4 feet or more. These valley-fill soils occupy only 69 acres.

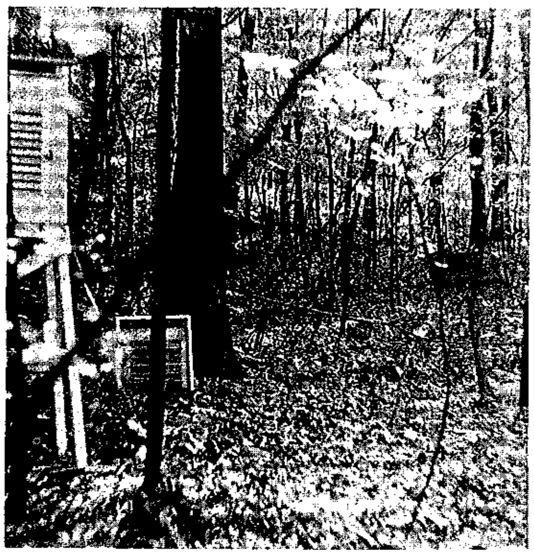
Hinkley soils have developed on deposits of glacial outwash. Only one small area, 2 acres, has been mapped in the Forest. Muck soils are found throughout the Forest in swampy depressions and occupy 27 acres.

---

[1] Tryon, 1930.
[2] Denny, 1938.
[3] For a detailed description of the physiography of the Forest see Denny, 1938.
[4] Köppen, 1931.
[5] U.S. Department of Agriculture Yearbook, 1941.
[6] Meigs and de Percin, 1956.
[7] Denny, 1938.
[8] Schulz, 1931.
[9] Hardesty, 1940.

May 10, 1956

July 30, 1956



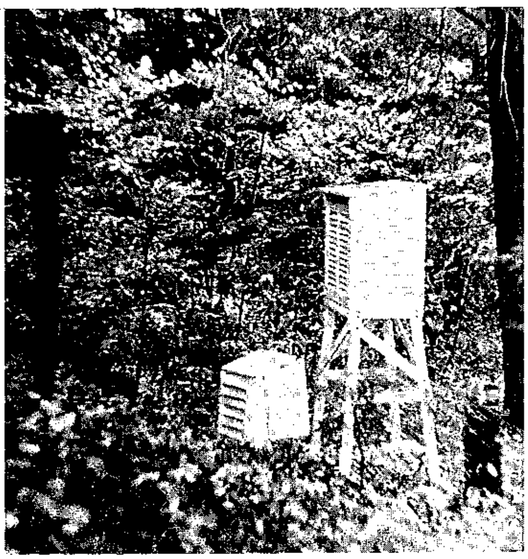
October 10, 1956

February 1, 1957

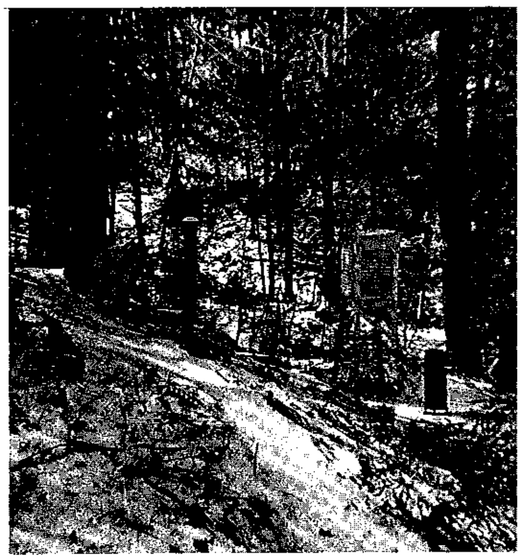
6. Field Station No. 1: lower north slope of Black Rock Hill. This station at an elevation of 480 feet was situated near the lowest area of the Forest. The vegetation type is the mixed hardwood association.

May 10, 1956

July 30, 1956



October 10, 1956



February 1, 1957

7. Field Station No. 2: Black Rock Brook ravine. The vegetation type is the hemlock-hardwood association.

CHAPTER III

METHODS OF STUDY

General Procedure

The microclimate of the Harvard Black Rock Forest was studied for a period of sixteen months, April, 1956, to August, 1957. A network of weather stations was installed both within and outside the forest canopy to gather data on (1) temperature and its vertical stratification, (2) relative humidity, and (3) precipitation. Soil moisture and temperature observations were also obtained at these sites.

Solar radiation data were obtained with an Eppley Pyrheliometer and a Leeds and Northrup two point potentiometer recorder installed at the office of the Harvard Black Rock Forest. Barometric readings were also recorded here. Climatic data were also obtained from the Stewart Air Field, an Air Force Base at Newburgh, New York, eight miles north of the Forest. This station was selected for comparison with the field stations in the Forest because it was desired to determine the degree of differences that can be expected between observations at a regular observing station and those within the Forest proper.

The vegetation of the Harvard Black Rock Forest was studied by means of quadrats set up at each microclimatic station. A map of the vegetation for the area under study was made by field observations and aerial photographs. Phenological observations were recorded by means of photographs and by field notes.

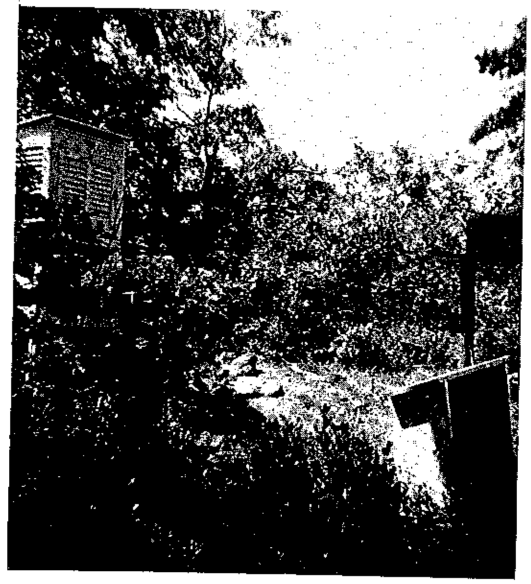
Description of Sites

Sites for the study of the microclimate and the vegetation in the Harvard Black Rock Forest were selected with regard to vegetation, physiography, and soils. Sites No. 1 through 4 were located in the Northern Slopes section of the Forest; Sites No. 5 through 10 were located in the Highlands section. Figures 6 through 15 show the general features of the 10 sites.

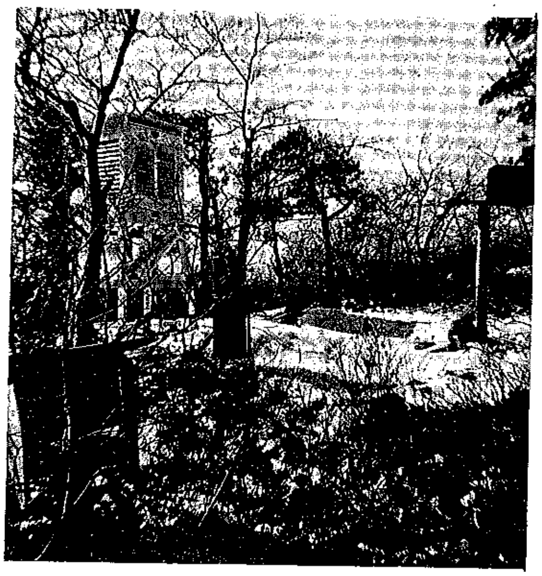
Site No. 1 was located at the base of the northern slope of Black Rock Hill at 480 feet on the deep glacial till soils. The vegetation at this site is classified as a mixed hardwood association, comprising primarily the following trees: Acer saccharum, Quercus rubra var. borealis, Q. velutina, Q. Prinus, Q. alba, Fraxinus americana, and Carya ovata. Site No. 2 was located in Black Rock Brook Ravine halfway down the west-facing slope at the 700 foot level. The brook has cut a ravine 50 feet into the deep glacial till at this location. Honey Hill rises to 1140 feet to the southeast of this site, and Black Rock Hill rises to 1410 feet to the southwest. The vegetation is similar to Site No. 1 except for an increase of Tsuga canadensis and is classified as a hemlock-mixed hardwood association. Site No. 3 was located on the rocky summit of Black Rock Hill. To the north the hill mass slopes sharply to the Newburgh lowland four miles away. The area to the south is part of the rolling Highlands section. The Quercus ilicifolia association, Pinus rigida phase, is the vegetation type on the summit. Site No. 4 was located 310 feet down the steep north slope from the summit of Black Rock Hill at the 1100 foot level. This site was located in the open Quercus Prinus association. Site No. 5 was located in the Highlands section of the Forest near a rock outcrop at an altitude of 1461 feet. The vegetation is representative of the Quercus ilicifolia association, Quercus coccinea phase.

Additional sites were selected in the southeastern section of the Forest around the bowl-shaped area known as Glycerine Hollow. Site No. 6 was located at 1160 feet in a swampy depression just off the Carpenter Road near the head of Glycerine Hollow. A brook flows through the area maintaining a high water table in the depression. The vegetation is of the mixed hardwood association, swamp phase, with Betula lutea, Acer rubrum, Liriodendron Tulipifera the major tree species. Site No. 7 was located at 1160 feet on the west-facing slope of Glycerine Hollow in a Quercus Prinus association. Site No. 8 was located on a south-facing slope at an altitude of 1180 feet. The vegetation is typical of the Quercus alba-Carya glabra association. Site No. 9

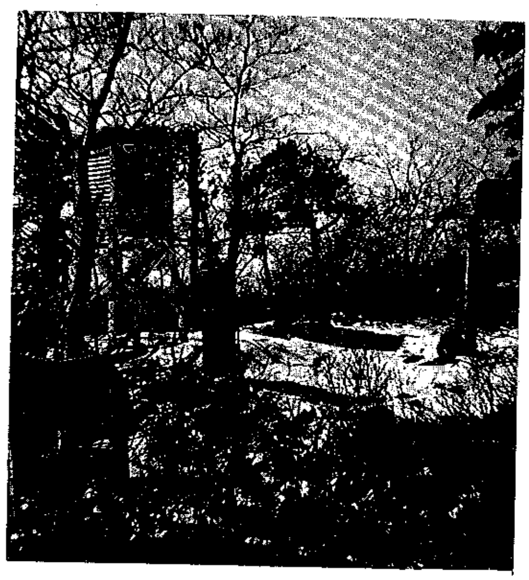
May 10, 1956



July 30, 1956



October 10, 1956



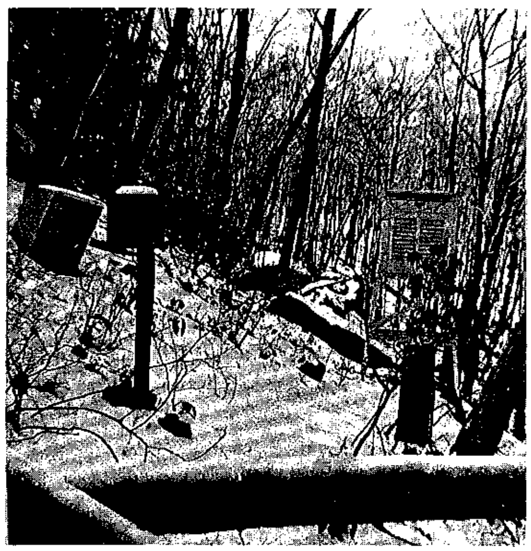
February 1, 1957

8. Field Station No. 3: Black Rock Hill summit. The vegetation type is the Quercus ilicifolia (Scrub Oak) association.

May 10, 1956

July 30, 1956

October 10, 1956



February 1, 1957

9. Field Station No. 4: north slope of Black Rock Hill. The vegetation type is the Quercus Prinus (Chestnut Oak) association.

was located in the moist, flat bottom of Glycerine Hollow at the 900 foot level in a Quercus rubra association. Site No. 10 was located at the 1100 foot level of the steep east-facing slope of the Hollow. Rattlesnake Hill rises to 1400 feet directly west of the site. The Quercus rubra association is the vegetation type at this site.

Field Stations

A standard meteorological instrument shelter was installed at each site, oriented to face the north. The shelter housed a maximum thermometer, a minimum thermometer, and a Bendix-Friez Model No. 594 hygrothermograph. A thermograph, instead of the hygrothermograph, was used at Station No. 8. The hygrothermographs were checked frequently with a sling psychrometer to insure accurate readings. Maximum and minimum temperatures were obtained at 7.5 cm and 25 cm above the surface of the ground at each site, utilizing maximum and minimum thermometers. For protection from direct solar radiation a three-sided shelter, louvred and roofed, was placed over the instruments with the open side facing north. During the winter months, December through March, the shelter and the thermometers were secured to a nearby tree by means of a moveable iron band fastened with a bolt and wing nut. With this arrangement the instruments could be kept at the required height above the ground, or surface of the snow. Each site was provided with a standard 8 inch Lietz precipitation gage. During the winter months the funnel and the inner cylinder were removed and the snow and rain caught directly in the larger cylinder. Ice and snow were melted by a portable alcohol stove and measured weekly as liquid precipitation. Figure 1 shows the instruments installed at each site.

Soil Moisture and Soil Temperature Stations

At each of the ten field stations, fiberglas units were installed to obtain soil moisture and temperature data. The fiberglas unit selected for this study is more durable than other similar equipment and provides more accurate soil-moisture measurements.[1] The unit also differs from other types in that each contains a thermistor, thus permitting soil-temperature measurements to be taken with each soil-moisture measurement. Procedures described by Lull and Reinhart for the installation, calibration, and measurement of the soil moisture and soil temperature units were followed. Figure 1 shows the terminal housing box and soil moisture ohmmeter used during the project.

Two fiberglas units were installed in the sides of a pit: the first, at the soil surface beneath the humus layer, and the second, 30 cm below the soil surface. The units were not placed deeper because the soil depth at eight of the ten sites was less than 40 cm thick. The units were pressed into the moist soil perpendicular to the surface so as to offer the least possible impediment to vertical water movement in the soil. To insure against the possibility of waterflow down the soil-unit cables, the cables were led downward 6 cm from the units, then led for 30 cm under the surface of the soil before being brought above ground. The soil was then replaced and repacked.

Wires from the soil units were led to a terminal housing box placed on a post one meter above the ground. The box was fastened to the side of a small platform that also provided a support for the soil-moisture ohmmeter when temperature and moisture measurements were being made. The wires from each sensing element were connected to a triple-contact phone jack secured to a Plexiglas terminal panel mounted in the box.

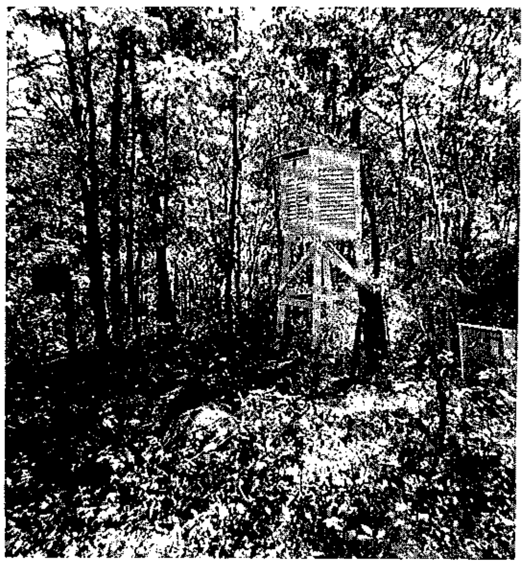
The fiberglas units were calibrated by laboratory and field methods after installation at each station. The laboratory method consisted of drying, periodically weighing the soil samples, and measuring the resistances of an inserted fiberglas unit. The field method consisted of taking gravimetric samples over the range of soil moisture in 6-ounce cans from an area close to the soil units. The percent volume of soil moisture in each sample was then plotted with the corresponding measured resistance on semi-logarithmic graph paper to form a calibration curve. The calibration curves from both field and laboratory methods were compared and found to differ by not more than 3 percent.

Vegetational Studies

The vegetation of the Forest was studied as to its composition and distribution and then mapped. The vegetation was classified as to plant associations to provide a means for characterizing or describing the vegetation, for comparing the plant communities of the Forest, and

May 10, 1956

July 30, 1956

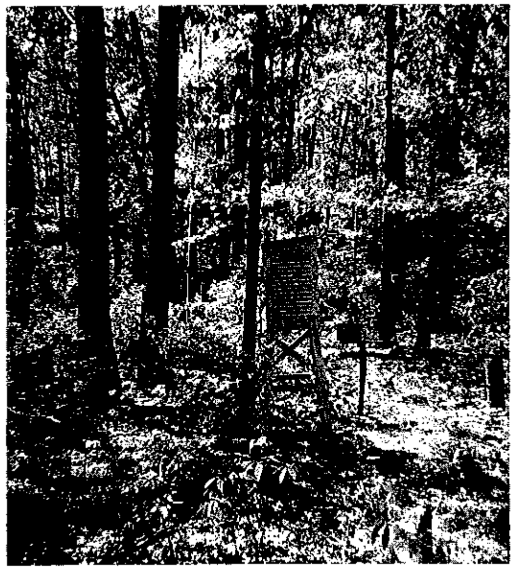


October 10, 1956

February 1, 1957

10. Field Station No. 5: rock outcrop off Eagle Cliff Trail. This station at 1461 feet was situated near the highest elevation in the Forest. The vegetation type is the *Quercus ilicifolia* (Scrub Oak) association.

May 10, 1956

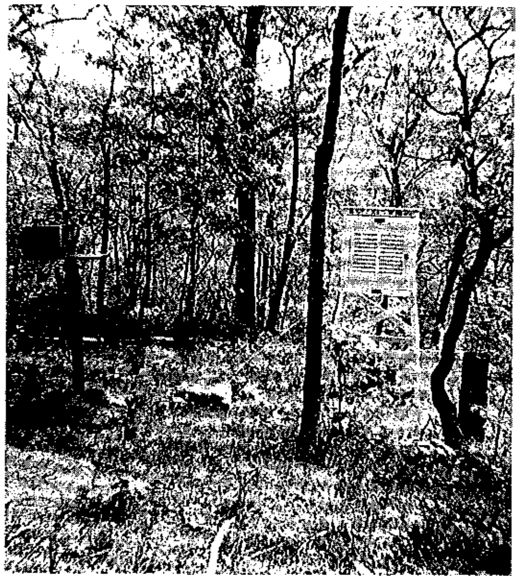


July 30, 1956

October 10, 1956

February 1, 1957

11. Field Station No. 6: swamp off Carpenter Road. The vegetation type is the mixed hardwood association.



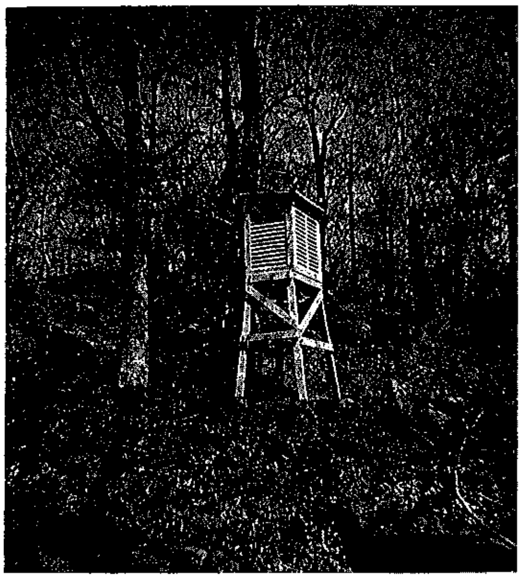
May 10, 1956

July 30, 1956

October 10, 1956

February 1, 1957

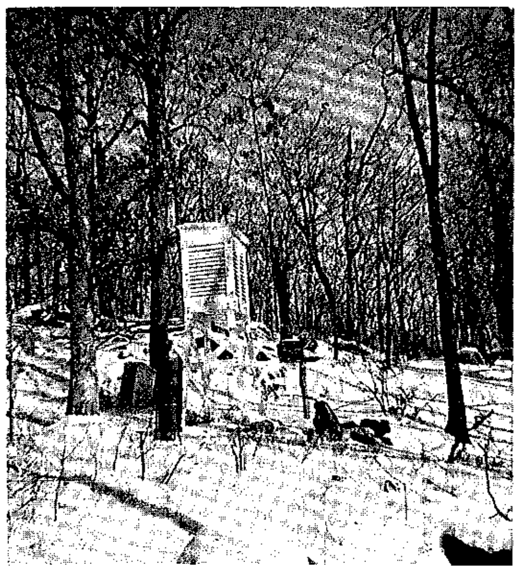
12. Field Station No. 7: west-facing slope of Glycerine Hollow. The vegetation type is the Quercus Prinus (Chestnut Oak) association.



May 10, 1956

July 30, 1956

October 10, 1956



February 1, 1957

13. Field Station No. 8: south-facing slope off Carpenter Road. The vegetation type is the Quercus alba-Carya glabra (White Oak-Pignut Hickory) association.

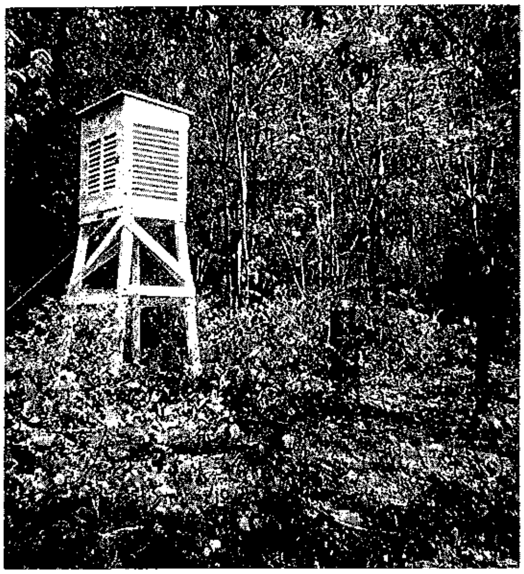
for providing a permanent record of the nature and occurrence of the plant communities.

Quadrats were laid out in a checkerboard pattern at each of the sites chosen for the studies in order to provide a quantitative analysis of their vegetation. Each quadrat consisted of a ten by ten meter area for the listing of all trees two inches in diameter and greater, a four by four meter area for the listing of low trees and tall shrubs, and two by two meter area for the listing of small shrubs, and a one by one meter area for the listing of the herbaceous vegetation. After the plants were listed for each quadrat, species area curves were drawn to establish the number of quadrats necessary to sample adequately the area under study.[2] Usually ten quadrats were necessary at each site. From the data collected by quadrating, frequency and density figures were calculated for the plants at each site.

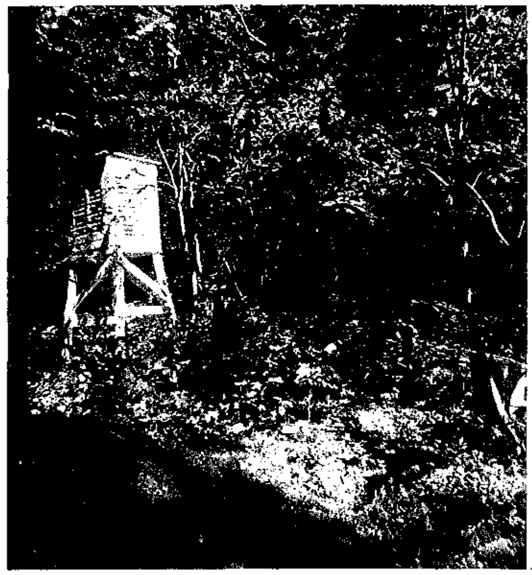
The plant associations mapped are defined as follows: (1) the mixed hardwood association has three or more primary trees occurring in any combination, Acer saccharum, Acer rubrum, Quercus rubra var. borealis, Q. alba, Q. velutina, Carya cordiformis, Fraxinus americana, Betula lutea, and Liriodendron Tulipifera; (2) the hemlock-hardwood association is composed of the same hardwoods as listed above but also has Tsuga canadensis as a primary tree; (3) the Quercus rubra association has Quercus rubra var. borealis in approximately 2:1 ratio to Quercus Prinus; (4) the Quercus Prinus association has Quercus Prinus in approximately 2:1 ratio to Quercus rubra var. borealis; (5) the Quercus ilicifolia association has the shrub Quercus ilicifolia as a primary species; (6) the Quercus alba-Carya glabra association has 75 percent of the total number of trees made up of the two primary trees.

---

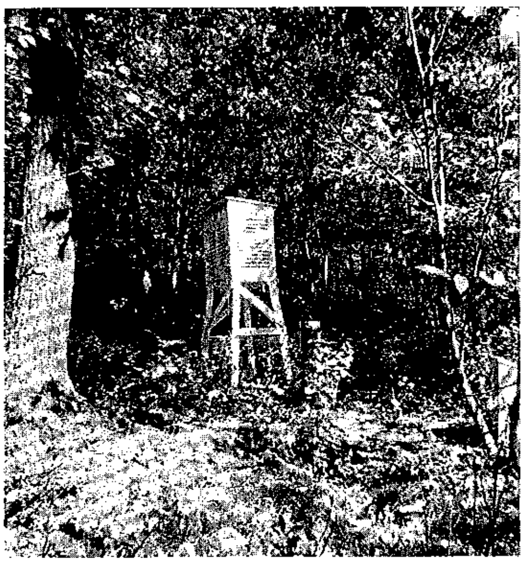
[1] Lull and Reinhart, 1955.
[2] Cain, 1938.



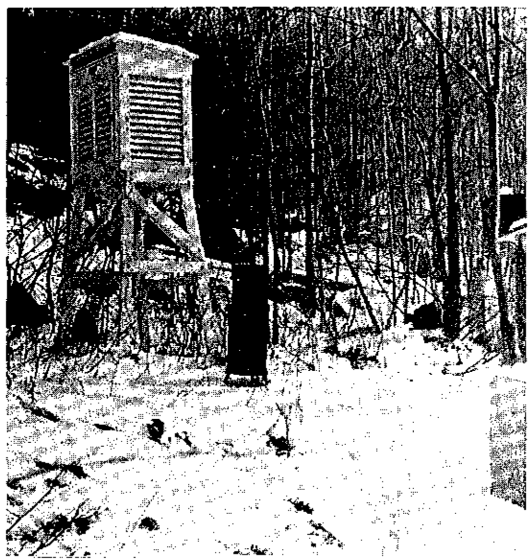
May 10, 1956



July 30, 1956



October 10, 1956

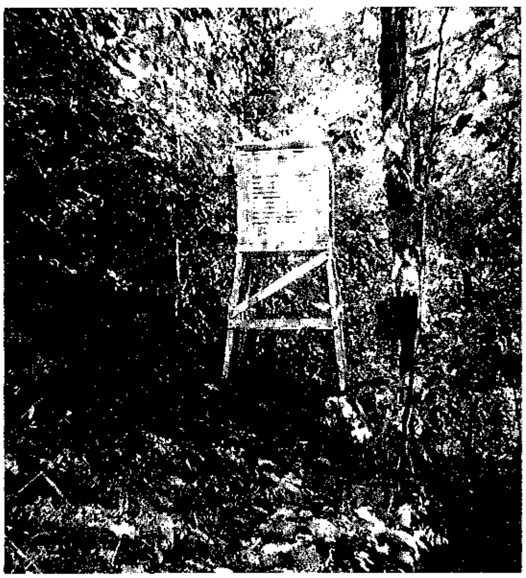


February 1, 1957

14. Field Station No. 9: bottom of Glycerine Hollow. The vegetation type is the Quercus rubra (Red Oak) association.

May 10, 1956

July 30, 1956



October 10, 1956

February 1, 1957

15. Field Station No. 10: east-facing slope of Glycerine Hollow. The vegetation type is the Quercus rubra (Red Oak) association.

TABLE 1: Frequency (Percent) and Density (Average Number) of Plant Species at Ten Field Stations, July, 1956

Tree Species Sampled by 10 Quadrats, 10 Meters by 10 Meters

	1		2		3		4		5		6		7		8		9		10	
Species	F.	D.	F.	D.	F.	D.	F.	D.	F.	D.	F.	D.	F.	D.	F.	D.	F.	D.	F.	D.
Acer saccharum	100	3.0	70	1.3									80	1.4	40	0.6			100	7.2
Acer rubrum	10	0.2	50	1.2			100	4.6	100	3.6	100	6.8					100	5.6		
Betula lenta			30	0.8			80	3.6									100	1.8	80	4.0
Betula lutea		·	50	1.0							100	2.8					20	0.4		
Carya cordiformis	100	2.1															40	0.8		
Castanea dentata																	40	1.2		
Carya glabra					60	2.2							100	2.8	100	7.4				
Carya ovata	10	0.1							40	0.8					60	0.8				
Fagus grandifolia	20	0.2	60	2.1													20	0.4	40	0.6
Fraxinus americana	50	1.1	30	0.5							60	1.8			40	1.6				
Liriodendron Tulipifera	20	0.2	20	1.2							80	2.2								
Nyssa sylvatica	40	0.7	10	0.2							40	0.8								
Pinus rigida					80	3.6														
Prunus pensylvanica									40	0.4					60	1.0				
Prunus serotina	20	0.2			40	0.6							40	0.6	40	1.0				
Quercus alba	70	1.0	10	0.1	40	0.4			100	6.0	20	0.2	40	0.6	100	7.0	80	2.0		
Quercus rubra	90	2.1	70	1.7	100	3.0	100	2.4	100	7.8	60	1.2	100	5.8	100	4.2	100	9.6	100	4.6
Quercus coccinea									100	7.0			20	0.2						
Quercus Prinus			60	1.3	40	0.6	100	8.2			40	0.4	100	8.0	40	0.6	40	1.2	40	0.6
Quercus velutina	60	1.3																		
Sassafras albidum			10	0.1													20	0.6		
Tilia americana			10	0.1															40	0.6
Tsuga canadensis	20	0.4	100	7.4																

Woody Vegetation from 2 to 4 Meters in Height Sampled by 10 Quadrats, 4 by 4 Meters

	1		2		3		4		5		6		7		8		9		10	
Species	F.	D.	F.	D.	F.	D.	F.	D.	F.	D.	F.	D.	F.	D.	F.	D.	F.	D.	F.	D.
Acer pensylvanicum			50	1.4			20	0.4											100	4.8
Amelanchier canadensis					80	2.4			60	1.2			60	2.0						
Ceanothus americanus															80	2.6				
Cornus florida	80	5.5	30	1.0									40	2.2	100	2.2	80	2.0	100	8.4
Corylus cornuta																			40	0.6
Crataegus macrosperma													40	0.4						
Hamamelis virginiana	90	3.3	70	3.2	20	0.2	40	0.6			80	2.6							60	2.0
Kalmia latifolia					60	.80	100	9.2	60	0.8							40	0.4		
Lindera Benzoin			10	2.0							80	3.2								
Ostrya virginiana	50	1.0															20	0.2		
Quercus ilicifolia					100	10.2			100	6.2										
Rhododendron roseum	10	0.1	60	1.7			100	7.6												
Vaccinium corymbosum	10	0.1									100	3.6					60	1.4		
Vitis aestivalis	30	0.5																		

Shrubby Vegetation up to 2 Meters in Height Sampled by 10 Quadrats, 2 by 2 Meters

	1		2		3		4		5		6		7		8		9		10	
Species	F.	D.	F.	D.	F.	D.	F.	D.	F.	D.	F.	D.	F.	D.	F.	D.	F.	D.	F.	D.
Pyrus melanocarpa									60	3.2										
Diervilla Lonicera									60	4.2										
Gaylussacia baccata	10	0.2			60	7.4			100	9.6			100	1.2						
Myrica asplenifolia					20	0.4														
Prunus pumila					80	1.2														

Ribes rotundifolium													40	0.4						
Rubus allegheniensis													20	0.4	20	0.2	20	0.2		
Rubus frondosus					20	0.2														
Vaccinium angustifolium	30	1.5			40	6.0	100	6.8	100	9.4							100	5.6		
Vaccinium vacillans					60	22.0									100	14.4				
Viburnum acerifolium	100	6.9	70	11.0							20	0.2	10	0.4	20	0.2			100	5.8
Viburnum dentatum			10	0.4													40	0.4	100	4.2
Viburnum Rafinesquianum													10	0.4	80	4.06				

Herbaceous Vegetation Sampled by 10 Quadrats, 1 by 1 Meter

Amphicarpa bracteata			10	0.2																
Adiantum pedatum			10	0.3															40	0.4
Agrostis perannans	10	0.6																		
Andropogon scoparius					100	12.4														
Apocynum androsaemifolium													20	0.4						
Aralia nudicaulis			20	0.7							80	3.8							60	1.0
Arisaema triphyllum											20	0.6								
Asarum canadense			10	0.4																
Aster acuminatus	40	0.6	10	0.2																
Aster divaricatus																	20	0.2	60	1.4
Aster macrophyllus	10	0.1	60	1.7											80	1.2				
Aster umbellatus											40	0.4								
Brachyelytrum erectum																	100	3.0	60	2.4
Bidens frondosa													20	0.6						
Danthonia spicata													100	9.6						
Deschampsia flexuosa					20	1.2														
Desmodium rotundifolium													20	0.8						
Dryopteris noveboracensis											40	5.0								
Festuca obtusa											20	0.4								
Galium tinctorium			10	0.2																
Gaultheria procumbens			40	2.7			20	0.8	40	0.6										
Glyceria canadensis											40	0.6								
Hystrix patula															80	2.2				
Leersia oryzoides	30	0.7																		
Lysimachia quadrifolia									60	0.6										
Medeola virginiana											20	0.2								
Maianthemum canadense											20	0.4								
Mitchella repens	30	0.5	30	3.3																
Mitella diphylla											100	3.0								
Osmunda Claytoniana	10	0.1	10	0.7							80	1.6								
Panicum dichotomum															100	7.8				
Panicum latifolium													60	1.8	80	3.0				
Parthenocissus quinquefolia											20	0.4	20	0.2						
Polygonatum pubescens			20	0.4																
Polypodium virginianum							40	0.6												
Polystichum acrostichoides	40	0.5	70	3.3															60	6.0
Potentilla simplex															20	0.2				
Pteridium aquilinum	10	0.3							80	1.0										
Smilacina racemosa											100	4.2								
Solidago bicolor													60	1.2	20	0.2				
Solidago odora															20	0.2				
Thalictrum dioicum			10	0.3																
Uvularia sessilifolia			10	0.1					20	0.4										

CHAPTER IV

VEGETATIONAL ANALYSIS

Plant Associations

In order to discuss concisely the forest vegetation of the area under study, the classification by Raup of aggregations of living plants into plant associations was adopted.[1] The plant associations described in this paper have a distinct floral composition and physiognomy, and they are considered a strictly local phenomenon. In discussing the associations the writer will follow Raup in using the word "primary" in place of the word "dominant." Primary species are those which numerically predominate in the association. Table 1 shows the frequency and density of the plant species at each field station. The principal woodland plant associations have been divided into three major groups: cove, slope, and hilltop associations. The vegetation map shows the distribution of plant associations in the Harvard Black Rock Forest.

Cove Associations

The cove associations are found on the deep till of the Northern Slopes section of the Forest and in the moist depressions between the hills in the Highlands section of the Forest. Site No. 1 at the foot of Black Rock Hill is representative of the lower north slope type of cove hardwoods. It supports a mixed hardwood plant association with six primary tree species: Acer saccarum, Quercus rubra var. borealis, Q. alba, Q. velutina, Carya cordiformis, Fraxinus americana. Nyssa sylvatica, Fagus grandifolia, Liriodendron Tulipifera, Prunus Serotina, and Tsuga canadensis are secondary species scattered over the area. All the trees have tall, straight, high branching trunks, forming a closed canopy, and are the most valuable timber in the Forest. Figure 17 shows this association.

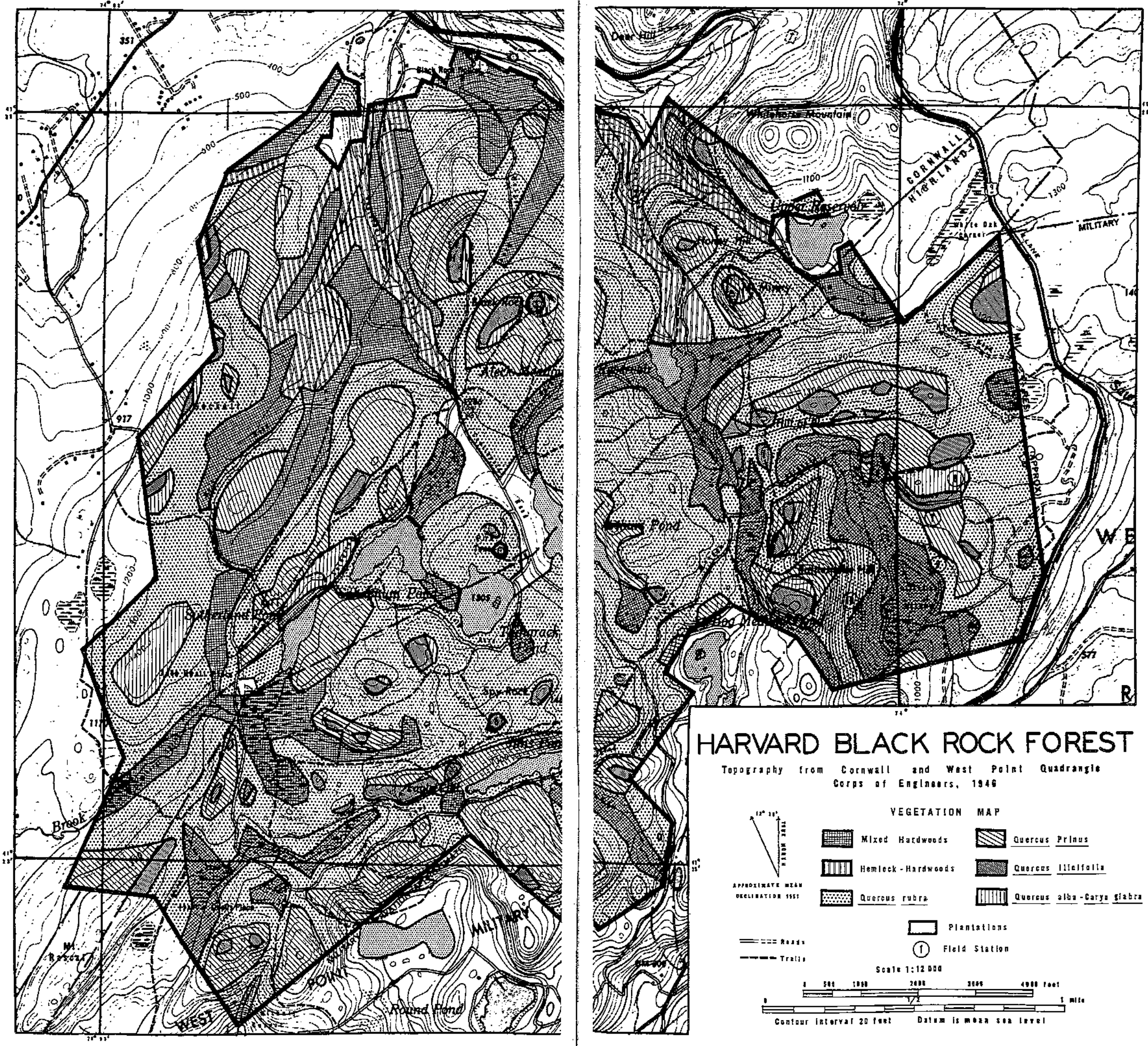
The tall shrub layer is composed of scattered clumps of Cornus florida, Hamamelis virginiana, and Ostrya virginiana. The low shrub layer covers more area; Viburnum acerfolium is the major plant. The herbaceous vegetation is scant: Mitchella repens, Polystichum acrostichoides, Leersia oryzoides, and Aster acuminatus are scattered in leaf debris. There is little moss or lichen on the ground.

Site No. 6 is located in a wet depression which has a vegetation type of mixed hardwoods, swamp phase. Acer rubrum and Betula lutea are abundant; Liriodendron Tulipifera, Fraxinus americana, and Quercus rubra var. borealis are scattered over the depression. The trees form a closed canopy and are tall with straight trunks branching well above the ground. Figure 18 shows this association in the bottom of Glycerine Hollow.

The tall shrubs, principally Lindera Benzoin and Vaccinium corymbosum, are found near the stream in the center of the depression, and Hamamelis virginiana is scattered on the drier edges. Only one plant of the low shrubs, Viburnum acerifolium, was found in this area. The herbaceous vegetation is fairly rich in species even though much of the area has been cleaned off by overflowing of the stream in early spring floods. Smilacina racemosa covers the ground between clumps of Dryopteris noveboracensis and Osmunda Claytoniana. Aralia nudicaulis, Aster umbellatus, Glyceria canadensis, and Mitella diphylla are common. Mosses are thick over the bare ground.

Tsuga canadensis occurs in relatively pure stands in the hemlock-hardwood association at Site No. 2 in Black Rock Brook ravine. The species of hardwoods in the ravine are principally those found in the mixed hardwood association. Quercus Prinus, Betula lenta, and Fraxinus americana are established on the upper, drier, and unstable slopes of the ravine while Quercus rubra var. borealis, Acer saccharum, and Liriodendron Tulipifera are found on the lower more moist and stable soils. Fagus grandifolia, Acer rubrum, Betula lutea, and Plantanus occidentalis are on the small flood plains in the brook. Figure 19 shows the vegetation in Black Rock Brook ravine. Figure 20 shows the ravine in winter.

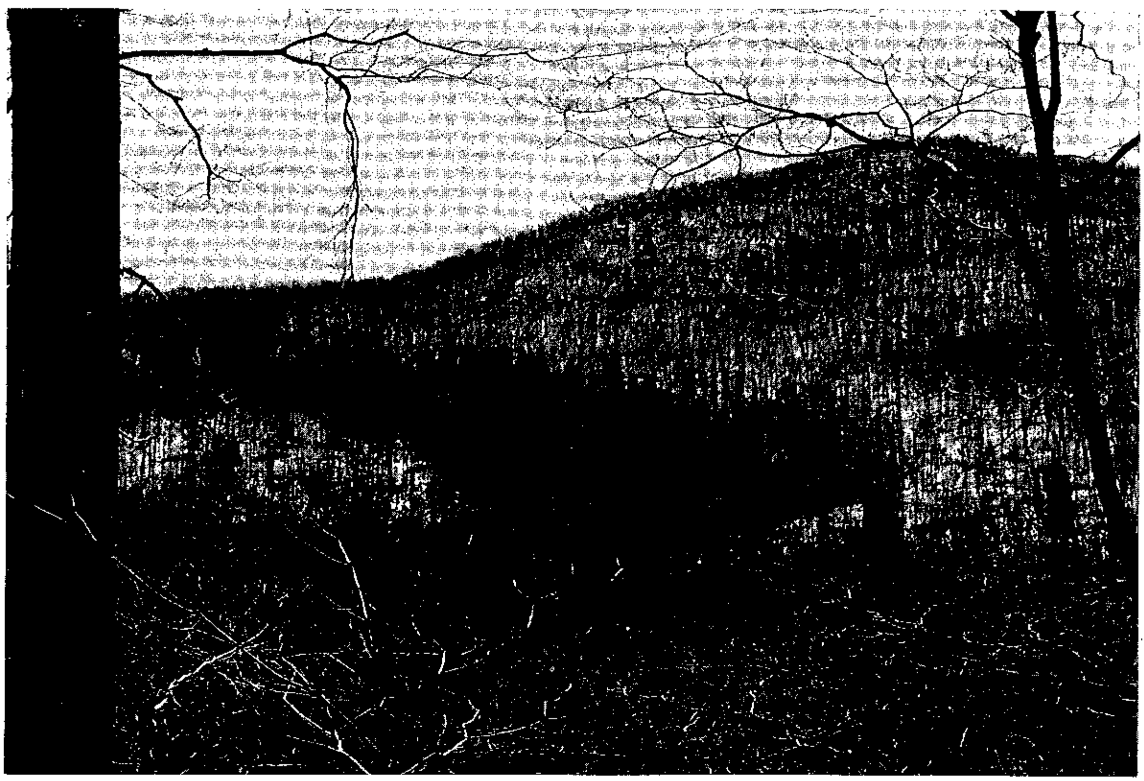
Tall shrubs are not common, covering less than one-half of the area. Cornus florida grows on the upper slopes of the ravine while Hamamelis virginiana and Rhododendron roseum


HARVARD BLACK ROCK FOREST
Topography from Cornwall and West Point Quadrangle
Corps of Engineers, 1946
VEGETATION MAP
Mixed Hardwoods
Hemlock-Hardwoods
Quercus rubra
Quercus Prinus
Quercus ilicifolia
Quercus alba-Carya glabra
Plantations
Field Station
TRUE NORTH
APPROXIMATE MEAN DECLINATION 1951
Roads
Trails
Scale 1:12000
Contour interval 20 feet
Datum is mean sea level
CORNWALL
HIGHLANDS
MILITARY
WEST
POINT
Round Pond
Brook

17. Mixed hardwood association on the lower north slope of Black Rock Hill. View looking down slope. Acer saccharum, Quercus rubra var. borealis, Fraxinus americana, and Liriodendron Tulipifera visible in picture.

18. Mixed hardwood association, swamp phase in Glycerine Hollow. The trees at the right of the picture are Liriodendron Tulipifera; the tree in the center is Betula lutea.

19. Hemlock-hardwood association in Black Rock Brook ravine. The trees on the upper slopes of the ravine are Tsuga canadensis.



20. Tsuga canadensis visible in Black Rock Brook ravine during January, 1957. Black Rock Hill is at the right.

21. View looking west across Glycerine Hollow to the southeast slope of Rattlesnake Hill. The slope is covered mainly with Quercus rubra.

22. Quercus rubra (Red Oak) association on the southeast slope of Rattlesnake Hill.

are the most frequent tall shrubs over the lower slopes. Acer pensylvanicum is scattered over the slopes. The low shrub layer is limited to Viburnum acerifolium. The shade-tolerant herbs, Polystichum acrostichoides, Aster macrophyllus, Gaultheria procumbens, and Mitchella repens are established on the more stable soils.

Slope Associations

The vegetation of the Highlands section of the Forest is composed primarily of slope and hilltop plant associations. An open type of vegetation, the Quercus Prinus association, is established at Site No. 4 on the steep and rocky north slope of Black Rock Hill. Quercus Prinus, Acer rubrum, and Quercus rubra var. borealis are evenly distributed over the area, but Quercus Prinus comprises about one-half the number of trees. The trees are twisted, of poor form, and have short boles. Many snags of Castanea dentata are scattered over the slope. The tall shrub layer is almost continuous. Kalmia latifolia and Rhododendron roseum are the two primary shrubs, and Acer pensylvanicum and Hamamelis virginiana are the secondary species present. The small shrubs are conspicuous by their absence. Vaccinium angustifolium is the only shrub growing on the slope. Polypodium virginianum and Gaultheria procumbens are the only primary herbs. Mosses and lichens are abundant on the rocks.

A different aspect of the Quercus Prinus association is found at Site No. 7 located on the west-facing slope of Glycerine Hollow. This site supports a rather open park-like stand of Quercus Prinus and Quercus rubra var. borealis. Acer saccharum and Carya glabra are common. All the trees are small with many low branches. Figure 23 shows the open association at Site No. 7.

Amelanchier canadensis, Cornus florida, and Crataegus macrosperma are characteristic of the tall shrub layer. Gaylussacia baccata, among the low shrubs, forms almost a continuous layer over the rough hillside. Ribes rotundifolium and Rubus allegheniensis are common species of the low shrubs. A development of grasses, Danthonia spicata and Panicum latifolium, covers the ground where patches of soil have developed in rock crevices. Solidago bicolor is also characteristic of the herbaceous vegetation. The mosses and lichens are almost absent.

The more gently rolling slopes of the Forest support a Quercus rubra association. Site No. 9, located just off the swampy bottom of Glycerine Hollow, supports this type of vegetation instead of the mixed hardwood, swamp phase type, found in the moist bottom. Quercus rubra var. borealis is the primary tree, but Acer rubrum is also numerous. Betula lenta and Quercus alba are secondary species scattered over the area.

The tall shrub layer covers one-half of the area. Cornus florida is common; Vaccinium corymbosum and Kalmia latifolia are also present. Viburnum acerifolium and Vaccinium angustifolium are characteristic of the low shrubs. The herbaceous vegetation has only one primary species, Brachyelytrum erectum. Mosses are abundant while lichens are scarce.

The east-facing slope of Glycerine Hollow, where Site No. 10 is located, also supports a Quercus rubra association. Figure 22 shows this association. Acer saccharum, as well as Quercus rubra var. borealis, is characteristic at this site. A few trees of Tilia americana, Betula lenta, Quercus Prinus, and Fagus grandifolia are scattered over the area. Cornus florida is again the primary tall shrub, but Acer pensylvanicum is also numerous. Viburnum acerifolium and Viburnum dentatum are common low shrubs. The herbaceous vegetation is rich with species of Brachyelytrum erectum, Aster divaricatus, Polystichum acrostichoides, and Aralia nudicaulis.

Hilltop Associations

The tops of the hills support two types of plant associations depending upon location on the hill. The westerly parts of the hilltops have a Quercus ilicifolia association, and the easterly parts support a Quercus alba-Carya glabra association. There are two phases of the Quercus ilicifolia association in the Forest: Pinus rigida phase and Quercus coccinea phase. Raup has determined a third phase which exists on the gentle slopes with heavy soil, in areas typified by Mt. Misery and White Oak Corner. However, this phase will be considered under the Pinus rigida phase.

The first phase of the Quercus ilicifolia association can be seen on the north and northwest side of Black Rock Hill near Site No. 3. Figure 25 shows this association at Site No. 3. Quercus ilicifolia grows in dense patches in the rock crevices. Single trees of Pinus rigida are scattered throughout the area but there is little reproduction of this tree. On the eastern side

23. Quercus Prinus (Chestnut Oak) association on the west-facing slope of Glycerine Hollow. Rock outcrops are visible in the picture.

24. Quercus alba-Carya glabra (White Oak-Pignut Hickory) association on the south-facing slope of Glycerine Hollow. The tree at the right is Quercus alba; the tree at the left is Carya glabra.

of this association Quercus rubra var. borealis, Q. Prinus, Q. alba, and Carya glabra are common. On the northern side Kalmia latifolia is characteristic. Amelanchier canadensis is scattered throughout the area. The trees and shrubs do not form a closed cover.

The low shrubs such as Prunus pumila, Vaccinium vacillans, and Gaylussacia baccata come into the open areas between the clumps of Quercus ilicifolia or are found in rock crevices. The grasses Andropogon scoparius and Deschampsia flexuosa are the primary herbs and form large patches in the crevices of the rocky outcrops.

The second phase of the Quercus ilicifolia association, the Quercus coccinea phase, can be seen at Site No. 5 by a rock outcrop off the Eagle Rock Trail. Quercus ilicifolia is again common, but Pinus rigida is scarce. Quercus coccinea, Quercus alba, Q. rubra var. borealis, and Acer rubrum are the primary tree species around the rock outcrop. Amelanchier canadensis and Kalmia latifolia are the primary tall shrubs. The low shrubs such as Vaccinium angustifolium, Gaylussacia baccata, Pyrus melanocarpa, and Diervilla Lonicera form a dense layer near the ground. The herbaceous vegetation is scarce, but Lysimachia quadrifolia and Pteridium aquilinum var. latiusculum are present in small numbers. Figure 26 shows the association by a rock outcrop off the Eagle Rock Trail.

The second hilltop vegetation type, the Quercus alba-Carya glabra association, is found on southern and southeastern exposures such as Site No. 8 located in Glycerine Hollow. Quercus alba, Q. rubra var. borealis, and Carya glabra are common. Prunus pensylvanica and Carya ovata are secondary species. The trees form a relatively open stand. Figure 24 shows this open association at Site No. 8.

Cornus florida and Ceanothus americanus are common tall shrubs. The low shrub level is almost restricted to Vaccinium vacillans and Viburnum Rafinesquianum. Panicum dichotomum and P. latifolium are primary herbaceous species. Hystrix patula, Aster macrophyllum, Potentilla simplex, Solidago odora, and S. bicolor are distributed throughout the area.

Phenological Observations

On April 10, 1956, Tussilago Farfara was in flower in the Forest on the dry roadsides. On the lower slopes and in the swamp of Glycerine Hollow Populus grandidentata, Acer rubrum, Hamamelis virginiana, and Alnus rugosa were observed in flower. Green shoots of Veratrum viride were also showing in the swamp in the Hollow. By April 30, 1956, the spring flowers such as Trillium erectum, Asarum canadense, Epigaea repens, and Hepatica americana were in blossom. By May 27, 1956, all the trees in the Forest were in full leaf with the exception of Quercus alba which filled out a week later.

The flowering of summer plants began around June 1, 1956, in the open fields and roadsides and lasted until September 4, 1956, when signs of fall were evident. The asters and goldenrods were in full flower at this time. The leaves of Aralia nudicaulis and Cornus florida were the first to show color change; the height of the foliage color was reached by October 12, 1956. By October 28, 1956, 85 percent of the trees were without leaves.

Tussilago Farfara was again the first plant to produce flowers in the spring. It was observed in flower on April 1, 1957. The flowering of plants in the spring of 1957 was two weeks earlier than in the spring of 1956. By May 20, 1957, the summer flowers such as Erigeron strigosus, Euphorbia vermiculata, Rosa carolina, Silene Cucubalus, and Asclepias quadrifolia were in blossom.

Figures 6 through 15 show the changes in appearance of the vegetation at each of the ten field stations during the four seasons: spring, summer and fall, 1956, and winter, 1957.

[1] Raup, 1938.

25. Quercus ilicifolia (Scrub Oak) association, Pinus rigida (Pitch Pine) phase on the summit of Black Rock Hill. View looking north up the Hudson River.

26. Quercus ilicifolia (Scrub Oak) association, Quercus coccinea (Scarlet Oak) phase by a rock outcrop off the Eagle Cliff Trail.

TABLE 2: Weekly Precipitation

Month	Week	Field Stations 1	2	3	4	5	6	7	8	9	10	Stewart Field
Apr	16-22	.20	.20	.24	.20	.01	.01	.01	.01	.01	.02	.51
	23-29	1.22	1.63	1.97	1.99	1.78	1.89	1.95	1.79	2.05	2.16	2.00
May	30- 6	1.87	1.52	1.56	1.65	1.56	1.42	1.57	1.35	1.67	1.72	1.16
	7-13	.12	.03	.18	.01	.14	.17	.16	.18	.18	.18	.28
	14-20	.62	.47	.77	.75	.66	.66	.76	.80	.83	.78	.53
	21-27	.20	.13	.25	.27	.26	.24	.30	.28	.32	.30	.23
June	28- 3	3.00	2.75	2.60	2.77	2.00	3.45	3.40	4.10	3.50	3.40	1.82
	4-10	.05	T	.05	.03	.04	.05	.07	.03	.03	.04	.08
	11-17	T	T	T	.04	T	T	T	T	.03	T	T
	18-24	.46	.48	.47	.42	.26	.37	.47	.33	.30	.40	.40
July	25- 1	.50	.55	.50	.40	.65	.80	1.27	1.03	1.00	1.10	.65
	2- 8	2.10	2.50	2.40	2.00	2.80	2.85	3.45	2.90	3.20	3.60	2.06
	9-15	1.90	2.05	2.10	1.65	1.75	2.05	2.30	1.70	2.00	2.00	1.55
	16-22	.65	.68	.90	1.00	.70	1.00	.90	.85	.80	.80	.89
	23-29	.26	.27	.26	.17	.23	.26	.30	.27	.28	.23	.18
Aug	30- 5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	6-12	.30	.25	.50	.48	.70	.85	1.10	.60	1.05	.85	.57
	13-19	.16	.18	.22	.15	.20	.35	.45	.35	.40	.45	.27
	20-26	1.00	.95	1.10	.70	.58	.73	.75	.60	.55	.60	1.06
Sept	27- 2	1.35	1.30	1.65	1.30	2.70	2.25	2.70	2.00	2.00	2.15	.93
	3- 9	2.00	2.00	2.00	1.40	1.70	2.00	2.30	2.25	2.15	2.00	2.19
	10-16	.90	1.00	1.00	.80	1.00	1.15	1.10	1.00	1.15	1.05	.89
	17-23	.63	.55	.75	.72	.65	.75	.85	.50	.67	.65	1.04
	24-30	.35	.25	.20	.35	.30	.35	.27	.35	.35	.23	.32
Oct	1- 7	.60	.60	.65	.60	.85	.95	.95	.85	.75	.85	.90
	8-14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	15-21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	22-28	.75	.80	.80	.80	.75	.90	.80	.75	.80	.75	.21
Nov	29- 4	1.58	1.87	2.08	2.10	2.15	2.35	2.30	2.20	2.20	2.35	1.01
	5-11	.06	.03	.07	.07	.08	.06	.06	.05	.06	.08	.06
	12-18	1.00	1.00	1.00	.90	.85	1.05	.90	.90	1.05	1.05	.76
	19-25	1.00	.90	1.30	1.20	.65	.68	.63	.60	.64	.60	.15
Dec	26- 2	T	T	T	T	T	.08	T	T	T	T	T
	3- 9	.75	.50	1.00	1.00	1.00	.95	1.00	.90	.95	1.00	.79
	10-16	2.70	3.20	2.30	2.30	2.60	2.40	2.40	2.30	2.50	2.40	2.18
	17-23	.70	.95	.75	.95	.65	.70	.75	.80	.80	.70	1.48
	24-30	.65	.95	.80	.90	.75	.65	.90	.85	.80	.85	.54
Jan	31- 6	.65	.60	.50	.70	.70	.70	.65	.65	.65	.70	.06
	7-13	.40	.35	.45	.35	.50	.45	.50	.35	.45	.50	.68
	14-20	.40	.40	.35	.30	.50	.45	.75	.45	.35	.40	.36
	21-27	.65	.65	.55	.50	.60	.75	.75	.80	.85	.80	.60
Feb	28- 3	.85	.80	.67	.72	.85	.90	.85	.75	.83	.76	.49
	4-10	.30	.30	.35	.40	.30	.30	.30	.35	.30	.46	.71
	11-17	.04	.04	.05	.05	.06	.06	.05	.06	.05	.06	.07
	18-24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	T

TABLE 2: Weekly Precipitation (continued)

Month	Week	Field Stations 1	2	3	4	5	6	7	8	9	10	Stewart Field
Mar	25- 3	1.20	1.25	1.35	1.00	1.40	1.45	1.85	1.90	1.80	1.80	.81
	4-10	1.25	1.00	1.30	1.50	1.35	1.45	1.40	1.43	1.60	1.55	.80
	11-17	.20	.23	.25	.30	.30	.31	.31	.32	.31	.35	.65
	18-24	.26	.24	.30	.32	.42	.41	.40	.36	.38	.39	.33
	25-31	.25	.20	.30	.35	.35	.45	.50	.47	.51	.52	.04
April	1- 7	2.00	2.35	1.92	1.98	2.00	2.45	2.20	2.15	2.37	2.40	2.95
	8-14	1.10	1.25	1.10	1.26	.95	1.50	1.52	1.35	1.70	1.45	1.13
	15-21	.16	.08	.15	.16	.14	.14	.13	.10	.15	.17	.08
	22-28	.29	.19	.24	.23	.33	.32	.32	.28	.30	.34	.38
May	29- 5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	6-12	.12	.13	.16	.17	.16	.18	.18	.15	.18	.19	.16
	13-19	.13	1.64	1.56	1.90	2.10	2.25	2.15	1.83	2.05	2.20	.83
	20-26	.05	.05	.10	.10	.12	.13	.15	.10	.10	.15	.74
June	27- 2	.14	.13	.15	.11	.12	.14	.16	.15	.13	.16	0.00
	3- 9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	T
	10-16	T	T	.10	.10	.08	T	.14	T	T	T	.25
	17-23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	24-30	.45	.50	.62	.61	.50	.88	1.10	1.10	1.20	1.33	.61
July	1- 7	.42	.35	.42	.43	.44	.40	.48	.30	.41	.51	.09
	8-14	1.60	1.73	1.90	1.85	1.35	1.75	1.78	1.45	2.00	2.05	1.19
	15-21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	22-28	.35	.65	.80	.70	.55	1.05	1.20	.90	1.10	1.00	.27
Aug	29- 4	.47	.55	.62	.75	.72	.50	.60	.25	.52	.67	2.27
	5-11	.32	.33	.42	.42	.24	.39	.42	.25	.77	.40	.50

CHAPTER V

ANALYSIS OF THE FOREST CLIMATE

General Climatic Conditions During Period of Study

The following discussion of the general climatic conditions for the Harvard Black Rock Forest area from April 15, 1956, through August 12, 1957, is based on data from the field stations compared to the thirty year averages of conditions recorded at the weather station at West Point, New York.[1] Precipitation in the Forest for the first twelve months of the study averaged 3.09 inches over the mean of 41.18. Stewart Field had 3.81 inches less than the mean for the same period. The month with the least precipitation was February, 1957, during which an average of 1.19 inches fell in the Forest. The month with most precipitation was July, 1956, during which an average of 6.59 inches fell in the Forest, during local thunderstorms.

Mean air temperatures for the spring and summer months of 1956 were lower than the average air temperatures computed from the thirty years of data at the West Point station. Mean air temperatures for the spring months of 1957 were above the average, or "normal," for the period. During the week of May 21, 1956, below freezing temperatures were recorded at eight of the ten stations in the Forest. The first freezing temperatures in the fall were recorded at three of the ten stations during the week of September 17, 1956. Below freezing temperatures were recorded in the Forest until the week of April 29, 1957.

Climatic Conditions at Stewart Field

At Stewart Field during the first twelve months of the study 37.37 inches of precipitation were recorded. Table 2 lists the weekly precipitation at Stewart Field. The month with the least precipitation was June, 1957, when .86 inches were recorded. Low elevation compared to the Forest and absence of orographic effects may account for the lower amount than the average for the Forest.

Maximum and minimum temperatures at the 2 meter level are listed in Table 3 in the Appendix. Frequencies of hourly temperatures for April 16 to 30, 1956, the months May, 1956, to July, 1957, and August 1 to 12, 1957, are shown in Tables 9 through 25. The tables show that Stewart Field was warmer during the summer months of 1956 than the stations in the Forest. It averaged 71.2°F, .4°F higher than the warmest station in the Forest.

During December, January, and February weekly mean air temperatures at Stewart Field averaged 29.1°F, which again was warmer than those in the Forest and is indicative of the altitudinal surface heating and differences that can be expected between Stewart Air Force Base and the station at a higher elevation within the Forest.

The hourly relative humidities at the Field were lower during the period of study than at the field stations. For the month of August, 1956, relative humidity from 70% to 79% occurred most frequently (22.3% of the time). Only 5.78% of the hours had relative humidity of 90% to 100%. Low readings were occasionally recorded in the range of 20% to 29%. During January, 1957, 31.05% of the hourly readings occurred in the range 80% to 89% R,H. Relative humidities for the month of January, 1957, followed the same pattern as the humidities for July, 1956. The greatest frequency of observations, 25.64%, occurred in the range of 60% to 69% R.H. Only 10.39% of the hourly values occurred in the relative humidity range of 90% to 100%. Relative humidities in the winter months at Stewart Field were generally lower than those of the Forest.

Microclimatic Conditions at the Field Stations

Precipitation

Precipitation amounts received at individual field stations during the first twelve months of the observing period varied from 39.80 to 49.20 inches. The stations located in the Northern

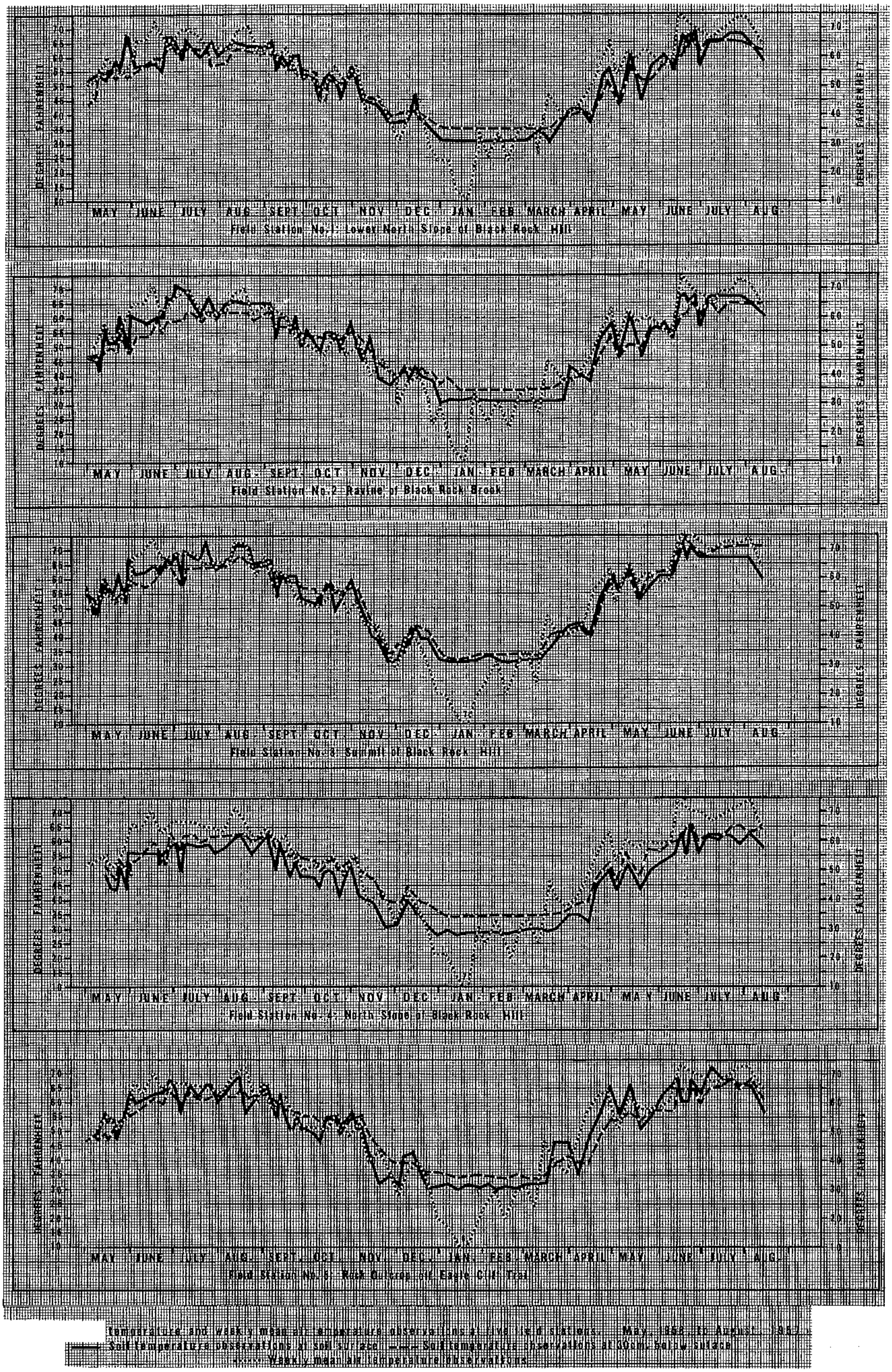
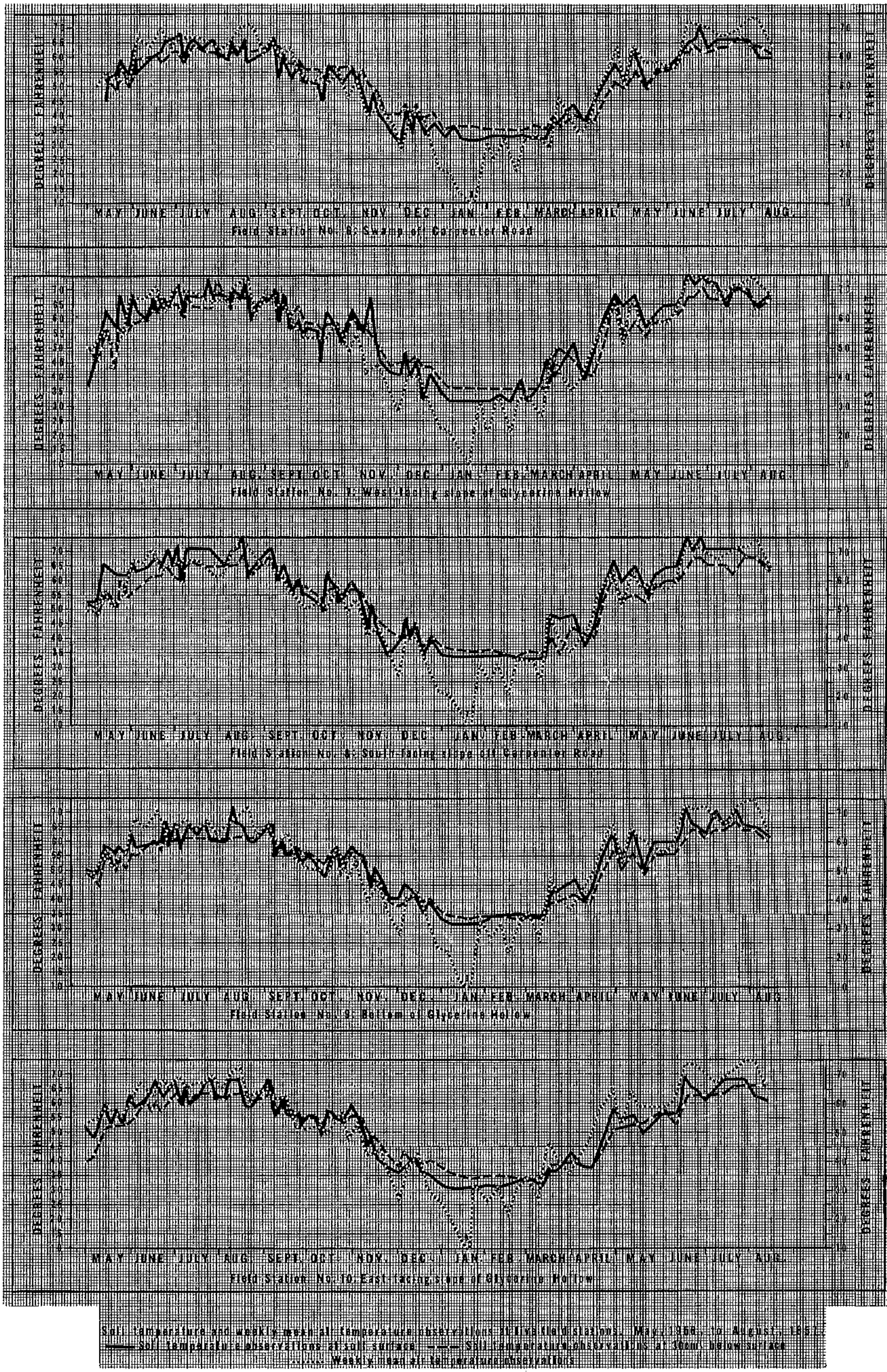

DEGREES FAHRENHEIT
MAY JUNE JULY AUG. SEPT. OCT. NOV. DEC. JAN. FEB. MARCH APRIL MAY JUNE JULY AUG.
Field Station No. 1: Lower North Slope of Black Rock Hill
Field Station No. 2: Ravine of Black Rock Brook
Field Station No. 3: Summit of Black Rock Hill
Field Station No. 4: North Slope of Black Rock Hill
Field Station No. 5: Rock Outcrop off Eagle Cliff Trail
temperature and weekly mean air temperature observations at five field stations. May, 1956 to August, 1957
Soil temperature observations at soil surface
Soil temperature observations at 30cm. below surface
Weekly mean air temperature observations

Figure 28



DEGREES FAHRENHEIT
MAY JUNE JULY AUG. SEPT. OCT. NOV. DEC. JAN. FEB. MARCH APRIL MAY JUNE JULY AUG.
Field Station No. 7: West facing slope of Glycerine Hollow
Field Station No. 9: Bottom of Glycerine Hollow
Field Station No. 10: East facing slope of Glycerine Hollow
Soil temperature observations at soil surface
Weekly mean air temperature observations

Figure 29

TABLE 6: Prevailing Wind Direction and Speed in Knots per Hour at Stewart Field, Newburgh, New York.

Day	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	July	Aug.
1		NE- 7	SW- 8	SW-10	W- 8	SE- 8	NW-13	SE- 7	W-15	NW-25	NE- 7	NE-11	SW-13	NW-22	SW- 8	NW-20	N- 4
2		SE-12	NE-10	SW-12	E-10	SW- 5	SW- 8	SE-10	SW-10	NW-23	W- 4	NW-16	SW- 7	NE-10	SW- 5	NW-17	NW- 5
3		W-10	SE-12	SW- 5	NE-10	C- c	NW-10	SE-13	NW-15	NW-18	C- c	NW-12	NW-15	N-15	SE-14	W-15	W- 8
4		NW-17	SW- 8	NE- 8	W- 7	SW- 7	SW-10	NE-10	NW-20	SW-15	NW- 8	NW-15	SW-18	NW-12	W- 7	W-16	NW- 9
5		W-12	SW-10	NE-10	SW- 4	SW- 4	E- 9	E-15	NW-20	NE-10	C- c	E- 7	SE- 8	SE-10	SE- 8	W-15	NE- 7
6		NE-12	C- c	NE- 8	SE-14	SW- 5	SE-10	SW- 7	SW- 7	SE- 7	SW- 4	SE- 7	NW- 8	NW-15	SW-12	NW-18	NW- 7
7		E-10	SW- 4	SW- 7	NE-10	NE- 7	NW-20	SW-10	NW- 8	C- c	SW-10	SE- 6	NW-19	NW-14	W-12	NW-10	NW- 5
8		NE- 6	SE- 6	SW-10	W-14	N-12	NW-14	C- c	W- 8	SW- 8	NE- 7	E-15	SE-15	W-10	E- 7	W-10	NW- 8
9		SW-16	E- 4	SW-10	NW- 9	NE-14	NE-14	NW-15	NE-10	SE- 7	SW- 5	NW-17	NE-16	SW-12	SW-10	W- 5	W- 5
10		SW-14	SW-10	SW- 8	W- 8	NW-12	NE-13	NW-15	NW-15	SE-12	NW-20	NW-25	NW-20	W-12	SW-12	NW-16	W- 5
11		SE- 8	N- 5	NW-10	NW- 9	W- 8	SE-14	SW-10	SW-10	NW-10	E-14	NW- 6	SW-15	NE-13	W-12	W-11	NW- 6
12		SW- 7	SW-12	NW- 8	NW-10	SW- 7	SE- 7	SW-12	SW-15	SW-10	SE- 7	W- 7	NW-10	SW-10	NW-12	NW-12	NW- 8
13		NW- 8	SW- 5	SW-10	S- 8	SW-10	SE- 7	NW-18	NW-20	NW-15	SE- 6	W-10	NW-15	W- 8	SW- 8	E- 5	
14		SE-15	SW- 8	NW-15	NW-12	NW-15	NE-10	SW-14	NE-15	NW-18	SE-10	S- 5	NW-22	SW- 9	NW-10	NW- 3	
15		NW- 4	SW- 8	W-10	NW-10	SE- 7	NE- 8	SW-10	C- c	SE- 8	SE- 8	SE- 9	NW- 8	W-12	NW-10	NW- 8	
16	SE- 8	NW-17	SW- 6	W- 9	W- 7	SW- 5	NE-10	SW-18	W-10	C- c	SW- 8	NW-17	SW-13	NE-16	NW- 5	W-12	
17	SW-14	NW- 5	NE- 3	SE- 7	NW- 9	SW- 4	C- c	NE-10	NW- 8	NW-10	NW-22	NW-15	W-10	SW-12	SE-10	NW-12	
18	SW-15	NE- 8	NE-10	NW- 7	NW-10	NW-10	SE- 9	NE-15	NW-20	SW-10	NW-17	NW-10	SW- 3	NE-12	SW-12	W-10	
19	NW-15	SW-15	S-10	SE- 6	NW-10	SW-10	SE-10	NE- 6	NW-12	NW-15	NW-14	E-10	SE- 4	NE-15	W-10	NW-12	
20	SW- 8	NE- 6	SW-12	SE- 4	NW- 5	SW-14	W-10	SW-10	NW-15	SW-10	NW-18	NE-10	SW- 9	NE-15	NW-10	NW-10	
21	NW-10	SW- 8	SW- 6	SE- 9	SW- 4	SW-10	C- c	SW-25	C- c	W- 9	NW- 8	NW- 8	NW-15	NE-14	E- 3	SE-10	
22	NW-15	SW-10	SW-10	W- 5	NW- 8	SW- 9	SE- 8	NW-20	C- c	SW- 6	SW-10	NW- 5	SW-17	NE-15	SW-12	SW- 7	
23	NE-12	NW-14	SE- 8	NW-10	SW-10	SW-12	E-10	NW-19	NE-10	W-20	NW-12	NE-10	SW-10	SW-10	W- 8	NE- 7	
24	NW-10	NW- 9	SW- 9	SW-10	NW-18	NW-15	SE-14	SW-10	C- c	E- 7	SW- 4	NW-15	S-15	W- 8	SW- 6	NE- 5	
25	SW- 8	W- 8	W-10	W- 7	NW- 8	NW-10	SE-16	SE-17	NW-17	C- c	SW- 8	NW- 9	SE-10	NW-18	SW-10	SW- 8	
26	SW- 7	SW-14	SW- 6	NW-10	NW-10	SE-18	SE-14	NE- 7	NW- 5	NW-15	SE- 8	NE-10	SW- 5	SW- 8	SW- 5	W- 5	
27	W- 7	SW- 8	SW- 8	SW- 7	SW- 8	SE-20	E-12	W-11	SW- 7	NW- 9	N-10	NW- 8	SW-10	SW-18	SW-10	SW- 8	
28	SW-10	NW-14	SW-12	W- 9	NW-12	NE-20	SE-18	SW-10	SW- 8	NW- 7	E-12	SE- 4	NW-10	W- 7	SW- 8	W- 5	
29	NE- 5	SW-12	SW- 9	NW-12	SW- 8	W- 5	E- 8	SW- 7	NE- 7	E- 4		NW- 9	NE- 8	NW-18	NW-10	W- 8	
30	NW-15	SW-10	SW-12	NW-10	SE- 7	W- 8	E- 5	NW- 7	NW-28			NE- 7	NW-10	SW- 8	NW-20	NW-10	
31		SW-12		W- 5	SE-10		SE- 9		W- 8			NW- 9		SW-10		NW- 6	

Slopes section of the Forest were grouped at the low end of the precipitation scale, and those in the Highlands section at the high end.

Lowest precipitation amounts were received at stations located on north-facing slopes. Amounts varied from 39.80 inches at Station No. 4 on the north slope of Black Rock Hill to 41.23 inches at Station No. 1 at the base of the north slope of the hill. The only other station located on a north-facing slope, Station No. 2 in the ravine of Black Rock Brook, recorded 40.20 inches during the same period. This pattern of lower precipitation amounts at these stations indicates a rain-shadow effect on the Northern Slopes section of the Forest. Storms that bring precipitation to the area are predominantly from the southeast and tend to deposit more precipitation in the Highlands than on the Northern Slopes.

Figure 28 shows the distribution of the precipitation at each field station during the five months of the growing or frost-free season and also during the remainder of the year. The figures show that the major differences in precipitation occurred during the growing season. The vegetation on the lower north slopes should show the effect of less precipitation by poorer growth rates in comparison with the growth rates of trees around Glycerine Hollow.

Figure 27. Distribution of Precipitation for the First Twelve Months

Field Station	1	2	3	4	5	6	7	8	9	10
Frost-free Season	16.21	16.96	19.17	16.05	17.37	20.21	22.68	18.79	19.11	25.56
Frost-present Season	25.02	23.24	22.69	23.75	23.91	25.84	26.52	26.07	29.11	21.92
12 Mos. Total	41.23	40.20	41.86	39.80	41.28	46.05	49.20	44.86	47.22	47.48

In the Highlands, the west- and east-facing slopes of Glycerine Hollow, Stations No. 7 and No. 10, received the largest amount of precipitation in the Forest, 49.20 inches and 47.48 inches respectively. Station No. 8 on the south-facing slope received 44.86 inches, while Station No. 9 at the bottom of the Hollow received 47.22. Station No. 6, in a wet depression near Glycerine Hollow, received 46.05 inches.

The station with the highest elevation was located in the Highlands section. This station, No. 5, received 41.28 inches. The next highest station, Station No. 3 on the summit of Black Rock Hill, received 41.86 inches. These stations are located between the north slopes and Glycerine Hollow, and the precipitation values are between the values for the two areas.

The largest amount of precipitation recorded in any one week was 3.60 inches which fell at Station No. 10 during the week of July 2, 1956. During the sixteen months of the study the precipitation averaged over 6 inches for the months of July and September, 1956; over 5 inches for December, 1956; over 3 inches for June and November, 1956, and March and April, 1957; over 2 inches for May, 1956, and January and July, 1957; and under 2 inches for August and October, 1956, and February, May, and June, 1957. Precipitation during the first twelve months of the study was evenly distributed; there was no pronounced wet or dry season. May, June, and July, 1957, was a dry period averaging 2.34 inches of precipitation less per month than the same months in 1956. Eight weeks recorded no precipitation: the weeks of July 30, October 8 and 15, 1956, and February 18, April 29, June 3 and 17, and July 15, 1957.

The first snow of the year fell on November 17, 1956. Rain and snow fell intermittently during the winter through April 9, 1957, when the last snow fell in the Forest. Accumulation of snow during the season never amounted to more than 6 inches and usually melted within a three day period.

Air temperatures

Table 3 lists the weekly maximum and minimum temperatures for each of the ten stations at three points above the ground: 7.5 cm, 25.0 cm, and 2 meters. Weekly mean air temperatures are shown for the field stations in graph form in Figures 28 and 29 along with soil temperature observations. Mean air temperatures were computed from daily maximum and minimum temperatures. Frequencies of hourly temperatures for the field stations for April 16 to 30, May, 1956, to July, 1957, and August 1 to 12, 1957, are shown in Tables 9 through 25.

The tables show that the coolest station during the summer months of June, July, and August, 1956, were Station No. 9 at the bottom of Glycerine Hollow and Station No. 2 in the ravine of Black Rock Brook. During these months the weekly mean air temperatures at Station No. 9 averaged 65.9°F and at Station No. 2 averaged 66.1°F. Station No. 1 on the lower slope of Black Rock Hill was the warmest, averaging 70.8°F. The bottom of Glycerine Hollow is probably cooler because of cool air drainage and accumulation, while Black Rock Brook Ravine probably maintains cooler temperatures because of the protection from direct radiation provided by the heavy canopy of *Tsuga canadensis.* The maximum air temperature recorded during the summer months was 96.0°F at the summit of Black Rock Hill on June 15, 1956.

During the months of December, January, and February, Station No. 8, on the south slope of Glycerine Hollow, was the coldest of all stations. Weekly mean air temperatures here averaged 25.7°F for the winter period. Nighttime radiation from the ground through the open vegetation probably accounts for the lower temperatures. The minimum air temperature recorded during the winter months was -17.0°F at Stations No. 3 and No. 5 on January 15, 1957. Station No. 1, lower in elevation, remained the warmest station during the winter with a weekly mean air temperature of 28.4°F.

To facilitate the discussion of temperature differences among the field stations two representative months, July, 1956, and January, 1957, will be discussed in detail.

Table 12 shows the frequencies and percents of hourly temperatures at the field stations for the month of July, 1956.

Highest temperatures occurred at the summit of Black Rock Hill, in the range of 90° to 94°F. Stations on the lower north slope of Black Rock Hill and the west-facing slope of Glycerine Hollow had their highest temperatures in the range of 85°F to 89°F. The other stations recorded no temperatures above 84°F. Coolest temperatures were recorded in the range of 45°F to 49°F for Stations No. 1, No. 2, No. 5, No. 8, No. 9, No. 10. The other stations recorded their coolest temperatures from 50°F to 54°F.

Station No. 3 was the warmest during July with 77.4% of the hourly temperatures at 65°F or above; Station No. 4 recorded 65.2% of the hours at or above 65°F. Stations No. 5 and No. 9 recorded hourly temperatures, at 65°F or above, 48.6% and 49.4% of the time respectively; and Station No. 1 recorded 65.01% at or above the same temperature level. The rest of the stations recorded hourly temperatures at 65°F or above between 50% and 60% of the time.

The figures show that the north slopes of the Harvard Black Rock Forest were warmer during the month of July than the south slopes in Glycerine Hollow. Percentage frequency figures for July, 1957, also substantiate this fact. The north slopes covered by a denser shrub and tree layer tend to retard nighttime radiation. It is the experience of the writer that the predominant winds from the south and southwest maintain lower temperatures on the slopes of Glycerine Hollow than are experienced on the relatively protected north slopes of Black Rock Hill. The east-facing and west-facing slopes of Glycerine Hollow differed less than 1% in the occurrence of hourly temperatures at or above 65°F. They had 19% fewer hours at or above 65°F than the summit of Black Rock Hill. The station at the highest elevation in the Forest, Station No. 5, showed a greater frequency of lower temperatures than the station on the summit of Black Rock Hill, although this station is only 50 feet higher in elevation.

The closed canopy of small trees at Station No. 5 reduces the radiation received at the ground surfaces, and gives some protection from the winds.

Table 18 shows the hourly temperature frequencies for the ten field stations for the month of January, 1957. The highest temperatures recorded at Stations No. 1 and No. 2 were in the range of 55°F to 59°F. All the other field stations had high temperatures in the range of 50°F to 54°F. The two stations of highest elevation, Stations No. 3 and No. 8, recorded the lowest temperatures. These occurred in the range of -16°F to -20°F. Hourly temperatures of greatest frequency occurred in the range of 20°F to 24°F at Stations No. 3 and No. 8. All the other stations recorded the greatest temperature frequencies in the range of 25°F to 29°F.

Table 18 shows that the frequencies of hourly temperatures did not vary so widely during the month of January as they did during the month of July. With the exception of Stations No. 1 and No. 2 the percentage frequencies at 24°F and below varied only 9%. Station No. 1 recorded only 51.06% of the monthly frequencies at or below 24°F; Stations No. 3 and No. 8 recorded 69.38% and 69.39% at or below 24°F. Stations No. 3 to No. 10 all recorded percents in the 60's for temperatures of 24°F and below. Station No. 2 recorded temperatures at or below 24°F 55.19% of the time.

The fact that the hourly air temperatures at the field stations in January did not vary so much as they did in July suggests that the leaf cover on the vegetation influences the tempera-

TABLE 7: Solar and Sky Radiation at Harvard Black Rock Forest

Langleys (gm cal/cm^2)

Day	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
1		212	668	251	312	M	233	R
2		M	453	127	M	M	R	R
3		M	620	230	M	548	R	R
4		547	835	540	M	438	R	R
5		464	632	554	195	R	R	R
6		M	M	505	R	R	R	R
7		129	M	368	R	R	R	R
8		865	M	91	R	R	R	R
9		90	695	340	R	R	539	R
10		995	473	435	R	R	143	R
11		390	600	112	R	R	482	657
12		317	546	97	R	R	88	296
13		386	606	365	328	R	415	720
14		M	240	305	M	R	600	845
15		445	R	368	M	R	710	107
16		M	R	156	278	R	220	710
17	755	M	R	91	82	R	187	755
18	656	945	R	73	410	R	645	R
19	M	825	R	420	338	R	132	R
20	M	475	306	252	327	R	M	R
21	328	650	245	103	51	R	723	R
22	350	453	R	315	55	R	590	R
23	785	500	R	295	27	R	295	830
24	542	434	R	361	57	R	613	900
25	755	R	R	146	39	R	480	790
26	826	R	R	84	333	R	175	197
27	685	R	R	244	107	R	220	306
28	540	454	934	382	164	R	233	710
29	550	660	850	98	55	R		
30	140	148	875	442	460	R		
31	269		238		275	R		

M - Data missing
R - Equipment under repair

TABLE 8: Solar and Sky Radiation at New York Meteorological Observatory, Central Park, New York.

Langleys (gm cal/cm^2)

Day	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	July
1	605.5	621.4	473.7	619.4	513.9	323.0	497.7	57.0	132.5	162.7	24.4	107.1	438.8	687.5	431.7	782.8
2	250.8	382.8	70.0	581.0	624.7	133.1	328.0	67.5	143.7	202.0	257.0	230.4	132.8	733.3	391.8	810.6
3	176.3	349.7	460.7	551.7	715.5	593.7	473.9	81.3	150.3	223.9	56.2	470.0	536.8	758.5	635.5	715.2
4	103.7	505.5	409.5	137.3	695.9	479.4	63.3	315.0	211.0	128.1	138.6	454.8	40.9	347.3	591.0	499.0
5	611.0	643.0	464.3	58.8	92.9	358.2	430.5	310.2	152.9	136.6	157.7	439.7	30.8	551.7	362.0	540.8
6	425.4	449.8	685.9	49.8	58.8	155.7	318.2	239.2	116.5	142.9	110.1	258.2	228.7	500.3	655.7	743.7
7	50.1	135.4	571.4	540.1	528.3	186.5	237.4	235.9	131.3	110.8	94.4	118.6	520.6	655.2	355.0	675.4
8	151.2	760.5	664.7	564.1	635.3	574.4	430.1	38.1	149.2	201.2	218.2	30.0	87.7	652.4	259.6	630.5
9	643.9	612.2	253.8	315.0	626.0	621.4	437.7	250.8	9.9	41.1	29.7	73.1	434.5	664.4	778.5	400.8
10	609.3	299.6	183.4	568.2	531.1	555.5	451.8	250.5	196.3	33.5	178.3	497.6	462.3	628.9	718.5	678.7
11	398.4	625.9	696.0	725.0	647.1	280.7	432.2	129.5	58.5	197.9	253.8	379.1	554.3	66.9	689.7	659.9
12	624.2	453.1	481.1	546.5	506.7	293.3	271.1	156.9	120.0	109.2	341.6	175.4	414.8	361.6	460.3	685.6
13	445.5	607.4	597.7	317.6	287.2	416.8	302.8	217.0	40.0	216.4	190.8	441.9	446.9	506.8	599.4	158.6
14	639.0	606.3	684.2	475.8	460.6	406.5	339.1	212.1	8.5	240.0	80.2	366.3	537.6	323.6	483.0	609.0
15	168.1	571.5	528.4	668.7	582.8	266.9	322.8	238.4	23.5	161.3	340.4	53.3	686.2	531.1	608.6	625.3
16	413.5	353.8	428.1	158.1	513.6	122.5	254.7	130.4	139.7	61.9	78.9	533.3	501.3	662.7	637.8	703.0
17	404.5	514.1	441.4	586.7	507.3	229.3	222.8	26.8	97.4	216.0	360.4	506.6	104.4	620.0	685.3	739.6
18	410.5	83.9	623.3	747.7	536.5	539.0	49.8	119.1	203.4	168.2	323.4	433.5	127.2	483.1	593.9	596.7
19	324.3	649.4	602.3	393.2	443.1	446.9	382.5	183.2	151.5	225.6	209.8	42.1	331.8	146.0	552.4	584.4
20	140.5	728.5	682.1	210.1	119.1	376.7	222.1	163.6	172.7	157.0	359.0	61.4	322.9	63.0	603.0	657.6
21	616.0	669.0	110.3	75.0	83.8	479.8	214.6	83.4	64.1	23.1	400.0	265.5	418.1	552.7	666.0	577.7
22	618.2	638.7	571.9	487.6	242.0	206.1	48.7	200.0	13.3	99.0	257.4	217.0	648.7	408.9	695.8	616.1
23	207.9	174.8	630.7	634.7	606.9	418.1	146.0	175.1	31.0	188.5	145.8	537.3	324.8	419.5	628.0	199.7
24	309.2	783.6	566.1	252.1	458.3	274.0	171.6	219.6	21.3	226.6	296.5	557.6	473.5	779.1	451.7	694.7
25	606.9	713.5	652.8	601.6	622.6	483.4	353.2	66.5	77.7	32.4	167.4	451.0	131.7	760.7	649.2	670.5
26	66.3	551.9	643.0	608.4	488.5	386.5	118.1	97.8	145.5	248.6	67.6	89.7	456.8	540.7	183.1	488.2
27	490.9	50.0	354.2	327.8	328.5	104.7	173.4	192.1	55.4	191.6	150.7	82.4	450.3	298.5	488.4	502.1
28	398.0	742.5	570.6	423.9	480.5	43.9	336.4	195.0	74.5	52.4	129.6	395.1	435.2	725.3	498.9	217.1
29	565.6	684.4	680.3	744.1	498.4	447.8	307.7	85.0	18.3	13.6		321.2	572.8	735.8	583.0	386.9
30	696.0	350.3	637.6	624.6	151.4	129.9	182.8	156.3	235.1	252.0		415.0	729.6	686.3	645.4	417.7
31		607.3		593.7	273.1		26.6		104.7	27.5		607.2		707.1		459.9

tures at the various sites. Stations No. 1 and No. 2, the two stations lowest in elevation and protected from the cold winds, averaged warmer than the other stations. The stations in the Highlands section of the Forest all had greater frequencies of lower temperatures. The stations are all higher in elevation and are exposed to the winds in Glycerine Hollow. [2]. Stations No. 3, No. 5, and No. 8 recorded lower temperatures more frequently than the other stations. The high elevation of these stations may be the factor that explains this result. The east-facing and west-facing slopes stations differed in frequency of temperatures at or below 24°F by only 1.3%.

Table 3 shows the weekly maximum and minimum air temperatures at three heights above the ground: 7.5 cm, 25.0 cm, and 2 meters. During the summer and winter months the maximum air temperatures near the ground were higher than the air temperature at 2 meters. Stations No. 3, No. 7, and No. 8 had higher maximum temperatures at the 7.5 cm level than the 2 meter level. These stations have relatively open vegetation permitting solar radiation to heat the ground. A maximum temperature of 112°F was recorded during the week of July 2, 1956, for 7.5 cm above the ground at Station No. 8. The maximum air temperature at 2 meters was 84°F. The maximum temperatures at the three levels were the same or different by only one or two degrees at Stations No. 1, No. 2, No. 9, and No. 10. These stations have a closed tree canopy.

Relative Humidities

Tables 26 to 32 show the frequencies of hourly relative humidities during the period of study for nine field stations. No data for relative humidity are available for Station No. 8. The tables show that a greater frequency of relative humidities in the Forest occurred in the range of 90% to 100% than in any other range. The highest monthly frequency, 71.3%, during September, 1956, occurred at Station No. 2 in the range 90% to 100% R.H.

To facilitate the discussion of relative humidity differences among the field stations, two representative months, August, 1956, and January, 1957, will be discussed in detail. Data for July, 1956, were not recorded.

Table 26 shows that the lowest relative humidities for August, 1956, at Stations No. 1, No. 5, and No. 9 were in the range of 30% to 39%. All the other stations recorded low humidities in the range of 40% to 49%. Station No. 2 in the ravine of Black Rock Brook and under a closed canopy of *Tsuga canadensis* recorded relative humidities between 90% and 100% 58.76% of the hours. Station No. 6 in a wet depression recorded humidities in the range of 90% to 100% 49.8% of the time. Stations No. 5 and No. 7 had humidities in the range of 90% to 100% 25.03% and 24.73% of the time, respectively.

Table 28 shows the hourly relative humidities for January, 1957, recorded at nine field stations. Stations No. 1, No. 4, and No. 6 had low relative humidities in the range of 30% to 39%. All the other stations had infrequent occurrence of relative humidities as low as from 20% to 29%. The table shows that in the range of 90% to 100% Station No. 2 had the greatest frequency, 34.64%. The greatest frequencies again occurred in the highest range, 90% to 100%, but a second maximum occurred in the range 60% to 69%. This second maximum was also present during the summer months but was not so prominent as during the winter months. The lower maximum results from the lower daytime humidities.

Soil Temperature

Table 4 lists the observations of soil temperatures at the surface and 30 cm level during the period of study. The observations of soil temperature, along with weekly mean air temperatures, are graphically portrayed in Figures 28 and 29. The graphs show that the soil temperatures follow very closely the trends of the mean air temperature. During the winter months of December, January, February, and into March, when the weekly mean air temperatures were as low as 7°F, the soil temperatures remained relatively constant between 30°F amd 35°F. Snow and leaf cover on the ground would tend to hold the soil temperatures constant during the winter months.

Figures 28 and 29 show that the soil temperatures at Station No. 4 averaged colder than all the other average soil temperatures. The surface soil temperatures were usually five or ten degrees below the mean air temperatures except in winter when the weekly mean air temperatures were lower than either of the two soil temperatures. Stations No. 7 and No. 8 had higher temperatures at the soil surface than the mean air temperatures. The open condition of the vegetation at these stations permits solar radiation to heat the rock outcrops and patches of soil. Stations No. 5 and No. 10 with a closed canopy had lower soil temperatures. Stations No.

No. 5 and No. 10 with a closed canopy had lower soil temperatures. Stations No. 3 and No. 9 had soil temperatures intermediate between those of the open and those of the closed canopy stations.

The surface soil temperature at all field stations recorded higher than the 30 cm soil temperatures except during the winter months of December, January, and February when the surface temperatures averaged between three and ten degrees colder than the 30 cm level. One exception to this pattern is Station No. 4 which recorded lower temperature at the surface during summer, spring, and fall. Evaporation from the moist soil surface may lower the surface temperatures enough to give this result. The highest temperature reached at the soil surface was at Station No. 8 which recorded 78°F on June 17 and 24, 1957, when the maximum air temperature at this time reached 90°F. At the 30 cm level the highest temperature reached was 71°F at Station No. 3 on August 20, 1956, and at Station No. 8 on July 23, 1957, when the maximum air temperature reached 90°F.

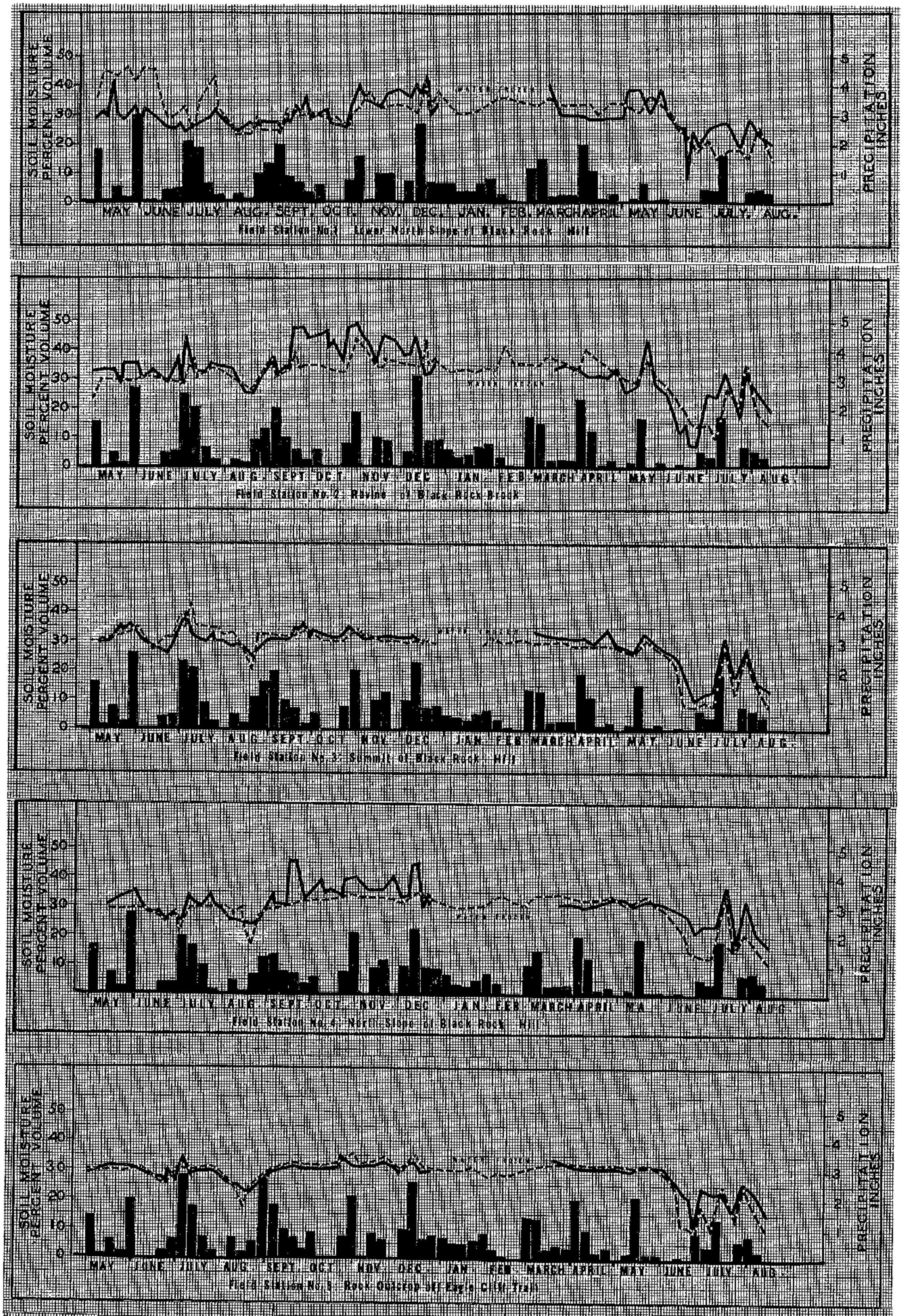
Soil Moisture

Table 5 lists the observations of soil moisture in percent volume. These data, along with weekly precipitation data, are shown in graph form in Figures 30 and 31. The graphs show that soil moisture increased from a low in August, 1956, until it leveled off in December, 1956. A downward trend started in May, 1957, and lasted to the end of the project in the middle of August, 1957. The soil moisture constants in percent volume for all the soils with the exception of the swamp soils of Station No. 6 are as follows: saturation point – 46%; field capacity – 36%; permanent wilting percentage – 11%.

The tables indicate that the driest soil condition existed at Station No. 8 on the south slope of Glycerine Hollow. Wind and solar radiation could account for a high evapo-transpiration rate to dry the soils even though the station ranked high on the list for precipitation. Runoff from the steep rocky slopes may also be an important factor. Station No. 7, where the soil moisture reached a low of 2.5% on June 24, 1957, was the second driest station. The soil moisture at Station No. 5 remained below field capacity during the sixteen months of study. The soil moisture at Station No. 1 remained at or above field capacity from October, 1956, to March, 1957. During the remainder of the period of study the soil moisture varied between 25% and 35% with the exception of the dry spring and summer of 1957 when it dropped to an average of 20%. Soil moisture at Station No. 3 varied slightly around the 30% value, dipping below the permanent wilting percentage in June. The soil moisture at Station No. 4 followed the trends of the moisture at Station No. 3 except for October, November, and December, when the moisture remained at or above field capacity. The soils of Station No. 2, the ravine of Black Rock Brook, were moist, above 30% moisture per unit volume of soil; but they dried out more quickly than the other soils. Station No. 9 at the bottom of Glycerine Hollow also had moist soils during the period of study especially at the 30 cm level. Readings at Station No. 10 were above 30% for twelve of the sixteen months. The soils at Station No. 6, in a wet depression, had a high water table during the sixteen months of study, and the soil moisture remained above 55% until June, 1957, when it started downward, establishing an average of 30%.

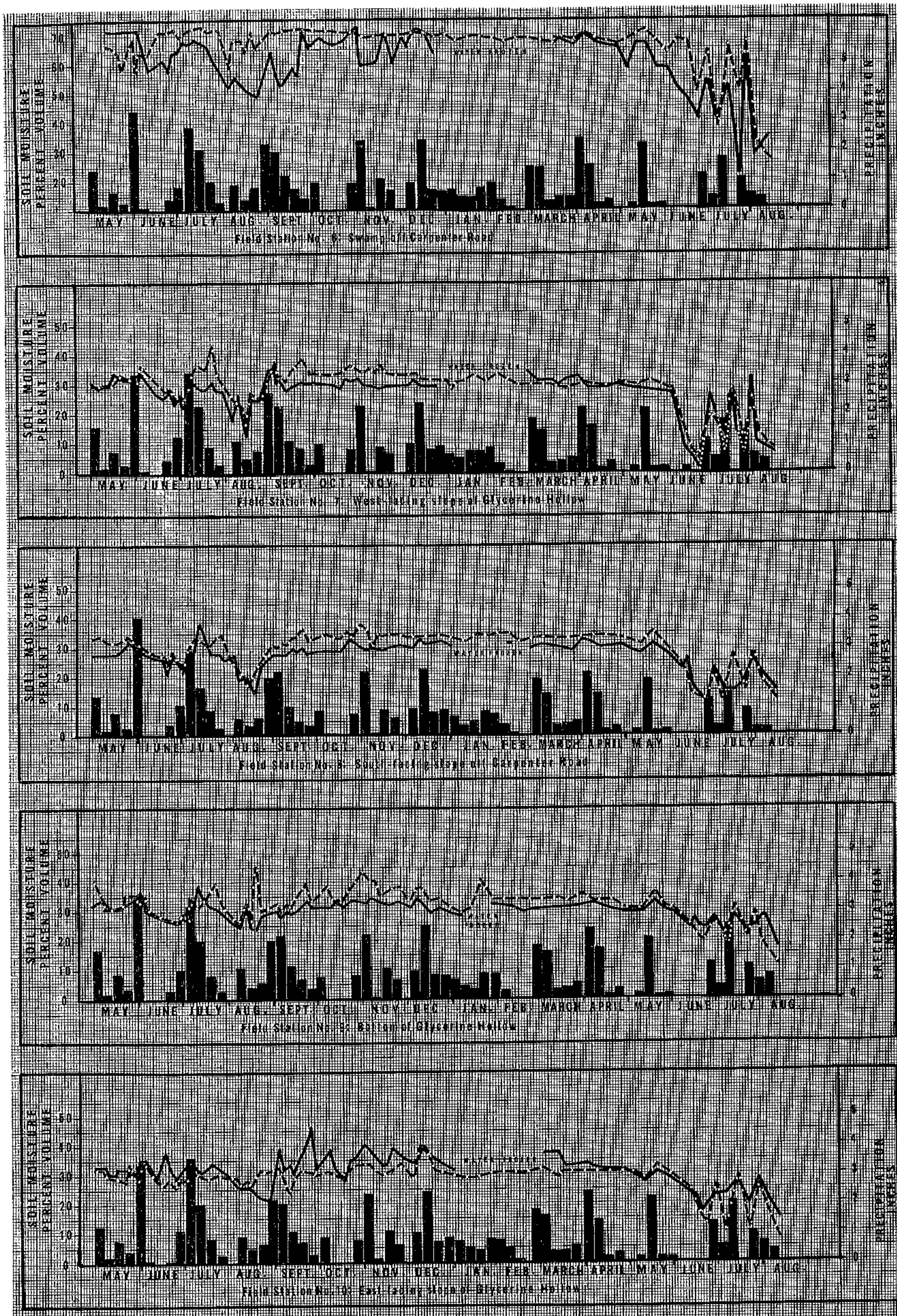
The moisture in the surface of the soil fluctuated more than the soil moisture content of the 30 cm level. Even though the monthly precipitation rate was similar for Stations No. 3 and No. 5 the surface soil at Station No. 3 tended to be moister than the surface soil at Station No. 5. Station No. 2 in Black Rock Brook ravine and Station No. 4 on the north slope of Black Rock show similar moisture curves. In the ravine, the surface soils were moister until the severe drought depleted the surface soil moisture faster than the moisture at the 30 cm level. On the lower north slope of Black Rock Hill at Station No. 1 the soil moisture at the 30 cm level was much higher than on the surface during the first summer; after that the surface soil moisture remained higher. The higher soil moisture at the 30 cm level in spring may be due to water storage in the thick till soils at that site. In the soils at the bottom of Glycerine Hollow and in soils in the swamp off the Carpenter Road the surface was usually drier than the 30 cm level. The south-facing slope and west-facing slope of Glycerine Hollow at Stations No. 7 and No. 8 also had drier surface soils. The east-facing slope of Glycerine Hollow had the opposite condition: more moist surface soils. The aspect of the slope and vegetation cover may account for this condition.

During the winter months the moisture in the surface soil at all stations was frozen but moisture at the 30 cm level remained in a liquid state except on the summit of Black Rock Hill, Station No. 3, where both levels were frozen. The moisture in the surface soil at all stations



Soil moisture and weekly precipitation observations at five field stations. May, 1956 to August, 1957.
— Soil moisture observations at soil surface - - - Soil moisture observations at 30cm below surface

Figure 30



Soil moisture and weekly precipitation observations at five field stations — May, 1956 to August, 1957
— Soil moisture observations at soil surface. — — — Soil moisture observations at 30cm below surface

Figure 31

with the exception of Stations No. 8, No. 9, and No. 10 froze by January 1, 1957. At the other three stations, the surface soil moisture froze the next week. Station No. 9 remained frozen for only three weeks, until January 28, 1957. Stations No. 7 and No. 8 remained frozen until February 18th, Stations No. 3 and No. 10 until February 25th, Station No. 1 until March 4th, Stations No. 2, No. 5, and No. 6 until March 14th, and Station No. 4 remained frozen until March 18th.

Wind Direction and Velocity

Table 6 shows that the wind direction at Stewart Field is predominantly westerly. Northwest and southwest winds are both major in importance although the northwest winds tend to average stronger by ten to fifteen knots.

The wind system in the Forest is complicated and needs more study before a pattern can be determined and its influence suggested. The following remarks are from observations made in the Forest by the writer during the period of study. There is a strong air current from the south along the Hudson River which is channeled up the ravines and coves. This air current can be seen when fog hangs over the river. One such air current blows up through Glycerine Hollow and over the tops of the hills in the Highlands and above the Northern Slopes section of the Forest.

Solar and Sky Radiation.

The recording of solar radiation at the Harvard Black Rock Forest office was hindered by equipment failures. Table 7 shows that the amount of radiation is greatest in September with an average of 433 langleys per day. February averaged 386 langleys per day. During the winter months, fog and cloudy conditions kept the radiation values low. Table 8 shows more detailed solar radiation data for the weather observatory in Central Park, New York.

Fog and Glaze Occurrence

In the Forest two types of fog have been observed. Radiation or ground inversion fogs have been seen in Glycerine Hollow and other depressions in the Highlands. Advection fogs are the more common and are formed by the transport of moist warm air from the Hudson River over the Highlands. These fogs are most prevalent during the winter when the warm air from the south meets cold surfaces and cold air on the northern slopes.

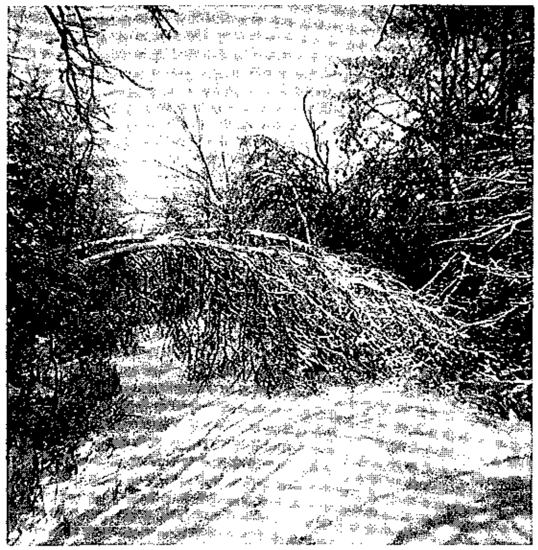
During the winter months a glazed frost often forms over the vegetation in the Highlands with injurious results to the taller trees. Glaze forms on solid objects when rain falls at an air temperature below the freezing point.

Damage to the exposed trees can be heavy from glazed frost. The main damage to the trees results in shattered tops, loss of branches, and open wounds. Only rarely are trees uprooted. Damage has been heavy in the Forest on the exposed ridges. During the course of the present study the most severe glaze formed on December 9, 1956. Figure 32 shows the glaze and damage from the storm. Over one-half inch of ice formed on all vegetation. Damage was heavy in the plantations of *Larix decidua*, *Pinus resinosa*, and *Picea glauca*. In the Forest the main damage was the breaking of branches from the larger trees of *Quercus rubra* var. *borealis* and *Quercus alba*.

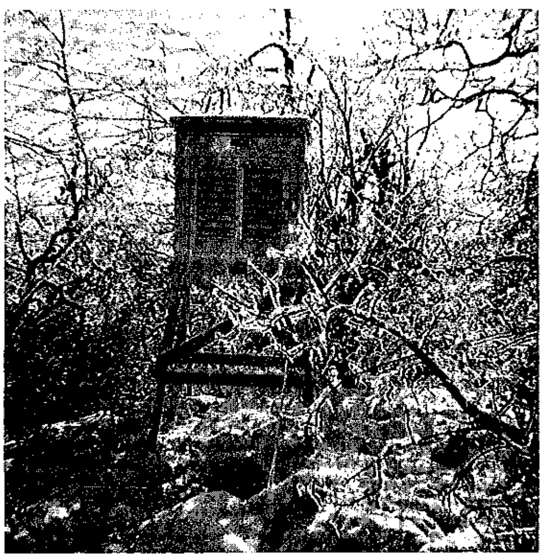
---

[1] U.S. Department of Agriculture Yearbook, 1941.
[2] See section on wind direction and velocity.

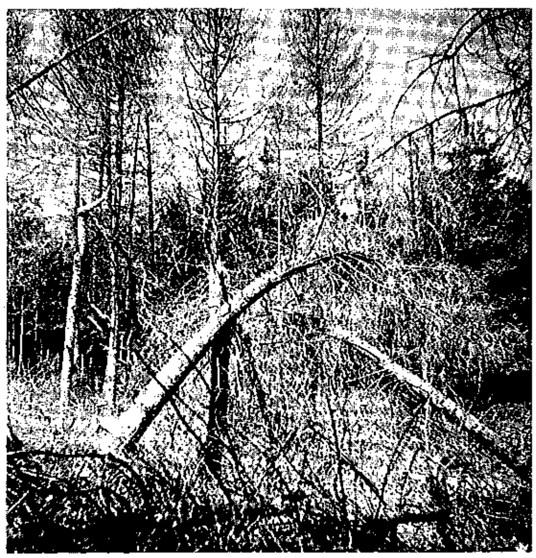
Continental Road.



Betula pepulifolia bent by glaze



Instrument shelter on the summit of Black Rock Hill



Damage in larch plantation (Larix dicidua) Santalis

32. Glaze and damage from the storm of December 9, 1956.

TABLE 3: Weekly Maximum and Minimum Air Temperatures in Degrees Fahrenheit

Month	Week	Height above ground	1 Max.	1 Min.	2 Max.	2 Min.	3 Max.	3 Min.	4 Max.	4 Min.	5 Max.	5 Min.	6 Max.	6 Min.	7 Max.	7 Min.	8 Max.	8 Min.	9 Max.	9 Min.	10 Max.	10 Min.	Stewart Field Max.	Stewart Field Min.
April	16-22	2.0 m	65	28	58	29	68	28	62	28	52	25	55	23	53	25	55	8	52	25	68	42	67	29
	23-29	2.0 m	87	30	81	27	83	30	81	32	80	28	83	29	82	28	80	42	87	36	75	33	82	31
May	30- 6	2.0 m	70	33	67	34	67	35	67	37	64	34	66	35	66	34	65	35	65	31	69	40	72	38
	7-13	2.0 m	87	32	83	31	84	28	85	25	85	25	83	28	85	26	84	28	83	29	82	37	86	33
	14-20	2.0 m	75	33	73	32	75	32	73	30	72	28	73	30	73	29	72	30	75	30	75	35	75	34
	21-27	2.0 m	83	30	78	32	80	33	81	32	80	33	78	31	78	31	78	32	80	29	80	39	85	32
June	28- 3	2.0 m	87	51	85	50	89	48	86	47	87	47	86	48	87	48	87	48	86	49	85	49	90	40
	4-10	2.0 m	82	50	80	51	89	49	82	48	82	46	81	48	86	48	84	48	82	48	78	49	87	53
	11-17	2.0 m	89	56	88	55	96	52	89	52	90	51	88	52	92	51	89	51	87	52	84	52	97	55
	18-24	2.0 m	84	43	82	42	87	47	82	45	83	43	83	45	86	41	84	44	83	44	81	50	90	48
July	25- 1	2.0 m	85	50	84	51	86	51	81	54	83	51	83	52	87	53	83	51	82	48	82	55	91	54
		25.0cm	86	49	84	51	103	49	--	--	--	--	84	53	93	52	--	--	--	--	--	--		
		7.5cm	86	50	84	49	101	48	--	--	--	--	83	55	93	51	--	--	--	--	--	--		
	2- 8	2.0 m	87	54	85	53	87	49	84	51	84	48	84	51	87	51	84	51	81	53	79	51	92	56
		25.0cm	87	54	85	53	103	50	--	--	--	--	--	--	92	51	105	64	89	53	82	52		
		7.5cm	86	54	85	51	102	50	--	--	--	--	--	--	92	50	112	51	88	52	80	53		
	9-15	2.0 m	78	58	77	59	81	57	77	58	77	56	77	58	80	58	75	58	73	56	77	57	85	61
		25.0cm	79	57	78	58	96	55	79	58	81	55	85	58	85	59	91	58	81	57	78	57		
		7.5cm	78	58	77	56	92	56	80	59	81	57	84	58	84	55	97	58	82	56	76	57		
	16-22	2.0 m	77	51	74	51	79	52	76	54	78	53	78	53	81	54	78	53	80	53	77	55	84	53
		25.0cm	76	51	74	51	97	49	79	55	81	53	78	52	87	53	92	52	82	53	78	55		
		7.5cm	77	52	73	50	96	47	79	55	81	54	85	53	95	51	89	53	83	53	77	56		
	23-29	2.0 m	80	47	79	48	83	49	79	51	79	48	79	48	83	49	74	49	80	47	91	49	87	58
		25.0cm	81	47	79	48	93	48	84	49	84	48	80	47	88	49	88	49	83	48	80	49		
		7.5cm	80	48	78	46	90	49	84	50	84	49	79	48	89	47	94	47	82	48	79	50		
Aug.	30- 5	2.0 m	77	49	75	50	80	52	75	54	77	51	78	52	80	52	78	51	79	51	76	53	83	51
		25.0cm	77	49	76	49	98	49	78	52	85	50	77	51	88	52	87	50	82	51	77	53		
		7.5cm	77	50	75	48	97	49	78	53	81	51	78	51	86	52	94	51	81	51	77	54		
	6-12	2.0 m	82	57	81	57	86	60	81	61	82	60	83	59	86	59	83	59	80	57	80	61	90	61
		25.0cm	83	56	81	49	95	56	85	60	84	59	84	59	94	60	91	56	87	57	83	60		
		7.5cm	82	57	81	55	94	58	84	60	85	59	82	59	92	59	98	53	86	56	83	60		
	13-19	2.0 m	85	58	83	58	87	58	77	60	85	60	84	60	89	61	86	59	85	57	85	62	93	60
		20.0cm	85	57	82	57	98	57	84	59	88	59	85	60	94	60	90	61	88	58	83	60		
		7.5cm	84	58	83	56	96	58	84	60	87	60	84	61	98	61	88	60	88	60	85	60		
	20-26	2.0 m	70	55	68	55	70	52	66	54	69	53	69	53	72	53	80	52	70	52	69	54	80	51
		25.0cm	71	54	70	54	81	53	68	53	71	53	70	53	78	52	76	49	75	52	69	53		
		7.5cm	72	55	73	53	83	53	69	54	72	54	70	52	79	53	75	53	73	51	72	54		
Sept.	27- 2	2.0 m	80	48	79	49	83	52	74	54	80	51	80	52	84	53	81	52	79	51	80	51	86	62
		25.0cm	81	48	79	48	88	51	80	53	83	50	82	51	87	53	85	49	83	50	79	51		
		7.5cm	80	49	80	48	90	51	79	54	84	51	82	50	88	53	84	52	83	49	81	52		
	3- 9	2.0 m	78	39	75	40	79	41	77	43	78	41	80	43	84	43	79	43	77	43	78	44	87	45
		25.0cm	78	39	75	39	88	40	77	42	81	41	81	42	89	43	85	40	82	43	76	45		
		7.5cm	77	•40	74	38	86	40	78	43	80	41	80	42	88	44	84	42	79	42	79	45		

Sept.	10-16	2.0 m	79	47	78	43	75	46	77	48	78	47	79	47	80	48	74	46	78	47	78	47	85	40
		25.0cm.	78	47	77	43	86	47	78	47	80	47	82	47	88	50	82	45	78	48	77	45		
		7.5cm	79	48	77	43	87	48	78	48	71	47	80	46	85	49	82	47	80	47	79	46		
	17-23	2.0 m	74	35	71	35	72	35	73	36	75	32	76	34	79	33	74	32	78	30	72	33	83	41
		25.0cm	74	35	71	35	83	35	74	36	75	34	78	34	85	33	79	30	77	31	70	33		
		7.5cm	72	36	70	34	84	35	74	37	75	34	76	33	85	34	78	32	77	31	72	33		
	24-30	2.0 m	65	41	62	40	64	39	62	39	63	39	64	39	68	40	62	39	63	39	62	40	73	43
		25.0cm	63	41	62	39	70	38	60	39	62	39	67	39	75	42	68	36	68	39	63	40		
		7.5cm	64	42	61	38	72	38	63	40	64	40	67	38	72	40	67	38	69	39	63	41		
Oct.	1- 7	2.0 m	66	36	64	36	66	38	64	40	65	40	66	38	70	39	67	38	66	35	65	40	72	37
		25.0cm	65	36	64	36	72	38	63	39	66	40	69	39	75	46	69	35	73	36	64	40		
		7.5cm	65	37	64	35	73	37	63	39	65	40	68	38	77	40	68	37	72	35	66	40		
	8-14	2.0 m	69	29	64	30	74	33	71	35	72	31	72	31	77	32	71	31	72	28	68	32	78	31
		25.0cm	68	30	65	30	90	30	69	34	79	31	80	34	84	31	82	29	83	29	85	32		
		7.5cm	69	30	66	30	95	32	68	35	78	31	79	32	82	32	79	30	85	29	86	33		
	15-21	2.0 m	78	35	73	35	80	33	75	34	79	33	79	33	81	34	79	33	80	35	78	35	84	35
		25.0cm	78	35	72	36	86	28	75	31	79	32	81	36	91	32	84	32	78	33	85	35		
		7.5cm	77	35	71	35	87	30	74	32	79	32	80	30	88	31	82	29	85	32	83	37		
	22-28	2.0 m	66	34	62	34	68	26	66	30	64	32	60	33	64	33	64	32	64	33	60	34	69	35
		25.0cm	66	32	62	33	67	27	65	28	66	31	63	43	65	31	70	31	61	31	66	33		
		7.5cm	65	33	62	34	68	26	66	30	67	32	62	30	65	30	70	28	68	29	67	34		
Nov.	29- 4	2.0 m	70	42	66	42	68	41	68	42	66	41	65	40	67	42	66	41	67	39	66	41	71	42
		25.0cm	70	40	65	40	75	40	70	38	69	40	67	36	75	41	73	41	63	37	68	42		
		7.5cm	71	40	64	39	76	39	72	35	70	39	67	36	73	41	72	38	72	35	70	41		
	5-11	2.0 m	63	19	60	20	71	19	60	19	62	18	63	16	64	18	64	18	65	15	64	18	66	20
		25.0cm	64	18	66	20	67	18	62	17	66	15	65	15	73	16	73	15	61	15	66	17		
		7.5cm	63	19	61	21	67	17	61	18	65	15	64	15	70	16	72	14	68	15	68	17		
	12-18	2.0 m	68	23	66	24	68	20	64	22	66	21	66	22	65	23	65	22	68	23	65	22	73	26
		25.0cm	68	24	65	20	70	21	65	21	67	21	67	24	71	22	70	22	63	23	68	22		
		7.5cm	68	24	64	25	69	21	65	22	68	22	65	21	68	22	68	21	68	22	68	22		
	19-25	2.0 m	64	15	61	17	59	13	60	15	59	12	59	13	59	14	60	13	60	13	60	12	66	17
		25.0cm	64	14	61	16	58	12	61	14	58	12	59	12	59	13	60	12	61	12	60	12		
		7.5cm	63	15	61	16	59	13	61	15	58	12	59	13	59	13	60	11	60	11	60	12		
Dec.	26- 2	2.0 m	42	19	40	20	40	18	45	20	41	17	38	18	39	19	36	18	39	17	36	17	45	21
		25.0cm	42	17	42	20	42	17	47	18	42	16	37	17	38	18	37	15	38	16	35	16		
		7.5cm	43	18	42	21	45	18	48	20	44	16	37	17	38	19	37	15	39	16	36	16		
	3- 9	2.0 m	65	18	62	19	62	13	60	18	60	15	63	17	63	18	63	16	64	16	63	16	62	20
		25.0cm	64	17	62	19	65	14	62	17	63	15	65	17	67	17	65	17	65	16	65	16		
		7.5cm	64	18	62	19	60	16	62	18	63	16	64	16	64	17	66	15	64	15	66	15		
	10-16	2.0 m	56	26	55	27	53	23	50	25	54	24	54	26	54	27	54	25	56	28	54	28	54	19
		25.0cm	55	24	55	27	54	23	52	26	55	25	56	27	55	27	55	26	57	27	56	28		
		7.5cm	55	25	55	27	54	24	52	25	55	26	54	26	58	27	55	26	56	27	57	28		
	17-23	2.0 m	46	14	46	16	47	14	45	14	47	13	47	13	48	14	47	13	49	13	48	14	46	18
		25.0cm	45	14	45	17	47	14	45	14	48	12	48	12	53	13	46	12	50	12	49	13		
		7.5cm	45	14	45	16	47	15	44	15	50	12	49	12	52	12	51	11	49	13	48	12		
	24-30	2.0 m	40	9	38	9	37	3	38	5	37	4	39	5	35	6	39	5	42	5	47	5	42	10
		25.0cm	44	7	40	9	38	3	40	6	39	4	42	4	43	5	42	4	42	5	48	3		
		7.5cm	45	8	39	8	37	3	38	7	41	3	42	5	46	6	43	3	41	5	47	2		
Jan.	31- 6	2.0 m	41	7	40	9	38	2	38	4	35	1	38	3	39	4	38	2	40	5	39	4	42	8
		25.0cm	42	5	40	8	38	- 1	38	4	37	0	39	2	43	3	39	2	43	6	40	2		
		7.5cm	42	7	40	8	37	- 2	37	3	38	3	37	2	44	2	40	0	41	6	41	2		

TABLE 3: Weekly Maximum and Minimum Air Temperatures in Degrees Fahrenheit (continued)

			Field Stations																					
		Height above	1		2		3		4		5		6		7		8		9		10		Stewart Field	
Month	Week	ground	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
Jan.	7-13	2.0 m	36	-7	35	-6	35	-9	36	-8	32	-6	34	-8	37	-6	35	-7	36	-9	34	-5	40	5
		25.0cm	39	-9	35	-6	35	-10	35	-7	35	-7	35	-9	38	-8	42	-8	37	-8	36	-7		
		7.5cm	339	-8	35	-6	35	-11	34	-8	34	-7	36	-10	37	-9	40	-8	37	-9	36	-7		
	14-20	2.0 m	34	-12	33	-12	32	-17	31	-16	29	-17	32	-15	32	-14	30	-16	32	-14	32	-13	38	-11
		25.0cm	32	-13	30	-12	29	-15	32	-14	28	-16	31	-15	34	-15	32	-16	32	-13	31	-14		
		7.5cm	32	-14	31	-14	30	-14	32	-14	29	-16	32	-15	34	-15	32	-17	32	-12	31	-13		
	21-27	2.0 m	60	9	57	9	57	4	55	6	56	4	56	6	57	7	57	4	58	6	56	6	59	9
		25.0cm	58	8	56	9	56	3	55	6	56	5	55	6	57	5	57	4	57	7	55	6		
		7.5cm	58	9	55	10	55	3	56	7	55	5	55	5	57	6	56	5	56	8	55	6		
Feb.	28- 3	2.0 m	38	15	35	13	34	15	36	15	35	15	38	12	39	16	36	14	38	15	36	16	40	12
		25.0cm	40	12	36	12	34	16	35	17	34	15	37	10	38	16	35	13	37	11	35	17		
		7.5cm	37	13	36	13	34	16	35	18	34	15	36	10	37	16	34	13	37	12	35	17		
	4-10	2.0 m	46	20	42	22	44	18	45	20	43	18	44	20	45	19	45	18	46	19	43	19	42	18
		25.0cm	45	18	41	21	43	18	44	20	43	18	43	19	45	15	46	15	45	19	47	20		
		7.5cm	45	18	41	22	43	17	43	20	43	18	43	19	43	16	47	15	44	19	48	20		
	11-17	2.0 m	39	9	36	9	37	4	36	5	37	4	37	5	40	5	38	4	39	6	37	6	43	9
		25.0cm	39	7	37	10	40	4	35	6	40	4	39	5	43	5	46	3	44	7	41	6		
		7.5cm	40	8	38	9	39	3	35	7	39	4	40	3	42	5	47	3	42	7	45	6		
	18-24	2.0 m	50	18	47	19	46	17	46	17	46	15	46	17	47	18	51	16	47	17	46	16	47	20
		25.0cm	53	16	48	18	51	15	48	17	51	15	49	17	54	17	62	13	59	16	54	15		
		7.5cm	52	17	49	19	52	15	48	17	50	15	49	16	53	16	63	14	58	17	53	14		
Mar.	25- 3	2.0 m	57	15	57	15	58	10	56	12	55	9	54	11	55	12	55	10	57	13	56	12	57	11
		25.0cm	60	11	54	15	63	10	58	12	60	10	57	15	60	12	59	9	59	13	65	12		
		7.5cm	59	14	59	16	64	10	59	13	60	10	57	11	61	12	60	9	57	14	62	12		
	4-10	2.0 m	40	14	39	15	37	11	36	15	38	12	39	19	40	14	40	12	41	15	40	15	42	16
		25.0cm	42	12	39	15	40	10	37	13	40	12	42	14	47	13	46	9	45	15	47	13		
		7.5cm	42	12	38	16	41	9	37	14	41	12	42	13	46	12	45	10	45	16	53	13		
	11-17	2.0 m	70	24	64	26	69	26	67	26	67	25	69	24	70	25	70	25	71	23	69	25	74	23
		25.0cm	68	22	63	26	75	23	65	24	74	24	71	23	76	23	76	19	75	22	77	23		
		7.5cm	68	22	62	27	75	23	64	25	73	23	70	22	74	22	79	20	72	22	78	22		
	18-24	2.0 m	59	23	56	24	57	23	56	24	57	22	56	23	60	23	58	22	60	22	57	23	59	29
		25.0cm	59	21	56	24	63	21	55	24	62	21	61	22	65	21	68	20	64	21	60	21		
		7.5cm	60	21	56	25	64	20	55	24	62	20	62	21	62	20	69	19	67	20	61	20		
	25-31	2.0 m	62	21	54	22	51	23	52	25	50	22	49	20	52	23	49	22	51	21	48	24	55	22
		25.0cm	61	15	57	22	66	24	55	22	60	21	55	22	60	20	62	19	60	19	52	21		
		7.5cm	60	10	58	23	68	26	57	23	59	20	56	19	61	20	63	18	61	19	53	20		
April	1- 7	2.0 m	60	27	57	28	58	26	56	27	55	25	57	21	56	26	57	25	59	27	56	26	58	30
		25.0cm	61	25	57	28	67	25	55	27	62	24	64	27	66	26	67	23	66	27	61	25		
		7.5cm	62	25	57	29	68	25	58	27	64	20	65	26	68	26	68	22	66	26	62	24		
	8-14	2.0 m	72	25	68	27	70	25	68	26	68	24	69	25	69	26	69	24	71	26	70	26	68	29
		25.0cm	75	23	68	26	80	23	70	26	75	24	75	26	77	25	76	20	75	25	76	24		
		7.5cm	76	23	68	27	82	24	69	26	74	23	76	25	77	22	79	20	73	25	77	23		
	15-21	2.0 m	84	27	81	27	80	35	80	33	80	35	81	26	82	34	81	33	83	27	82	34	82	27
		25.0cm	86	24	83	26	86	30	82	28	87	29	84	24	82	29	86	26	87	25	91	32		
		7.5cm	88	25	84	28	88	28	81	28	88	28	83	23	80	28	89	25	94	24	92	38		

April	22-28	2.0 m	87	45	83	44	83	42	84	42	84	42	84	42	85	43	84	42	86	44	85	43	86	46
		25.0cm	89	42	84	43	92	41	88	40	90	42	90	41	95	41	94	42	92	42	90	43		
		7.5cm	90	41	84	44	93	40	87	40	92	42	90	40	93	40	96	40	95	42	90	42		
May	29- 5	2.0 m	80	28	77	30	76	29	76	30	77	28	77	28	78	29	77	29	79	28	78	29	80	34
		25.0cm	80	28	78	30	82	28	78	29	83	26	82	29	85	27	81	27	85	27	83	29		
		7.5cm	82	28	78	29	85	27	78	30	85	27	82	28	88	26	83	25	90	26	86	28		
	6-12	2.0 m	85	42	83	44	84	45	84	46	83	45	85	44	85	46	83	45	86	42	84	45	87	45
		25.0cm	84	41	84	43	94	46	87	45	94	44	90	43	93	44	90	42	96	40	92	43		
		7.5cm	88	42	85	44	95	45	86	46	93	43	91	41	97	43	92	43	95	40	96	42		
	13-19	2.0 m	80	38	79	38	81	36	80	37	79	36	80	36	81	37	80	37	82	39	80	39	83	38
		25.0cm	81	38	78	37	87	35	82	37	85	36	84	38	90	37	86	36	87	39	80	39		
		7.5cm	82	38	79	38	88	35	82	38	85	36	84	37	91	38	87	34	87	38	80	39		
	20-26	2.0 m	80	44	78	42	81	43	79	42	76	41	78	41	79	42	76	42	79	40	76	43	83	43
		25.0cm	79	44	78	42	87	41	81	41	81	41	81	43	84	42	92	40	83	40	79	43		
		7.5cm	80	43	79	43	88	41	81	42	83	41	80	42	88	42	95	30	85	40	79	42		
June	27- 2	2.0 m	75	39	72	40	77	42	74	44	73	41	73	39	76	42	74	41	74	39	73	41	79	42
		25.0cm	76	39	73	39	82	41	78	41	79	40	78	40	85	41	87	40	81	38	74	42		
		7.5cm	78	40	74	40	83	41	78	42	81	41	79	39	88	42	89	41	82	37	81	41		
	3- 9	2.0 m	76	42	75	43	77	46	75	46	75	46	72	43	77	47	75	45	76	42	75	48	82	43
		25.0cm	75	42	76	42	82	45	78	45	79	46	79	44	86	47	87	44	83	41	78	48		
		7.5cm	78	43	77	43	83	45	78	46	80	47	80	43	88	48	89	43	84	40	79	49		
	10-16	2.0 m	89	60	88	60	97	58	90	59	90	56	89	56	94	57	89	56	90	54	88	59	96	41
		25.0cm	90	60	89	58	101	59	97	58	95	55	93	57	104	57	99	55	99	52.	86	56		
		7.5cm	90	59	87	59	103	58	94	58	95	56	94	56	106	50	102	53	101	50	90	56		
	17-23	2.0 m	89	52	86	53	97	54	88	55	89	54	88	53	93	55	90	54	89	53	89	57	96	52
		25.0cm	89	52	87	53	101	52	91	54	95	53	93	54	103	55	105	54	99	50	92	56		
		7.5cm	90	52	88	53	103	52	91	55	96	54	93	53	105	55	108	53	100	50	95	56		
	24-30	2.0 m	85	52	84	52	90	56	85	57	85	55	85	56	90	56	86	55	87	57	86	54	92	64
		25.0cm	84	52	84	51	94	55	90	54	92	54	90	57	98	56	99	55	95	55	86	55		
		7.5cm	86	52	86	50	96	55	88	55	94	54	90	56	101	55	100	54	97	52	89	55		
July	1- 7	2.0 m	84	48	80	48	88	50	84	51	87	49	85	49	87	50	85	50	85	49	85	49	89	50
		25.0cm	85	48	81	45	94	49	87	50	89	49	86	51	97	48	104	49	91	47	89	49		
		7.5cm	86	48	84	49	95	51	87	51	90	49	86	50	99	50	106	49	92	46	90	50		
	8-14	2.0 m	86	53	83	55	90	53	85	54	83	51	85	51	89	53	86	54	86	49	84	52	89	57
		25.0cm	86	53	84	54	96	52	88	52	92	50	90	53	99	53	103	52	95	48	86	52		
		7.5cm	88	53	85	54	98	52	87	52	92	50	89	52	101	52	105	52	96	46	86	52		
	15-21	2.0 m	91	51	88	51	95	52	90	53	90	51	91	50	95	51	90	52	92	52	89	53	97	55
		25.0cm	91	51	90	51	99	51	94	51	96	51	96	52	103	51	101	49	100	49	92	52		
		7.5cm	93	51	97	51	100	51	94	52	97	51	95	52	105	50	104	49	103	46	93	53		
	22-28	2.0 m	93	55	92	55	88	55	91	56	92	55	92	54	95	56	90	52	94	54	93	58	95	55
		25.0cm	92	55	92	51	94	55	93	54	96	54	96	55	96	55	105	52	102	52	94	57		
		7.5cm	94	55	93	51	90	55	94	55	98	55	95	54	98	54	108	52	104	51	95	57		
Aug.	29- 4	2.0 m	90	57	88	57	91	58	89	59	89	58	89	58	93	58	89	59	91	59	89	60	94	58
		25.0cm	91	57	88	57	97	58	91	58	94	57	96	59	98	58	101	55	98	56	93	59		
		7.5cm	92	57	88	58	98	58	92	58	94	58	96	59	99	58	104	55	99	53	95	59		
	5-11	2.0 m	85	46	83	47	88	47	84	49	85	47	85	46	89	47	86	47	86	45	84	50	89	53
		25.0cm	87	45	83	47	93	48	86	45	89	46	90	47	96	44	95	42	95	42	91	51		
		7.5cm	86	45	84	46	92	48	85	48	89	47	90	46	95	45	96	41	97	41	90	50		

TABLE 4: Observations of Soil Temperatures in Degrees Fahrenheit

		Field Stations																			
		1		2		3		4		5		6		7		8		9		10	
Month	Day	Surf.	30cm	Surf.	30cm	Surf.	30cm	Surf.	30cm	Surf.	30cm	Surf.	30cm	Surf.	30cm	Surf.	30cm	Surf.	30cm	Surf.	30cm
May	2	52	44	47	47	--	57	--	--	--	47	--	--	38	50	53	51	50	49	52	40
	7	45	45	47	45	53	48	--	--	--	49	--	--	45	46	51	50	49	47	48	41
	9	49	56	42	45	48	49	--	--	49	47	--	--	54	45	53	48	49	45	48	45
	14	52	54	56	49	58	60	48	51	57	49	45	52	62	56	65	56	58	54	59	51
	16	54	56	51	50	56	57	44	50	54	47	54	52	60	56	56	56	58	56	56	52
	21	59	52	51	48	56	53	44	47	54	49	53	48	57	44	62	51	56	50	54	52
	23	56	55	60	53	62	59	51	53	47	54	58	58	66	57	62	60	58	54	57	52
	29	68	53	50	50	52	54	44	49	56	54	54	50	58	55	62	54	56	51	53	52
June	1	60	56	61	52	67	60	56	53	64	57	63	52	68	59	66	56	62	56	62	54
	4	57	55	60	54	62	58	56	53	60	57	55	59	62	59	63	57	58	55	59	55
	12	57	57	58	54	--	--	--	--	--	--	58	--	59	60	65	60	--	--	--	--
	18	58	60	60	60	65	59	56	60	63	62	60	60	65	63	68	62	60	60	62	60
	21	55	59	60	55	62	65	53	56	63	60	62	58	62	68	65	61	60	57	63	57
	25	67	62	67	59	67	64	57	50	68	65	66	60	66	64	71	65	66	61	68	60
	28	67	65	66	59	65	64	58	62	67	62	66	62	65	64	65	62	60	59	62	57
July	2	65	62	71	59	68	67	59	60	64	62	68	62	72	65	71	65	66	61	68	63
	6	59	63	58	59	59	58	50	57	56	60	60	58	62	61	60	60	58	58	59	60
	9	66	62	69	62	70	64	59	62	63	61	65	62	68	67	71	65	63	61	66	63
	12	63	63	66	62	68	64	59	62	66	64	66	64	68	64	71	66	66	61	60	61
	19	60	62	61	59	67	64	58	60	63	61	63	62	68	64	71	65	62	61	63	63
	23	63	62	66	62	72	64	59	60	66	61	66	62	73	64	71	65	66	61	68	63
	26	65	57	65	62	64	67	59	62	66	62	66	62	68	64	71	65	66	61	68	63
	30	60	57	60	62	63	64	56	62	60	62	60	62	68	73	68	65	60	61	62	63
Aug.	6	63	57	65	62	67	64	58	62	63	62	60	62	65	64	65	65	60	61	62	61
	9	65	62	65	62	67	66	59	62	66	62	65	62	70	68	71	65	72	61	68	63
	13	65	63	66	62	72	71	62	62	68	62	60	62	68	67	71	65	66	62	68	63
	16	63	62	65	62	72	68	62	62	68	65	66	64	72	67	75	68	66	62	68	63
	20	65	65	65	62	71	71	59	63	56	62	58	62	59	67	62	65	60	61	59	63
	24	63	62	65	59	65	64	56	60	60	62	60	62	65	64	65	62	60	61	59	60

Sept.	4	63	62	65	62	67	66	62	62	66	65	63	64	68	67	71	68	66	64	68	63
	6	65	62	65	62	67	68	62	63	63	62	66	64	68	70	71	66	66	61	68	66
	10	54	57	53	57	53	59	50	57	55	60	53	64	59	61	60	60	56	56	56	57
	13	60	59	60	59	61	62	59	57	63	60	60	62	68	64	65	60	60	58	62	60
	17	57	55	60	57	61	59	53	57	54	57	55	58	57	61	60	59	56	56	56	57
	20	60	56	55	57	61	59	48	55	51	57	53	58	57	61	56	57	56	56	55	57
	24	60	57	60	57	61	59	53	57	55	57	57	59	59	64	60	57	58	58	56	55
	7	52	56	50	54	53	57	48	55	51	55	52	57	54	59	55	57	53	56	53	55
Oct.	1	54	54	55	54	53	57	48	54	51	55	51	55	57	58	55	57	55	56	55	55
	8	52	54	50	54	51	57	48	54	49	55	50	55	55	58	53	55	53	53	55	55
	11	45	45	48	50	53	51	44	50	46	54	45	53	46	56	49	53	49	53	50	53
	15	52	45	55	53	56	57	49	52	55	54	57	53	62	58	62	55	48	53	57	55
	18	54	54	55	55	58	59	50	54	55	55	55	57	60	58	59	57	55	56	57	55
	22	52	52	53	52	49	55	48	52	55	54	53	56	55	58	57	57	55	58	55	55
	25	45	52	49	52	53	55	41	50	51	49	51	56	52	52	53	53	53	49	55	53
Nov.	1	56	56	58	55	60	57	52	54	57	55	55	56	62	61	59	57	58	56	59	55
	5	52	53	50	54	53	57	46	54	51	55	53	53	57	56	57	57	55	53	55	55
	8	45	45	45	52	49	53	41	50	51	55	51	55	55	58	53	55	55	54	53	54
	13	44	45	54	51	45	47	40	49	42	48	41	50	66	54	44	50	45	47	45	49
	15	44	45	48	48	40	45	40	47	40	47	47	49	53	52	51	50	51	47	48	49
	19	43	46	39	45	39	42	38	47	32	45	40	48	45	50	43	46	45	45	41	47
	26	38	41	37	41	32	33	31	40	35	40	38	40	41	43	34	43	40	39	38	42
Dec.	3	37	41	40	40	34	38	31	39	32	39	31	41	41	45	40	40	41	38	36	39
	6	37	41	43	43	39	34	35	39	42	39	41	43	48	45	46	40	45	39	41	43
	10	38	41	39	43	37	42	39	45	42	39	34	41	40	45	40	43	40	40	40	40
	13	46	41	43	40	44	44	38	43	43	39	40	43	45	46	44	43	43	41	41	40
	19	38	39	39	41	34	37	35	39	34	36	33	39	34	43	34	37	36	39	35	39
	24	35	38	38	41	34	37	31	39	31	36	37	41	40	43	39	41	39	40	35	40
Jan.	1	31	35	30	37	32	35	28	36	31	36	32	35	34	39	34	37	33	36	32	38
	7	31	35	32	39	32	32	30	34	32	35	36	36	32	36	34	36	32	34	31	35
	14	31	35	31	35	31	32	28	34	30	34	32	36	32	36	34	36	32	34	31	35
	21	31	35	32	35	32	32	29	35	32	35	32	36	32	36	34	35	32	33	32	34
	28	31	35	32	35	32	34	29	34	31	35	32	35	32	36	34	35	32	34	31	34

TABLE 4: Observations of Soil Temperatures in Degrees Fahrenheit (Continued)

		Field Stations																			
		1		2		3		4		5		6		7		8		9		10	
Month	Day	Surf.	30cm	Surf.	30cm	Surf.	30cm	Surf.	30cm	Surf.	30cm	Surf.	30cm	Surf.	30cm	Surf.	30cm	Surf.	30cm	Surf.	30cm
Feb.	4	31	35	32	35	34	34	29	35	32	35	33	35	32	36	34	36	34	34	32	35
	11	31	35	32	35	32	34	29	35	30	34	33	35	34	36	34	35	34	34	31	35
	18	31	35	32	35	31	34	28	35	31	34	32	35	32	36	34	34	35	34	32	35
	25	31	35	32	35	32	34	29	34	30	35	33	34	39	36	33	34	35	33	34	34
Mar.	4	31	35	32	35	32	34	30	35	32	34	32	36	32	36	33	36	34	34	34	33
	14	35	35	32	35	32	32	30	34	32	34	32	35	39	36	34	35	34	34	32	35
	18	31	35	32	35	36	41	29	35	32	35	37	39	45	36	48	40	43	39	37	39
	23	35	38	32	39	39	41	30	35	46	39	38	36	41	50	46	34	43	39	37	39
Apr.	1	42	39	42	39	44	42	35	36	46	41	43	40	52	46	48	44	47	42	43	40
	8	42	41	40	40	42	42	35	39	35	39	38	38	39	41	37	41	40	39	38	38
	15	38	39	38	39	40	42	32	39	49	39	38	38	48	41	44	40	43	39	38	38
	22	54	45	53	48	53	53	46	49	56	49	52	47	62	52	59	53	55	49	52	47
	29	60	57	58	54	60	59	50	52	65	54	57	51	68	69	66	60	62	56	57	51
May	6	45	44	48	46	56	57	44	47	56	54	53	50	65	54	60	53	55	51	54	52
	13	60	57	60	52	63	62	51	55	66	57	60	55	68	59	65	55	63	56	56	53
	21	45	52	47	50	53	53	44	49	51	54	51	50	57	54	55	53	51	49	50	53
	28	57	52	56	57	58	62	51	57	56	57	55	56	62	59	62	57	60	56	54	55
June	3	60	57	58	55	61	62	53	57	63	57	57	56	65	59	65	60	60	56	56	57
	10	56	57	53	54	61	64	54	60	66	57	60	59	65	61	65	60	60	56	56	53
	13	60	59	67	59	67	68	56	60	68	65	63	62	68	64	71	62	63	61	59	57
	17	67	62	67	62	72	71	63	62	60	65	66	62	75	67	78	65	71	61	68	63
	20	63	68	65	62	67	74	56	65	60	65	66	64	72	67	71	68	66	64	65	63
	24	68	65	67	65	71	71	65	65	68	65	70	62	75	70	78	68	66	64	65	63
July	1	57	62	57	59	67	68	56	60	63	60	63	62	72	67	71	65	63	61	62	63
	8	65	65	67	65	67	68	62	62	72	65	66	64	72	67	71	65	71	64	65	63
	15	65	65	67	62	67	71	62	60	68	65	66	64	65	67	71	62	66	64	68	63
	23	68	65	67	65	67	71	62	65	68	68	66	67	72	70	71	71	71	67	68	66
	29	68	65	67	65	67	71	59	65	66	65	66	64	68	70	68	68	66	64	68	66
Aug.	5	65	65	65	65	67	71	62	62	66	68	60	64	65	64	68	68	66	64	62	66
	13	60	62	60	65	61	71	59	65	57	62	60	62	68	67	65	65	63	61	62	66

TABLE 5: Observations of Soil Moisture in Percent Volume

		Field Stations																			
		1		2		3		4		5		6		7		8		9		10	
Month	Day	Surf.	30cm	Surf.	30cm	Surf.	30cm	Surf.	30cm	Surf.	30cm	Surf.	30cm	Surf.	30cm	Surf.	30cm	Surf.	30cm	Surf.	30cm
May	2	29.0	36.0	32.5	24.0	--	29.8	--	--	29.0	29.5	--	--	31.5	30.0	28.0	35.5	35.5	40.0	33.5	32.5
	7	31.5	45.5	33.0	30.0	30.0	31.0	--	--	29.5	30.0	--	--	29.0	30.0	28.5	34.5	34.5	35.0	33.0	31.5
	9	29.5	45.0	34.0	30.0	29.5	31.0	--	--	30.5	29.4	--	--	28.5	30.7	28.0	33.0	33.0	31.0	31.0	29.0
	14	42.0	44.0	33.0	29.5	30.2	31.2	31.0	28.8	31.0	30.5	72.0	66.0	31.0	32.0	28.0	32.0	31.3	31.3	30.5	28.5
	16	36.0	44.0	33.5	29.5	32.0	32.0	31.5	29.0	31.5	30.5	71.0	66.0	34.5	32.0	27.8	32.0	31.3	31.3	32.5	29.0
	21	29.0	45.5	28.5	29.3	35.0	32.0	33.0	29.0	31.5	30.0	71.0	64.0	33.0	34.5	29.5	32.0	31.5	31.0	32.5	28.5
	23	29.5	46.5	35.5	29.5	34.0	32.5	34.0	29.5	30.5	30.0	72.0	58.0	32.5	32.0	33.0	34.5	33.0	35.5	31.0	34.0
	29	33.5	42.0	35.5	28.5	36.5	33.0	34.5	29.5	31.5	29.4	72.0	66.0	32.0	33.0	29.5	34.5	31.3	35.5	31.0	28.0
June	1	29.0	44.0	35.5	28.5	34.2	35.0	35.5	30.0	31.0	30.0	72.0	68.0	31.5	32.5	30.5	31.0	37.0	33.0	35.5	29.5
	4	32.0	46.5	31.0	31.5	32.0	34.5	31.0	30.3	31.0	31.0	72.0	58.0	34.5	36.5	28.5	30.5	30.5	35.0	35.0	29.5
	12	29.5	45.5	33.0	31.5	28.0	28.5	27.5	28.0	28.0	29.5	58.0	64.0	27.5	31.5	27.5	28.0	28.0	29.0	29.0	28.0
	18	26.0	32.0	31.0	29.0	27.6	29.4	27.0	26.0	27.5	27.0	60.0	71.0	26.0	27.0	26.5	27.5	27.0	27.5	37.5	26.5
	21	25.5	29.0	29.5	29.0	26.3	27.0	25.5	25.0	27.5	29.5	66.0	71.0	28.0	28.0	22.0	25.0	27.0	28.0	31.5	28.0
	25	25.5	29.0	32.0	29.0	28.5	30.8	27.0	26.3	26.0	25.4	58.0	71.0	24.0	25.0	27.0	28.0	26.0	26.0	28.5	26.5
	28	27.0	27.0	38.0	30.5	31.0	35.5	27.8	28.0	30.0	27.5	64.0	72.0	26.5	26.5	26.0	25.7	28.4	28.5	30.5	29.0
July	2	24.0	33.0	28.5	28.5	37.0	39.5	25.5	22.0	26.0	31.8	65.0	69.0	23.5	25.0	24.0	22.0	26.0	26.0	29.0	27.0
	6	25.5	26.0	44.5	33.0	39.5	36.5	28.0	29.5	34.5	33.0	67.5	71.5	28.0	33.0	29.5	30.5	31.5	34.5	35.0	30.5
	9	28.0	27.5	35.0	36.5	33.0	42.0	34.5	31.5	29.5	30.5	67.0	72.5	31.5	36.5	29.5	33.5	31.0	34.5	32.0	30.5
	12	27.8	34.5	33.0	32.0	31.0	35.5	31.5	32.0	28.8	29.0	68.0	72.0	31.0	36.5	38.5	32.0	39.0	31.5	30.0	29.5
	19	29.5	39.0	32.8	32.8	30.5	35.0	30.0	30.5	30.0	31.0	67.0	71.5	29.5	35.5	28.0	31.0	31.0	36.5	34.0	29.0
	23	32.0	43.0	35.5	35.0	32.0	34.5	34.5	31.5	30.8	31.5	66.0	71.0	31.0	43.0	28.5	33.5	31.5	39.5	32.8	30.0
	26	29.5	32.7	34.5	33.5	30.5	35.5	31.0	31.0	30.0	31.0	60.0	72.0	28.8	34.4	28.0	33.5	30.5	34.2	30.5	29.0
	30	27.0	29.0	34.5	33.0	30.0	32.0	30.0	29.5	29.5	30.0	58.0	72.5	27.5	30.5	26.0	28.5	29.0	31.5	29.5	29.0
Aug.	6	25.0	24.0	29.0	30.0	27.5	34.5	25.6	30.0	29.5	27.5	53.0	59.0	18.0	25.0	27.8	24.0	25.5	26.0	25.5	29.5
	9	25.0	24.0	31.0	30.8	29.0	31.0	25.8	26.0	25.0	24.8	60.0	68.0	26.0	23.0	19.0	21.5	25.0	25.5	25.5	26.5
	13	26.8	24.5	27.0	28.0	27.5	28.3	25.0	29.5	25.0	24.0	64.0	68.0	20.0	23.2	20.5	20.0	32.8	32.4	26.0	28.0
	16	27.3	24.3	25.0	27.3	27.3	27.3	24.6	21.0	24.4	19.0	56.0	64.0	13.5	17.0	19.0	17.0	24.8	25.0	25.0	25.5
	20	26.0	27.0	25.2	25.5	25.0	20.0	23.0	17.5	22.0	24.0	55.0	71.0	25.5	27.5	15.0	23.5	24.8	44.0	22.5	32.5
	24	27.7	25.0	30.8	29.5	27.8	32.0	25.5	26.5	23.5	24.5	54.0	66.0	25.0	25.5	24.5	25.0	28.5	28.5	25.5	31.0

TABLE 5: Observations of Soil Moisture in Percent Volume (Continued)

Field Stations

Month	Day	1 Surf.	1 30cm	2 Surf.	2 30cm	3 Surf.	3 30cm	4 Surf.	4 30cm	5 Surf.	5 30cm	6 Surf.	6 30cm	7 Surf.	7 30cm	8 Surf.	8 30cm	9 Surf.	9 30cm	10 Surf.	10 30cm
Sept.	4	27.8	25.0	37.0	32.0	32.0	33.5	34.5	29.5	30.0	27.8	64.0	71.0	36.5	39.5	28.0	31.5	30.0	32.0	39.5	32.5
	6	25.5	24.5	32.0	30.5	31.0	31.0	31.0	28.5	29.0	30.5	56.0	70.0	31.0	33.0	27.0	30.0	28.5	30.0	31.5	29.5
	10	28.5	31.5	33.5	34.5	31.5	32.8	31.5	31.0	30.0	30.5	53.5	71.0	30.0	33.5	28.0	32.0	30.0	32.5	32.5	24.0
	13	27.5	29.0	33.0	33.0	30.8	31.0	30.5	30.0	30.5	30.0	55.0	72.5	28.5	31.0	27.8	31.0	29.4	31.0	30.0	29.5
	17	33.5	31.0	48.0	39.0	35.5	32.0	46.0	32.7	31.0	32.0	58.0	72.0	30.5	35.5	30.0	34.5	30.8	35.0	36.0	31.0
	20	31.0	30.5	48.0	34.5	34.5	32.0	45.5	32.5	31.5	31.0	56.0	72.0	30.5	36.5	29.5	34.5	32.0	37.0	38.5	31.0
	24	37.0	30.0	48.0	36.0	36.5	33.0	39.0	33.5	31.5	32.5	71.0	72.0	31.5	39.0	30.0	36.5	34.5	39.5	46.5	32.0
	27	28.5	29.5	45.0	35.5	32.8	32.8	33.0	33.0	30.2	31.5	66.0	72.0	30.0	33.5	28.8	33.0	31.0	34.5	32.5	30.5
Oct.	1	30.0	29.5	44.5	35.0	33.5	33.0	35.0	33.5	31.0	32.0	66.0	72.0	30.0	34.5	29.0	34.5	31.0	35.5	33.5	30.5
	8	32.0	29.0	46.5	35.0	33.5	30.0	39.0	33.5	31.0	32.0	69.0	71.0	30.0	34.5	29.5	35.5	31.5	38.0	38.0	31.0
	11	27.0	28.0	41.0	33.5	32.5	31.0	35.0	33.0	30.0	31.5	67.0	71.0	30.0	33.5	29.0	34.5	31.0	33.5	32.0	30.0
	15	26.5	29.0	43.0	33.5	32.0	31.0	36.0	33.0	31.0	31.0	67.0	72.0	30.0	34.5	29.0	33.5	34.5	33.5	30.0	28.0
	18	26.0	27.0	39.0	32.0	31.0	30.5	35.0	32.5	31.0	32.0	67.0	72.0	29.0	34.5	29.0	33.5	31.0	34.5	28.5	29.5
	22	25.5	27.0	36.0	31.5	32.0	30.0	34.0	33.0	31.0	31.0	68.0	71.0	32.0	36.0	31.0	36.0	33.5	38.0	35.5	31.5
	25	33.0	31.0	48.0	36.0	35.5	31.0	39.0	34.0	35.5	33.0	68.0	71.0	31.5	37.5	33.5	34.0	34.5	38.0	35.5	33.5
Nov.	1	40.5	32.0	49.0	43.0	34.5	34.0	40.0	35.5	31.0	35.5	72.5	71.0	32.5	35.0	30.5	38.0	33.5	43.0	40.0	33.5
	5	34.5	37.5	44.0	40.0	32.0	31.0	33.5	33.0	31.0	32.0	60.0	68.5	30.5	34.5	29.5	36.0	33.5	40.0	38.0	33.0
	8	34.5	34.5	43.0	35.0	31.5	32.0	36.0	33.5	32.0	32.0	60.0	68.5	30.0	36.0	30.0	30.0	34.5	40.0	36.0	31.0
	13	33.0	33.0	36.0	34.0	31.5	31.5	36.0	33.0	31.0	31.0	60.0	69.0	30.0	35.5	29.5	34.5	33.0	35.5	33.5	30.0
	15	33.0	32.5	40.0	34.0	32.0	31.0	36.0	33.0	32.0	34.5	61.0	70.6	29.0	37.5	29.5	33.5	33.0	36.5	33.5	30.5
	19	31.5	33.0	45.0	37.5	32.0	30.5	36.0	34.0	33.0	34.0	70.0	70.5	30.0	34.0	30.5	35.0	32.0	38.0	39.0	31.5
	26	39.0	33.5	44.0	36.0	31.5	31.0	40.0	33.5	31.0	32.0	61.0	70.0	30.0	33.5	31.0	34.5	33.5	38.0	36.0	34.0
Dec.	3	36.5	33.0	39.0	36.0	31.0	30.0	34.5	32.5	29.5	31.0	69.0	70.5	30.0	33.0	30.0	33.5	32.0	34.5	33.5	29.5
	6	36.0	32.0	39.0	36.0	31.5	29.5	34.5	32.5	31.0	30.0	66.0	70.5	30.0	33.5	30.0	33.5	31.0	34.5	34.5	30.0
	10	40.5	31.5	45.0	36.0	32.5	30.5	44.0	34.0	32.0	33.0	71.0	70.5	31.0	34.5	33.0	34.5	34.5	38.5	39.0	40.0
	13	37.0	33.0	40.0	34.0	31.5	31.5	45.0	36.0	33.0	35.0	72.0	70.5	29.5	32.5	31.0	34.5	33.0	38.0	38.0	39.0
	19	30.0	32.0	32.0	35.0	--	31.5	33.0	31.0	30.0	31.0	70.5	70.0	29.0	32.0	32.0	33.5	29.5	33.5	35.0	31.0
	24	33.5	36.5	36.0	37.0	31.5	29.0	31.0	33.5	30.0	31.0	64.0	69.0	30.5	31.5	32.0	34.5	31.0	34.0	33.0	30.0

Jan.	1	--	33.0	--	33.5	--	--	--	31.5	--	30.0	--	70.0	--	31.0	30.0	30.0	29.5	31.0	32.0	30.0
	7	--	31.0	--	33.5	--	--	--	30.5	--	30.0	--	68.0	--	31.0	--	33.0	29.0	29.0	--	29.5
	14	--	31.5	--	34.0	--	--	--	30.5	--	29.5	--	69.0	--	31.5	--	33.0	--	31.5	--	29.5
	21	--	30.5	--	32.5	--	--	--	30.0	--	31.5	--	70.0	--	33.5	--	34.5	--	40.0	--	30.0
	28	--	34.0	--	34.5	--	29.0	--	30.0	--	29.0	--	69.0	--	31.0	--	34.0	--	34.5	--	31.0
Feb.	4	--	36.5	--	33.5	--	31.5	--	33.0	--	28.0	--	69.5	--	34.5	--	35.0	32.0	33.5	--	31.0
	11	--	36.5	--	42.0	--	30.5	--	34.5	--	28.5	--	67.5	--	32.5	31.5	35.0	31.5	33.5	36.0	31.5
	18	--	34.5	--	35.0	--	30.0	--	31.5	--	28.5	--	69.0	--	30.0	--	32.0	29.5	34.5	--	30.5
	25	--	34.5	--	36.0	--	31.0	--	30.5	--	29.0	--	69.0	34.5	30.0	29.0	33.5	31.5	33.5	--	31.0
Mar.	4	--	33.5	--	35.0	34.0	29.5	--	33.5	--	31.0	--	68.0	31.0	30.5	31.0	34.0	31.0	34.5	37.5	32.0
	14	42.0	36.5	--	38.0	32.0	30.0	--	33.5	--	32.0	--	68.0	31.0	30.5	30.0	33.5	31.0	34.5	36.5	29.5
	18	30.0	34.5	33.5	36.5	32.0	29.5	--	34.5	33.5	31.0	68.0	67.5	30.0	30.5	30.5	33.5	31.5	34.5	33.5	31.0
	23	30.0	33.5	35.0	35.0	31.0	31.5	31.0	34.5	33.0	33.0	67.5	69.5	32.0	28.5	29.5	33.5	31.0	33.5	33.0	31.0
Apr.	1	30.0	34.0	34.0	33.5	31.0	28.5	31.0	33.0	31.0	32.0	67.0	68.0	33.0	30.5	33.0	34.0	32.0	36.0	34.5	31.0
	8	28.5	34.0	31.0	40.0	32.0	29.0	29.5	32.0	31.5	31.0	70.0	69.5	29.0	30.5	32.0	33.5	33.5	33.5	32.0	31.5
	15	29.0	30.0	31.5	37.0	29.5	29.0	30.5	32.0	30.0	31.0	67.0	67.5	29.5	29.5	30.0	34.5	31.0	33.5	31.5	31.0
	22	29.0	34.5	30.5	35.5	33.0	29.0	32.0	32.5	31.0	31.5	66.0	67.5	29.5	29.5	30.0	33.5	30.0	33.5	32.0	31.0
	29	29.5	34.5	34.0	33.0	29.5	29.0	33.5	33.5	31.0	31.5	66.0	67.0	31.0	31.5	31.0	33.5	30.0	31.0	31.0	31.0
May	6	39.0	32.0	25.5	30.5	28.0	27.0	33.0	31.5	30.0	31.0	58.0	68.0	27.5	30.0	29.0	32.5	29.5	31.5	29.5	30.0
	13	39.0	31.5	27.5	28.5	27.0	26.0	30.5	31.5	29.5	31.0	67.0	70.0	28.5	28.5	28.0	31.5	29.0	31.0	27.5	28.0
	21	31.5	37.0	43.0	36.5	32.5	31.5	32.5	34.5	32.0	31.5	66.0	71.0	28.0	31.5	31.5	35.5	33.0	37.0	30.5	34.5
	28	39.0	33.5	28.0	30.0	29.5	27.5	32.0	30.5	31.0	31.0	58.0	67.0	28.0	30.0	29.0	31.5	29.5	31.0	28.5	30.0
June	3	30.0	30.5	25.5	27.0	27.5	26.0	31.5	29.0	31.0	29.0	58.0	64.5	27.0	28.0	26.5	28.0	29.0	31.0	26.5	28.0
	10	26.0	26.5	16.0	24.5	25.5	22.5	29.0	25.0	26.5	26.0	51.0	68.0	14.5	19.0	23.0	24.5	25.5	26.5	24.5	25.5
	13	26.0	25.0	12.0	21.5	24.0	15.0	29.5	23.0	25.0	22.5	50.5	68.0	8.5	9.5	26.5	20.0	24.5	25.0	22.5	25.0
	17	9.0	22.0	14.0	19.0	17.0	8.5	27.0	20.0	21.0	12.0	49.0	67.0	6.0	6.5	16.0	14.0	27.0	23.5	23.0	18.5
	20	24.0	20.0	7.0	15.0	14.0	8.0	26.0	15.0	21.0	12.0	45.5	58.0	5.0	4.0	15.0	13.0	19.0	20.0	17.0	14.0
	24	20.0	18.0	7.0	13.5	10.5	7.5	21.0	14.0	11.5	9.0	41.5	50.5	2.5	4.5	11.0	10.5	19.0	20.5	19.0	12.0
July	1	26.5	21.0	25.5	14.0	13.5	10.0	24.5	13.0	24.5	17.5	54.0	64.0	26.5	19.0	23.0	21.0	27.0	25.5	23.0	26.5
	8	27.0	15.0	24.0	10.5	13.5	8.0	24.5	13.0	22.0	10.5	41.5	39.0	7.5	8.0	15.0	12.0	20.0	19.0	23.0	11.0
	15	27.5	18.0	31.0	26.5	31.5	29.5	37.0	33.0	23.5	25.5	52.0	66.5	26.5	28.0	15.0	27.5	27.5	31.5	28.0	29.0
	23	19.0	18.0	18.5	18.5	18.0	13.0	18.0	16.0	16.5	13.0	22.0	52.0	7.0	9.5	17.5	15.0	18.0	16.5	19.5	11.0
	29	29.0	15.0	32.0	34.0	27.0	27.0	32.0	21.5	26.5	25.5	62.0	67.0	32.0	28.5	26.0	27.0	25.5	29.0	28.0	27.5
Aug.	5	23.0	26.0	25.5	18.5	16.5	15.0	21.0	16.0	23.0	17.5	28.5	34.0	10.0	18.0	21.0	19.5	28.0	19.0	20.0	16.5
	13	20.0	15.0	20.0	14.0	14.0	9.0	17.5	12.0	16.0	11.0	35.0	28.5	8.0	8.5	16.0	13.0	17.0	12.0	15.0	8.0

DISCUSSION AND SUMMARY

One factor shown by this study was the smaller amount of rainfall on the Northern Slopes section of the Forest compared to the Highlands section. Even though Station No. 1 on the lower north slope recorded eight inches of precipitation less than Station No. 7 on the west-facing slope of Glycerine Hollow, the diameter growth and height growth of vegatation at the former station far exceed that of the latter station. Presumably other factors offset the smaller amount of precipitation. The closed canopy of the trees at Station No. 1 would prevent solar radiation from heating the soils. The lower soil temperature would reduce the evaporation rate. Runoff from the upper north slopes of Black Rock Hill may also add to the soil moisture at Station No. 1. Running water in small, rocky tributaries has been observed above Station No. 1 in early spring and late fall. During the summer, water stored in the thick till would presumably be available to trees at Station No. 1. The soil moisture curves for Station No. 1 show the results of these conditions in that the soil moisture remained high, near field capacity, during the period of study. The high soil moisture, at or above saturation at the 30 cm level in the spring and summer of 1956, was probably due to the water storage effect of the thick till. The only other station on the north slope on thick till is Station No. 2 which again shows high soil moisture curves even though the precipitation was less than at other stations in Glycerine Hollow. The good diameter and height growth of the vegetation may also be correlated with higher soil moisture due to lower evaporation and deeper soils. The high relative humidity at Station No. 2 would also decrease the evaporation rate of moisture from the soils.

The growth of trees in the wet depressions and coves in the Forest is not directly related to the precipitation and evaporation patterns at these localities. Soil moisture was always available even during the dry summer of 1957. High soil moisture, high relative humidity, and low evaporation provide ideal conditions for growth of vegatation as witnessed by the trees of relatively large diameter and tall height found in the mixed hardwood association, swamp phase.

On the east- and south-facing slopes of Glycerine Hollow, Stations No. 7 and No. 8 received the greatest amount of precipitation. However, the soil moisture was lower than on the north slopes. The larger amount of precipitation is probably offset by the high evaporation rate due to high air temperatures near the ground and high soil temperatures. Low relative humidity and exposure to wind would also increase evaporation. Figure 30 shows that the average soil moisture content was lower than at other stations during the period of study and shows the extremely low readings recorded during the dry summer of 1957. All the soil moisture curves show large fluctuations during the dry period in spring and summer of 1957. This occurs when soil moisture is critically low and water added to the soil by precipitation is quickly reduced by evaporation and by uptake in the root system of plants. Water seepage through the small patches of soil and runoff would also reduce the soil moisture.

The surface soil moisture at the stations in the Northern Slopes section remained frozen longer into spring than at stations in Glycerine Hollow. Soil temperature during the first week of February warmed slightly in the Hollow, enough to thaw the soil at Station No. 9 at the bottom of Glycerine Hollow.

The first appearance in the Forest of new vegetative growth in the spring can be correlated with areas whose surface soils first thaw. The first plant to blossom in the spring, Tussilago Farfara, is found on the dry sandy banks of the roadsides. In Glycerine Hollow new green shoots of Veratrum viride appear very early in the spring. The soils in the Hollow were only frozen for three weeks, becoming thawed by January 28. The vegetation on the north slope of Black Rock Hill remained inactive longer into spring. The soils remained frozen at Station No. 4 until March 18th.

The warmest field station during the period of the project, Station No. 1, was located at the lowest elevation in the Forest. Station No. 9 at the bottom of a bowl-shaped depression, Glycerine Hollow, recorded lower average temperatures during the summer months than those on either side slope of the depression, indicating an accumulation of cooler air. During the winter months the south slope of Glycerine Hollow recorded lower average temperatures than any of the other stations.

Vegetation cover at the Forest stations definitely influenced both air temperatures and relative humidity. Comparison of summer temperature frequency distributions from the field stations with those of Stewart Field shows a greater frequency of occurrence of high temperatures at the Air Force Base.

Vegetation also influences the temperatures near the ground. Field stations with a partly open canopy had maximum temperatures during the summer months at the 7.5 cm level 10 to 23 degrees higher than the stations with a closed canopy. Vegetation types that usually have a partially open canopy, the Quercus Prinus and Quercus ilicifolia association, have a dense low shrub layer of Gaylussacia baccata and Vaccinium vacillans which seem to be able to stand the high temperatures near the ground. One exception to this condition is found on the cooler and more moist north slopes where a dense shrub layer of Kalmia latifolia prevents the heating of air near the ground and the development of the small shrub layer.

The presence of leaves on the trees and the lower temperatures of the Forest stations also influenced the relative humidities. High relative humidities were recorded more frequently at the field stations than at Stewart Field. Relative humidities in the range of 90 percent to 100 percent occurred more frequently during the summer than during the winter. Relative humidities in Black Rock Brook ravine, under a closed canopy of Tsuga canadensis, averaged higher than those of the other stations during the entire period of study.

Glaze storms are an important factor in the environmental complex of the Forest. Glaze forms during winter when moist air from the Hudson River is pushed up over the colder Highlands.

During one glaze storm the writer recorded above freezing temperatures and no fog at the bottom of a cove on the southeast side of the Forest, below freezing temperatures, fog, and glaze forming on the vegetation in the uplands, and above freezing temperatures and no fog on the lower north slope of the Forest.

The form of the trees, especially in the Highlands, is influenced by the weight of the glaze and breakage of the branches. The oak trees on the high rocky ridges in the Highlands section of the Forest were the most severely damaged.

It has been observed that the contours of the tree tops on the slopes of the Forest do not necessarily follow the contours of the slopes. Near the top of the hills the trees have short, twisted trunks with many low branches and often broken crowns. Down the slopes the trees have longer and straighter trunks. This condition is outstanding on the steep south slopes of the hills. Glaze may be the factor responsible for this condition since branches above the general canopy level exposed to icing conditions would tend to be broken and bent. Figure 21 shows the smooth contour formed by the tree canopy on Rattlesnake Hill.

Causes of the present distribution of the plant associations and species in the Harvard Black Rock Forest cannot be defined with present knowledge. Only through partial solutions and multiple working hypotheses derived from experimental data can the causes of the present vegetational distribution be approximated.

A comparison of the topographic map and the vegetation map of the Harvard Black Rock Forest shows important relationships. Two associations, the mixed hardwood and the hemlock-hardwood associations, are found almost exclusively in the Northern Slopes section of the Forest. One exception is noted: the mixed hardwood association, swamp phase, is found in the wet coves and depressions in the Highlands.

The Quercus rubra assocation is widely spread over the entire Forest; however, this association has developed principally on the lower slopes of the hills. The Quercus Prinus association is found primarily on the upper slopes of the hills. The maps also show that the remaining two associations are related to the topography of the hilltops. The Quercus ilicifolia association is found principally on the western and northern sections of the hilltops, and the Quercus alba-Carya glabra association is found on the eastern and southern sections. The probable causes of these relationships will be discussed in the following paragraphs.

A comparison of the soils map and the vegetation map indicates the relationship between the Rockaway soils that have developed on the deep glacial till and the mixed hardwood and hemlock-hardwood associations on the lower north slopes. In the Highlands the mixed hardwood association, swamp phase, is usually found on Peru and Whitman soils. Soil moisture seems to be the influencing factor in the development of both the vegetation type and the soils series. As the deep till thins out on the upper slopes, the vegetation types change to the Quercus rubra and Quercus Prinus associations. There seems to be no relationship between the variations in the thin till soils on the upper slopes and hilltops and the slope and hilltop associations. The Chatfield soils and Rough Stony Land support Quercus Prinus and Quercus rubra associations, as well as Quercus ilicifolia and Quercus alba-Carya glabra associations.

Raup suggests a relationship between the thick glacial till and the mixed hardwood association on the lower north slopes in that the upper boundary for the deep till is the same as the upper boundary for the mixed hardwood association.[1] There seems to be no relation between the mixed hardwood association and the microclimatic factors studied, except a coincidence with some air temperatures which averaged higher on the lower north slope of Black Rock Hill than at any of the other stations. This fact in addition to Raup's suggestion of the water factor in the horizons of the deep till soils may account for the good diameter and height growth of the mixed hardwood association. The high soil moisture associated with the mixed hardwood association, swamp phase, located in wet depressions and coves in the Forest corroborates the opinion that soil moisture is of considerable importance.

The hemlock-hardwood association found in the ravines that cut the deep till soils of the Northern Slopes section of the Forest is subjected to lower average air and ground temperatures than any other association. Both the soil moisture and the relative humidity are high in the ravines. It is suggested that these three factors - high soil moisture, high relative humidity, and cooler temperatures - may account for the distribution of the hemlock-hardwood association. It is also these factors which are maintained and accentuated by the evergreen condition of the hemlocks.

The Quercus Prinus association is located mainly on the steep, rocky upper slopes, although it is also found on rocky knobs on the lower slopes. The association is characterized by short, gnarled trees of which Quercus Prinus comprises over one-half. Tall shrubs are scarce; however, the small shrubs form a continuous layer above the ground. The soil moisture at the two sites in the Quercus Prinus association was relatively low due to evaporation and runoff from the open exposed sites and from the thin soils on the steep slopes. Air temperatures were significantly high during the period of study.

The more moist areas of the Forest that are not swampy support the Quercus rubra association. This association is found on areas that are lower and more level than those in which the Quercus Prinus association is located. The Quercus rubra association may also be found far up the north and northeast slopes. Tall trees, Quercus rubra var. borealis, with straight boles, represent over half the trees in this association. Relatively high soil moisture due to lower rates of runoff on the level areas, greater water retention in some of the north slope soils, together with low relative humidity and evaporation seem to be important factors in the distribution of the association.

The Quercus ilicifolia association is found on the westerly side of the hilltops on thin patchy soils. The sites are usually open and exposed to the prevailing westerly winds. During the period of study the average air temperatures were relatively low. Relative humidity and soil moisture were also low compared to other sites in the Forest. Runoff from the thin patchy soils and a high evaporation rate would tend to keep the soil moisture low. The dry conditions of the air and soil in addition to low air temperatures strongly affect the distribution of the Quercus ilicifolia association.

[1] Raup, 1958.

The open Quercus alba-Carya glabra association is found on the easterly and southerly sides of the hilltops. Small patches of the association are found on the northeast sides of rocky knobs in the Highlands. On the southerly slopes the extremes of air temperature were greater, and the soil temperatures warmer than at other sites. The high evaporation rate and low relative humidity act to keep the soil moisture low. These factors are characteristic of the Quercus alba-Carya glabra association site on the southerly slopes. Whether these same conditions exist on the northeast side of the hilltops where this association is also found is not known.

LITERATURE CITED

Aikman, J. M. 1941. The Effect of Aspect of Slope on Climatic Factors, Iowa State Coll. Jour. Sci. 15: 161-167.

Alexander, G.W. 1930. Fire Weather and Fire Climate, Monthly Weather Rev. 58: 370-372.

Batchelor, L. D. & E. L. West. 1915. Variations in Minimum Temperatures Due to Topography of Mountain Valleys in its Relation to Fruit Growing, Utah Agric. Coll. Expt. Sta. Bull. 141.

Bliss, L. C. 1956. A Comparison of Plant Development in Microenvironments of Arctic and Alpine Tundras, Ecol. Monogr. 26: 303-337.

Burnes, J. I. 1953. Small-scale Topographic Effects on Precipitation Distribution in San Dimas Experimental Forests, Amer. Geophysical Union Trans. 34: 761-767.

Cain, S. A. 1931. Ecological Studies of the Vegetation of the Great Smoky Mountains of North Carolina and Tennessee: I. Soil Reaction and Plant Distribution, Bt. Gaz. 91: 22-41.

1938. The Species-area Curve, Amer. Midland Nat. 19: 573-581.

1944. Foundations of Plant Geography, Harper and Brothers, N.Y.

Cantlon, J. E. 1953. Vegetation and Microclimates on North and South Slopes of Cushetunk Mountain, N. J. Ecol. Monogr. Vol. 23, No. 3, 241-270.

Cottle, H. J. 1932. Vegetation on North and South Slopes of Mountains in Southwestern Texas, Ecol. XIII: 121-134.

Cowles, H. C. 1901. The Physiographic Ecology of Chicago and Vicinity; a Study of the Origin, Development, and Classification of Plant Societies, Bot. Gaz. 31: 73-108, 145-182.

Cox, H. J. 1910. Frost and Temperature Conditions in the Cranberry Marshes of Wisconsin, Bull. of the U. S. Weather Bureau.

1922. Thermal Belts and Fruit Growing in North Carolina, Monthly Weather Rev. Sup. 19: 1-98.

Daubenmire, R. F. 1936. The "Big Woods" of Minnesota: Its Structure, and Relation to Climate, Fire and Soils, Ecol. Monogr. 6: 233-268.

1947. Plants and Environment, John Wiley and Sons, N.Y.

Denny, C. S. 1938. Glacial Geology of the Black Rock Forest, Black Rock Forest Bull. 8.

Fuller, G. D. 1912. Evaporation and the Stratification of Vegetation, Bot. Gaz. 54: 424-426.

Gast, P. R. & P. W. Stickel. 1929. Solar Radiation and Relative Humidity in Relation to Duff Moisture and Forest Fire Hazard, Monthly Weather Rev. 57: 466-467.

Geiger, R. 1950. The Climate Near the Ground, Harvard Univ. Press, Cambridge, Mass.

Graham, S. A. 1939. Climax Forests of the Upper Peninsula of Michigan, Ecol. 22: 355-362.

Hardesty, J. S. 1940. Soils and Soil Erosion in the Black Rock Forest, Unpublished MS., Harvard Black Rock Forest, Cornwall-on-Hudson, N.Y.

Harshberger, J. W. 1919. Slope Exposure and the Distribution of Plants in Eastern Pennsylvania, Geog. Soc. Phila. Bull. 17: 53-61.

Hawley, L. F. 1926. Theoretical Considerations Regarding Factors Which Influence Forest Fires, Jour. Forestry 24: 756-763.

Hayes, G. L. 1941. Influence of Altitude and Aspect on Daily Variations in Factors of Forest Fire Danger, U.S.D.A. Circ. 591.

Hough, A. F. 1945. Frost Pocket and Other Microclimates in Forests of the Northern Allegheny Plateau, Ecol. 26: 235-250.

Huffaker, C. B. 1942. Vegetaion Correlated with Vapor Pressure Deficit and Relative Humidity, Amer. Midland Nat. 28: 486-500.

Köppen, W. 1931. Grundriss der Klimakunda, Walter de Gruyter Co., Berlin.

Larsen, J. A. 1929. Fires and Forest Succession in the Bitterroot Mountains of Northern Idaho, Ecol. 10: 67-76

Livingston, B. E. 1907. Evaporation and Plant Development, Plant World 10: 269-276.

Lull, H. W. & K. G. Reinhart. 1955. Soil-Moisture Measurement, So. Forest Exp. Sta., Occasional Paper 140.

Lundegårdh, H. 1931. Environment and Plant Development (Translated by Eric Ashby), Edward Arnold and Co., London.

Meigs, P. & F. de Percin. 1956. Frequency of Cold-Wet Climatic Conditions in the United States, QM Research & Development Command, Tech. Report EP-25.

Mitchell, J. A. 1929. Forest Fire Hazard, Agric. Exp. Sta., Univ. of Wisconsin, Research Bull. 91: 1-26.

Oosting, H. J 1948. The Study of Plant Communities, W. H. Freeman and Co., San Francisco
Pierce, L. T. 1934. Temperature Variations Along a Forested Slope in the Bent Creek Experimental Forest, North Carolina, Monthly Weather Rev. 62: 8-12.
Potzger, J. E. 1939. Microclimate and a Notable Case of Its Influence on a Ridge in Central Indiana, Ecol. 20: 29-37.
Raup, H. M. 1938. Botanical Studies in the Black Rock Forest, Black Rock Forest Bull. 7.
Scholz, H. F. 1931. The Physical Properties of the Cove Soils on the Black Rock Forest, Black Rock Forest Bull. 2.
Smith, J. W. 1920. Agricultural Meteorology, The Macmillan Co., N.Y.
Stickel, P. W. 1931. The Measurement and Interpretation of Forest Fire Weather in the Western Adirondacks, Bull. N. Y. State Coll. Forestry IV, Tech. Pub. 34.
Thornthwaite, C. W. 1940. Atmospherical Moisture in Relation to Ecological Problems, Ecol. 21: 17-28.
Tryon, H. H. 1930. The Black Rock Forest, Black Rock Forest Bull. 1.
United States Department of Agriculture. 1941. Climate and Man.
Vaartaja, O. 1954. Temperature and Evaporation at and near Ground Level on Certain Forest Sites, Can. Jour. of Bot. 32: 760-783.
Whitney, M. 1894. Announcement of the Creation of the Division of Agricultural Soils, U. S. Weather Bureau, Div. of Agric. Soils Circ. 1.
Wolfe, J. N., R. T. Wareham & H. T. Scofield. 1949. Microclimates and Macroclimate of Neotoma, a Small Valley in Central Ohio, Ohio Biol. Surv. Bull. 41.
Young, F. D. 1920. Effect of Topography on Temperature Distribution in Southern California, Monthly Weather Rev. 48: 462-463.

TABLE 9: Frequencies of Hourly Temperatures (Number of Hours and Percent Hours) for Ten Field Stations and Stewart Field, Newburgh, New York, April 16 to 30, 1956.*

Temp. Range	1 No. Hr.	1 %	2 No. Hr.	2 %	3 No. Hr.	3 %	4 No. Hr.	4 %	5 No. Hr.	5 %	6 No. Hr.	6 %	7 No. Hr.	7 %	8 No. Hr.	8 %	9 No. Hr.	9 %	10 No. Hr.	10 %	Stewart Field No. Hr.	Stewart Field %
020/024							3	.88	4	1.17	3	.87					8	2.35				
025/029	16	4.38	17	3.45	7	1.94	20	5.88	16	9.33	24	6.98	15	4.39	6	1.71	30	8.82			1	.28
030/034	42	11.51	63	18.10	45	12.47	38	11.18	72	20.99	39	11.34	57	16.77	22	6.25	56	16.47	8	2.57	24	6.67
035/039	73	20.00	81	23.28	74	20.50	74	21.76	71	20.70	70	20.35	67	19.59	56	15.91	46	13.53	26	7.43	67	18.61
040/044	68	18.63	62	17.82	83	22.99	73	21.47	57	16.62	78	22.67	67	19.59	60	17.05	64	18.82	38	10.86	70	19.44
045/049	62	16.99	33	9.48	48	13.30	45	13.24	46	13.41	34	9.88	41	11.99	86	24.53	41	12.06	76	43.43	62	17.22
050/054	31	8.94	28	8.05	36	9.92	22	6.47	17	4.96	24	6.98	24	7.02	28	7.95	28	8.24	72	20.57	47	13.06
055/059	20	5.48	31	8.91	16	4.43	18	5.29	19	5.54	24	6.98	14	4.09	14	3.98	8	2.35	53	15.14	30	8.33
060/064	25	6.85	6	1.72	23	6.37	16	4.71	19	5.54	22	6.40	22	6.43	25	7.20	19	5.59	41	11.71	32	8.89
065/069	7	1.61	21	6.03	10	2.77	14	4.12	5	1.46	8	2.33	7	2.05	25	7.20	21	6.18	26	7.43	11	3.06
070/074	5	1.37	5	1.54	8	2.22	4	1.18	7	2.04	8	2.33	18	5.26	8	2.27	3	.88	6	1.71	4	1.11
075/079	8	2.19	6	1.72	6	1.66	7	2.06	7	2.04	4	1.16	4	1.17	8	2.27	7	2.06	3	.86	7	1.94
080/084	4	1.10			5	1.39	6	1.76	3	.87	6	1.74	6	1.75	8	2.27	5	1.47			5	1.37
085/089	4	1.10													6	1.71	4	1.18				

*The discrepancies in the percent values among the stations arise from errors in the reading of the hygrothermograph charts. The errors were 2% or less.

TABLE 10: Frequencies of Hourly Temperatures (Number of Hours and Percent Hours) for Ten Field Stations and Stewart Field, Newburgh, New York, May, 1956.

Temp. Range	Field Stations 1		2		3		4		5		6		7		8		9		10		Stewart Field	
	No. Hr.	%	No. Hr.	%	No. Hr.	%	No. Hr.	%	No. Hr.	%	No. Hr.	%	No. Hr.	%	No. Hr.	%	No. Hr.	%	No. Hr.	%	No. Hr.	%
025/029					4	.51	5	.69	9	1.25	8	1.03	19	2.47	4.	.51	7	.93				
030/034	15	1.94	27	3.50	13	1.66	16	2.22	18	2.50	36	4.65	22	2.86	18	2.29	39	5.18			7	.94
035/039	55	7.12	58	7.51	56	7.15	71	9.86	84	11.68	62	8.00	90	11.70	59	7.51	82	10.89	12	1.57	24	3.21
040/044	81	10.49	96	12.43	96	12.26	105	14.58	102	14.19	125	16.13	99	12.87	120	15.27	109	14.48	47	6.15	59	7.89
045/049	125	16.19	142	18.39	144	18.39	133	18.43	130	18.08	144	18.58	157	20.42	147	18.70	127	16.87	107	14.01	89	11.90
050/054	147	19.04	123	15.93	132	16.86	122	16.94	108	15.02	115	14.84	142	18.47	133	16.92	122	16.20	184	24.08	132	17.65
055/059	115	14.90	125	16.19	123	15.71	107	14.86	109	15.16	107	13.81	92	11.96	117	14.89	110	14.61	143	18.72	137	18.32
060/064	108	13.99	105	13.60	88	11.24	71	9.86	57	7.93	76	9.81	62	8.06	74	9.41	74	9.83	125	16.36	108	14.44
065/069	70	9.07	53	6.87	72	9.20	57	7.92	63	8.76	60	7.74	48	6.24	73	9.29	46	6.11	90	11.78	91	12.17
070/074	27	2.98	22	2.85	25	3.19	16	2.22	18	2.50	13	1.68	17	2.21	16	2.04	15	1.99	25	3.27	60	8.02
075/079	15	1.94	15	1.94	19	2.43	14	1.94	13	1.81	20	2.58	14	1.82	17	2.16	14	1.86	24	3.14	15	2.01
080/084	18	2.33	6	.78	11	1.40	3	.42	7	.97	9	1.16	7	.91	8	1.02	8	1.06	7	.92	15	2.01
085/089									1	.14											10	1.34
090/094																					1	.27

TABLE 11: Frequencies of Hourly Temperatures (Number of Hours and Percent Hours) for Ten Field Stations and Stewart Field, Newburgh, New York, June, 1956.

Temp. Range	Field Stations 1 No. Hr.	1 %	2 No. Hr.	2 %	3 No. Hr.	3 %	4 No. Hr.	4 %	5 No. Hr.	5 %	6 No. Hr.	6 %	7 No. Hr.	7 %	8 No. Hr.	8 %	9 No. Hr.	9 %	10 No. Hr.	10 %	Stewart Field No. Hr.	Stewart Field %
035/039													4	.53								
040/044					4	.56							12	1.59	3	.43						
045/049	4	.54	5	.71	15	2.11	24	3.31	24	3.27	26	3.50	35	4.64	30	4.30	25	3.57	4	.57	4	.56
050/054	50	6.73	46	6.50	57	8.01	57	7.86	76	10.34	103	13.80	96	12.73	78	11.91	122	17.40	32	4.53	20	2.88
055/059	117	15.75	104	14.69	106	14.89	124	17.10	131	17.82	131	17.63	149	19.76	137	19.66	128	19.69	127	13.99	102	14.17
060/064	145	19.52	147	20.76	114	16.01	151	20.83	148	20.14	137	18.44	122	16.18	143	20.52	125	19.26	147	20.82	104	14.44
065/069	156	21.00	141	19.92	121	17.00	124	17.10	138	18.78	140	18.84	97	12.86	127	18.22	117	16.69	165	23.37	111	15.42
070/074	115	15.48	111	15.68	114	16.01	118	16.28	105	14.29	102	13.73	113	14.99	87	12.48	89	12.70	113	16.01	142	19.72
075/079	95	12.79	96	13.56	87	12.22	73	9.93	64	8.71	68	9.15	64	8.49	65	9.33	62	8.84	96	13.60	103	14.31
080/084	41	5.52	39	5.51	51	7.16	42	5.78	39	5.31	32	4.31	40	5.31	27	3.87	27	3.85	22	3.12	69	9.58
085/089	20	2.69	19	2.68	31	4.35	12	1.66	10	1.36	4	.54	19	2.52			6	.86			49	5.56
090/094					12	1.67							3	.40							21	2.92
095/100																					4	.56

TABLE 12: Frequencies of Hourly Temperatures (Number of Hours and Percent Hours) for Ten Field Stations and Stewart Field, Newburgh, New York, July, 1956.

Temp. Range	Field Stations 1 No. Hr.	1 %	2 No. Hr.	2 %	3 No. Hr.	3 %	4 No. Hr.	4 %	5 No. Hr.	5 %	6 No. Hr.	6 %	7 No. Hr.	7 %	8 No. Hr.	8 %	9 No. Hr.	9 %	10 No. Hr.	10 %	Stewart Field No. Hr.	Stewart Field %
045/049	3	.40	4	.54					2	.26					4	.56	5	.67	3	.42		
050/054	37	4.91	55	7.36	6	.82	32	4.53	84	10.84	65	8.52	81	10.45	91	12.78	80	10.80	14	1.98	10	1.34
055/059	103	13.66	89	11.91	69	9.41	78	11.05	93	12.00	97	12.71	99	12.77	87	12.21	128	17.20	103	14.55	43	5.78
060/064	135	18.04	171	22.87	91	12.41	136	19.26	211	27.23	183	23.98	164	21.16	159	22.33	163	21.94	188	26.55	103	13.84
065/069	219	29.05	244	32.66	149	20.33	232	32.86	227	29.29	237	31.06	201	25.94	214	30.06	208	27.99	220	31.07	155	20.93
070/074	63	21.62	127	17.00	181	24.69	151	21.39	108	13.94	128	16.78	138	17.81	108	15.17	112	15.07	117	16.53	180	24.29
075/079	79	10.48	49	6.56	130	17.74	71	10.06	42	5.42	45	5.90	71	9.16	45	6.32	37	4.98	53	7.49	125	16.90
080/084	10	1.33	8	1.07	81	11.05	6	.85	8	.32	8	1.05	19	2.45	4	.56	10	1.35	10	1.41	90	12.10
085/089	4	.53			22	3.00							2	.26							33	4.44
090/094					4	.55															5	.67

TABLE 13: Frequencies of Hourly Temperatures (Number of Hours and Percent Hours) for Ten Field Stations and Stewart Field, Newburgh, New York, August, 1956.

Temp. Range	1 No. Hr.	1 %	2 No. Hr.	2 %	3 No. Hr.	3 %	4 No. Hr.	4 %	5 No. Hr.	5 %	6 No. Hr.	6 %	7 No. Hr.	7 %	8 No. Hr.	8 %	9 No. Hr.	9 %	10 No. Hr.	10 %	Stewart Field No. Hr.	Stewart Field %
045/049																	3	.39				
050/054	26	3.34	34	4.56	55	7.48	11	1.42	31	3.98	21	2.81	23	3.01	31	4.40	43	5.58	13	1.65	11	1.48
055/059	87	11.18	107	14.36	83	11.29	102	13.21	159	20.41	103	13.17	90	11.80	86	12.20	128	16.60	94	11.93	28	3.76
060/064	198	25.45	254	34.10	195	26.53	186	24.09	222	28.50	213	28.48	207	27.13	197	27.94	267	34.63	242	30.71	109	14.65
065/069	240	30.85	198	26.58	170	23.13	226	29.27	172	22.08	223	29.81	173	22.67	150	21.28	156	20.23	221	28.05	189	25.40
070/074	129	16.58	104	13.96	128	17.41	168	21.76	117	15.02	119	15.91	150	19.66	142	20.14	104	13.49	142	18.02	147	19.76
075/079	85	10.93	43	5.77	73	9.93	71	9.20	66	8.47	58	7.75	74	9.70	73	10.35	60	7.78	65	8.25	128	17.20
080/084	13	1.67	5	.67	28	3.81	8	1.04	12	1.54	11	1.47	37	4.85	23	3.26	10	1.30	11	1.40	79	10.62
085/089					3	.41							9	1.18	3	.43					45	6.05
090/094																					8	1.08

TABLE 14: Frequencies of Hourly Temperatures (Number of Hours and Percent Hours) for Ten Field Stations and Stewart Field, Newburgh, New York, September, 1956.

Temp Range	Field Stations 1 No. Hr.	1 %	2 No. Hr.	2 %	3 No. Hr.	3 %	4 No. Hr.	4 %	5 No. Hr.	5 %	6 No. Hr.	6 %	7 No. Hr.	7 %	8 No. Hr.	8 %	9 No. Hr.	9 %	10 No. Hr.	10 %	Stewart Field No. Hr.	Stewart Field %
030/034					9	1.20			5	.67	4	.55	4	.55	5	.68	7	.98	6	.78		
035/039	5	.67	7	.98	18	2.41	13	1.63	11	1.47	9	1.24	6	.83	16	2.17	17	2.37	6	.78	6	.83
040/044	45	6.06	59	8.29	59	7.90	59	7.39	63	8.45	67	9.23	61	8.26	72	9.78	75	10.47	61	7.89	26	3.59
045/049	83	11.19	97	13.61	103	13.79	116	14.54	130	17.43	114	15.70	107	14.60	123	16.71	123	17.18	135	17.46	65	8.98
050/054	161	21.70	158	22.19	152	20.35	176	22.06	163	21.85	151	20.80	130	17.89	151	20.52	128	17.88	178	23.03	101	13.95
055/059	157	21.16	159	22.33	119	15.93	155	19.42	129	17.29	122	16.67	149	20.52	119	16.17	122	17.04	136	17.59	138	19.06
060/064	121	16.31	80	11.24	101	13.52	101	12.66	81	10.86	112	15.43	111	15.29	112	15.22	102	14.25	100	12.94	104	38.67
065/069	82	11.05	98	13.76	115	15.39	122	15.29	118	15.82	81	11.02	92	12.67	71	9.65	84	11.73	90	11.64	101	13.95
070/074	72	9.70	48	6.74	47	6.29	56	7.02	38	5.09	49	6.75	40	5.51	57	7.74	43	6.01	55	7.12	59	8.15
075/079	16	2.16	5	.70	24	3.21			8	1.07	17	2.20	23	3.03	10	1.36	15	2.09	6	.78	45	6.22
080/084													3	.41							32	4.42
085/089																					11	1.52

TABLE 15: Frequencies of Hourly Temperatures (Number of Hours and Percent Hours) for Ten Field Stations and Stewart Field, Newburgh, New York, October, 1956.

APPENDIX A

Temp. Range	Field Stations 1 No. Hr.	1 %	2 No. Hr.	2 %	3 No. Hr.	3 %	4 No. Hr.	4 %	5 No. Hr.	5 %	6 No. Hr.	6 %	7 No. Hr.	7 %	8 No. Hr.	8 %	9 No. Hr.	9 %	10 No. Hr.	10 %	Stewart Field No. Hr.	Stewart Field %
025/029					1	.31											5	.55				
030/034	19	2.67	26	3.47	34	4.62	31	4.11	34	4.56	21	2.91	20	2.64	30	4.15	33	4.55	17	2.35	16	2.19
035/039	45	6.32	68	9.07	51	6.69	85	11.27	45	6.22	62	8.60	50	6.61	62	8.61	83	11.45	60	8.31	50	6.83
040/044	80	11.24	82	10.93	83	10.88	102	13.53	122	16.85	94	13.04	106	14.00	101	14.03	82	11.30	99	13.71	64	8.74
045/049	98	13.76	150	20.00	116	15.20	136	18.04	129	17.68	137	19.00	117	15.46	133	18.47	129	17.78	139	19.25	90	12.23
050/054	185	25.98	190	25.33	126	16.51	188	24.93	165	22.65	156	21.64	163	21.53	153	35.14	154	21.10	161	22.30	137	18.72
055/059	182	25.56	170	22.67	208	27.26	130	17.24	131	17.96	179	24.83	189	24.97	134	18.61	158	21.66	156	21.61	145	19.81
060/064	67	9.41	46	6.13	75	9.83	49	6.50	56	7.58	38	5.27	62	8.19	60	8.33	42	5.66	55	2.62	141	19.26
065/069	17	2.39	14	1.87	34	4.46	22	2.92	19	2.49	12	1.66	21	2.77	24	3.19	14	1.93	14	1.94	51	6.97
070/074	12	1.69	4	.53	24	3.15	11	1.46	17	2.21	14	1.94	13	1.72	15	1.94	15	1.94	12	2.35	17	2.32
075/079	7	.98			11	1.49			6	.83	8	1.11	13	1.72	8	1.11	10	1.38	4	.55	9	1.23
080/084													3	.40							12	1.64

TABLE 16: Frequencies of Hourly Temperatures (Number of Hours and Percent Hours) for Ten Field Stations and Stewart Field, Newburgh, New York, November, 1956.

Temp. Range	1 No. Hr.	1 %	2 No. Hr.	2 %	3 No. Hr.	3 %	4 No. Hr.	4 %	5 No. Hr.	5 %	6 No. Hr.	6 %	7 No. Hr.	7 %	8 No. Hr.	8 %	9 No. Hr.	9 %	10 No. Hr.	10 %	Stewart Field No. Hr.	Stewart Field %
010/014					12	1.65	3	.41	13	1.79	16	2.20			12	1.63	10	1.38	10	1.39		
015/019	20	2.81	23	3.21	28	3.85	36	4.90	35	4.80	26	3.58	27	3.73	36	4.88	20	2.76	28	3.89	11	1.52
020/024	35	4.91	51	7.11	64	8.80	62	8.45	54	7.41	39	5.46	53	7.32	62	8.40	40	5.52	57	7.92	29	4.02
025/029	50	7.01	73	10.28	82	11.28	83	11.31	95	13.03	104	14.31	65	8.86	103	13.96	102	14.07	87	12.08	66	9.14
030/034	125	17.53	132	18.41	136	18.71	143	19.48	124	17.01	119	16.37	133	18.12	133	18.02	109	15.03	127	17.64	97	13.43
035/039	98	13.74	100	13.95	83	11.42	92	12.53	82	11.25	91	12.52	104	14.56	77	10.43	93	12.83	77	10.69	110	15.24
040/044	85	11.92	71	9.90	60	8.25	68	9.26	76	10.43	78	10.73	68	9.39	61	8.27	83	11.45	67	9.31	98	13.57
045/049	85	11.92	110	15.34	86	11.83	89	12.13	103	14.13	102	14.03	100	13.81	101	13.69	86	11.86	114	15.83	86	11.91
050/054	89	12.48	77	10.74	64	8.80	80	10.90	58	7.96	68	9.35	66	9.11	66	8.94	78	10.76	72	10.00	77	10.66
055/059	53	7.43	39	5.44	65	8.94	57	7.77	65	8.92	61	8.39	61	8.42	43	5.83	50	6.90	48	6.67	58	8.03
060/064	41	5.75	33	4.60	43	5.91	21	2.86	24	3.29	23	3.26	47	6.49	44	5.96	47	6.48	33	4.58	41	5.68
065/069	32	4.49	8	1.12	4	.55											7	.97			41	5.68
070/074																					8	1.11

TABLE 17: Frequencies of Hourly Temperatures (Number of Hours and Percent Hours) for Ten Field Stations and Stewart Field, Newburgh, New York, December, 1956.

Temp. Range	Field Stations 1 No. Hr.	1 %	2 No. Hr.	2 %	3 No. Hr.	3 %	4 No. Hr.	4 %	5 No. Hr.	5 %	6 No. Hr.	6 %	7 No. Hr.	7 %	8 No. Hr.	8 %	9 No. Hr.	9 %	10 No. Hr.	10 %	Stewart Field No. Hr.	Stewart Field %
000/004															6	.80	5	.67	6	.81		
005/009					25	3.34	24	3.24	22	2.93	14	1.88	10	1.35	22	2.94	23	3.08	21	2.83		
010/014			28	3.76	7	.93	14	1.89	11	1.46	12	1.61	19	2.56	12	1.60	22	2.95	13	1.75	18	2.51
015/019	31	4.18	26	3.49	28	3.74	31	4.19	39	5.19	26	3.59	24	3.23	45	6.01	37	4.95	36	4.85	23	3.08
020/024	64	8.63	66	8.87	70	9.35	74	10.00	69	9.19	55	7.37	58	7.82	64	8.54	69	9.24	71	9.56	29	3.89
025/029	85	11.46	103	13.84	191	24.17	187	25.27	169	22.50	151	20.13	111	14.96	219	27.90	180	24.10	190	24.23	66	8.85
030/034	224	30.19	269	36.16	158	21.09	129	17.53	119	23.83	212	28.32	214	28.84	149	19.89	170	22.76	174	23.42	165	22.39
035/039	191	23.05	113	15.19	121	16.15	145	19.59	131	17.44	123	16.49	141	19.00	107	14.29	116	15.53	124	16.69	243	32.57
040/044	85	11.46	64	8.60	85	11.35	70	9.56	70	9.32	87	11.66	87	11.83	74	9.88	62	8.30	69	9.29	107	14.34
045/049	49	6.60	45	6.05	29	3.87	22	2.97	25	3.33	29	3.89	29	3.91	25	3.34	25	3.35	25	3.36	57	7.64
050/054	13	1.75	15	2.12	14	1.87	25	3.37	18	2.40	21	2.82	27	3.64	21	2.80	22	2.95	13	1.75	17	2.28
055/059	15	2.02	15	2.12	28	3.74	19	2.57	18	2.70	16	2.14	22	2.96	15	2.00	16	2.14	11	1.48	10	1.34
060/064	5	.67			3	.40															11	2.95

TABLE 18: Frequencies of Hourly Temperatures (Number of Hours and Percent Hours) for Ten Field Stations and Stewart Field, Newburgh, New York, January, 1957.

Temp. Range	Field Stations 1 No. Hr.	1 %	2 No. Hr.	2 %	3 No. Hr.	3 %	4 No. Hr.	4 %	5 No. Hr.	5 %	6 No. Hr.	6 %	7 No. Hr.	7 %	8 No. Hr.	8 %	9 No. Hr.	9 %	10 No. Hr.	10 %	Stewart Field No. Hr.	Stewart Field %
-16/-20					5	.67			3	.40												
-11/-15	3	.40	4	.53	5	.67	12	1.60	8	1.07	7	.93	4	.53	6	.82	7	.95	5	.67	2	.27
-06/-10	9	1.19	6	.80	18	2.40	16	2.13	6	.81	5	.67	5	.77	9	1.22	15	2.04	5	.67	7	.94
-01/-05	12	1.59	27	3.59	19	2.53	44	5.97	40	5.37	23	3.07	12	1.60	27	3.67	26	3.53	31	4.17	19	2.54
000/004	40	5.31	35	4.65	51	6.79	39	5.20	44	5.91	53	7.08	43	5.75	53	7.30	37	5.03	31	4.17	37	4.95
005/009	36	4.77	59	7.85	74	9.85	79	10.53	79	10.60	73	9.75	64	8.56	85	11.55	73	9.92	74	9.95	47	6.29
010/014	83	11.01	78	10.37	89	11.85	89	11.97	84	11.28	92	12.28	85	11.46	67	9.10	77	10.46	80	10.75	69	9.24
015/019	89	11.80	90	11.97	94	12.52	55	7.33	93	12.48	107	14.29	97	12.97	123	16.71	72	9.78	92	12.37	77	10.31
020/024	113	14.99	116	15.43	166	22.10	159	21.20	155	20.81	126	16.82	139	18.58	140	19.02	139	18.89	140	18.82	98	13.22
025/029	177	23.47	156	20.74	143	19.04	169	22.53	154	20.67	148	19.76	161	21.52	122	16.58	151	20.62	159	21.37	142	19.01
030/034	125	16.58	113	15.03	31	4.13	28	3.73	38	5.10	58	7.74	62	8.29	57	7.74	69	9.38	76	10.22	150	20.08
035/039	28	3.71	38	5.05	19	2.53	22	2.93	18	2.42	18	2.40	34	4.55	8	1.09	33	4.48	21	2.82	51	6.83
040/044	14	1.86	9	1.20	19	2.53	22	2.93	8	1.07	25	3.34	16	2.14	22	2.99	19	2.58	12	1.61	22	2.95
045/049	11	1.46	7	.93	8	1.07	7	.93	5	.67	5	.67	15	2.01	7	.95	8	1.09	7	.94	9	1.20
050/054	5	.66	9	1.20	10	1.32	9	1.20	10	1.34	9.	1.30	11	1.47	10	1.36	10	1.36	11	1.48	4	.54
055/059	9	1.19	5	.66																	13	1.74

TABLE 19: Frequencies of Hourly Temperatures (Number of Hours and Percent Hours) for Ten Field Stations and Stewart Field, Newburgh, New York, February, 1957.

Temp. Range	1		2		3		4		Field Stations 5		6		7		8		9		10		Stewart Field	
	No. Hr.	%	No. Hr.	%	No. Hr.	%	No. Hr.	%	No. Hr.	%	No. Hr.	%	No. Hr.	%	No. Hr.	%	No. Hr.	%	No. Hr.	%	No. Hr.	%
000/004					5	.74			5	.74												
005/009					10	1.48	9	1.42	10	1.47	9	1.33	4	.59	8	1.18	8	1.17	8	1.18	2	.30
010/014	11	1.60	10	1.48	15	2.22	13	1.92	21	3.19	20	2.95	16	2.37	24	3.55	16	2.45	15	2.21	9	1.34
015/019	22	3.21	24	3.55	78	11.52	59	8.65	84	12.35	68	10.04	40	5.92	69	10.29	61	8.94	54	7.94	19	2.82
020/024	119	17.35	119	17.60	149	22.01	130	19.06	167	24.56	166	24.52	180	26.63	156	23.04	155	22.83	155	22.79	92	13.67
025/029	191	27.84	172	25.41	143	21.12	185	27.13	143	21.03	142	20.97	125	18.49	144	21.27	139	20.38	167	24.56	159	23.63
030/034	107	15.60	141	20.86	103	15.21	138	20.23	103	15.15	109	16.10	120	17.75	129	19.05	108	15.84	121	17.79	144	21.40
035/039	130	18.95	132	19.70	106	15.66	82	12.02	87	12.79	93	13.84	108	15.98	84	12.41	109	15.98	98	14.41	136	20.21
040/044	51	7.43	36	5.33	21	3.10	20	2.93	17	2.50	20	2.95	32	4.73	17	2.51	42	6.16	23	3.38	64	9.51
045/049	24	3.50	24	3.55	27	3.99	33	4.84	36	5.29	23	3.40	23	3.40	20	2.95	14	2.05	28	4.12	15	2.23
050/054	28	4.08	18	2.66	18	2.66	13	1.91	7	1.03	27	3.99	28	4.14	26	3.84	30	4.40	11	1.62	26	3.86
055/059	3	.44			2	.30															7	1.04

TABLE 20: Frequencies of Hourly Temperatures (Number of Hours and Percent Hours) for Ten Field Stations and Stewart Field, Newburgh, New York, March, 1957.

Temp. Range	Field Stations 1 No. Hr.	1 %	2 No. Hr.	2 %	3 No. Hr.	3 %	4 No. Hr.	4 %	5 No. Hr.	5 %	6 No. Hr.	6 %	7 No. Hr.	7 %	8 No. Hr.	8 %	9 No. Hr.	9 %	10 No. Hr.	10 %	Stewart Field No. Hr.	Stewart Field %
010/014					13	1.72	11	1.46	13	1.84	6	.79			7	.94	6	.79	2	.27		
015/019	7	.93	12	1.59	27	3.58	24	3.18	30	4.02	24	3.17	11	1.48	24	3.21	26	3.44	25	3.38	10	1.34
020/024	56	7.47	54	7.15	65	8.61	67	8.87	72	9.64	67	8.86	59	7.93	78	10.44	66	8.84	69	9.32	27	3.63
025/029	126	16.80	105	13.91	189	25.03	168	23.25	189	25.30	143	18.92	119	15.99	185	24.77	113	14.97	130	17.57	91	12.23
030/034	176	23.47	246	32.68	163	21.59	185	24.50	169	22.49	181	23.94	206	27.79	175	23.43	224	29.67	202	27.30	203	27.28
035/039	152	20.27	168	22.25	117	15.50	135	17.88	120	16.06	166	21.96	172	23.12	116	15.53	156	20.66	144	19.46	166	22.31
040/044	104	13.87	87	11.52	88	11.66	90	11.92	74	9.91	87	11.51	85	11.42	87	11.65	76	10.07	81	10.95	120	16.13
045/049	81	10.90	55	7.28	60	7.95	49	6.59	49	6.56	55	7.28	52	6.99	44	5.89	55	7.28	57	7.70	65	8.74
050/054	25	3.33	12	1.59	13	1.72	13	1.72	13	1.74	12	1.69	20	2.69	16	2.14	12	1.59	13	1.86	36	4.84
055/059	8	1.07	13	1.72	13	1.72	8	1.06	10	1.34	8	1.06	13	1.75	8	1.07	10	1.32	10	1.36	11	1.48
060/064	10	1.33	3	.40	2	.26	2	.26	4	.54	3	.40	7	1.88	5	.67	6	.79	3	.41	10	1.34
065/069	5	.67			5	.66	3	.40	4	.54	4	.53	5	.67	2	.27	5	.66	4	.54	2	.27
070/074																					3	.40

TABLE 21: Frequencies of Hourly Temperatures (Number of Hours and Percent Hours) for Ten Field Stations and Stewart Field, Newburgh, New York, April, 1957.

Temp. Range	1 No. Hr.	1 %	2 No. Hr.	2 %	3 No. Hr.	3 %	4 No. Hr.	4 %	5 No. Hr.	5 %	6 No. Hr.	6 %	7 No. Hr.	7 %	8 No. Hr.	8 %	9 No. Hr.	9 %	10 No. Hr.	10 %	Stewart Field No. Hr.	Stewart Field %
020/024					7	.96	4	.55	12	1.64	6	.83			8	1.11	3	.42				
025/029	40	5.50	46	6.32	102	14.03	97	13.40	98	13.41	100	13.76	76	10.40	118	16.32	95	13.18	76	10.45	9	1.25
030/034	97	13.34	121	16.62	76	10.45	89	12.29	101	13.82	77	10.59	85	11.63	81	11.30	70	9.70	85	11.69	103	14.27
035/039	81	11.14	83	11.40	72	9.90	79	10.91	48	6.57	66	9.08	82	11.22	70	9.68	92	12.76	73	10.04	87	12.05
040/044	77	10.59	70	9.62	66	9.08	84	11.60	61	8.34	100	13.76	58	7.93	56	7.75	70	9.70	100	13.76	85	11.77
045/049	115	15.82	94	12.91	135	18.57	110	15.19	112	15.32	120	16.51	128	17.51	98	13.65	112	15.53	112	15.41	73	10.11
050/054	77	10.59	81	11.13	57	7.84	58	8.01	71	9.71	72	9.90	75	10.26	87	12.03	69	9.57	66	9.08	104	14.40
055/059	90	12.38	82	11.26	56	7.70	68	9.39	57	7.80	80	11.05	61	8.34	55	7.61	68	9.43	76	10.55	73	10.11
060/064	56	7.80	67	9.20	60	8.25	61	8.43	85	11.63	42	5.78	65	8.89	74	10.24	57	7.91	57	7.94	74	10.24
065/069	33	4.54	30	4.12	38	5.23	26	3.58	32	4.38	23	3.16	42	5.75	26	3.60	31	4.30	32	4.40	43	5.96
070/074	24	3.30	21	2.88	25	3.44	27	3.73	20	2.74	21	2.89	21	2.87	20	2.77	18	2.50	24	3.30	28	3.88
075/079	26	3.58	28	3.85	19	2.61	21	2.90	29	3.97	20	2.75	29	3.97	26	3.60	30	4.16	23	3.16	22	3.05
080/084	11	1.51	5	.68	14	1.93			5	.68			9	1.23	4	.55	6	.83	3	.41	18	2.49
085/089																					3	.42

TABLE 22: Frequencies of Hourly Temperatures (Number of Hours and Percent Hours) for Ten Field Stations and Stewart Field, Newburgh, New York, May, 1957.

Temp. Range	Field Stations 1		2		3		4		5		6		7		8		9		10		Stewart Field	
	No. Hr.	%	No. Hr.	%	No. Hr.	%	No. Hr.	%	No. Hr.	%	No. Hr.	%	No. Hr.	%	No. Hr.	%	No. Hr.	%	No. Hr.	%	No. Hr.	%
025/029											3	.41					4	.54	3	.40		
030/034	9	1.21	6	.82	3	.40	8	1.07	8	1.07	17	2.31	6	.81	9	1.21	5	.69	12	1.61	4	.54
035/039	14	1.88	22	3.00	26	3.50	36	4.80	28	3.76	36	4.89	31	4.21	38	5.09	26	3.52	29	3.89	15	2.02
040/044	41	5.51	56	7.63	86	11.57	70	9.33	85	11.41	86	11.68	84	11.40	79	10.59	105	14.23	89	11.93	49	6.59
045/049	118	15.86	115	15.67	102	13.73	111	14.80	118	15.94	141	19.16	99	13.43	134	17.96	108	14.63	121	16.22	97	13.04
050/054	125	16.80	140	19.07	141	18.98	143	19.07	135	18.12	114	15.49	146	19.81	151	20.24	139	18.83	137	18.36	108	14.62
055/059	137	18.41	134	18.26	105	14.13	102	13.60	110	14.77	91	12.36	94	12.75	88	11.80	105	14.23	110	14.75	122	16.40
060/064	91	12.23	82	11.17	78	10.50	80	10.77	91	12.21	87	11.82	77	10.45	97	13.00	75	10.16	91	12.20	109	14.65
065/069	99	13.31	93	12.67	95	12.79	91	12.13	84	11.28	86	11.68	75	10.18	74	9.92	73	9.89	75	10.05	85	11.42
070/074	45	6.05	47	6.40	50	6.73	59	7.87	42	5.64	45	6.11	65	8.82	36	4.83	38	5.15	41	5.50	65	8.74
075/079	46	6.18	26	3.64	42	5.67	45	6.00	38	5.10	26	3.53	46	6.24	35	3.69	45	6.10	33	4.42	44	5.91
080/084	19	2.55	13	1.77	15	2.02	5	.67	6	.81	4	.54	15	2.04	5	.67	15	2.03	5	.67	42	5.65
085/089																					4	.54

TABLE 23: Frequencies of Hourly Temperatures (Number of Hours and Percent Hours) for Ten Field Stations and Stewart Field, Newburgh, New York, June, 1957.

Temp. Range	1		2		3		4		Field Stations 5		6		7		8		9		10		Stewart Field	
	No. Hr.	%	No. Hr.	%	No. Hr.	%	No. Hr.	%	No. Hr.	%	No. Hr.	%	No. Hr.	%	No. Hr.	%	No. Hr.	%	No. Hr.	%	No. Hr.	%
040/044	3	.41	4	.56							10	1.38					15	2.05			6	.83
045/049	16	2.19	15	2.11	32	4.40	21	2.98	28	3.86	39	5.36	23	3.15	25	3.43	27	3.70	27	3.71	25	3.46
050/054	31	4.25	40	5.62	37	5.09	41	5.62	42	5.79	47	6.46	49	6.71	44	6.04	42	5.75	36	4.95	41	5.68
055/059	49	6.71	52	7.30	74	10.18	60	8.25	97	13.36	90	12.38	69	9.45	84	11.52	68	9.32	95	13.05	34	4.71
060/064	90	12.33	100	14.04	109	14.99	115	15.78	119	16.30	117	16.09	121	16.58	122	16.74	139	19.04	127	17.45	69	9.56
065/069	150	20.55	111	15.69	147	20.32	176	24.14	167	23.00	194	26.69	174	23.84	172	23.59	179	24.52	196	26.92	106	14.68
070/074	189	25.89	148	20.79	139	19.12	153	20.99	120	16.53	111	15.37	124	16.99	128	17.56	125	17.12	111	15.25	153	21.19
075/079	97	13.29	145	20.37	78	10.73	93	12.76	96	13.22	76	10.45	76	10.41	86	11.80	74	10.24	79	10.85	115	15.93
080/084	70	9.59	73	10.25	58	7.98	50	6.86	41	5.65	33	4.54	55	7.53	42	5.76	41	5.62	49	6.73	75	10.49
085/089	35	4.79	24	3.37	32	4.40	20	2.74	16	2.20	10	1.38	26	3.56	26	3.57	20	2.74	8	1.10	67	9.28
090/094					21	2.89							13	1.78							26	3.60
095/100																					5	.69

APPENDIX A

TABLE 24: Frequencies of Hourly Temperatures (Number of Hours and Percent Hours) for Ten Field Stations and Stewart Field, Newburgh, New York, July, 1957.

Temp. Range	1 No. Hr.	1 %	2 No. Hr.	2 %	3 No. Hr.	3 %	4 No. Hr.	4 %	5 No. Hr.	5 %	6 No. Hr.	6 %	7 No. Hr.	7 %	8 No. Hr.	8 %	9 No. Hr.	9 %	10 No. Hr.	10 %	Stewart Field No. Hr.	Stewart Field %
045/049			4	.54													3	.40	3	.40	1	.13
050/054	17	2.27	20	2.68	20	2.64	5	.67	12	1.59	25	3.32	24	3.18	20	2.74	35	4.67	28	3.75	11	1.48
055/059	47	6.27	55	7.37	73	9.67	60	8.05	61	8.08	70	9.28	61	8.08	76	10.40	69	9.20	68	9.10	31	4.17
060/064	77	10.27	136	18.23	131	17.35	152	20.40	145	19.21	172	22.81	142	18.81	164	22.44	166	22.13	153	20.48	78	10.48
065/069	164	21.87	179	23.99	157	20.79	93	12.48	212	28.08	180	23.87	170	22.52	149	20.38	173	23.07	199	26.64	142	19.09
070/074	179	23.87	172	23.06	123	16.29	149	20.00	168	22.25	146	19.36	146	19.34	150	20.52	140	18.67	169	22.62	156	20.97
075/079	140	18.77	129	17.29	97	12.85	113	15.17	128	16.95	110	14.59	105	13.91	114	15.60	104	13.87	93	12.45	137	18.41
080/084	103	13.73	35	4.69	88	11.66	55	7.38	55	7.28	34	4.51	76	10.07	39	5.34	42	5.60	21	2.81	96	12.90
085/089	16	2.13	16	2.14	47	6.23	18	2.42	21	2.78	17	2.25	23	3.05	16	2.19	12	1.60	13	1.74	70	9.41
090/094	7	.93			19	2.52							8	1.06	3	.41	6	.80			17	2.28
095/100																					5	.67

APPENDIX A

TABLE 25: Frequencies of Hourly Temperatures (Number of Hours and Percent Hours) for Ten Field Stations and Stewart Field, Newburgh, New York, August 1-12, 1957.

Temp. Range	1 No. Hr.	1 %	2 No. Hr.	2 %	3 No. Hr.	3 %	4 No. Hr.	4 %	5 No. Hr.	5 %	6 No. Hr.	6 %	7 No. Hr.	7 %	8 No. Hr.	8 %	9 No. Hr.	9 %	10 No. Hr.	10 %	Stewart Field No. Hr.	Stewart Field %
045/049	4	1.47	5	1.79							3	1.12					4	1.43			1	.35
050/054	16	5.86	22	7.86	11	3.82	13	4.48			17	6.37	20	6.87	7	2.47	23	8.21	13	4.38	11	3.82
055/059	19	6.96	24	8.57	21	7.29	29	10.00	16	6.20	18	6.74	12	4.12	31	10.95	23	8.21	18	6.06	24	8.33
060/064	47	17.22	62	22.14	59	20.49	68	23.45	37	14.34	53	19.85	57	19.59	56	19.79	64	22.86	54	18.28	33	11.46
065/069	86	31.50	90	32.14	76	26.39	87	30.00	77	29.84	93	34.83	86	29.55	67	23.67	77	27.50	102	34.34	59	20.49
070/074	39	14.29	32	11.43	56	19.44	48	16.55	75	29.07	32	11.99	47	16.15	56	19.79	38	13.57	53	17.85	64	22.32
075/079	32	11.72	31	11.07	23	7.99	31	10.69	29	11.24	28	10.49	26	8.93	31	10.95	24	8.57	39	13.23	40	13.89
080/084	22	8.06	9	3.21	25	8.68	11	3.79	19	7.36	17	6.37	28	9.62	22	7.87	21	7.50	15	5.05	26	9.03
085/089	8	2.93	5	1.79	14	4.86	3	1.03	5	1.94	6	2.25	13	4.47	13	4.59	6	2.14	3	1.01	24	8.33
090/094					3	1.04							2	.69							6	2.08

TABLE 26: Frequencies of Hourly Relative Humidities (Number of Hours and Percent Hours) for Nine Field Stations and Stewart Field, Newburgh, New York.

R.H. Range	1 No. Hr.	1 %	2 No. Hr.	2 %	3 No. Hr.	3 %	4 No. Hr.	4 %	5 No. Hr.	5 %	6 No. Hr.	6 %	7 No. Hr.	7 %	8 No. Hr.	8 %	9 No. Hr.	9 %	10 No. Hr.	10 %	Stewart Field No. Hr.	Stewart Field %
August, 1956 Field Stations																						
020/029																					2	.27
030/039	18	2.44							3	.39							2	.27			45	6.05
040/049	32	4.34	16	2.06	33	4.52	17	2.15	60	7.78	20	2.60	24	3.16			51	6.76	3	.40	89	11.96
050/059	87	11.79	31	3.99	79	10.82	85	10.77	139	18.03	56	7.28	71	9.75			82	10.88	58	7.83	93	12.70
060/069	90	12.20	55	7.09	138	18.90	139	17.62	143	18.53	89	11.57	136	18.54			90	11.94	96	12.96	146	19.62
070/079	109	14.77	85	10.95	103	14.11	120	15.21	124	16.08	101	13.13	132	18.13			107	14.19	169	22.81	166	22.31
080/089	118	16.03	133	17.14	92	12.60	117	14.83	109	14.14	120	15.60	185	25.41			170	22.55	141	19.03	160	21.51
090/100	284	38.59	456	58.76	285	39.04	311	39.42	193	25.03	383	49.80	180	24.73			252	33.42	274	36.98	43	5.78
September, 1956																						
020/029																					1	.14
030/039	14	1.86							6	.79	4	.54	4	.54							17	2.35
040/049	30	3.99	11	1.43	42	5.39	18	2.45	46	6.09	40	5.40	49	6.80			27	3.79	6	.84	60	8.29
050/059	58	7.72	25	3.25	72	9.24	31	4.22	51	6.76	43	5.80	51	7.07			37	5.19	16	2.25	75	10.36
060/069	112	14.91	35	4.55	110	14.12	60	8.16	101	13.38	61	8.23	87	12.07			86	12.06	45	6.32	101	13.95
070/079	99	13.18	59	7.66	110	14.12	80	10.88	111	14.70	91	12.28	114	15.81			102	14.31	80	11.24	120	16.57
080/089	90	11.98	91	11.82	100	12.83	160	21.77	118	15.63	122	16.46	120	16.50			108	15.15	137	19.24	180	24.86
090/100	348	46.34	549	71.30	345	44.29	386	52.52	322	42.65	380	61.28	296	41.04			353	49.51	428	60.11	170	33.48

TABLE 27: Frequencies of Hourly Relative Humidities (Number of Hours and Percent Hours) for Nine Field Stations and Stewart Field, Newburgh, New York.

R.H. Range	1 No. Hr.	1 %	2 No. Hr.	2 %	3 No. Hr.	3 %	4 No. Hr.	4 %	5 No. Hr.	5 %	6 No. Hr.	6 %	7 No. Hr.	7 %	8 No. Hr.	8 %	9 No. Hr.	9 %	10 No. Hr.	10 %	Stewart Field No. Hr.	Stewart Field %
October, 1956 Field Stations																						
020/029	8	1.11			9	1.21	3	.41	15	2.10	13	1.74	13	1.76			8	.11	3	.42	7	.96
030/039	42	5.84	10	1.39	31	4.17	22	3.01	38	5.31	29	3.88	50	6.78			34	4.77	24	3.36	47	6.42
040/049	67	9.32	19	2.50	67	9.01	42	5.75	90	12.59	81	10.83	78	10.57			62	8.69	36	5.04	90	13.21
050/059	88	12.24	41	5.55	127	17.07	103	14.11	125	17.48	70	9.36	106	14.36			67	9.40	99	13.87	110	15.03
060/069	79	10.99	56	7.61	114	15.32	113	15.48	101	14.13	91	12.17	128	17.34			84	11.78	94	13.17	110	15.03
070/079	82	11.40	78	10.82	67	9.01	106	14.52	62	8.67	99	13.24	75	10.16			67	9.40	88	12.32	126	17.21
080/089	90	12.52	88	12.21	70	9.41	75	10.27	74	10.35	88	11.76	87	11.74			103	14.45	66	9.24	167	22.81
090/100	263	36.58	429	59.36	259	34.81	266	36.44	310	29.37	277	37.03	201	27.24			288	40.39	304	42.58	69	9.43
November, 1956																						
020/029	9	1.25	2	.28	5	.68	12	1.65	17	2.36	14	1.92	16	2.22			10	1.38	9	1.24	13	1.90
030/039	28	3.88	13	1.82	31	4.22	16	2.30	28	3.88	27	3.70	38	5.27			35	4.83	13	1.80	35	4.85
040/049	102	14.15	37	5.17	92	12.52	56	7.69	101	14.01	53	7.37	99	13.73			69	9.53	58	8.02	92	12.74
050/059	128	17.75	46	6.43	140	19.05	108	14.84	107	14.84	102	13.99	146	20.25			114	15.75	81	11.20	135	18.70
060/069	125	17.33	110	14.13	115	15.65	141	19.37	114	15.81	127	17.42	111	15.40			108	14.92	112	15.49	166	22.99
070/079	85	11.79	.89	12.45	95	12.93	97	13.32	108	14.98	114	15.64	102	14.15			100	13.81	97	13.42	129	17.87
080/089	83	11.51	93	13.01	68	9.25	71	9.75	83	11.51	94	12.89	74	10.26			96	13.26	89	12.41	122	16.90
090/100	161	23.33	325	45.45	189	25.71	227	31.18	163	22.61	198	77.16	135	18.72			192	26.52	264	36.51	30	4.16

TABLE 28: Frequencies of Hourly Relative Humidities (Number of Hours and Percent Hours) for Nine Field Stations and Stewart Field, Newburgh, New York.

December, 1956

Field Stations

R.H. Range	1 No. Hr.	1 %	2 No. Hr.	2 %	3 No. Hr.	3 %	4 No. Hr.	4 %	5 No. Hr.	5 %	6 No. Hr.	6 %	7 No. Hr.	7 %	8 No. Hr.	8 %	9 No. Hr.	9 %	10 No. Hr.	10 %	Stewart Field No. Hr.	Stewart Field %
020/029																						
030/039					15	2.11			5	.67	7	.94	16	2.14			15	2.02	14	1.98	2	.27
040/049	17	2.28	26	3.49	43	5.86	30	4.00	52	6.99	27	3.62	59	7.89			49	6.59	16	2.14	27	3.63
050/059	80	10.74	22	2.95	87	11.66	61	8.13	65	8.74	62	8.31	90	12.03			95	12.79	45	6.03	99	13.31
060/069	83	11.14	74	9.93	124	16.62	101	13.47	93	12.50	111	14.88	107	14.30			93	12.52	53	7.10	139	18.68
070/079	110	14.77	69	9.26	87	11.66	108	14.40	102	13.71	113	15.15	119	15.91			66	8.88	51	6.94	161	21.64
080/089	101	13.56	83	11.14	91	12.20	97	12.93	104	13.98	120	16.09	83	11.10			137	18.40	84	24.66	231	31.05
090/100	354	47.32	471	63.22	299	40.08	353	47.07	323	43.41	306	41.02	274	36.63			288	38.76	38	51.34	85	11.42

January, 1957

R.H. Range	1 No. Hr.	1 %	2 No. Hr.	2 %	3 No. Hr.	3 %	4 No. Hr.	4 %	5 No. Hr.	5 %	6 No. Hr.	6 %	7 No. Hr.	7 %	8 No. Hr.	8 %	9 No. Hr.	9 %	10 No. Hr.	10 %	Stewart Field No. Hr.	Stewart Field %
020/029			4	.54	5	.68			4	.54			5	.68			21	2.80	11	1.49	2	.27
030/039	20	2.72	28	3.79	43	5.87	6	.81	32	4.33	24	3.36	35	4.86			56	7.48	43	5.83	14	3.78
040/049	82	11.16	78	10.55	102	13.92	48	6.48	102	13.90	92	12.50	83	11.28			162	21.63	124	16.80	92	12.42
050/059	120	16.33	75	10.25	119	16.33	85	11.47	123	16.64	129	13.53	143	19.43			129	17.22	105	14.23	165	22.27
060/069	110	14.97	122	16.51	176	24.01	174	23.48	137	18.54	143	19.33	172	23.37			113	15.09	148	20.05	190	25.64
070/079	150	21.73	85	11.60	78	10.64	134	18.08	107	14.58	100	13.59	78	10.70			107	14.29	76	10.30	115	15.52
080/089	92	12.52	91	12.31	83	11.32	98	13.23	73	9.88	85	11.55	72	9.78			72	9.61	88	11.92	86	11.61
090/100	151	20.54	256	34.64	127	16.92	196	26.45	161	21.79	159	21.60	148	20.11			89	11.88	143	19.38	77	10.39

TABLE 29: Frequencies of Hourly Relative Humidities (Number of Hours and Percent Hours) for Nine Field Stations and Stewart Field, Newburgh, New York

R.H. Range	1 No. Hr.	1 %	2 No. Hr.	2 %	3 No. Hr.	3 %	4 No. Hr.	4 %	5 No. Hr.	5 %	6 No. Hr.	6 %	7 No. Hr.	7 %	8 No. Hr.	8 %	9 No. Hr.	9 %	10 No. Hr.	10 %	Stewart Field No. Hr.	Stewart Field %
February, 1957 Field Stations																						
020/029	2	.30	5	.74					5	.76	3	.46	9	1.48			5	.77	3	.46		
030/039	19	2.87	23	3.39	21	3.14	17	2.56	51	7.84	31	4.72	43	6.58			60	9.23	37	5.67	7	1.04
040/049	82	12.41	63	9.28	68	10.18	53	7.98	89	13.51	84	12.79	88	13.48			61	9.38	72	11.04	47	6.98
050/059	85	12.86	91	13.40	89	13.32	92	13.86	83	12.59	58	8.83	107	16.39			91	14.00	106	16.26	105	15.60
060/069	92	13.92	73	10.85	97	14.07	106	15.96	90	13.66	103	15.68	88	13.48			84	12.92	86	13.19	142	21.10
070/079	95	14.37	78	11.49	84	12.57	88	13.25	77	11.68	81	12.33	93	14.24			124	19.08	73	11.20	143	21.25
080/089	87	13.16	107	15.76	68	10.18	93	14.01	105	15.93	114	17.35	88	13.48			89	13.69	85	13.04	128	19.02
090/100	199	30.11	239	35.20	241	36.08	215	32.38	159	24.13	183	27.85	137	20.98			136	20.92	190	29.14	101	15.01
March, 1957																						
010/019			5	.66	13	1.73	10	1.35	15	2.00	9	1.20	13	1.74			8	1.08	13	1.76	1	.13
020/029	7	.95	18	2.37	40	5.33	36	4.86	61	8.16	45	5.98	66	8.85			20	2.70	47	6.34	16	2.15
030/039	55	7.48	80	10.54	119	15.97	91	12.30	113	15.11	101	13.43	127	17.02			95	12.82	108	14.61	67	9.01
040/049	70	9.52	65	8.56	127	16.93	119	16.08	117	15.64	103	13.70	119	15.95			86	11.61	132	17.86	99	13.31
050/059	103	14.01	92	12.12	99	13.20	99	13.38	76	10.36	103	13.70	109	14.61			102	13.77	93	12.58	115	15.46
060/069	99	13.57	70	9.22	89	11.87	106	14.32	107	14.30	119	15.22	93	12.47			110	14.84	94	12.72	128	17.20
070/079	102	13.88	76	10.01	65	8.67	67	9.05	59	7.89	73	9.71	36	4.83			77	10.39	57	7.71	123	16.53
080/089	64	8.71	65	8.56	23	3.07	28	3.78	33	4.41	49	6.52	39	5.23			75	10.12	33	4.57	87	12.69
090/100	235	31.97	288	37.94	175	23.33	184	24.86	167	22.33	150	19.95	144	19.30			168	22.67	163	18.00	108	14.52

APPENDIX B

TABLE 30: Frequencies of Hourly Relative Humidities (Number of Hours and Percent Hours) for Nine Field Stations and Stewart Field, Newburgh, New York.

R.H. Range	1 No. Hr.	1 %	2 No. Hr.	2 %	3 No. Hr.	3 %	4 No. Hr.	4 %	5 No. Hr.	5 %	6 No. Hr.	6 %	7 No. Hr.	7 %	8 No. Hr.	8 %	9 No. Hr.	9 %	10 No. Hr.	10 %	Stewart Field No. Hr.	Stewart Field %
April, 1957 Field Stations																						
010/019									9	1.23			9	1.22					4	.55	1	.12
020/029	22	3.06	35	4.89	68	9.37	57	7.87	62	8.49	57	7.74	63	8.56			59	8.19	59	8.07	28	3.88
030/039	15	2.08	60	8.38	118	16.23	98	13.54	110	15.07	107	14.54	137	18.61			105	14.58	119	16.28	71	9.83
040/049	28	3.89	83	11.59	106	14.58	113	15.61	95	13.01	84	11.41	97	13.18			90	12.50	88	12.04	88	12.19
050/059	79	10.07	82	11.45	99	13.62	90	12.43	92	12.60	114	15.49	107	14.54			126	17.60	99	13.54	146	20.22
060/069	150	20.83	81	11.31	84	11.55	76	10.50	85	11.64	78	10.60	80	10.87			74	10.28	87	11.90	121	16.76
070/079	121	16.81	67	9.36	65	8.94	82	11.33	83	11.37	72	9.78	63	8.56			66	9.17	61	8.34	69	9.56
080/089	118	16.39	74	10.34	43	5.91	44	6.08	40	5.48	56	7.61	40	5.53			47	6.63	47	6.43	69	9.56
090/100	187	25.97	234	32.68	144	19.81	164	22.65	154	21.10	168	22.83	140	19.02			153	21.25	167	22.85	129	17.87
May, 1957																						
010/019									5	.69												
020/029			25	3.39	29	3.85	34	4.51	50	6.94	61	8.14	41	5.47			44	5.81	48	6.47	8	1.08
030/039			49	6.64	101	13.40	102	13.53	77	10.69	102	13.62	104	13.89			86	11.36	85	11.46	28	3.86
040/049	11	1.49	62	8.40	118	15.65	95	12.60	111	15.42	82	10.95	95	12.68			56	7.40	116	15.09	49	6.59
050/059	37	5.03	85	11.52	97	12.86	95	12.60	87	12.08	99	13.22	79	10.55			97	12.81	94	12.67	89	11.96
060/069	117	15.90	89	12.06	116	15.38	128	16.98	115	15.97	116	15.49	125	16.69			131	17.31	96	12.94	171	22.98
070/079	134	18.21	95	12.87	78	10.34	55	7.29	78	10.83	61	8.14	90	12.02			77	10.17	94	12.67	150	20.16
080/089	170	23.20	56	7.59	69	9.15	85	11.27	45	6.25	70	9.35	64	8.54			97	10.54	39	5.26	135	18.15
090/100	267	36.28	277	37.53	146	19.36	160	21.11	152	21.11	158	21.09	151	20.16			187	24.70	174	23.45	114	15.32

TABLE 31: Frequencies of Hourly Relative Humidities (Number of Hours and Percent Hours) for Eight Field Stations and Stewart Field, Newburgh, New York.

R.H. Range	1 No. Hr.	1 %	2 No. Hr.	2 %	3 No. Hr.	3 %	4 No. Hr.	4 %	5 No. Hr.	5 %	6 No. Hr.	6 %	7 No. Hr.	7 %	8 No. Hr.	8 %	9 No. Hr.	9 %	10 No. Hr.	10 %	Stewart Field No. Hr.	Stewart Field %
June, 1957 Field Stations																						
020/029					11	1.51			12	1.75	11	1.51	11	1.61			11	1.60	9	1.23	4	.55
030/039			15	2.07	39	5.34	9	1.24	40	5.45	42	5.76	38	5.21			30	4.10	33	4.53	26	3.60
040/049			28	3.87	89	12.20	24	3.31	102	14.01	84	11.52	107	14.68			80	10.94	74	10.15	90	12.47
050/059			56	7.73	108	14.79	75	10.33	114	15.66	110	15.09	116	15.91			100	13.68	126	17.28	135	18.70
060/069			124	17.13	103	14.11	109	15.01	92	12.74	99	13.58	110	15.09			100	13.68	118	16.19	119	16.48
070/079			95	13.12	93	12.74	103	14.19	99	13.60	78	10.70	86	11.80			70	9.58	89	12.21	139	19.25
080/089			83	11.46	90	12.33	80	11.02	94	12.91	90	12.35	90	12.35			82	11.22	87	11.93	141	19.63
090/100			323	44.61	197	26.99	326	44.90	175	24.04	215	29.49	171	23.46			258	35.29	193	26.47	68	9.42
July, 1957																						
020/029			7	.94	15	1.99			30	4.00	8	1.07	27	3.57			19	2.52			12	1.61
030/039			30	4.02	84	11.17	35	4.65	87	11.60	57	7.70	94	12.43			70	9.27	26	3.48	60	8.06
040/049			63	8.45	117	15.56	109	14.48	145	19.53	110	14.67	113	14.95			105	13.91	91	12.18	121	16.26
050/059			75	10.05	173	17.69	137	18.19	110	14.67	107	14.27	130	17.20			98	12.98	101	13.52	96	12.90
060/069			80	10.72	95	12.63	115	15.27	100	13.33	90	12.00	95	12.57			103	13.64	108	14.46	136	18.28
070/079			125	16.76	91	12.10	79	10.49	77	10.27	99	13.20	109	14.42			94	12.45	99	13.25	143	19.32
080/089			93	12.47	76	10.11	92	12.22	62	8.27	84	11.20	65	8.60			78	10.33	83	11.11	127	17.07
090/100			273	36.60	141	18.75	186	24.70	139	18.53	195	26.00	123	16.27			188	24.90	239	31.99	49	6.99

TABLE 32: Frequencies of Hourly Relative Humidities (Number of Hours and Percent Hours) for Eight Field Stations and Stewart Field, Newburgh, New York.

August 1-12, 1957

Field Stations

R.H. Range	1 No. Hr.	1 %	2 No. Hr.	2 %	3 No. Hr.	3 %	4 No. Hr.	4 %	5 No. Hr.	5 %	6 No. Hr.	6 %	7 No. Hr.	7 %	8 No. Hr.	8 %	9 No. Hr.	9 %	10 No. Hr.	10 %	Stewart Field No. Hr.	Stewart Field %
020/029							7	2.64	11	3.91	2	.72	25	8.71								
030/039			21	7.27	44	16.71	54	20.38	52	18.51	38	13.72	47	16.38			41	14.29	12	8.25	1	.35
040/049			41	14.19	37	14.07	47	17.74	52	18.51	29	16.47	49	17.07			36	12.54	39	13.88	13	4.51
050/059			22	7.61	56	21.29	52	19.62	47	16.73	27	9.75	53	18.47			29	10.10	55	19.57	32	11.11
060/069			23	7.96	37	14.07	30	11.42	40	14.23	34	16.43	41	14.29			27	9.41	38	13.52	69	23.96
070/079			17	5.98	28	10.65	24	9.06	17	6.05	34	16.43	21	7.32			50	17.42	36	12.81	68	23.61
080/089			42	14.63	15	5.80	8	3.02	15	5.34	39	14.08	15	5.23			55	19.16	26	9.25	78	27.08
090/100			123	42.56	46	17.49	43	16.23	47	16.73	74	26.71	36	12.54			49	34.15	75	26.69	27	9.38