HARVARD UNIVERSITY
DEPARTMENT OF ANTHROPOLOGY

Peabody Museum
Cambridge, Massachusetts 02138

April 11, 1966

Dr. Elizabeth K. Ralph, Associate Director
Applied Science Center for Archaeology
The University Museum
University of Pennsylvania
33rd & Spruce Streets
Philadelphia, Pennsylvania 19104

Dear Dr. Ralph:

I was glad to catch you prior to your departure to Italy and I trust this letter will follow you there. I had Mrs. Dincauze take the enclosed photographs of the site. Number 1 shows the front lawn area which has not been excavated. Black streaks have been found at the time of laying brick walk and are indications of further crematory pits. Number 2 shows the back wood area where the original crematory pit was found which contained many stone artifacts. The third photo shows the wood lot to the rear which has not been investigated.

I have discussed the situation with Mrs. Dincauze and at our last meeting she said that she felt that she would "leave it up to you as to whether or not to attempt a magnetometer survey." I would certainly go along with that decision, so I hope you have sufficient evidence on which to make a reasonable decision. I hope you can give me an early reply since I still have to see about raising the necessary funds.

Sincerely,

Stephen Williams
Associate Professor of Anthropology

Enclosures

SW:rl

Replied 4/19/66
Pits could be detected if massive —
1 m dia.
10-20 cm thick
buried ~ 1 m deep

a copy was made of letter

Dr. Williams
Harvard

HARVARD UNIVERSITY
HARVARD FOREST
PETERSHAM, MASSACHUSETTS
01366

Ralph

617-724-3303

October 17, 1966

Prof. Froelich Rainey, Director
The University Museum
University of Pennsylvania
33rd and Spruce Sts.
Philadelphia, Pa. 19104

Dear Prof. Rainey:

This is in answer to your letter of October 13. Let's hope you can arrange a weekend at the Harvard Forest in the near future. I have the weekend of October 22 filled but from then on I shall be available. If possible I'd like to keep the weekend of October 29 free for recovery from a two-week conference that has just started here but this isn't essential. The cold weather will soon be with us but we do have delightful weather often in November and my schedule is flexible enough so we could arrange specific dates on a day or two notice by phone.

We are about 8 hours by automobile from Philadelphia via New Jersey Garden State Parkway, New York Thruway, Mass. Turnpike, and Rte 32; or alternatively (and some 40 miles closer) by New Jersey Turnpike, Connecticut Turnpike, Wilbur Cross Highway (Rte 15) and Rte. 32. We have dormitory space here at the Harvard Forest and eating places are not far away.

Enclosed is a map showing the location of the Harvard Forest.

Sincerely yours,

Walter H Lyford

Walter H. Lyford
Soil Scientist

WHL/s
Enclosures:
Map of The Harvard Forest
" " How to Find Harvard Forest.

Nov. 12, 19

October 25, 1966

Dr. Walter H. Lyford
Harvard Forest
Harvard University
Petersham, Massachusetts 01366

Dear Dr. Lyford:

In the Rainey-Ralph team I seem to be the "leg-man" so I am writing to bother you with a few more questions.

1) I hope that the site is not covered with trees because the roots generally cause large anomalies that mask the ones sought.

2) Can the grids be reached by car? I left our portable batteries in Italy, so will bring car batteries unless we have to walk far to reach the grids. If so, I'll have Varian Associates send some portable ones from California.

3) Can you supply two assistants to help with the magnetometer survey?

4) If the dormitory is for men only, I'll find a motel or stay with friends in Keene, N.H.

5) Saturday, November 12th or November 19th would be most convenient for me. I guess that we can do the survey in one day, but if not, I hope that we can work on Sunday. If a week day or other weekends are better for you, please let me know.

Sincerely yours,

EKR:amg

Elizabeth K. Ralph

November 3, 1966

Dr. Walter H. Lyford
Harvard University
Harvard Forest
Petersham, Massachusetts 01366

Dear Dr. Lyford:

Since we shall be working among the trees, etc., I have asked Varian to send some portable batteries. Also, I am putting together some larger ones here that will be more portable than five 6-volt car batteries. Therefore, my departure from here will be dictated by when the batteries arrive. I hope to leave not later than Friday, November 11th (to be ready for work on the 12th). If by any chance, things are ready a day earlier, I'll send a telegram the day before.

Unfortunately, I have to be back here on Wednesday, November 16th. If you think that more time will be required, especially, weekday time, then, perhaps, we should change the starting date to November 18th or any day thereafter. The one day that I have to be here is November 16th.

Any grid size, up to 150 x 150 meters, is O.K. Among the trees, smaller ones would be easier to handle. On the large plain of Sybaris, we measure the distances between lines, but within the lines, we use paces as measures. If we want to be more precise, plastic clotheslines with the intervals marked with tape are good--non-magnetic and easy to move from one line to the next. A supply of short surveyors' stakes (2 to 2½' long) would be handy to have.

Sincerely yours,

Elizabeth K. Ralph

EKR:lm

Army Cs price

HARVARD UNIVERSITY
HARVARD FOREST
PETERSHAM, MASSACHUSETTS
01366

October 28, 1966

Dr. Elizabeth K. Ralph
The University Museum
University of Pennsylvania
33rd & Spruce Streets
Philadelphia, Pa. 19104

Dear Dr. Ralph:

I am real excited about the prospect of your visit and either of the dates you suggest are satisfactory. Let's plan on November 12th as we will be less likely to have uncomfortably cold weather and the earlier date will allow us to postpone to the 19th if the weather is unsuitable. Sunday work is more or less the rule with many of us here.

If you can come during the week this would give us even more flexibility. Personally I can work at any time as I have no classes or seminars at all this semester and at the moment November is completely open. Also I am willing to spend several days if this is what it takes to provide a good test of the potential value of your equipment in the study of soils.

Now for your questions.

1. I was rather taken aback by your question about the trees because of course we are in the tree research business and these areas are the ones we are most interested in. After a moment or two, however, I cheered to the fact that roots cause large anomalies. How nice! The location of roots would be especially helpful to us. So I hope we can work both in cleared and forested areas. We have an abandoned field that can be used to advantage as a starting point, but I hope we can graduate to forested areas.

2. We have many automobile trails through the forest and so can drive directly to any area we will wish to study. If there is a problem of transport to any particular area away from the trails we have a wheelbarrow, jeep and trucks and if necessary we will cut trees and make paths.

3. Whether on the weekend or not I can provide assistants to help with the magnetometer survey but the week days might make it possible to use our woods crew and bulldozer to rapidly examine any puzzling underground features, or to remove trees, boulders or other obstructions.

4. The dormitory is not for men only and we will make sure you have satisfactory lodging either at the dormitory or at my home.

5. Answered previously.

When we get the date settled I shall wish a little more information about the grid that would be most useful.

Sincerely yours,

Walter H Lyford

Walter H. Lyford
Soil Scientist

WHL/s

HARVARD UNIVERSITY
HARVARD FOREST
PETERSHAM, MASSACHUSETTS
01366

7 Nov. 66

Dr Elizabeth K. Ralph.

Dear Dr Ralph:

Thank you for your letter of Nov. 3. I think our major hazard will be the weather and for this reason I suggest you drive up on the 11th (or earlier) so that we can have the weekend available. We can pick representative sites near drivable roads on our property and can perhaps work back and forth across these roads if your present equipment is not at all portable.

I suspect that once you see our area you can predict immediately whether or not your methods will work. Possibly, therefore, I can contribute most merely by showing you some of our soil and geomorphic features and pointing out some of our ideas about soil processes that have gone on and are now going on. If the methods do not work here perhaps I can suggest other areas where a try might be worthwhile.

My guess is that if your methods are not at all applicable one good day will suffice. If the methods show some promise perhaps you may wish to spend more time - say two or three days - or you may wish to leave your equipment and return later.

With this in mind I have made a reservation for you at the Quabbin Gateway Motel, Orange, Mass about 10 miles from here at the junction of Routes 202 and 2 (see attached

Map) for the nights of Nov. 11th & 12th. I have done this rather than making arrangements at our own dormitory because our caretaker suddenly died this past week and as a result the motel will be more convenient for you. Motel Tel. No (Area Code 617) 544-2986

If these plans need modification I suggest you phone me rather than telegraph. We are rather in the country here and I mistrust telegrams. If the telegraph office doesn't get us immediately by phone the telegrams are sent by mail and we may get the message a couple days later.

My office temporarily is at my home Tel No. 617-724-3303 If no response the Harvard Forest Headquarters phone is 724-3285. and they will get the message to me. (I live only a 5 minute walk away). I am almost always home for lunch - say 12[15] - 1 pm and after about 5[30] pm.

Sincerely Yours.

Walter H Lyford.
Soil Scientist.

P.S. We have stakes and plastic clothesline.

HARVARD UNIVERSITY
HARVARD FOREST
PETERSHAM, MASSACHUSETTS
01366

8 Nov. 66

Miss Elisabeth K Ralph

Dear Dr Ralph:

Here's the map I didn't enclose.

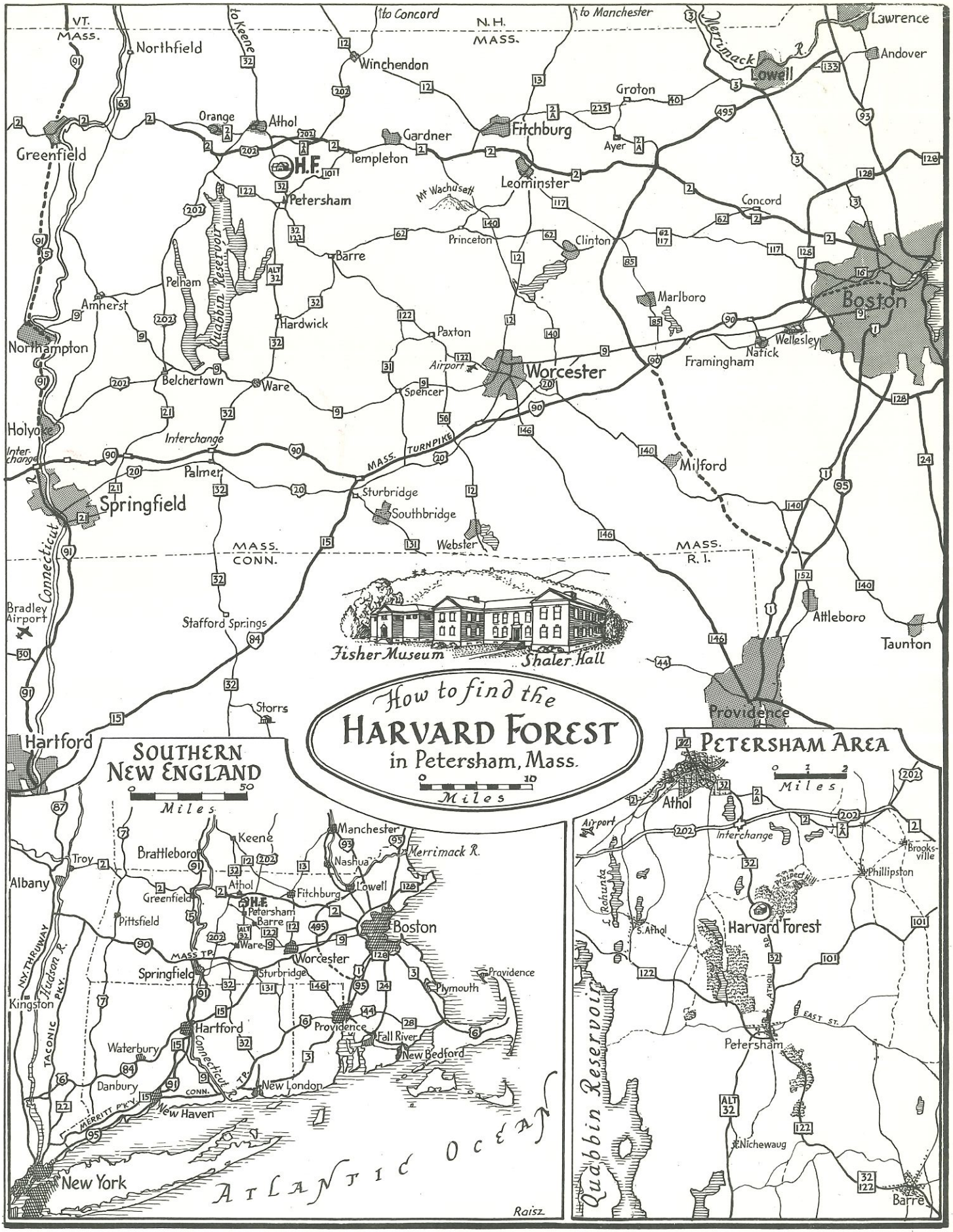
We use either of the two routes marked in blue. They are about equal in time even though the N.Y Thruway + Mass Turnpike route is some 30-40 miles farther.

Eating near the motel may be a problem though I think there a restaurant nearby. Bellinger's Restaurant in Athol is satisfactory.

Harvard Forest is just three miles south on Route 32 from the overpass at the junction of Rt 2 + 32. I'll be at the Harvard Forest Headquarters building from 9 AM on Nov. 12, earlier probably.

Sincerely.

Walter H Lyford


How to find the
HARVARD FOREST
in Petersham, Mass.
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to Keene
to Concord
to Manchester
Merrimack R.
Lawrence
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Groton
Orange
Athol
Gardner
Fitchburg
Ayer
Greenfield
H.F.
Templeton
Leominster
Mt Wachusett
Petersham
Concord
Princeton
Clinton
Barre
Quabbin Reservoir
Pelham
Amherst
Hardwick
Paxton
Marlboro
Boston
Northampton
Belchertown
Ware
Airport
Worcester
Framingham
Natick
Wellesley
Spencer
Holyoke
Interchange
MASS. TURNPIKE
Palmer
Springfield
Sturbridge
Southbridge
Webster
Milford
MASS.
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R.I.
Connecticut
Bradley Airport
Stafford Springs
Fisher Museum
Shaler Hall
Attleboro
Taunton
Storrs
Providence
Hartford
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Manchester
Brattleboro
Nashua
Merrimack R.
Troy
Albany
Greenfield
Athol
Fitchburg
Lowell
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Petersham
Pittsfield
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Providence
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Connecticut TP.
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Fall River
New Bedford
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New Haven
New York
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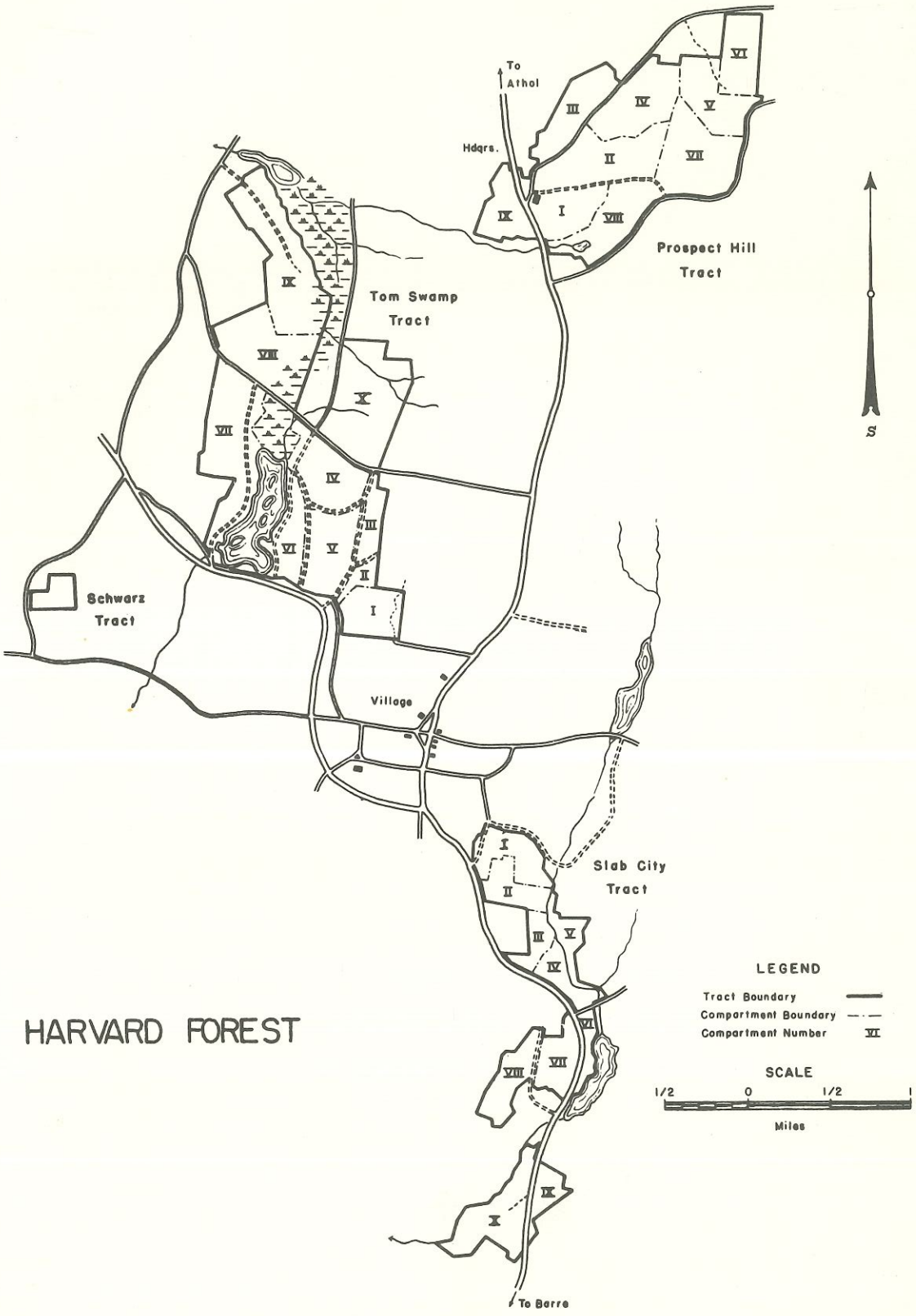
Airport
Interchange
Brooks-ville
Phillipston
Rahunta
Prospect Hill
S. Athol
Harvard Forest
ATHOL RD.
EAST ST.
Petersham
Quabbin Reservoir
ALT 32
Nichewaug
Barre
Raisz.



HARVARD FOREST

Willett Kinglands

January 3, 1967

Mr. Walter Lyford
Harvard Forest
Harvard University
Petersham, Mass. 01366

Dear Walt:

Your report is fine and I think that it is a good idea to circulate it among colleagues whom you think would be interested. The main change that I suggest is in the first paragraph. Please revise it as you like, but what I had in mind was that it was because of the interfering bedrock that negated the finding of soil changes in this particular region. At another site without magnetic bedrock, it might be possible to detect something. Also, the title seems a bit strongly negative, but please keep it your way if you like.

You must be the senior author because you initiated the idea and wrote the whole report.

Thank you for the reprints and greetings. The weather in Tucson was wonderful - 80° F at midday, but alas, I found only magnetic rocks again.

With best wishes for 1967,

EKR:amg

Elizabeth K. Ralph

PRESERVATION COPY 03/04/2015

REPORT OF AN UNSUCCESSFUL ATTEMPT TO MEASURE SOIL VARIATION AT THE HARVARD FOREST WITH THE CESIUM MAGNETOMETER.

Walter H. Lyford, Elizabeth K. Ralph and Richard K. McHenry 1/

ABSTRACT

The cesium magnetometer has been used successfully in locating some buried archaeological features and there seemed to be some possibility that this instrument might also be useful in soil studies as a means of locating soil features such as horizons disrupted by tree-throw, buried boulders, tree roots, or even soil boundaries. Tests at three representative sites on the Harvard Forest, Petersham, Mass. showed that it was impossible to measure either soil or regolith features because the highly magnetic bedrock caused anomalies much larger than the possible ones from the soil or regolith.

BACKGROUND

The recently developed cesium magnetometer has proven useful in locating some kinds of buried archaeological features (Rainey and Ralph, 1966). There seemed to be some possibility that it might also locate variations in soils, such as buried boulders or stones, presence of fragipan horizons, horizons disrupted in the past by wind throw of trees, and distribution of the larger tree roots.

1/ Mr. Lyford is soil scientist at the Harvard Forest, Harvard University, Petersham, Mass. Miss Ralph is an associate in the department of physics at the Univ. of Pennsylvania and associate director of the Applied Science Center for Archaeology, Univ. of Pennsylvania, Philadelphia, Penn. Mr. McHenry is a graduate student at the Harvard Forest. (This report was prepared in December, 1966 principally to have a record in the Harvard Forest files and to provide copies to the participants and to others who might have an interest.)

Inasmuch as some of these soil features have been studied in detail at the Harvard Forest (Stephens, 1956; Lyford, 1963; Lyford and Wilson, 1963), and recently in New Brunswick, Canada (Lyford and MacLean, 1966), a trial of the cesium magnetometer was made at the Harvard Forest by Miss Ralph during November, 1966 on three different sites representative of several common soil conditions found throughout the northeastern United States.

This report of the unsuccessful attempt at this site to measure soil variations may be useful if for no other reason than to stimulate further investigations of other electrical instruments in the study of the soil. Archaeologists seem to be in the forefront in the study of many new instruments.

PROCEDURE

The technique of measurement of magnetic intensity by the cesium magnetometer has been given by Rainey and Ralph (1966). Briefly the sensor, the sensitive part of the instrument, is held over a designated point at the height of about 26 inches above the surface (arms length) and actual numbers representing differences in magnetic intensity are read from the dial.

Three sites were chosen to provide a range in soil features as a means of testing the usefulness of the magnetometer for soil examinations.

Tom Swamp X site. This is a 100 foot-square area with a 2-5 percent gradient, on a gently sloping convex area toward the top of a knoll in an abandoned field. The soil is Gloucester sandy loam, a somewhat excessively drained Brown Podzolic (Entic Haplorthod) soil developed on bouldery sandy glacial till derived mostly from granite or gneiss. Bedrock is thought to be at a depth of 10 or more feet below the surface of the soil. Partially exposed boulders

occur at intervals of 10 to 20 feet and completely buried boulders and stones probably are spaced 5 to 10 feet apart.

Measurements were made on a grid at 2½ x 5 foot intervals. Location was kept by means of a marked 100 foot-long cord stretched from one edge of the plot to the other. This cord was moved systematically across the plot.

At this site the main soil variation is in the boulder and stone spacing and possible disrupted soil horizons the remnants of which are below the plow layer. These disrupted horizons would have been caused by tree-throw before the land was originally cleared. Where present they can still be recognized if the soil is trenched.

Prospect Hill I site. This 40 by 100 foot area has a 2-5 percent gradient and is on a gentle slope near the top of a knoll. The 65 year-old hardwood forest here consists of dominant red oak but with many red maple, black birch and yellow birch trees also. Prior to about 1890 the forest was nearly pure white pine and the well decayed white pine stumps still remain. Three soils cross this narrow plot. Somewhat excessively drained Gloucester soil is near the top of the knoll, moderately well and somewhat poorly drained Scituate soils are in the mid-slope portion, and poorly drained Ridgebury soils are at the base of the slope. The Scituate and Ridgebury soils have dense, brittle, strong fragipan horizons, the Gloucester soils lack the fragipan or it is weak. Distinct wind throw mounds with a relief of 1-1½ feet and with 1-½ foot deep associated pits are common on this area because the microrelief has never been leveled by plowing and harrowing. Bedrock is probably at a depth of 10 or more feet.

Readings of magnetic intensity were taken on a grid at 2½ foot intervals. This small interval was used to make sure that at least some of the readings would be made directly over mounds and pits. The instrument was kept at a constant height above the actual spot being measured, whether mound, pit, or nearly level intermediate area, by means of a firmly attached wooden stick of known length.

At this site the main variations are soil horizons disrupted by wind throw, changes in soil type, buried or partially exposed boulders and stump or root systems of trees.

Prospect Hill III site. This is within a small watershed area studied by Mr McHenry as a basis for a Master's Thesis. Readings of magnetic intensity were made at 5 foot intervals within a transect 20 feet wide by 400 feet long beginning on a small knoll with about a 5 percent slope, occupied by the Gloucester soil, extending through a narrow border of the Scituate soils into a level area of shallow peat. A 30-year-old red pine plantation is on the Gloucester and Scituate soils. A nearly pure red maple stand is on the shallow peat. Depth to bedrock is thought to be at least 5 feet below the surface and may be much deeper. Depth of peat was determined along the center line of the 20 foot-wide transect by means of an auger.

Soil variation at this site is mostly in soil type. The contrast in soil type here is greater than at the other two sites because of the presence of shallow peat.

RESULTS AND DISCUSSION

At the Tom Swamp X site (Fig. 1) the northeast-southwest trend of the contour lines of equal magnetic intensity does not relate to known soil or surficial mantle features and seems more likely to be related to bedrock characteristics. Boulders apparently had no influence on the readings because even when the measuring device was held directly over the boulder there was no appreciable differences in magnetic intensity as compared with that of the immediately adjacent soil. Density of the boulder is 2.65 whereas that of the friable soil is 1.2-1.4 so there is no effect from density alone.

Scattered small ellipse-shaped areas shown in Figure 1 are about the size of wind-throw mounds and might represent the location of formerly disrupted horizons. None of these areas was excavated because later measurements at the Prospect Hill I site, where there had been no leveling from previous cultivation, showed no obvious relationship between magnetic intensity and conspicuous mound and pit microrelief.

Two marked anomalies in the northwesternern portion of the plot are thought to be the location of buried pieces of metal. An old barbed wire fence was removed from this portion of the plot during the magnetometer survey.

Near a 12-inch-diameter white pine tree in the northeast corner of the plot some of the magnetic variation was thought at first to be related to the root system of the tree. Studies made later at the Prospect Hill I site showed that dead or live stumps or root systems at the base of trees caused little if any variation in the magnetic intensity as compared with the immediately adjacent soil.

Figures 2,3 and 4 show magnetic intensity contours, location of mounds and pits, and soil boundaries at the Prospect Hill I site. Magnetic intensities increase regularly from southeast to northeast and show little or no relationship to mound-pit microrelief, soil boundaries, or to stumps or roots of trees. A marked anomaly near the central portion of the plot is probably due to a piece of metal.

Figures 5 and 6 show magnetic intensity contours, soil boundaries and depth of peat at the Prospect Hill III site. Magnetic intensity at the western end of this long transect varies a great deal more over a short distance than at the other two sites. Presumably this results from the character of the bedrock. Here the bedrock may be the Brimfield schist whereas in the other two sites the bedrock was probably the Hardwick granite.

The great variation in magnetic intensity overshadows any differences due to soil variations. Even the presence of shallow peat was not enough to cause appreciable variations in magnetic intensity although this provides the greatest contrast in soils of any of the three sites. At the Prospect Hill III site freshly cut tree stumps and root systems of trees did not cause any noticeable changes in the magnetic intensity. In the shallow peat portion of the transect the variation was not as great as at the knoll at the western end . Here the 10-unit-interval contours have about the same spacing and pattern as at the Prospect Hill I site. But again this is thought to be related to the character of the bedrock rather than the character of the soils.

The overall conclusion from the study is that the changes in magnetic intensities measured by the cesium magnetometer are related to the bedrock rather than to the soil or the regolith. This conclusion is valid only for the Harvard Forest, and similar areas, where both the bedrock and soil contain a rather high proportion of mafic minerals. The instrument is likely to be of more value for soil studies in highly quartzose areas.

LITERATURE CITED

LYFORD, W. H. 1964. Coarse fragments in the Gloucester soils of the Harvard Forest. Harvard Forest Paper No. 9.

LYFORD, W. H. and D.W. MACLEAN. 1966. Mound and pit microrelief in relation to soil disturbance and tree distribution in New Brunswick, Canada. Harvard Forest Paper No. 15.

LYFORD, W. H. and B. F. WILSON, 1964. Development of the root system of Acer rubrum L. Harvard Forest Paper No. 10.

RAINEY, F. and E. K. RALPH, 1966. Archeology and its new technology. Science 153: 1481-91.

STEPHENS, E. P. 1956. The uprooting of forest trees: a forest process. Soil Sci. Soc Amer. Proc. 20: 113-16

FIGURE 1

Contours of equal magnetic intensity at intervals of 10 "differential" units. Tom Swamp X site. (1 unit ≈ 0.5 gamma)

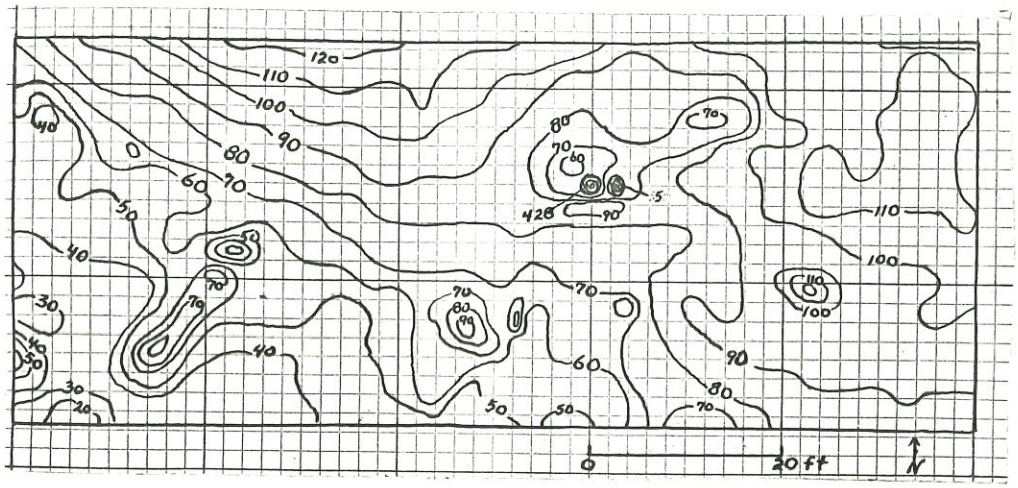


FIGURE 2

CONTOURS OF EQUAL MAGNETIC INTENSITY SHOWN IN "DIFFERENTIAL" UNITS OF 10. PHI SITE

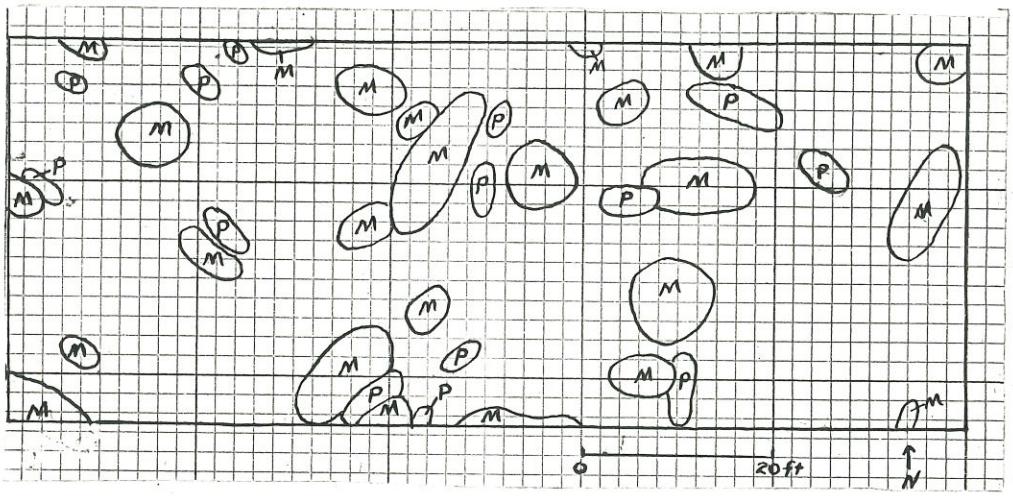


FIGURE 3

LOCATION OF MOUNDS (M) AND PITS (P). PHI SITE.

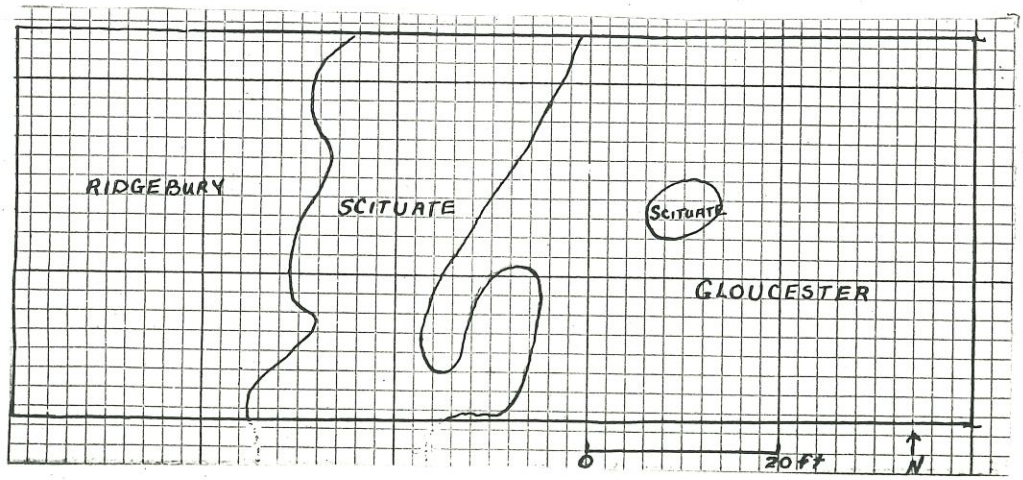


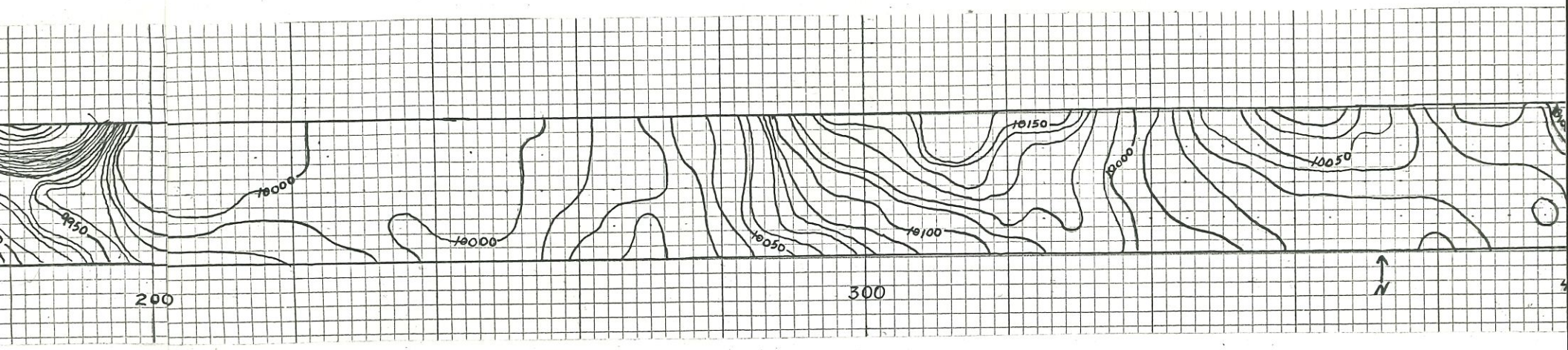
FIGURE 4

SOIL MAP. PHI SITE.

Top: Mr McHenry (left) is reading the dial on the read-out instrument. Mr Lyford is holding the sensor over a point on the grid.

Bottom: Miss. Ralph holds the five-foot-long sensor. A 26 inch-long wooden stick is fastened to the sensor so it can be held at a constant distance from the surface of the soil.

Was is an afterthought - no reference to this figure in the text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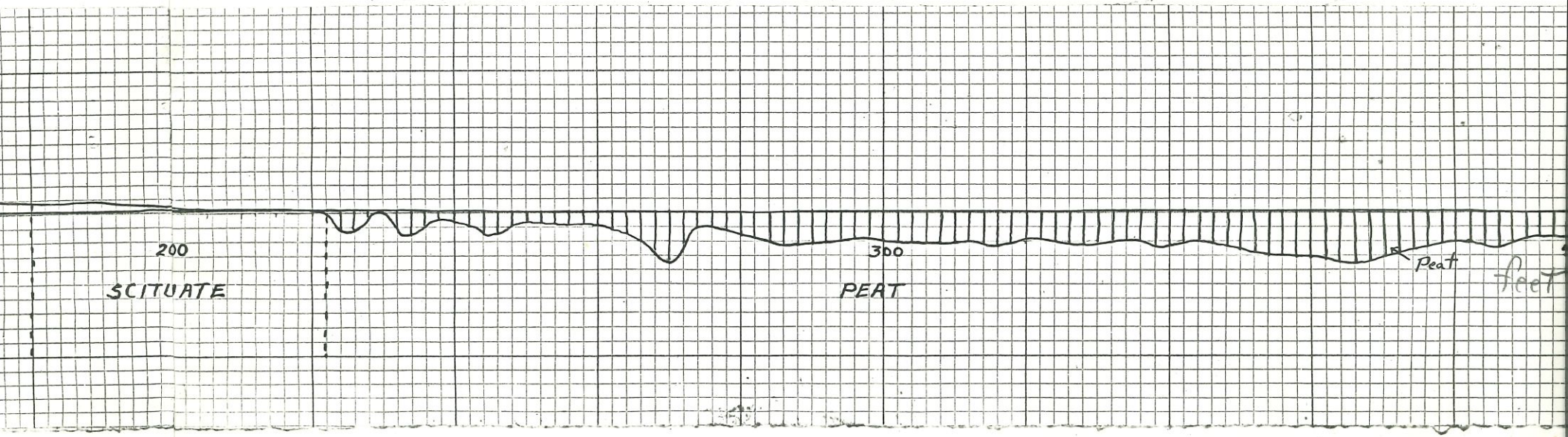
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PEAT
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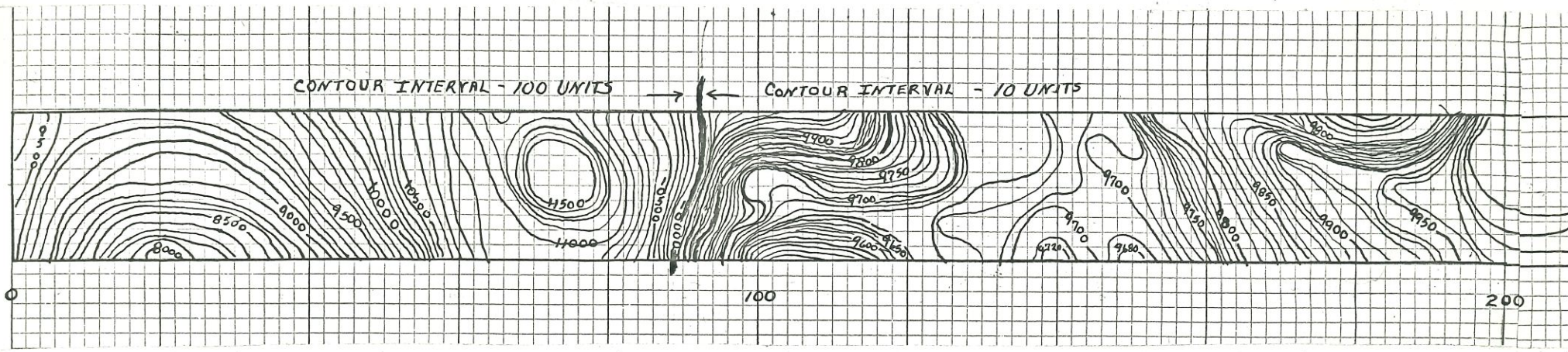


FIGURE 5

CONTOURS OF MAGNETIC INTENSITY SHOWN IN "DIFFERENTIAL" UNITS OF 10 OR 100. PH III SITE

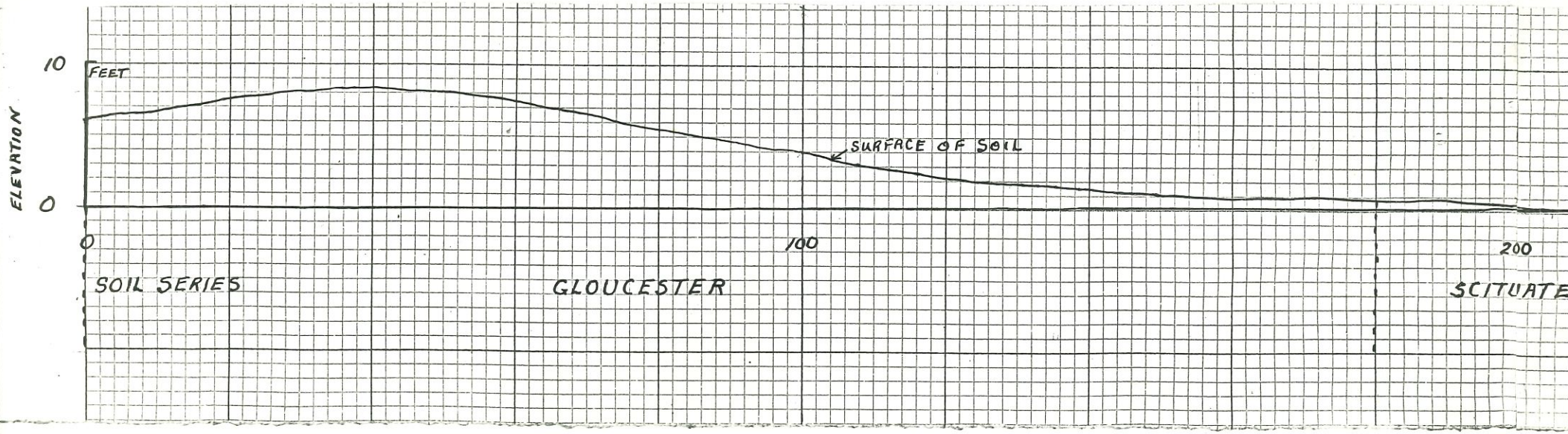


FIGURE 6

GENERALIZED RELIEF OF TRANSECT, SOIL MAP, AND DEPTH OF PEAT. PH III SITE.

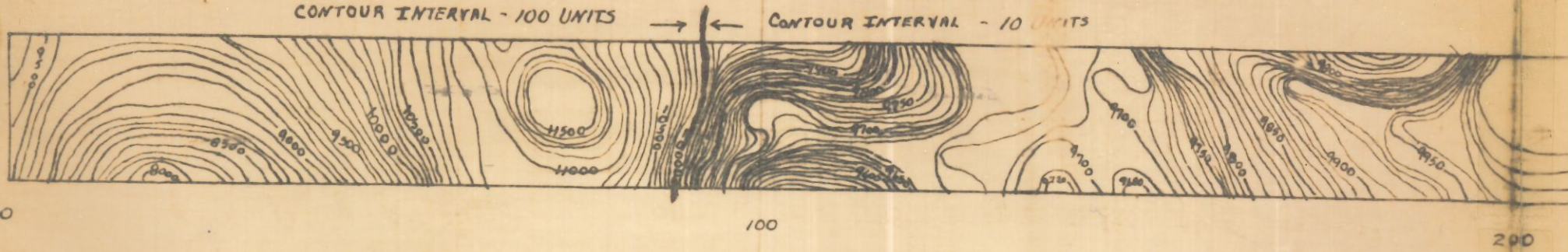


FIGURE 5

CONTOURS OF MAGNETIC INTENSITY SHOWN IN "DIFFERENTIAL" UNITS OF 10 OR 100. PH III SITE

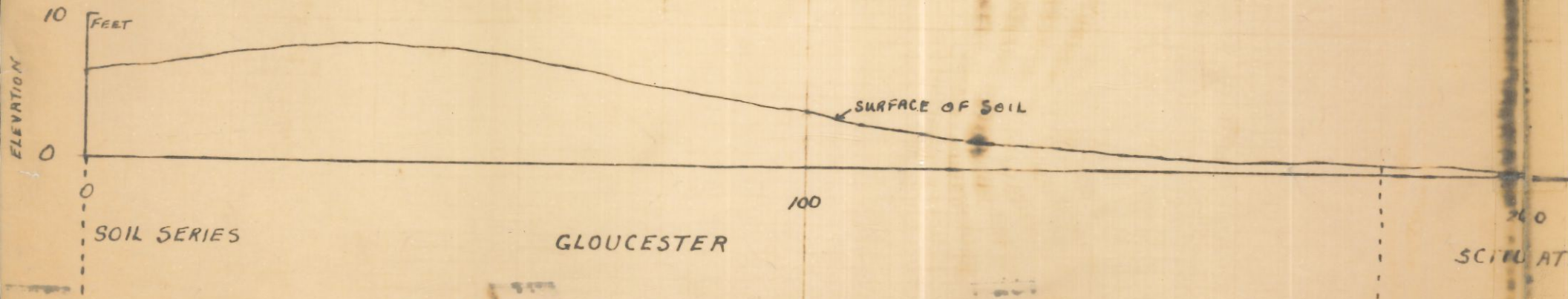
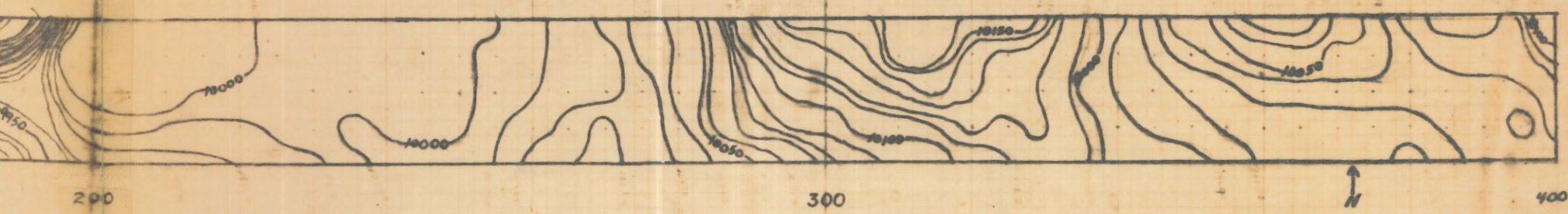


FIGURE 6

GENERALIZED RELIEF OF TRANSECT, SOIL MAP, AND DEPTH OF PEAT. PH III SITE.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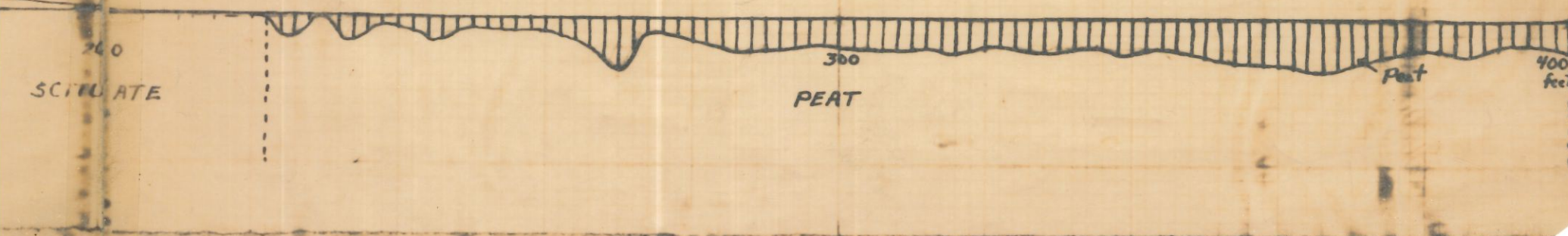

200
SCITUATE
300
PEAT
Peat
400
feet

GRID #1

CESIUM MAGNETOMETER SURVEY

MAGNETIC INTENSITY MAP

0 2 4 6 8 10
METERS

BASE VALUE = 44,000 GAMMA
MEASUREMENT SPACING = 1M
SENSOR HEIGHT = 0.8 M
CONTOUR = 20 GAMMA

45°
N (MAGNETIC)

TRAVERSE

SOUTHERN MOST TOMB PIT EXCAVATION AT THIS TIME

SANTA GERTRUDIS
MAGDALENA BASIN, JALISCO, MEXICO
19 APRIL 1972

TEMPORAL VARIATION < 5 GAMMA
(UNCORRECTED)

TEST PIT AT NE26, SE 19 WAS 1M SQUARE
TEPETATE AT 10-15 CM, ANOMALY SOURCE STILL BELOW

NE

SE

MAGNETIC INTENSITY MAP

0 2 4 6 8 10
METERS

TRAVERSE

45°

N (MAGNETIC)

SANTA GERTRUDIS
MAGDALENA BASIN, JALISCO, MEXICO
20 APRIL 1972

N
GRID #1
GRID #2

BASE VALUE = 44,000 GAMMA
MEASUREMENT SPACING = 1 M
SENSOR HEIGHT = 0.8 M
CONTOUR INTERVAL = 20 GAMMA

1.5 M DEEP PIT (NO TOMB)

TEST EXCAVATION AT SE30, NE11 EXPOSED TEPETATE AT 10-25 CM

TEMPORAL VARIATION: 8 GAMMA LINEAR DECREASE (UNCORRECTED)

BARE TEPETATE

TOMB PIT

≈15 CM SOIL, 1.5 M TEPETATE

18 M
TOMB PIT

CESIUM MAGNETOMETER SURVEY

MAGNETIC INTENSITY MAP

0 2 4 6 8 10

METERS

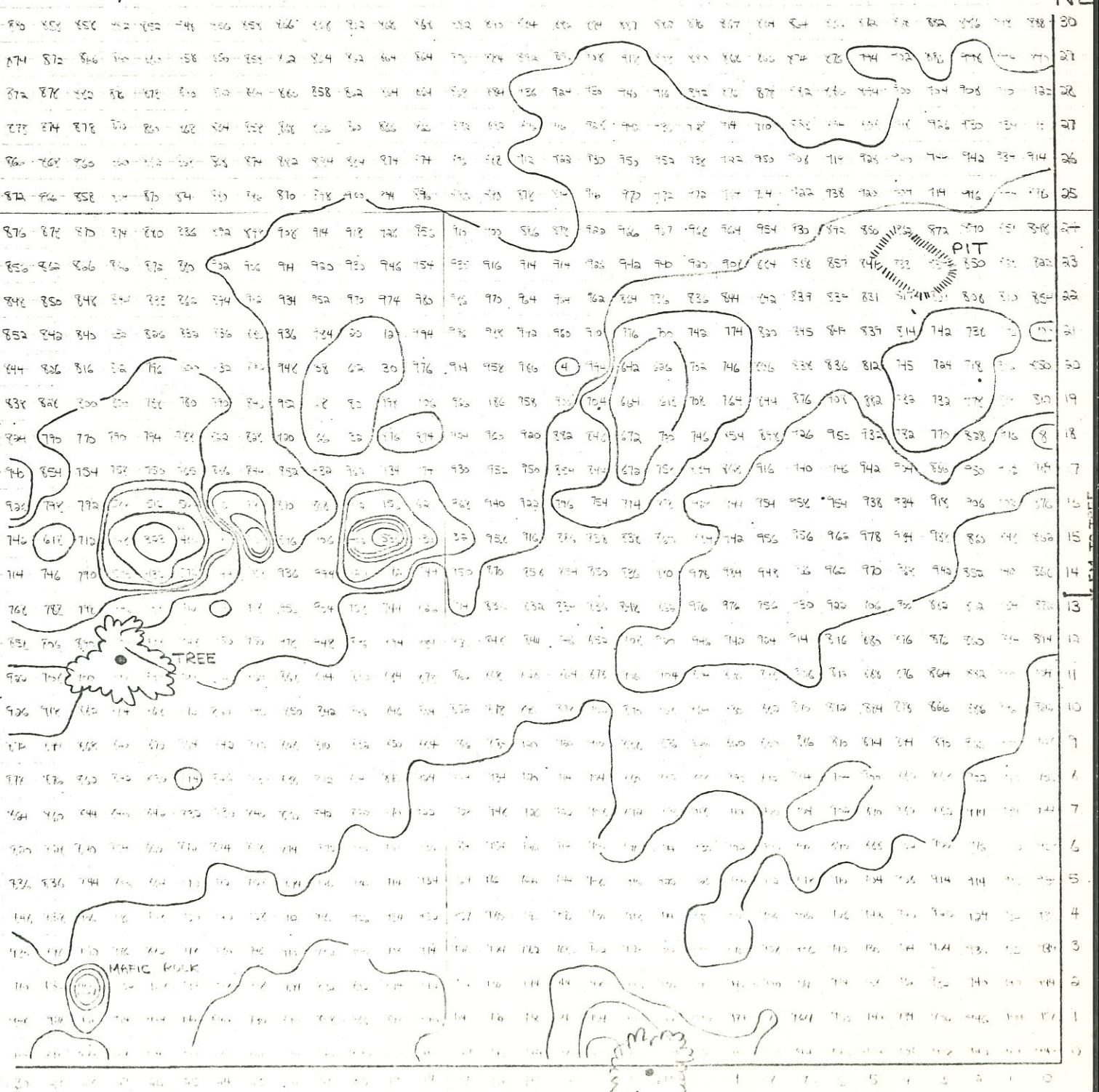
N (MAGNETIC)

45°

BASE VALUE = 44,000 GAMMA
MEASUREMENT SPACING = 1M
SENSOR HEIGHT = 0.8 M
CONTOUR INTERVAL = 100 GAMMA

RANCHO AGUACERO
(BETWEEN SANTA GERTRUDIS AND HACIENDA GUADALUPE)
MAGDALENA BASIN, JALISCO, MEXICO
21 APRIL 1972

TRAVERSE



CESIUM MAGNETOMETER SURVEY

MAGNETIC INTENSITY MAP

0 2 4 6 8 10

METERS

TEMPORAL VARIATION = 4 GAMMA (UNCOR.)
BASE VALUE = 44,000 GAMMA
MEASUREMENT SPACING = 1M
SENSOR HEIGHT = 0.8 M
CONTOUR = 10 GAMMA

RANCHO AGUACERO
MAGDALENA BASIN, JALISCO, MEXICO
22 APRIL 1972

TRAVERSE

45°

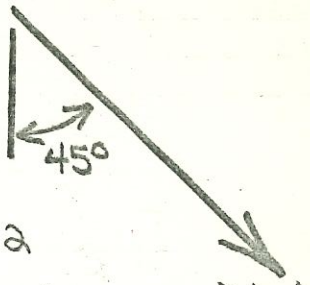
N (MAGNETIC)

24 M TO TEPETATE LEDGE

DIP = 3.5°

GRID #5

CESIUM MAGNETOMETER SURVEY
MAGNETIC INTENSITY MAP

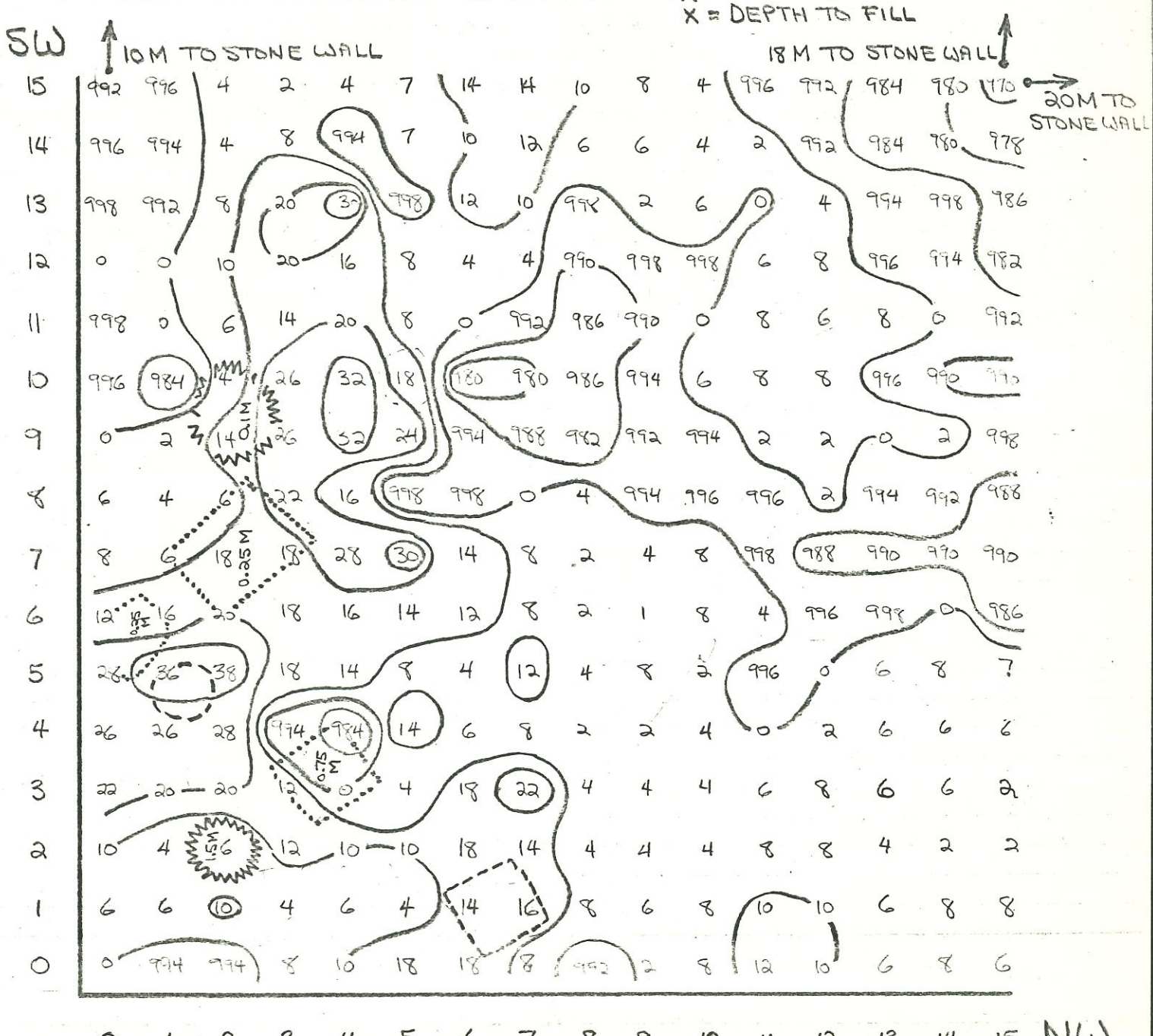


22 APRIL 1972

RANCHO AGUACERO, MAGDALENA BASIN, MEXICO

BASE VALUE = 44,000 GAMMA
MEASUREMENT SPACING = 1M
SENSOR HEIGHT = 0.8 M
CONTOUR INTERVAL = 10 GAMMA

◯ = REFILLED HOLE
⊗ = PARTIALLY REFILLED HOLE
✳ = TOMB, REFILLED
X = DEPTH TO FILL



GRID #6 CESIUM MAGNETOMETER SURVEY

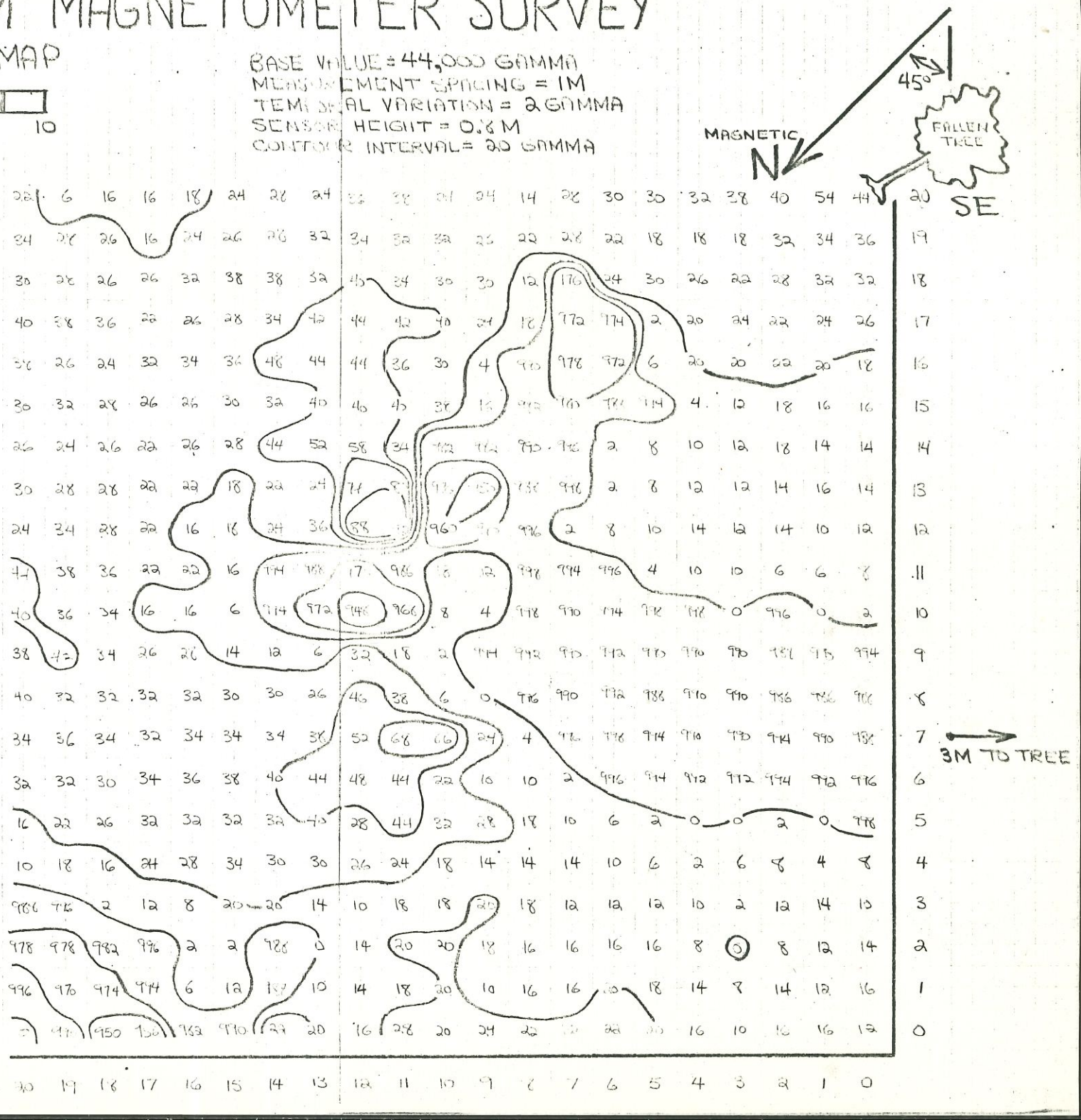
MAGNETIC INTENSITY MAP

0 2 4 6 8 10
METERS

BASE VALUE = 44,000 GAMMA
MEASUREMENT SPACING = 1M
TEMPORAL VARIATION = 2 GAMMA
SENSOR HEIGHT = 0.6 M
CONTOUR INTERVAL = 20 GAMMA

RANCHO AGUACERO
MAGDALENA BASIN
JALISCO, MEXICO

22 APRIL 1972



GRID #6

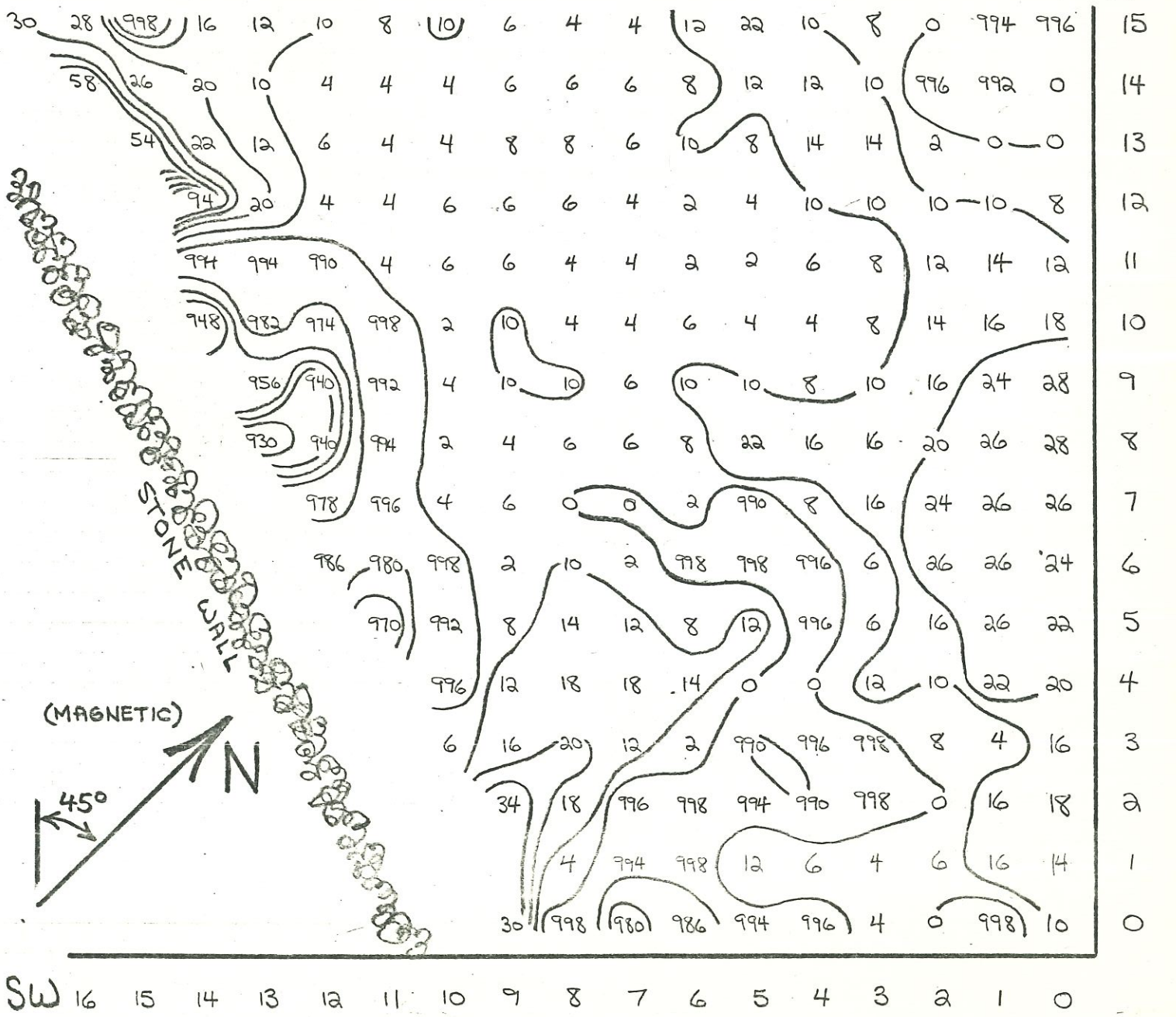
MAGNETIC INTENSITY MAP

CESIUM MAGNETOMETER SURVEY

23 APRIL 1972

BASE VALUE = 44,000 GAMMA
MEASUREMENT SPACING = 1M
SENSOR HEIGHT = 0.8 M
CONTOUR INTERVAL = 10 GAMMA

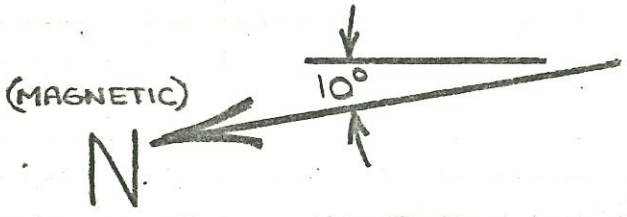
RANCHO AGUACERO
MUNICIPIO SAN MARCOS
MAGDALENA BASIN
JALISCO, MEXICO



CESIUM MAGNETOMETER SURVEY

GRID #7

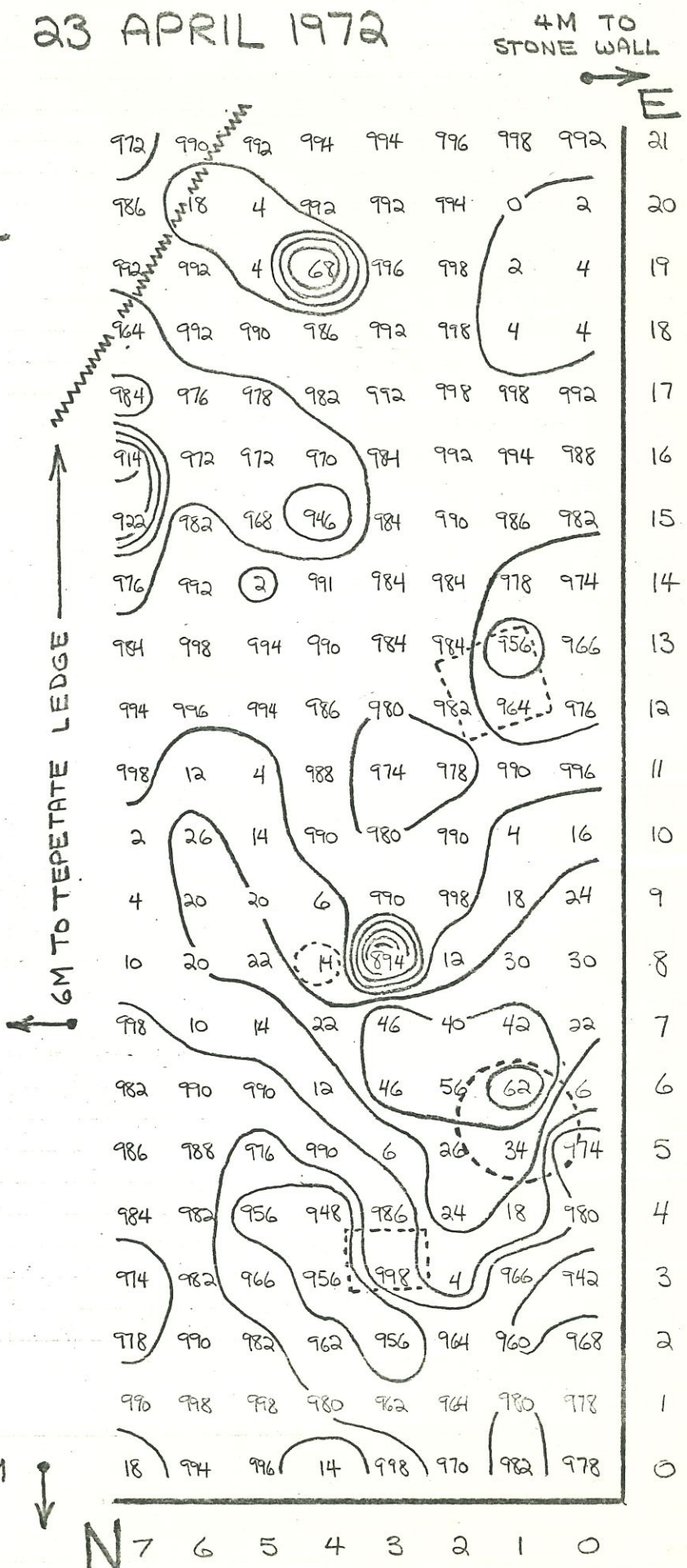
23 APRIL 1972



RANCHO AGUACERO
MUNICIPIO SAN MARCOS
MAGDALENA BASIN
JALISCO, MEXICO

BASE VALUE = 44,000 GAMMA
MEASUREMENT SPACING = 1M
SENSOR HEIGHT = 0.8 M
CONTOUR INTERVAL = 20 GAMMA

= PIT

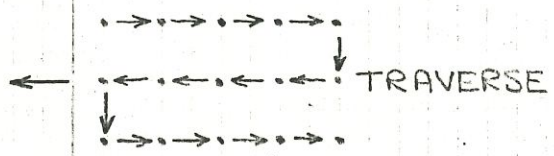


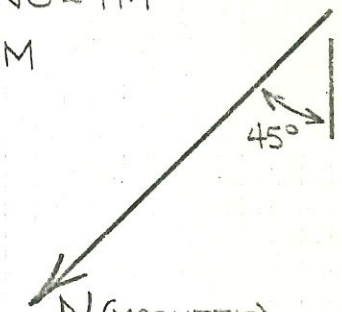
3 REDUCE

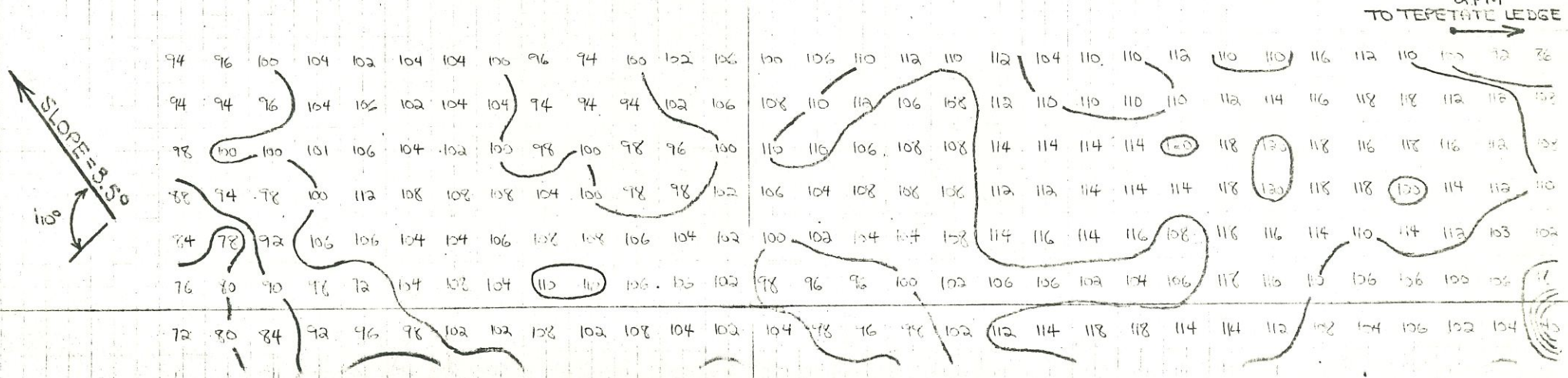
GRID #4
CESIUM MAGNETOMETER SURVEY
MAGNETIC INTENSITY MAP

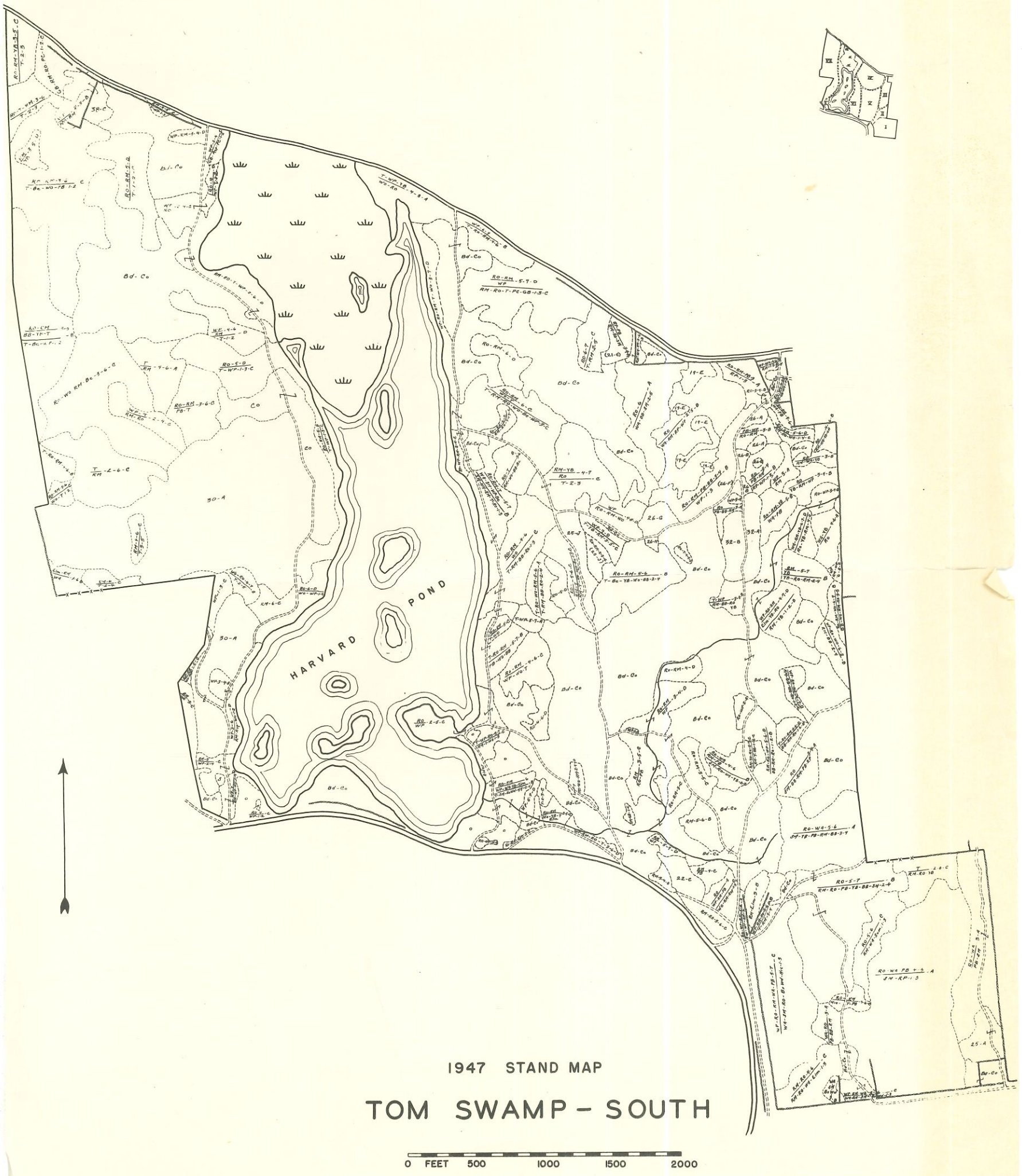
TEMPORAL VARIATION = 4 GAMMA (UNCOR.)
BASE VALUE = 44,000 GAMMA
MEASUREMENT SPACING = 1M
SENSOR HEIGHT = 0.8 M
CONTOUR = 10 GAMMA

RANCHO AGUACERO
MAGDALENA BASIN, JALISCO, MEXICO
22 APRIL 1972



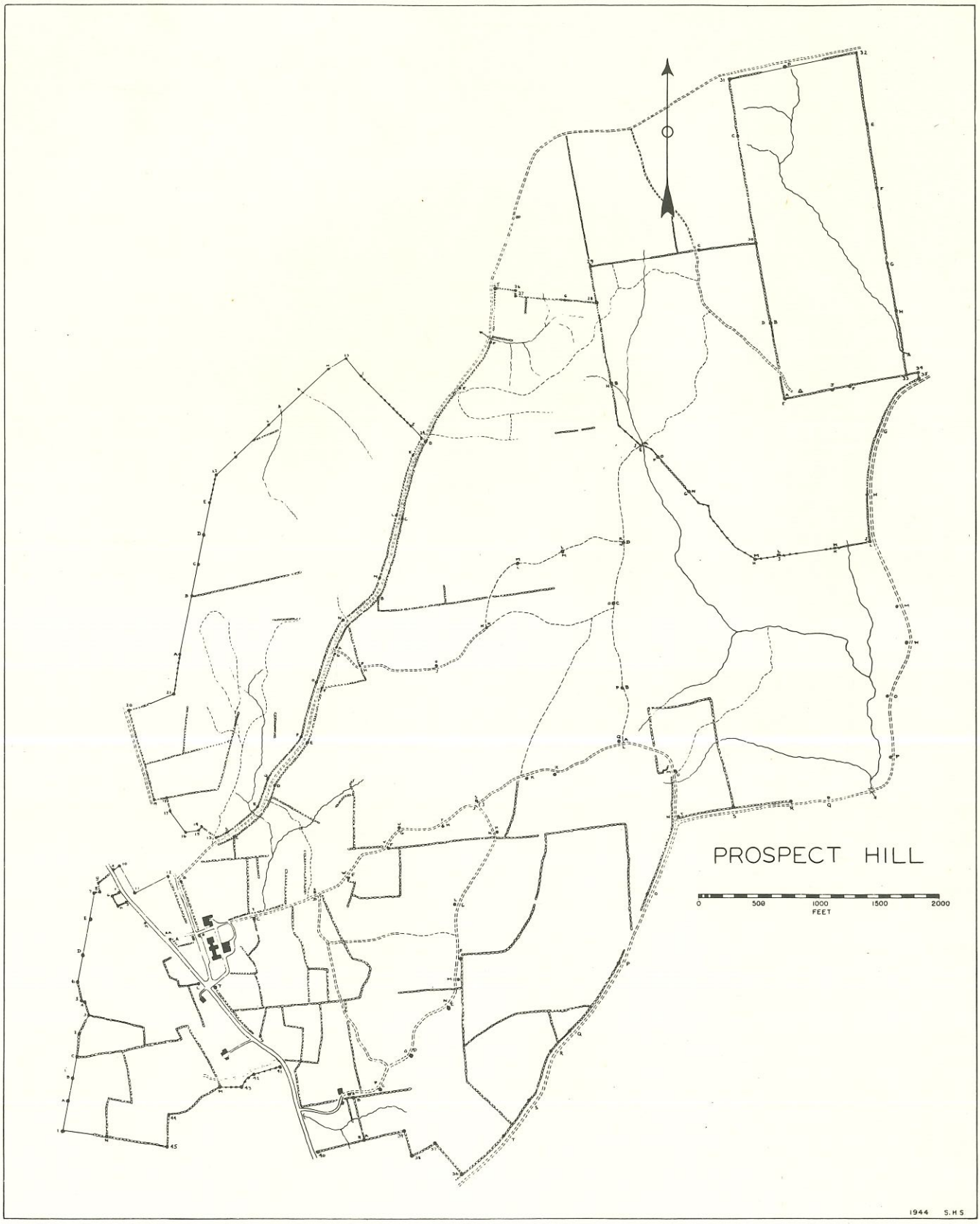






1947 STAND MAP

TOM SWAMP - SOUTH


PROSPECT HILL
0
500
1000
1500
2000
FEET
1944 S.H.S.

MASCA
Projects

PHOTOS.

HARVARD FOREST 1966

Top: Mr McHenry (left) is reading the dial on the read-out instrument. Mr Lyford is holding the sensor over a point on the grid.

Bottom: Miss. Ralph holds the five-foot-long sensor. A 26 inch-long wooden stick is fastened to the sensor so it can be held at a constant distance from the surface of the soil.

This is an afterthought - no reference to this figure in the text

PRINTS
HARVARD FOREST - INSTUMENT SURVEY
1966

PETERSHAM, MASS.

PRINTS (3)

CREMATORY PIT SITE (MASS.?) 1966

Approx. size 3¼" X 4" Date 1966?

Photographer/Artist/Writer Stephen Williams?

Additional description (3) photos of a crematory pit site in Massachusetts (?), See Stephen Williams (Harvard U.) letter (April 11, 1966) for further descriptn-

nclude condition): good cond-

EMK July 20'82

processor date

(1)

(2)

(3)

#1

#2

#3

THE HARVARD FOREST AND HARVARD BLACK ROCK FOREST
1966-67

Harvard University

Annual Report

Petersham

Massachusetts

(*Preprinted from the Report of the President of Harvard College and Reports of Departments, 1966–67*)

Harvard Forest

To the Dean of the Faculty of Arts and Sciences:

Sir, – The following is a report on the Harvard and Harvard Black Rock Forests for the year ending June 30, 1967.

Staff

The staff of the Forest during the year 1966–67 consisted of the following: Ernest M. Gould, Jr., Forest Economist; Walter H. Lyford, Soil Scientist; Jack J. Karnig, Forest Manager for both the Harvard and Black Rock Forests; Richard A. Howard, Research Fellow; J. M. A. Swan, Research Fellow, and myself. Charles F. Upham served as Woods Superintendent, Barbara M. Kelley as Business Secretary and Librarian; and Julia W. Savage as Secretarial Assistant. Additions during the year were Mrs. Barbara M. McCurda as Secretarial Assistant, and Mrs. Vibeke Holm as Assistant to the Librarian.

Dr. Gould took a four-month leave of absence from 1 January to 1 May, 1967. He went to the School of Natural Resources at the University of Michigan where he gave a seminar course in resource economics.

Graduate Students, Conferences, and Visitors

Four graduate students were in residence at the Forest during the academic year. Richard K. McHenry and Robert E. Lovegrove were candidates for the Master of Forest Science. They finished their theses in late spring, and were awarded their degrees in June. A. Jon Cassista pursued his thesis research for the Ph.D. in biology, under a fellowship from the Cabot Foundation. Alan Page began work toward M.F.S. in late summer of 1966, but transferred to the University of Massachusetts at the end of the fall term.

The thirteenth annual Conference on Forest Production was held at the Forest 16–28 October, 1966, with 17 members attending. They came from the New England States, Ohio, Missouri, Wisconsin, New Mexico, Oregon and Hawaii. Four were from the federal and provincial forest services of Canada. The group contained representatives of the U. S. Forest Service, state departments of natural resources and extension, the U. S. Soil Conservation Service, and private industry. One was a journalist concerned primarily with resource problems.

The Forest was again host to a group of graduate students of landscape architecture from the Harvard School of Design. They spent about five days (18–22 September) in a study of the natural environments represented in the Forest and its vicinity.

Student and staff visitors from the University in Cambridge or from other schools totaled approximately 275 during the year. These were single individuals, or groups ranging in size from 2 to 40.

Dr. David M. Smith, Professor of Silviculture at the Yale School of Forestry, spent the fall term at the Harvard Forest, on sabbatical leave. Most of his time was given to research and writing, but he took part in many of the Forest's activities and was a welcome and valued visitor.

Dr. Claud L. Brown, of the University of Georgia, was in residence at the Forest for six weeks in the summer of 1966. He was collaborating with Dr. Martin H. Zimmermann of the Cabot Foundation.

Research and Publications

Mr. Walter Lyford continued his studies of the roots of forest trees. A basic problem to which he has devoted much of his time is the identification of living tree roots found in any soil profile exposed in the forest. Criteria of tree taxonomy have been restricted almost entirely to above-ground parts, so that methods for root identification must be devised from original observations. In his studies of individual root systems Mr. Lyford has begun intensive investigations of red oak similar to those he has made

on red maple. He spent two months of the summer of 1966 in Sweden, at the invitation of the Royal College of Forestry, where he collaborated with Swedish soil scientists in field studies. He went to Puerto Rico for about 10 days in March of 1967, as soils consultant to a research program on cloud forest conditions being carried on by the Arnold Arboretum.

Dr. Gould's principal research during the year was a continuation of the simulation project mentioned in my report for 1965–66. Mr. Howard has continued as his programming assistant. This was the final part of a two-year program financed by a grant from the U. S. Forest Service. A collaborator in this study of landscape amenity and timber production planning has been Dr. William O'Regan, a former Bullard Fellow from the Pacific Southwest Forest and Range Experiment Station. Dr. O'Regan made two visits of about three weeks each at the Harvard Forest in the course of the year. Dr. Gould has prepared an invitation paper on "Simulation and forest management" to be presented at a meeting of the International Union of Forest Research Organizations at Munich in September, 1967.

In addition to his work with Dr. Gould on the simulation project, Mr. Howard collaborated with Dr. Brayton F. Wilson of the Cabot Foundation in developing and programming a model representing the growth of wood in cambium. This will soon be published. He is the author of a paper published by the Pacific Southwest and Range Experiment Station on a library retrieval system. In March, 1967, he presented a paper on the application of computer techniques to problems in forestry at a meeting of the New England Section of the Society of American Foresters.

Dr. Swan came to the Forest early in January, 1967. He immediately engaged in a study of species distribution on our lands, attempting an analysis of species composition in a variety of stands. Although much descriptive work has been done on "forest types" here, modern methods of vegetational analysis have never been applied. Dr. Swan is well-versed in these methods, and has initiated tests of their applicability in our landscape.

I completed two research papers based on my Greenland

studies, and sent them to the printers in Denmark. In addition, I finished drafts of seven others which will require minor revisions. I contributed to two symposia during the year: one on the nature of the plant community at Antigonish, Nova Scotia, and the other on modern concepts in forestry at a meeting of the Alleghany Section of the Society of American Foresters held at Baltimore. Both of these papers will be published in Proceedings.

Four Harvard Forest Papers were published in the year 1966–67: No. 14, "Development of the shoot system of Acer rubrum L.", by Brayton F. Wilson; No. 15, "Mound and pit microrelief in relation to soil disturbance and tree distribution in New Brunswick, Canada," by W. H. Lyford and D. W. MacLean; No. 16, "Controlled growth of forest tree roots: technique and application," by Walter H. Lyford and Brayton F. Wilson; No. 17, "Fungal hyphae and the morphology of B horizons of New England Soils," by Walter H. Lyford.

Bulletin No. 20, on "The history of land use in the Harvard Forest," by H. M. Raup and R. E. Carlson, was reprinted in the spring of 1967. This bulletin, published in 1941, has long been out of print, but has been in continuous demand.

An account of the Cabot Foundation's research for the year 1966–67 will be found in another report. However, it should be mentioned briefly here because of the Foundation's increasing activities at the Harvard Forest. Dr. Martin H. Zimmermann and Dr. Brayton F. Wilson, in their studies of the physiology and anatomy of trees, have found many points of common interest with members of the Forest Staff, leading to active and profitable research collaboration. Two of the papers prepared during the year resulted from this collaboration.

Bullard Fellows

Four Charles Bullard Fellows were in residence at the Forest during the year. Dr. F. David Morgan, a forest entomologist from the Waite Institute, Adelaide, Australia, came in February, 1966 and left about mid-December, 1966. Dr. Robert Zahner, who also came in February, 1966, was here until August of that

year. Dr. Arthur M. Gill came from the University of Melbourne in October, 1966, to be here for a year; and Dr. Milford D. McKimmy came from Oregon State University in July. Two Bullard Fellows resident at the University in Cambridge, Dr. Sherret S. Chase and Dr. James R. Wallis, utilized the Forest's library on several occasions during the year.

Forest Operations

Approximately 255 cords of fuel wood were utilized during the year, and about ten thousand feet of sawlogs were cut. Most of this wood came from thinning, improvement and harvest cuttings in Compartments IV and VII of the Tom Swamp Tract. The drought of the last few years appears to have been broken. Precipitation was abundant throughout the fall, winter and spring.

Buildings and Research Facilities

Alterations proposed in my report of last year for Shaler Hall were completed in the spring of 1967. The basement of the south wing of the building and the main basement corridor were changed to form three new offices and two new laboratories. At the same time the Fisher Museum basement was altered to house a workshop. A new office was also placed adjacent to the laboratories on the first floor of the building, and a new stairway constructed to the second floor in the south wing. Most of the work was paid for from Cabot Foundation income. Even with these additions to our facilities, it was becoming clear by the end of June that all available space would be occupied in the coming year by staff, students and research fellows.

With enlarged research operations have come increasing demands upon our living space for families. A new apartment was made during this year in our Higginson House in the Village of Petersham. This brings to 14 the number of families we can accommodate.

The Harvard Black Rock Forest

Activities at the Black Rock Forest were notably increased during the past year due to several events which improved its facilities and made it more attractive to visitors. Over 200 people toured selected portions of the area in organized groups under the guidance of the resident manager. This number does not include casual visits by metropolitan hiking clubs whose presence is not readily recorded.

Research and Publications

Research on diameter growth patterns in red oak following understory poison treatments was brought nearly to completion by Mr. Karnig. An analysis of diameter-crown relationships may be desirable in order to substantiate observed differences in the growth of differing diameter classes. Two temporary student employees during the summer of 1966 reviewed and analyzed tree data from several pairs of 30-year-old plots. These men also measured and stem-mapped a plantation of sugar maple that was established many years ago. Each tree in this plantation was tagged to provide a reliable basis for future studies of growth and form.

Three Black Rock Forest Papers were published during the year: No. 26, "Recreation use within the Harvard Black Rock Forest," by Jack J. Karnig; No. 27, "The issues in the Storm King controversy," by Calvin W. Stillman; No. 28, "The price of open space – the need for Research," by Calvin W. Stillman. Interest in the Forest has been stimulated by the printing of a revised map of the property. Much of the revision was done in 1966 by the student employees mentioned above. The map shows all roads, trails and major access highways.

The Black Rock Forest is located just north of a crescent-shaped upland extending southwest to the Delaware Water Gap and bordering metropolitan New York-New Jersey. This thinly populated mountainous area of nearly 2000 square miles, due to its nearness to some 20 million people, presents a unique opportunity for orderly development of recreational potential. A newly organized interstate body called the "Appalachian Highlands Association" was started in June, 1967, to focus attention on this development. Mr. Karnig is one of the directors of the Association.

Buildings and Woods Operations

In November, 1966, the new building for office and living quarters, mentioned in my report for 1965–66, was completed, furnished and occupied. Adequate space is now available for library, office and storage. Living accommodations are provided for up to twelve visitors.

General improvements were made during the year in the appearance of the Forest property surrounding the main buildings. This was done by the removal or replacement of outworn fencing, and by judicious landscaping. A small building that houses a workshop was reroofed and insulated.

Woods operations consisted of a contract thinning and improvement cutting in the southwest corner of Compartment XVI. This cutting yielded about 40 cords of fireplace wood which has been stored under shelter, and another 20 cords left in the woods to cure. Most of this wood will go to local customers in the winter of 1967–68. A temporary employee in the summer of 1966 worked on road and trail maintenance.

Hugh M. Raup
Director

THE HARVARD FOREST, 1967-68

Harvard University

Frontispiece: Cross section from the basal part of a 98-foot-tall white pine which commenced growth at the Harvard Pisgah Tract shortly after 1665 and was blown down in the hurricane of 1938.

Magnification x 4.5

H A R V A R D F O R E S T

H A R V A R D B L A C K R O C K F O R E S T

Annual Report.....1967-1968

STAFF

The staff of the Harvard Forest during the year of 1967-68 consisted of the following persons:

Hugh M. Raup, Director (until September 1967)
Ernest M. Gould, Jr., Forest Economist
Walter H. Lyford, Soil Scientist
J. Mark A. Swan, Research Fellow (Harvard and Black Rock Forest)
Richard A. Howard, Research Fellow (until September 1967)
Jack J. Karnig, Forest Manager (Harvard and Black Rock Forest)
Charles F. Upham, Woods Superintendent
Barbara M. Kelley, Business Secretary and Librarian
Julia W. Savage, Secretarial Assistant
Vibeke Holm, Assistant to the Librarian

The staff of the Cabot Foundation, working at the Harvard Forest, during the year of 1967-68 consisted of the following:

Martin H. Zimmermann, Forest Physiologist
Brayton F. Wilson, Forest Botanist (until September 1967)
Philip R. Morey, Forest Botanist
P. B. Tomlinson, Forest Anatomist (Joint Appointment with Fairchild Tropical Garden, Miami, Florida)
A. Malcolm Gill, Research Fellow
Barbara M. McCurda, Secretary

The most important of the changes in staff during the past year has been the retirement of Dr. Hugh M. Raup as Charles Bullard Professor of Forestry and Director of the Harvard Forest, on September 1, 1967. He moved to Baltimore, Maryland, where he is now Visiting Professor

at the Isaiah Bowman Department of Geography at The Johns Hopkins University. Dr. Raup has been associated with Harvard University for 35 years, and has been Director of the Harvard Forest since 1946. This is perhaps a good place to express the appreciation of us all, present as well as past members of staff and students. We all treasure the memories of the past years when Dr. Raup was with us in Petersham and miss both him and Mrs. Raup very much. A search committee to find a new director has been formed by Dr. Franklin L. Ford, Dean of the Faculty of Arts & Sciences, under the Chairmanship of Professor John G. Torrey of the Department of Biology (the Director of the Cabot Foundation). The administrative duties are being carried out during the interim period by myself until October 1, and by Dr. Ernest M. Gould, Jr. from October 1, 1968, while I am taking a sabbatical leave for 10 months in Zürich, Switzerland.

Mr. Richard A. Howard left us in September 1967 to take up graduate work leading toward a Ph.D. at the University of Massachusetts. Changes in staff also include the departure of Dr. Brayton F. Wilson, who left the staff of the Cabot Foundation to take up a new position at the University of Massachusetts in Amherst. He has been replaced by Dr. Philip R. Morey who arrived in the early summer of 1967.

GRADUATE STUDENTS

Three graduate students were in residence during the period covered by this report: Mr. J. David Henry spent the summer of 1967 and two semesters here to obtain his Master's degree in Forest Science, which was awarded to him in June 1968. Mr. A. Jon Cassista continued his work (under the auspices of the Cabot Foundation) towards a Ph.D. in Biology. Mr. Melvin T. Tyree arrived here on June 8, 1968 after having received his B.S. degree from Pomona College in California, to spend the summer doing research under Cabot Foundation auspices. He will leave in September to begin a Ph.D. program with Professor Jack Dainty at the University of East Anglia in Norwich, England, with a Fulbright Fellowship.

BULLARD FELLOWS

Dr. Vera Gregorič, Assistant in the Biotechnical Faculty of the University of Ljubljana, Yugoslavia, arrived here on June 12, 1967 and left on September 14, 1967. During her stay here she was studying geology and soils of the northeastern United States with Mr. Lyford.

Dr. Bertram Husch, Chief of the Resource Surveys Section, Forestry and Forest Industries Division of F.A.O., arrived here on July 8, 1967 from Rome, Italy, and left again on June 11, 1968. He wrote to Professor J. D. Montgomery, Secretary to the Bullard Fellowship Committee, on July 1, 1968, "I believe this year has been one of the most satisfying and intellectually profitable of my professional career. It represented a rejuvenation of spirit as well as providing time for reflection, catching up on technical advances and writing. I was able to achieve the goals which I had set for the year; namely, a revision and modernization, with my collaborators, of my textbook on forest measurements, an understanding of the recent advances in linear and dynamic programming, simulation, model building and operations research and attendance at a course in economic development at Cambridge."

Mr. John Naysmith from the Canadian Department of Indian Affairs and Northern Development is a Bullard Fellow who worked in Cambridge, but spent a good deal of time with Dr. Gould at the Harvard Forest. He is the first one to use the year to work for a Master of Forest Science degree at the Forest.

Dr. Søren Ødum, Dendrologist of the Royal Veterinary & Agricultural College of Copenhagen, arrived here on July 1, 1967 to study the distribution of native woody species in eastern North America. He left here on June 2, 1968 to collect tree seeds and herbarium specimens in the western United States, including Alaska. He departed from Anchorage, Alaska on August 7, 1968 for Denmark.

Dr. Thomas O. Perry, Associate Professor of the School of Forestry at North Carolina State University, Raleigh, North Carolina, arrived here on September 1, 1967 and left in August 1968. While here, he worked on a manuscript for a textbook of forestry for college juniors. The book will be concerned with methods foresters can use to increase productivity, e.g. selection of genotypes and the manipulation of the environment. In addition to completing about 150 pages of text and illustration for this book, Dr. Perry wrote four papers, including a review article on "Dormancy in Trees."

Mr. T. Bruce A. Yerke, Station Librarian at the U.S. Forest Service Experiment Station in Berkeley, California, spent most of his time at the Widener Library in Cambridge. However, he made several visits at the Harvard Forest to discuss information storage and retrieval problems with members of the staff.

Dr. Robert C. Zimmermann was a Bullard Fellow jointly supported by the Cabot Foundation and the Harvard Black Rock Forest. He finished an extensive piece of work, begun many years ago by the late Dr. John C. Goodlett, to accurately map the ranges of key hardwood species in New England.

Dr. Bertram Husch, Chief of the Resource Surveys Section, Forestry and Forest Industries Division of F.A.O., arrived here on July 8, 1967 from Rome, Italy, and left again on June 11, 1968. He wrote to Professor J. D. Montgomery, Secretary to the Bullard Fellowship Committee, on July 1, 1968, "I believe this year has been one of the most satisfying and intellectually profitable of my professional career. It represented a rejuvenation of spirit as well as providing time for reflection, catching up on technical advances and writing. I was able to achieve the goals which I had set for the year; namely, a revision and modernization, with my collaborators, of my textbook on forest measurements, an understanding of the recent advances in linear and dynamic programming, simulation, model building and operations research and attendance at a course in economic development at Cambridge."

Mr. John Naysmith from the Canadian Department of Indian Affairs and Northern Development is a Bullard Fellow who worked in Cambridge, but spent a good deal of time with Dr. Gould at the Harvard Forest. He is the first one to use the year to work for a Master of Forest Science degree at the Forest.

Dr. Søren Ødum, Dendrologist of the Royal Veterinary & Agricultural College of Copenhagen, arrived here on July 1, 1967 to study the distribution of native woody species in eastern North America. He left here on June 2, 1968 to collect tree seeds and herbarium specimens in the western United States, including Alaska. He departed from Anchorage, Alaska on August 7, 1968 for Denmark.

Dr. Thomas O. Perry, Associate Professor of the School of Forestry at North Carolina State University, Raleigh, North Carolina, arrived here on September 1, 1967 and left in August 1968. While here, he worked on a manuscript for a textbook of forestry for college juniors. The book will be concerned with methods foresters can use to increase productivity, e.g. selection of genotypes and the manipulation of the environment. In addition to completing about 150 pages of text and illustration for this book, Dr. Perry wrote four papers, including a review article on "Dormancy in Trees."

Mr. T. Bruce A. Yerke, Station Librarian at the U.S. Forest Service Experiment Station in Berkeley, California, spent most of his time at the Widener Library in Cambridge. However, he made several visits at the Harvard Forest to discuss information storage and retrieval problems with members of the staff.

Dr. Robert C. Zimmermann was a Bullard Fellow jointly supported by the Cabot Foundation and the Harvard Black Rock Forest. He finished an extensive piece of work, begun many years ago by the late Dr. John C. Goodlett, to accurately map the ranges of key hardwood species in New England.

VISITORS

A great number of scientists from all over the world have again visited the Harvard Forest for shorter or longer periods, to discuss research with staff members. To list all of them would take too much space. We might, however, mention Dr. Edwin W. Mogren, Professor of Forest Science from the Colorado State University in Fort Collins, who used the Harvard Forest as a base of operations for his study of forest research and management in the northeastern United States during the summer of 1968.

The meeting of the northeastern forest economists again brought about 16 men to the Forest for two days in the fall. This annual event is becoming well known throughout the region and eastern Canada. The Canadian Chief of the Division of Economics attended, and this year has asked the group to visit Canada for its meeting.

As in preceding years, the Forest was host to many students. A group of graduate students of landscape architecture from the Harvard Graduate School of Design spent a few days at the Forest in September studying natural environments in the Forest and its vicinity, working with Dr. Gould. Many groups from neighboring forestry schools spent a day or two at the Forest.

The museum had numerous visitors, individuals as well as groups, many of which were taken on field trips by members of the staff.

RESEARCH

Dr. Gould's main activities for the year centered on the concluding phases of his project on planning the production of timber and landscape amenity. The grant supporting this work expired on January 1, and the final report to the U. S. Forest Service should be ready for publication sometime during the fall or winter 1968. Several interesting areas of research suggested by this report will hopefully be followed later. Mr. Richard A. Howard who collaborated with Dr. Gould in this project as a computer programmer, still gives him a few days of assistance while working in Amherst. The presence of Mr. John Naysmith offered an opportunity to test the new planning procedures on the real problem of initiating steps to develop the Yukon Territory. Dr. Gould also received several invitations for lectures and consultation visits. Cooperative research on the use of computers in forest planning has continued with

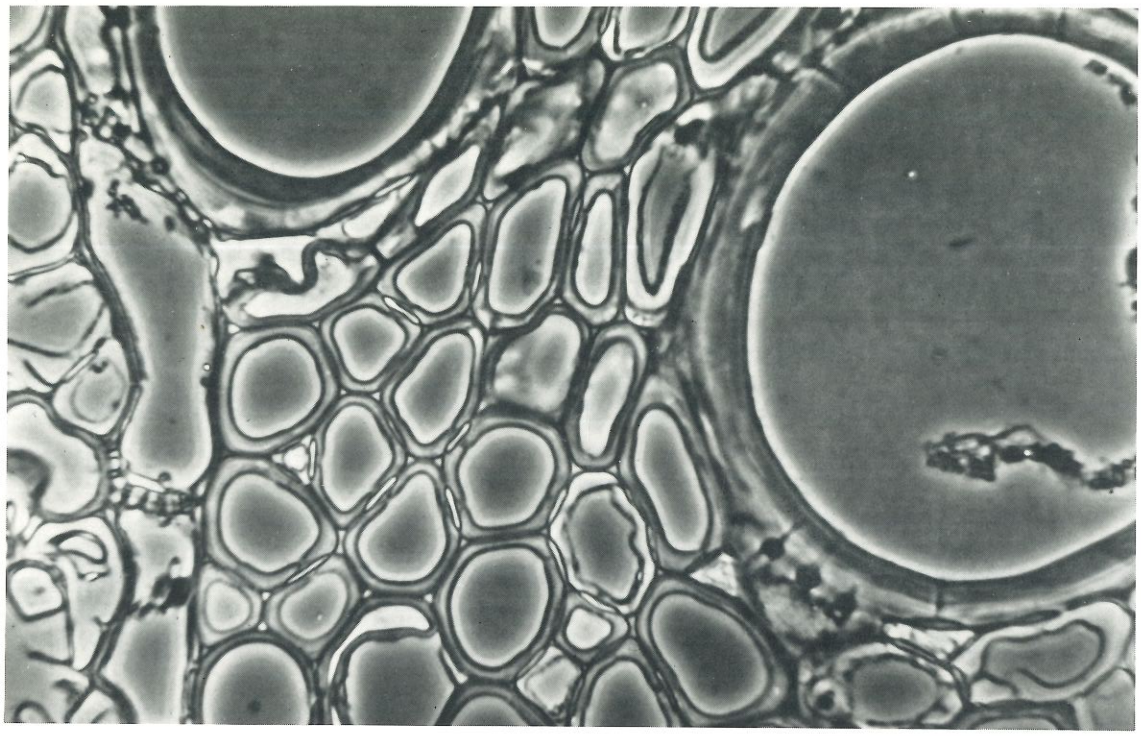
Dr. William G. O'Regan at the U. S. Forest Service Experiment Station in Berkeley, California.

For several years, Mr. Lyford has grown red maple roots on mature trees in root cellars ("rhizotrons"). During the past year red oak, sugar maple, yellow birch, trembling aspen, and white ash roots were also grown successfully. Detailed measurements of some of the roots were made to determine the parameters most useful for evaluating health. Preliminary work was started on three rather long-term projects: (1), soil morphology-root distribution at the Harvard Forest; (2), mortality and decay of forest trees, a joint study with Dr. D. W. MacLean, Canadian Department of Forestry and Rural Development, centered mostly in Canada; (3), weathering of surficial deposits in New England with special attention to transformation and translocation of iron and manganese by biological agencies, a joint study with F. Pessl of the U. S. Geological Survey.

Few direct ecological studies of vegetational change over long periods of time have been conducted because of obvious practical difficulties of measurement. Mr. J. David Henry has reconstructed forest growth and change over the last 300 years on a one-tenth acre plot of the Pisgah Tract in southern New Hampshire. He pieced this story together from a detailed examination of wood fragments, microtopography and stem locations on the plot, a method first used by Dr. Earl Stephens at the Harvard Forest in 1952. From the analysis of wood fragments buried in the forest floor, he and Dr. Swan are presently identifying the species of the larger stems that were in the forest before 1650.

Dr. Swan is conducting another study of vegetational change over time. He aims to find out how an extensive floating mat, largely composed of ericaceous shrubs and sphagnum moss, has formed at the northern margin of the Harvard Pond since the time the pond was made in the latter part of the 19th century. Dr. Swan is also currently working on methods of analyzing vegetational patterns in the field to search for consistent and therefore predictable relationships between species behaviours and their environment.

The primary purpose of the Maria Moors Cabot Foundation for Botanical Research is "to increase the capacity of the Earth to produce fuel by the growth of trees and other plants." In order to improve the growth of trees one has to learn how trees grow. Cabot Foundation activities, therefore, all center around the physiology of tree growth. Dr. Morey's research concerns the effect of plant growth regulators on the development of woody tissues in hardwood seedlings. Another of his projects is the study of the structure and microchemical nature of woody tissue preserved in fossil material. He found that lignin and cellulose are present in a lignite of Oligocene derivation.



Well-preserved hardwood specimen from Griffin Hill peat, about 10,000 years old. Magnification x 930 Photomicrograph by P.R. Morey

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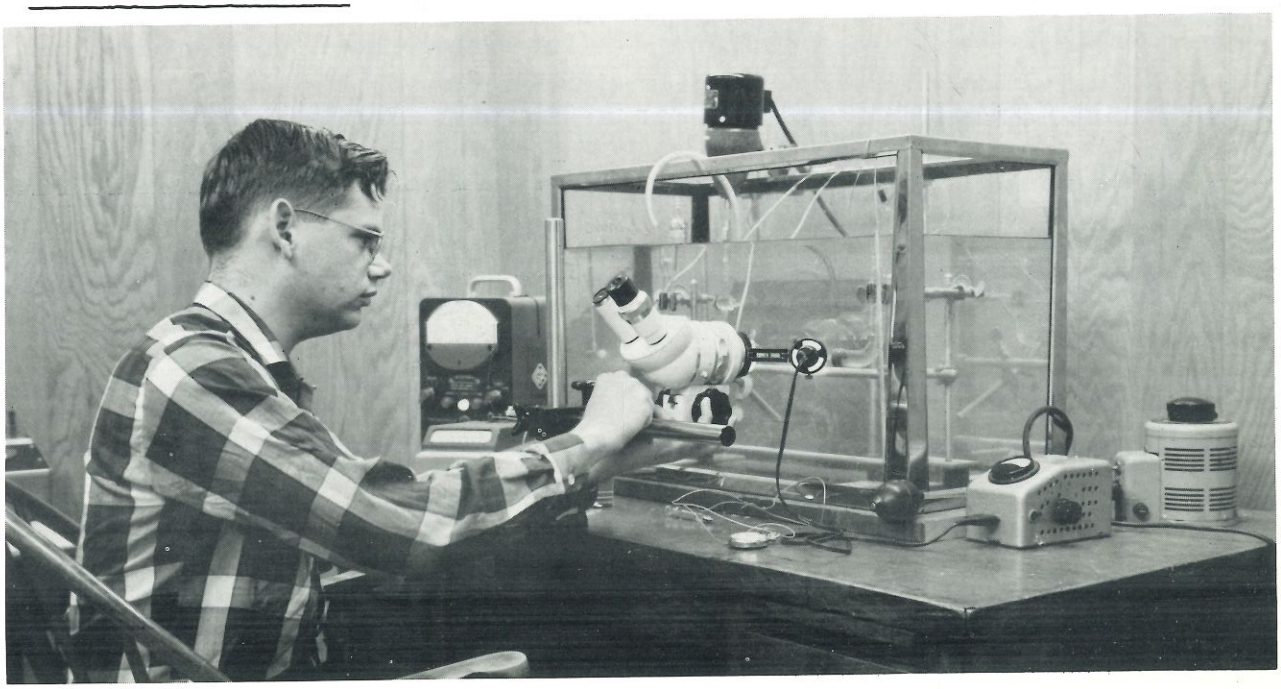
Dr. Gill continued his studies of the growth, morphology and development of shoot and root systems of white ash (Fraxinus americana L.). Root system studies have been extended to the aerial roots of trees of a Puerto Rican elfin woodland and of the Florida mangroves. A survey of patterns of bud distribution and shoot growth of the woody plants of the Forest is also under way.

Mr. Cassista's thesis project concerns the initiation and regulation of cambial activity. Few investigators attempt to attack this problem with fully grown trees. Seedlings are mostly used for ease of handling and uniformity of experimental material. Mr. Cassista approaches the problem mostly by girdling tall trees and sampling the cambium below the girdle for anatomical growth analysis and chemical analysis of growth regulators in various positions so that places of different intensities of growth can be compared.

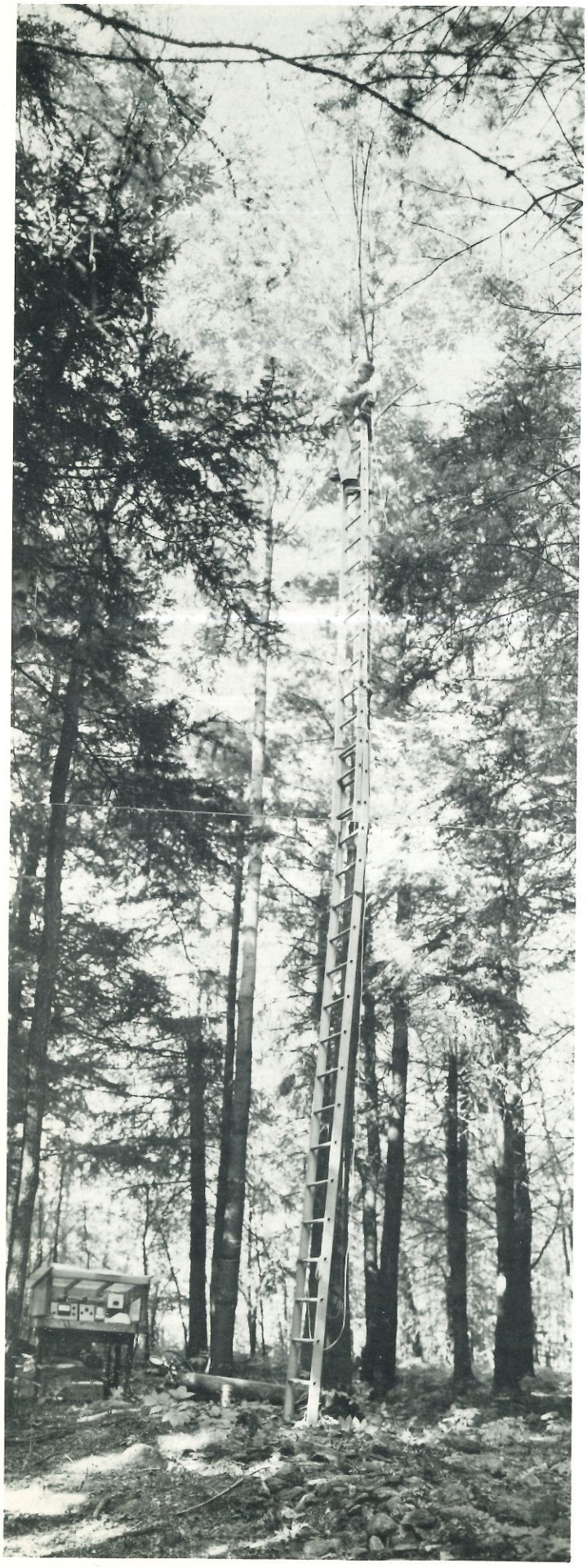
Dr. Tomlinson's research, carried out in collaboration with myself, concerns the vascular anatomy of monocotyledonous trees. This turned out to be a badly neglected field of endeavor, for quite obvious reasons: it is a microscopic problem on an enormous scale. Special methods of investigation had to be developed specifically for the problem, and the results obtained

during the past four years have been quite remarkable. The basic principle of vascularization in palms and its development have been discovered. The extension of the work to other monocotyledons suggests that these principles apply to monocotyledons in general. One of the devices we developed for this study, the shuttle microscope, is now used in many other fields in botany, zoology, paleontology and medicine (neuroanatomy in particular) (see the paper by Zimmermann & Tomlinson in Science 152: 72-73. 1966). Another device, a continuous-advance microtome clamp, has been perfected during the past year. It permits continuous photography of sequentially cut surfaces of the specimen. This method has already yielded valuable information not only about palms, but also on the three-dimensional distribution of vessels in wood, an aspect of wood anatomy about which very little is known. Dr. Tomlinson spends a few weeks at the Harvard Forest every year.

Problems of translocation of water and nutrients are of crucial importance for tree growth. We have to visualize that all the carbohydrates making up the tree trunk are produced in the leaves and have to be transported to the stem before they can be used for growth. Two translocation problems are under investigation at the Harvard Forest. Mr. Tyree continues a study on which he worked with Prof. David Fensom of Mt. Allison University in Sackville, New Brunswick, for several summers. He is testing the Onsager equations for steady state thermodynamics. With these it is possible to describe for the first time the inter-relation of the various forces (hydrodynamic, electric, etc.) acting upon the flow of solutes through a tree. Another project is a clever application of these equations: when a D.C.



Mel Tyree measuring cross coefficients of Onsager equation with a piece of red maple in his electro-osmometer.



voltage is applied at two points to the xylem of a tree alternately in two directions, a difference in electrical currents can be found if the tree is transpiring, i.e. if the current alternately has to go against and with the flow of water. The current difference is proportional to the water flux and to the pressure gradient. His present aim is to calibrate this electrical measurement of water flux with cut stems.

My main research project has, for many years, centered around the translocation of carbohydrates from leaves to stem and roots. In most trees the bulk of carbohydrate is transported in the form of sucrose. In white ash (Fraxinus americana L.) there are three major translocation sugars, sucrose, raffinose and stachyose, and even a sugar alcohol, D-mannitol. This makes many interesting experiments possible. The ratio of the various sugars changes slightly throughout each 24-hour period. The resulting "ratio wave" (for example conc. sucrose/conc. stachyose) can be tracked on its way down along the trunk, thus yielding a figure of the translocation velocity as well as the quantity of sugar moved.

At the Black Rock Forest, Mr. Karnig and Mr. Lyford completed a study on oak mortality in the Hudson Highlands caused by drought. Another study, by Mr. Karnig and Prof. B. B. Stout of the School of Forestry at Rutgers (the former manager of the Black Rock Forest), on the growth of northern red oak following understory control has also been finished. Data and photographs are being accumulated on all aesthetic thinnings installed since 1964 in an attempt to document this phase of cutting at the Black Rock Forest.

A "ratio-wave" experiment

FOREST OPERATIONS

Harvard Forest in Petersham. Experimental cutting activities have been concentrated on one 15-acre area in Compartment IV of the Tom Swamp Tract. Two degrees of thinning-and-improvement-cutting were made, leaving the best trees to grow into sawtimber. On the north half of the area 40 percent of the volume was cut, and on the south portion 60 percent was removed. Both cuttings greatly increased visibility through the residual stand and on the advice of our landscape architect friends we have set out to preserve this attraction by spraying sprouts with herbicides. Without some such control the view is likely to be obscured in a year or two. An unsprayed plot has been set out as a check. Total fuelwood production from this area during the past year was 220.75 cords.

A small number of logs were cut and sawed in the Forest mill during the year to produce slightly more than three thousand board feet. Some large sales of lumber reduced our inventory from 26 to 12 thousand board feet.

Forest operations for aesthetic purposes. Opening a "window" onto Brooks Pond, Tom Swamp Tract. Left before, right after cutting.

The new office building at the Harvard Black Rock Forest with living quarters on the upper level.

Black Rock Forest. General maintenance included building improvement work as well as road and trail clearing throughout the property. Road work has been made necessary particularly by a storm in April, 1968, during which 5 inches of rain fell and caused considerable damage to roads. Because of budget limitations, some of the repair work will have to be spread over the next two or three years.

Two aesthetic thinnings were installed and a new scenic trail was improved. Recreational use of the forest is on the increase and guided tours have become quite popular. Hunting and fishing rights are enjoyed exclusively by the Black Rock Fish and Game Club of Cornwall. This club does not pay for these privileges, but its large membership serves as a reserve force in the case of forest fires. This past April a forest fire did break out on our property and burned about ten acres before it could be stopped by the local fire departments, Conservation Department personnel and members of the above-mentioned club.

Contract logging has been carried out at three different locations during the past year. Ten cords of fuelwood were cut in Compartments XVI and XV. Another oak stand is marked for thinning in Compartment VII adjacent to the White Oak Road. The wood is being stockpiled in our shed for fall delivery to local customers.

1913

We recently obtained from Mr. Jesse Dennison a number of photographs taken by him in 1913 within the Harvard Black Rock Forest. The view above shows maneuvers by U.S. Military Academy cadets from West Point. The picture below shows the same view of Continental Road today.

1968

SWIFT RIVER VALLEY TRUST

During the last year the four landowners of contiguous areas in the Swift River Valley in Petersham formed the Swift River Valley Trust. The trust was signed by a representative from each of the following organizations: the James W. Brook Wildlife Sanctuary, Harvard University (the Harvard Forest), the Massachusetts Audubon Society and the Worcester Natural History Society. The land includes about 1000 acres of forest and fields along five miles of stream and is a good example of such attractive undeveloped outdoor environments in Central Massachusetts. The purpose of the Trust is to promote use of this area for scientific research and public education in various fields of biology, geology, forestry, conservation, etc. Only the Slab City Tract of the Harvard Forest is involved and this agreement will in no way limit present or future research projects, on the contrary, it is likely that all will gain by closer cooperation. One immediate goal is to restore Connor's Pond by rebuilding the dam which was damaged by the 1938 hurricane and the 1952 tornado.

Petersham, Massachusetts
August, 1968

Martin H. Zimmermann
Acting Director

PUBLICATIONS

The following articles have appeared in print during the fiscal year of 1967-1968:

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Wilson, Brayton F. 1967. Root growth around barriers. Bot. Gaz. 128: 79-82.

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Wilson, Brayton F. 1968. Red maple stump sprouts: Development the first year. Harvard Forest Paper No. 18, 1-10.

Zimmermann, M. H. and P. B. Tomlinson 1967. A method for the analysis of the course of vessels in wood. Bull. Internat. Assoc. of Wood Anatomists 1967/1: 2-6.

Zimmermann, M. H. 1967. Translocation of sugars and amino acids in relation to flowering in trees. Proc. 14th IUFRO Congr. (Section 22), Munich 1967. 3: 31-37.

Zimmermann, M. H., A. B. Wardrop and P. B. Tomlinson 1968. Tension wood in aerial roots of Ficus benjamina L. Wood Sci. & Technol. 2: 95-104.