October 1994 SIR-C/X-SAR Mission: Ancillary Data Report
Raco, Michigan Site

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October 5, 1995

Report 026511-6-T

26511-6-T = RL-2411

Abstract

This report documents the ancillary measurements taken during the period September 28 - October 10 at the Raco supersite in conjunction with the October 1994 SIR-C/X-SAR mission. For this mission, data collection concentrated on measurements in the following categories:

1. Calibration:
    - a. point targets
    - b. distributed targets
2. Surface properties:
    - a. Surface roughness:
        - (i) large scale under forest canopies and in clearings
        - (ii) small scale under agricultural canopies
    - b. Soil moisture in both forested and agricultural land cover types by:
        - (i) Soil cores
        - (ii) Dielectric measurements
3. Vegetation properties:
    - a. Leaf Area Index of forest stands and agricultural fields
    - b. Vegetation moisture content in both forest and agricultural land cover types by:
        - (i) Destructive sampling
        - (ii) Dielectric measurements (forest only)
4. Meteorological Observations:
    - a. Gross precipitation and net precipitation under forest canopies
    - b. Temperature
    - c. Weather radar and local weather stations observations

This report provides an introduction to the site, followed by measurement methodologies for each of the ground measurement efforts, summary data tables, and more detailed data in the form of appendices. Electronic versions of the summary data tables and appendices are available on request. Requests may be sent to: dobson@eecs.umich.edu

Acknowledgments

The following people contributed to the success of the SIR-C/X-SAR October experiment. We would like to thank each of them and acknowledge their hard work and dedication to this project:

Project Management: M. Craig Dobson, Fawwaz T. Ulaby, Leland E. Pierce, Kamal Sarabandi

Ancillary Data Measurements and Analysis: Kathleen Bergen, Tsen-Chieh Chiu, Roger DeRoo, Ron Hartikka, Josef Kellndorfer, John Kendra, Eric Li, Yi-Cheng Lin, Adib Nashashibi, Leland Pierce, Paul Siqueira, Jim Stiles, Aziza Ulaby, Jason Wheeler

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1. Introduction

1.1 PROJECT OBJECTIVES

On September 30, 1994, the SIR-C/X-SAR instruments were launched on their second 11-day mission on the NASA space shuttle Endeavor. Several supersites received frequent overflights, the Raco supersite in the upper peninsula of Michigan being among them. This site was imaged twelve times between September 30 and October 10. The purpose of the mission was to acquire SAR image data for the investigation and analysis of previously defined ecological and environmental questions particularly those related to global climate change. Specifically, eight research objectives were linked to the Raco site during the October mission:

Table 1. October 1994 SIR-C/X-SAR Project Objectives: Raco Supersite

Objectives
1. Above ground living vegetation biomass, density, BA, and height
2. Forest and agricultural vegetation canopy moisture content
3. Forest and agricultural soil moisture
4. Canopy leaf area index
5. Surface roughness conditions
6. Meteorological conditions
7. Image classification
8. Image calibration

A team of 14 scientists from the University of Michigan Radiation Laboratory made a number of ancillary measurements during this period in order to meet these objectives. Data collection concentrated on time-sensitive measurements including vegetation and soil moisture, leaf area index, and weather data. It also concentrated on describing surfaces, thus measurements of large and small scale roughness were made in both forested and agricultural land cover types. In addition, an array of point and distributed calibration targets planned specifically for the SIR-C/X-SAR mission was deployed and monitored.

This report presents a summary of the ground data taken during the period September 29 - October 10 in conjunction with the space shuttle overflights. It contains a brief introduction to the site, followed by measurement methodologies for each of the ground measurement tasks, summary data tables, and more detailed data in the form of appendices. Other less time sensitive measurements such as forest composition and biomass were made during the summers 1992-94 and are not included here. Electronic versions of the summary data tables and appendices are available on request. Requests may be sent to: dobson@eecs.umich.edu

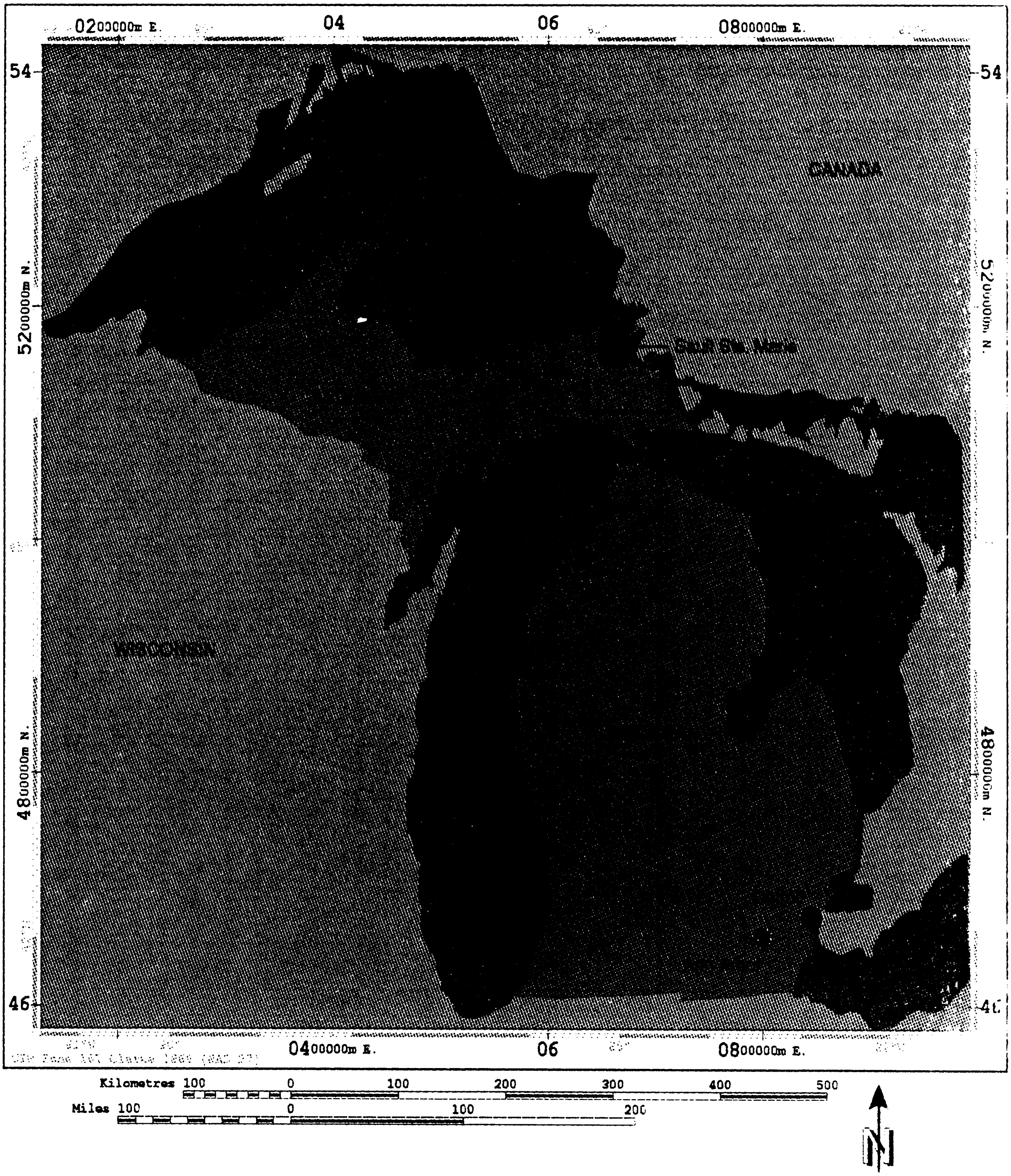
1.2 THE SITE

The Raco supersite, centered on 46.392° N. Latitude and 84.885° W. Longitude, is located in Chippewa County in the eastern part of Michigan's Upper Peninsula. The primary area under study imaged in the SIR-C/X-SAR crossover region of ascending and descending orbits is approximately 20 km E-W and 20 km N-S. Much of the study site, and all of the forest test stands used for ground truth data, are within the boundaries of the Eastern Division of the Hiawatha National Forest. Agricultural fields are located near Rudyard, MI and occupy the southeast portion of the SIR-C/X-SAR imagery. The map *SIR-C/X-SAR Supersite: Raco, Michigan* shows the location of the test site in Michigan.

1.2.1 Physiography

The site contains several distinct physiographic regions. A large area of excessively drained glacial outwash sands (the Raco Plains) dominates in the north-central. The south-central area contains an extensive poorly drained wetland area. Moderately well drained morainal features interspersed with low-lying somewhat poorly drained areas comprise the western portion. The northern edge of the site borders Lake Superior. Agricultural areas on lake plain border the northeast and southeast, and the Delirium Wilderness wetlands borders the south central. Forested areas on morainal till continue to the west.

SIR-C/X-SAR Supersite: Raco, Michigan



1.2.2 Climate

Regional climate is characterized by a mean annual temperature of 5°C, July average temperature of 24.5°C, January average temperature of -14°C, growing season of approximately 130 days, and mean annual precipitation of 79 cm. The SIR-C/X-SAR overflight occurred in the fall, a time of some seasonal change. At this time the vegetation canopy begins to dry and the deciduous leaves begin to undergo their fall color change. In October 1994, the deciduous leaves were still predominantly green at the beginning of the mission, and by the end of the mission most had turned. Agricultural field vegetation was fairly dry and much had been harvested.

1.2.3 Forest Composition

The Raco site's situation on the ecotone between the north-temperate and boreal forest biomes, its diversity of forest communities of varying ages and densities, and its forest stands of large geographical extent made it an ideal NASA supersite.

Present on the drier outwash are upland conifer communities; on the low sites lowland conifer or forested wetlands communities; on the richer sites either late successional northern hardwoods or early successional aspen communities. The map *Detail of Land Cover,* depicts the generalized land cover distribution for the test region. Table 2 lists the forest communities and dominant species which have been studied throughout the duration of the SIR-C/X-SAR project.

Over the past four years, sixty-six forest test stands representing the distribution of forest communities, ages, and densities found at the Raco site have been sampled. These have been described statistically and compiled into an extensive ground-truth database providing estimates of species composition, height, density, diameter, crown depth, LAI, and biomass [1]. While these data are documented in a separate report, the test stand locations are depicted on the map *SIR-C/X-SAR Test Stands and Calibration Sites* .

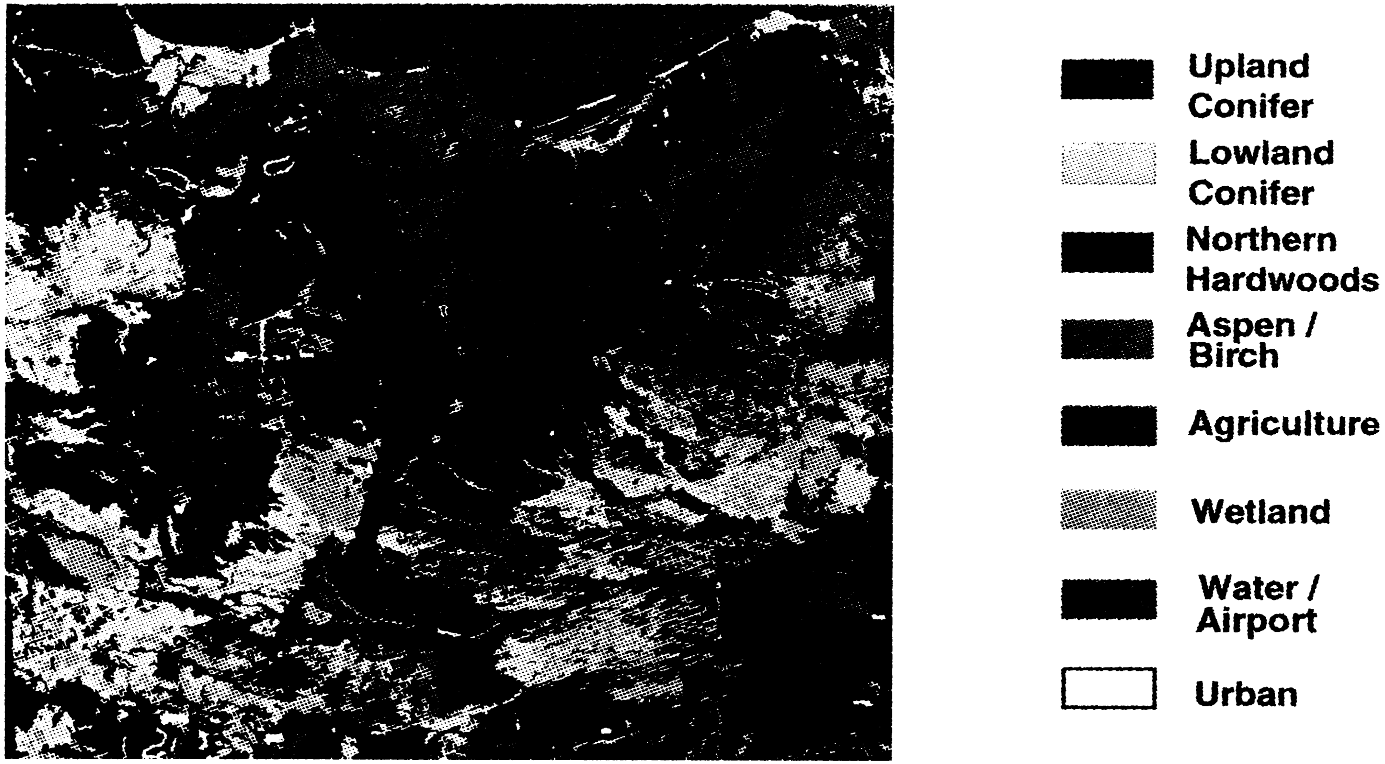
Table 2: Forest Communities and Dominant Species Studied During the SIR-C/X-SAR Project

Upland Conifer
Jack Pine (*Pinus banksiana*) Red Pine (*Pinus resinosa*) White Pine (*Pinus strobus*)
Lowland Conifer
Black Spruce (*Picea mariana*) White Spruce (*Picea glauca*) Northern White Cedar (*Thuja occidentalis*) Balsam Fir (*Abies balsemea*) Larch (*Larix laricina*)
Northern Hardwoods - late successional species
Sugar Maple (*Acer saccharum*) Red Maple (*Acer rubrum*) Beech (*Fagus grandifolia*) Yellow Birch (*Betula alleghaniensis*) Paper Birch (*Betula papyrifera*) Hemlock (*Tsuga canadensis*)
Aspen - early successional species
Trembling Aspen (*Populus tremuloides*) Bigtooth Aspen (*Populus grandidentata*) Pin Cherry (*Prunus Pensylvanica*)

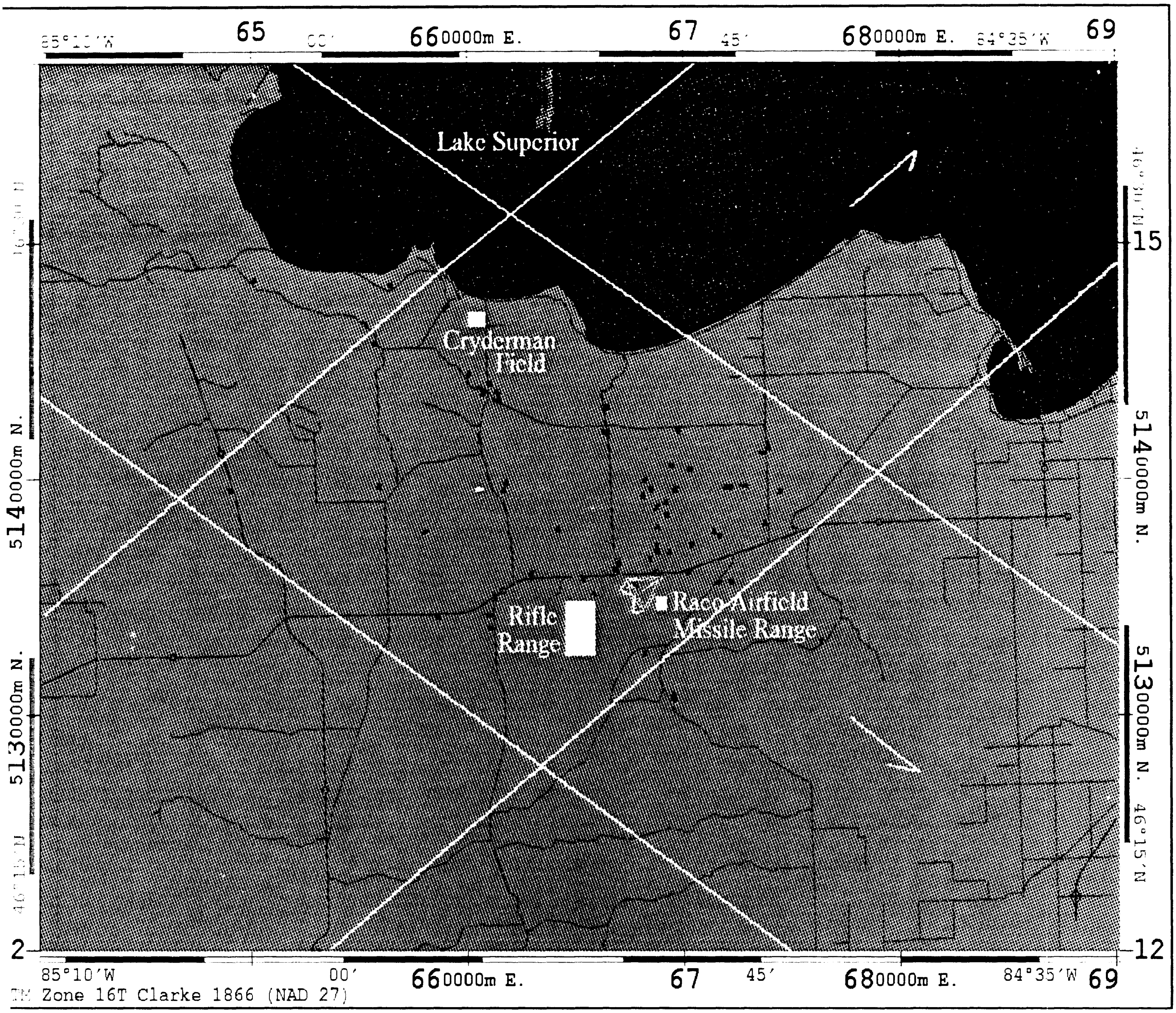
1.2.4 Agricultural Areas and Composition

In the agricultural southeast portion of the study area a set of twenty-one fields were identified for study. Sixteen hayfields (Timothy hay) were selected and these ranged from very short cut hay to very tall uncut hay. Hayfields, both cut and uncut, had an undergrowth of green grass. Five pastures were identified which contained mixtures of grass and clover or grass and dandelions. A list of the fields selected for study and their composition is provided in Table 3: *Agricultural Fields Studied During the October SIR-C/X-SAR Project.* Periodic roughness structures are likely of one of two types. Those with spacings on the order of 10-14 m are probably planned, though

Detail of Land Cover
Centered on the Raco Supersite
SIR-C/X-SAR Cross-Over Region

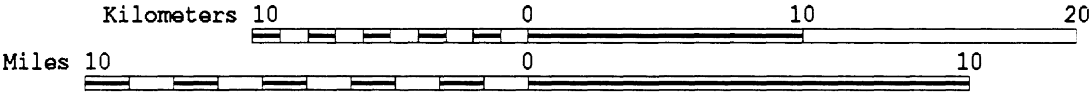


Source: manually interpreted from 1979 aerial photography
by the Michigan Department of Natural Resources



SIR-C Test Stands and Calibration Sites

Raco, Michigan Supersite



■ Forest test stands

☐ Calibration sites

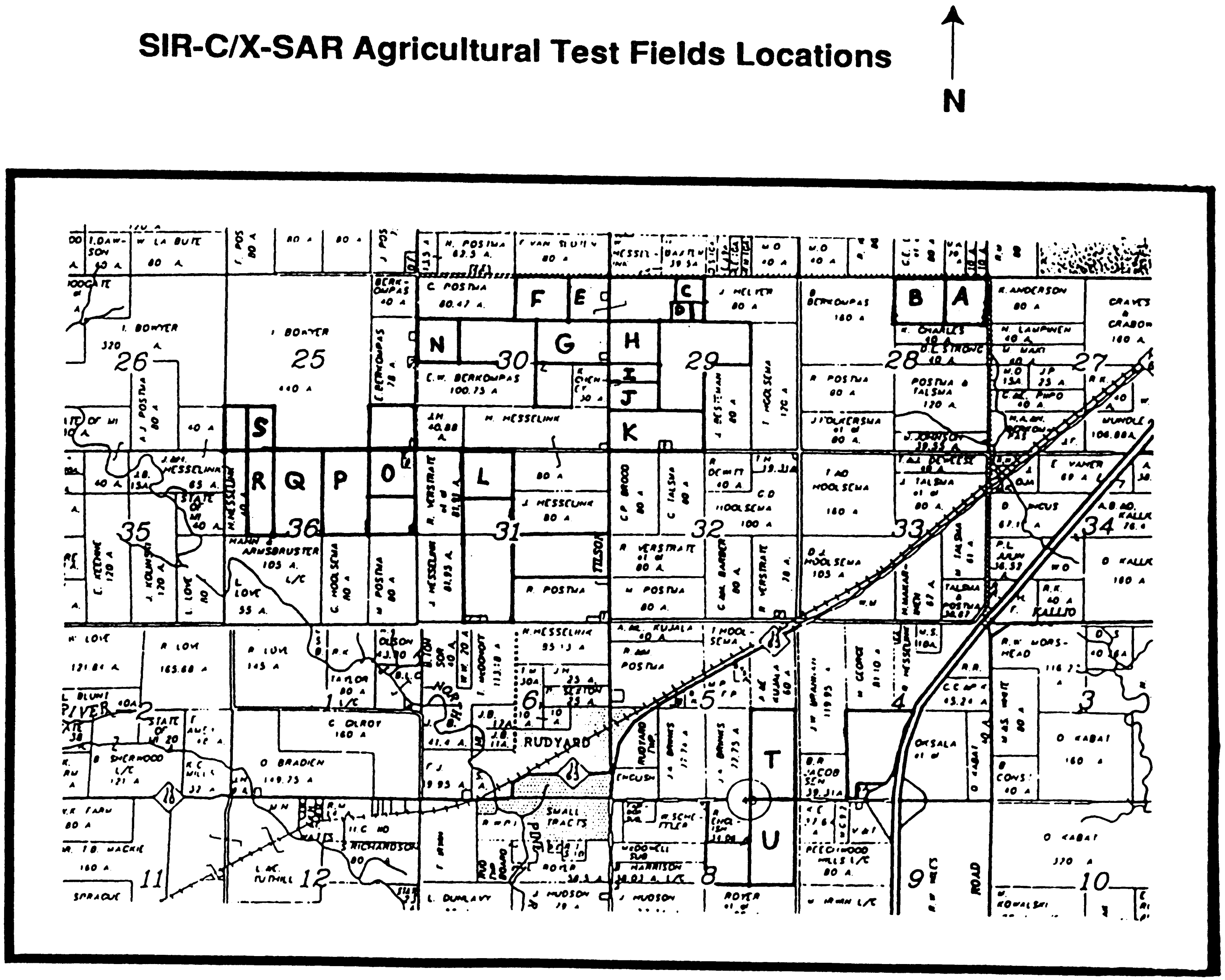
☐ SIR-C imaged swath

fairly shallow, drainage ditches. Those with spacings of 1.5-5 m are likely the result of planting or harvesting machinery and practices. Depth of the undulations ranged from approximately 15-25 cm. (deep) to 5-10 cm (medium) to very shallow depressions (shallow). The map *SIR-C/X-SAR Agricultural Test Fields Locations* shows their locations in the region around Rudyard Michigan.

Table 3: Agricultural Fields Studied During the October SIR-C/X-SAR Mission

Field	Vegetation Cover	Height (cm)	Periodic roughness direction	Depth	Spacing (m)
A	cut hay--short	10	N-S	medium	12
B	cut hay--short	15-20	E-W	medium	14
C	pasture--grass & clover	15	N-S	shallow	3.2
D	pasture--grass & clover	10-15	N-S	medium	11
E	pasture--grass & dandelions	15-20	E-W	medium	12
F	cut hay--very short	30	N-S	deep	12
G	pasture--grass & clover	35	E-W	very deep	12
H	pasture--grass & clover	5-15			
I	cut hay--medium	40	N-S	medium	1.6
J	cut hay--short	25-30	E-W	medium	3.2
K	cut hay--short	25	E-W	medium	1.5
L	cut hay--short	15	N-S	medium	10
M	cut hay--very short	15	N-S	medium	4
N	cut hay--very short	20-25	E-W		
O	cut hay--medium short	25	N-S	deep	13
P	uncut hay--tall	70	N-S	shallow	4
Q	uncut hay--tall	70	N-S	shallow	
R	cut hay--very short	15-20	N-S	shallow	5
S	uncut hay--very tall	100	N-S	very shallow	
T	uncut hay--tall	20-30	N-S	medium	10
U	uncut hay--tall	100	N-S	shallow	10

SIR-C/X-SAR Agricultural Test Fields Locations



1.3 THE SIR-C/X-SAR OVERFLIGHT

The SIR-C/X-SAR general flight path including overlap region is also depicted on the map *SIR-C/X-SAR Test Stands and Calibration Sites*. The ascending path had a track angle of 52° - 53°, and the descending path a track angle of 127° - 133°. Except for the agricultural fields and precipitation gauge network, almost all ground-truth data represented in this report were collected within the approximately 20 km x 20 km path overlap region. The time of the overflights ranged form 6:41 a.m. to 3:06 p.m. local time (EDT). Information pertaining to specific overflights, such as date and time, data take number, ascending/descending, look angle, and local incidence angle, can be found in Section 2.1, Table 6: *October SIR-C/X-SAR Calibration Point Targets.*

1.4 GROUND DATA COLLECTION OVERVIEW

Ancillary measurements made during the October SIR-C/X-SAR mission are in the general categories of 1) calibration, 2) surface observations including surface roughness and soil moisture/dielectrics, 3) vegetation observations including leaf area index and moisture/dielectrics, and 4) other efforts including precipitation measurement, ground photography, and GPS (global positioning system) location determinations. The following Table 4: *Overview of the October 1994 SIR-C/X-SAR Ancillary Data Collection Effort,* provides a guide to these measurements. This overview guide is followed by sections in the report corresponding to each of the measurement goals. These text sections provide 1) a table outlining the hypotheses, objectives, and methods, 2) an explanation of the methodology, and 3) results in the form of summary tables. More detailed data is found in appendices in the form of plots and tables where applicable.

Table 4: Overview of the October 1994 SIR-C/X-SAR Ancillary Data Collection Effort

Measurement Goal	Method	Locations	Level of Effort
CALIBRATION	1. Point Targets: trihedrals, PARCS, SAPARCS	Rifle Range, Raco Airfield, Cryderman Field	18 point targets
	2. Distributed targets / surfaces	Rifle Range	3 distributed targets/surfaces
SURFACE OBSERVATIONS			
A. Roughness	1. Large scale roughness measured along transects using surveying methods	Forest test stands and clearings	12 stands: 6 red pine, 1 jack pine, 1 white pine, 2 aspen and northern hardwoods, 2 lowland conifer, Raco Airfield, Rifle Range, Cryderman field
	2. Small scale roughness measured using both photographic and spray paint methods	Agricultural fields and clearings	All fields, plus Raco Airfield, Rifle Range, Cryderman field
B. Soil Moisture	Soil cores and temperature	Forest test stands, agricultural fields, and clearings	3 clearings, variable number of locations. 10 forest stands @ 3-15 samples/stand.
C. Soil Dielectrics	Portable dielectric probes	Forest test stands and clearings	10 forest stands and cal sites
VEGETATION OBSERVATIONS			
A. Leaf Area Index (LAI)	Li-Cor LAI meter	Forest test stands and agricultural fields	50 stands at 9-28 locations each 21 fields at 18 locations each
B. Direct Moisture Measurement	Destructive sampling--felled and sampled trees, and cut herbaceous field vegetation to arrive at wet and dry weights and volumes	Forest test stands, agricultural fields, Raco Airport, Cryderman field	10 trees (one of each major species), 21 agricultural fields, Cryderman field, Raco airport
C. Dielectric Measurements	Depth profiles, temporal variance	Forest test stands	12 stands in August, 13 stands in October for depth, 2 temporal
OTHER			
A. Precipitation Data	Network of rain guages	Forest test stands and clearings	5 forest stands (one of each community type), 5 clearings near the forest stands, 11 additional locations spanning the study site
B. Photography	Photos of forest test stands, target locations, and agricultural fields	Forest test stands, agricultural fields, target locations	50 test stands, 21 fields, 3 target locations
C. Measurement Locations	GPS (global positioning system)	Agricultural fields, target locations, and precipitation guages. Stands previously completed	21 fields, 21 target locations, 21 rain guages

2 Calibration

2.1 POINT TARGETS

Absolute image calibration and development of image calibration algorithms has been a goal throughout the duration of the SIR-C/X-SAR project. The objectives and methods used for assuring accurate calibration for the October mission imagery were as follows.

Table 5: Calibration: Objectives and Methods

Objective	Method
1. Absolute calibration of SIR-C/X-SAR imagery acquired at L, C, and X bands	1a. Deploy and monitor point targets 1b. Measure backscatter for area extended targets with a calibrated scatterometer system.
2. Accurate calibration over the geographical extent of the imaged scenes	2. Place 21 targets in several locations

Appropriate calibration targets needed to be distributed in open areas within the area imaged by the sensors. Both passive and active targets were deployed. Six 1.07 m trihedrals, one L-band single antenna polarimetric active radar calibrator (saparc), one C-band saparc, and four 2.4 m trihedrals were located at the Rifle Range near the Raco Airfield. Two C-band parcs were located at the Raco Airfield. Four 2.4 m trihedrals were located at Cryderman Field. In addition, three distributed targets areas were established at the Rifle Range.

Details regarding point target positioning, including GPS derived coordinates, target type, and measured elevation angles and azimuths, can be found in Table 6: *October SIR-C/X-SAR Calibration Point Targets.* The three target locations are depicted on the map *SIR-C/X-SAR Test Stands and Calibration Sites.* Point targets were repositioned and/or monitored for accurate positioning before each overflight using electronic levels and Brunton compasses.

Table 6: October SIR-C/X-SAR Calibration Point Targets

October 1994 Mission
Launch scheduled for 7:16 am on September 30
Local magnetic declination is 6.138° W

All PARCs: 1 1
-1 -1

MET (dd)	0	1
MET (hh:mm:ss)	7:50:29	7:31:51
Orbit No.	6	22
Data-Take No.	6.2	22.2
Ascending/Descending	D	D
North/South Looking (from Shuttle)	S	S
Look Angle (relative to SIR-C)	30.689	20.382
Local Incidence Angle	31.846	21.106
SIR-C Azimuth Heading (True North)	127.508	128.131
Target Azimuth (True North)	127.862	127.862
Target Looking (N/S)	N	N
Target Azimuth (Mag. North)	134	134

Site	Target Name	Ascending/ Descending	Location		Target Type	Size (cm)	Max. RCS (dBm^2)	Elevation Angles (From horizontal)	Azimuth (from true north	Level (degrees)	Temp (°C) or Atten. (dB)	Elevation Angles (From horizontal)	Azimuth (from true north)	Level (degrees)	Temp (°C) or Atten (dB)
			Latitude	Longitude											
Rifle Range	P1	A/D	46.3481	-84.8487	L-SAPARC			30.0	134.0	0.0	16°	21.1	134.0	0.0	
	P2	A/D	46.3369	-84.8519	C-SAPARC			30.0	134.0	0.0	16°	21.2	134.0	0.0	3 dB pad
	T1-7	A/D	46.3360	-84.8575	Trihedral	240		29.9	134.0	0.2		29.8	134.0	0.2	
	T1-8	A/D	46.3453	-84.8497	Trihedral	240		30.2	135.0	0.1		29.9	134.0	0.1	
	T1-9	A/D	46.3368	-84.8595	Trihedral	240		29.6	134.0	0.2		30.0	135.0	0.1	
	T1-10	A/D	46.3506	-84.8500	Trihedral	240		30.3	135.0	0.3		30.1	135.0	0.3	
	T2-1	A/D	46.3337	-84.8593	Trihedral	107		29.9	135.0	0.3		29.8	134.0	0.1	
	T2-2	A/D	46.3452	-84.8512	Trihedral	107		29.8	134.0	0.0		29.9	134.0	0.1	
	T2-3	A/D	46.3422	-84.8461	Trihedral	107		30.0	135.0	0.1		30.0	135.0	0.1	
	T2-4	A/D	46.3406	-84.8457	Trihedral	107		29.7	135.0	0.2		29.8	135.0	0.0	
	T2-5	A/D	46.3393	-84.8519	Trihedral	107		29.8	134.0	0.0		30.0	134.0	0.2	
	T2-6	A/D	46.3365	-84.8503	Trihedral	107		29.9	134.0	0.2		29.9	134.0	0.2	
Raco Airfield	P3	A/D	46.3568	-84.8048	C-PARC #1		44.5	31.8	134.0	0.4		21.1	134.0	0.2	
	P4	A/D	46.3508	-84.8196	C-PARC #2		42.4	31.8	134.0	0.5		21.2	134.0	0.6	
Cryderman	T1-1	A/D	46.4591	-84.9070	Trihedral	240		30.0	136.0	0.6		30.0?	136.0?	0.6?	
	T1-2	A/D	46.4562	-84.9093	Trihedral	240		30.5	133.5	0.4		30.5?	133.5?	0.4?	
	T1-3	A/D	46.4561	-84.9130	Trihedral	240		29.9	134.0	0.4		29.9?	134.0?	0.4?	
	T1-4	A/D	46.4571	-84.9152	Trihedral	240		30.2	134.5	0.1		30.2?	134.5?	0.1?	
			Local Day						Friday				Saturday		
			Local Date						30-Sep				1-Oct		
			Local Time						15:06:29				14:47:51		

October 1994 Mission
Launch scheduled for 7:16 am on September 30
Local magnetic declination is 6.138° W

All PARCs: 1 1
-1 -1

MET (dd)	4	5
MET (hh:mm:ss)	0:25:32	0:06:02
Orbit No.	66	82
Data-Take No.	66.2	82.2
Ascending/Descending	A	A
North/South Looking (from Shuttle)	S	S
Look Angle (relative to SIR-C)	21.263	29.916
Local Incidence Angle	22.009	31.022
SIR-C Azimuth Heading (True North)	51.887	52.304
Target Azimuth (True North)	232.862	232.862
Target Looking (N/S)	N	N
Target Azimuth (Mag. North)	239	239

			Location												
Site	Target Name	Ascending/ Descending	Latitude	Longitude	Target Type	Size (cm)	Max. RCS (dBm^2)	Elevation Angles (From horizontal)	Azimuth (from true north)	Level (degrees)	Temp (°C) or Atten. (dB)	Elevation Angles (From horizontal)	Azimuth (from true north)	Level (degrees)	Temp (°C) or Atten (dB)
Rifle Range	P1	A/D	46.3481	-84.8487	L-SAPARC			22.2	59.5	0.1	5°	31.0	59.0	0.1	1°
	P2	A/D	46.3369	-84.8519	C-SAPARC			21.9	59.0	yes	5°	31.2	59.0	yes	4°, 3 dB pad
	T1-7	A/D	46.3360	-84.8575	Trihedral	240		-	180° off	-		30.0	59.0	0.1	
	T1-8	A/D	46.3453	-84.8497	Trihedral	240		-	180° off	-		29.6	59.0	0.1	
	T1-9	A/D	46.3368	-84.8595	Trihedral	240		-	180° off	-		29.6	59.5	0.4	
	T1-10	A/D	46.3506	-84.8500	Trihedral	240		-	180° off	-		30.3	60.0	0.3	
	T2-1	A/D	46.3337	-84.8593	Trihedral	107		-	180° off	-		30.2	59.5	0.1	
	T2-2	A/D	46.3452	-84.8512	Trihedral	107		-	180° off	-		30.3	59.0	0.3	
	T2-3	A/D	46.3422	-84.8461	Trihedral	107		-	180° off	-		30.4	59.0	0.6	
	T2-4	A/D	46.3406	-84.8457	Trihedral	107		-	180° off	-		29.8	57.0	0.2	
	T2-5	A/D	46.3393	-84.8519	Trihedral	107		-	180° off	-		29.6	59.0	0.2	
	T2-6	A/D	46.3365	-84.8503	Trihedral	107		-	180° off	-		29.8	59.0	0.1	
Raco Airfield	P3	A/D	46.3568	-84.8048	C-PARC #1		44.5	22.0	239.0	0.8		31.0	239.0	0.0	
	P4	A/D	46.3508	-84.8196	C-PARC #2		42.4	22.0	240.0	0.5		31.0	243.0	0.4	
Cryderman	T1-1	A/D	46.4591	-84.9070	Trihedral	240		-	180° off	-		29.9	59.0	0.1	
	T1-2	A/D	46.4562	-84.9093	Trihedral	240		-	180° off	-	drizzle	30.3	59.0	0.0	
	T1-3	A/D	46.4561	-84.9130	Trihedral	240		-	180° off	-		29.9	318.0	0.1	
	T1-4	A/D	46.4571	-84.9152	Trihedral	240		-	180° off	-		30.1	319.0	0.1	
									Tuesday **4-Oct** **7:41:32**				**Wednesday** **5-Oct** **7:22:02**		

October 1994 Mission
Launch scheduled for 7:16 am on September 30
Local magnetic declination is 6.138° W

All PARCs: 1 1
-1 -1

MET (dd)	5	6
MET (hh:mm:ss)	6:15:59	23:45:44
Orbit No.	86	98
Data-Take No.	86.4	98.12
Ascending/Descending	D	A
North/South Looking (from Shuttle)	N	S
Look Angle (relative to SIR-C)	24.432	36.666
Local Incidence Angle	25.367	38.082
SIR-C Azimuth Heading (True North)	131.411	53.149
Target Azimuth (True North)	311.862	232.862
Target Looking (N/S)	S	N
Target Azimuth (Mag. North)	318	239

			Location												
Site	Target Name	Ascending/ Descending	Latitude	Longitude	Target Type	Size (cm)	Max. RCS (dBm^2)	Elevation Angles (From horizontal)	Azimuth (from true north)	Level (degrees)	Temp (°C) or Atten. (dB)	Elevation Angles (From horizontal)	Azimuth (from true north)	Level (degrees)	Temp (°C) or Atten. (dB)
Rifle Range	P1	A/D	46.3481	-84.8487	L-SAPARC			25.4	318.0	0.1	12°	38.1	59 0	0 1	
	P2	A/D	46.3369	-84.8519	C-SAPARC			25.4	318.0	yes	14°, 3 dB pad	38.1	59.0	yes	
	T1-7	A/D	46.3360	-84.8575	Trihedral	240		-	-	-		-	-	-	
	T1-8	A/D	46.3453	-84.8497	Trihedral	240		-	-	-		10.1	59 0	0.2	
	T1-9	A/D	46.3368	-84.8595	Trihedral	240		-	-	-		-	-	-	
	T1-10	A/D	46.3506	-84.8500	Trihedral	240		-	-	-		10.0	59 0	0 3	
	T2-1	A/D	46.3337	-84.8593	Trihedral	107		-	-	-		10.1	58.5	0 1	
	T2-2	A/D	46.3452	-84.8512	Trihedral	107		-	-	-		9.8	59.0	0 3	
	T2-3	A/D	46.3422	-84.8461	Trihedral	107		-	-	-		-	-	-	
	T2-4	A/D	46.3406	-84.8457	Trihedral	107		-	-	-		9 2	59.0	0 4	
	T2-5	A/D	46.3393	-84.8519	Trihedral	107		-	-	-		-	-	-	
	T2-6	A/D	46.3365	-84.8503	Trihedral	107		-	-	-		-	-	-	
Raco Airfield	P3	A/D	46.3568	-84.8048	C-PARC #1		44.5	25.4	318.0	0.5		38.0	239 0	0 7	
	P4	A/D	46.3508	-84.8196	C-PARC #2		42.4	25.4	318.0	0.4		38.1	239.0	0 6	
Cryderman	T1-1	A/D	46.4591	-84.9070	Trihedral	240		9.9	59.0	0.1		9 9	59 0	0 1	
	T1-2	A/D	46.4562	-84.9093	Trihedral	240		10.3	59.0	0.1		10.6?	59 0	0 1	
	T1-3	A/D	46.4561	-84.9130	Trihedral	240		29.9	318.0	0.1		29.5?	318 0	0 1	
	T1-4	A/D	46.4571	-84.9152	Trihedral	240		30.1	319.0	0.1		33.3?	322.0?	1 4?	
			Local Day						Wednesday				Thursday		
			Local Date						5-Oct				6-Oct		
			Local Time						13:31:59				7:01:44		

October 1994 Mission
Launch scheduled for 7:16 am on September 30
Local magnetic declination is 6.138° W

All PARCs: 1 1
-1 -1

MET (dd)	6	7
MET (hh:mm:ss)	5:55:31	23:25:02
Orbit No.	102	114
Data-Take No.	102.41	114.1
Ascending/Descending	D	A
North/South Looking (from Shuttle)	N	S
Look Angle (relative to SIR-C)	32.5	41.976
Local Incidence Angle	33.818	43.656
SIR-C Azimuth Heading (True North)	131.876	53.667
Target Azimuth (True North)	311.862	232.862
Target Looking (N/S)	S	N
Target Azimuth (Mag. North)	318	239

			Location												
Site	Target Name	Ascending/ Descending	Latitude	Longitude	Target Type	Size (cm)	Max. RCS (dBm^2)	Elevation Angles (From horizontal)	Azimuth (from true north)	Level (degrees)	Temp (°C) or Atten. (dB)	Elevation Angles (From horizontal)	Azimuth (from true north)	Level (degrees)	
Rifle Range	P1	A/D	46.3481	-84.8487	L-SAPARC			33.3	318.0	0.0	15°	43.7	59.0	0 1	11°
	P2	A/D	46.3369	-84.8519	C-SAPARC			32.2	310.0	yes	20°	43.7	59.0	yes	13°
	T1-7	A/D	46.3360	-84.8575	Trihedral	240		29.9	318.0	0.3		-	-	.	
	T1-8	A/D	46.3453	-84.8497	Trihedral	240		-	-	-		10.0	59.0	0 1	
	T1-9	A/D	46.3368	-84.8595	Trihedral	240		29.9	317.0	0.1		-	-	.	
	T1-10	A/D	46.3506	-84.8500	Trihedral	240		-	-	-		10.3	58.5	0 1	
	T2-1	A/D	46.3337	-84.8593	Trihedral	107		-	-	-		10.0	58 5	0 1	
	T2-2	A/D	46.3452	-84.8512	Trihedral	107		-	-	-		9.7	59 0	0 0	
	T2-3	A/D	46.3422	-84.8461	Trihedral	107		29.6	318.0	0.1		-	-	.	
	T2-4	A/D	46.3406	-84.8457	Trihedral	107			-	-		9.7	59.0	0 2	
	T2-5	A/D	46.3393	-84.8519	Trihedral	107		30.0	318.0	0.4		-	-	.	
	T2-6	A/D	46.3365	-84.8503	Trihedral	107		30.1	318.0	0.2		-	-	.	
Raco Airfield	P3	A/D	46.3568	-84.8048	C-PARC #1		44.5	33.8	318.0	0.4		43.7	239.0	0 2	
	P4	A/D	46.3508	-84.8196	C-PARC #2		42.4	33.8	318.0	0.4		43.8	239.0	0 2	
Cryderman	T1-1	A/D	46.4591	-84.9070	Trihedral	240		9.9	59.0	0.1		9.9	59 0	0 1	
	T1-2	A/D	46.4562	-84.9093	Trihedral	240		10.6?	59.0	0.1		10.6	59.0	0 1	
	T1-3	A/D	46.4561	-84.9130	Trihedral	240		29.5?	318.0	0.1		29.5?	318 0	0 1	
	T1-4	A/D	46.4571	-84.9152	Trihedral	240		33.3?	322.0?	1.4?		33.3?	322.0	1 4?	
			Local Day						Thursday				Friday		
			Local Date						6-Oct				7-Oct		
			Local Time						13:11:31				6:41:02		

October 1994 Mission
Launch scheduled for 7:16 am on September 30
Local magnetic declination is 6.138° W

All PARCs: 1 1
-1 -1

MET (dd)	7	8
MET (hh:mm:ss)	5:34:46	5:13:40
Orbit No.	118	134
Data-Take No.	118.6	134.3
Ascending/Descending	D	D
North/South Looking (from Shuttle)	N	N
Look Angle (relative to SIR-C)	39.559	39.594
Local Incidence Angle	41.211	41.247
SIR-C Azimuth Heading (True North)	132.43	132.427
Target Azimuth (True North)	311.862	311.862
Target Looking (N/S)	S	S
Target Azimuth (Mag. North)	318	318

Site	Target Name	Ascending/ Descending	Location		Target Type	Size (cm)	Max. RCS (dBm^2)	Elevation Angles (From horizontal)	Azimuth (from true north)	Level (degrees)	Temp (°C) or Atten. (dB)	Elevation Angles (From horizontal)	Azimuth (from true north)	Level (degrees)	Temp (°C) or Atten (dB)
			Latitude	Longitude											
Rifle Range	P1	A/D	46.3481	-84.8487	L-SAPARC			41.2 (31.5 AirSAR)	318.0	0.0	18° (20° AirSAR)	41.2 (42.7 AirSAR)	318.0	0.0	12.5° 15° SIR C
	P2	A/D	46.3369	-84.8519	C-SAPARC			41.2 (31.5 AirSAR)	316.5 (318 AirSAR)	yes	3dB pad (22°, 2 dB pad AirSAR)	41.2 (42.7 AirSAR)	318.0	0.0	(15°, 3 dB pad AirSAR)
	T1-7	A/D	46.3360	-84.8575	Trihedral	240		10.1	318.0	0.1		10.0	318.0	0.0	
	T1-8	A/D	46.3453	-84.8497	Trihedral	240		-	-	-		10.1	318.0	0.1	
	T1-9	A/D	46.3368	-84.8595	Trihedral	240		10.0	318.0	0.1		9.9	317.5	0.0	
	T1-10	A/D	46.3506	-84.8500	Trihedral	240		-	-	-		9.9	318.0	0.6	
	T2-1	A/D	46.3337	-84.8593	Trihedral	107		-	-	-		9.6	318.0	0.0	
	T2-2	A/D	46.3452	-84.8512	Trihedral	107		-	-	-		9.5	318.0	0.2	
	T2-3	A/D	46.3422	-84.8461	Trihedral	107		10.0	318.0	0.0		9.9	318.0	0.0	
	T2-4	A/D	46.3406	-84.8457	Trihedral	107		-	-	-		9.9	318.0	0.1	
	T2-5	A/D	46.3393	-84.8519	Trihedral	107		9.9	318.0	0.0		9.9	318.0	0.2	
	T2-6	A/D	46.3365	-84.8503	Trihedral	107		10.0	318.0	0.1		9.8	318.0	0.0	
Raco Airfield	P3	A/D	46.3568	-84.8048	C-PARC #1		44.5	41.2	318.0	0.5		41.2	318.0	0.1	
	P4	A/D	46.3508	-84.8196	C-PARC #2		42.4	41.2	318.0	1.2		41.2	318.0	0.7	
Cryderman	T1-1	A/D	46.4591	-84.9070	Trihedral	240		9.9	59.0	0.1		10.3	318.0	0.1	
	T1-2	A/D	46.4562	-84.9093	Trihedral	240		10.6	59.0	0.1		10.0	318.0	0.1	
	T1-3	A/D	46.4561	-84.9130	Trihedral	240		29.5	318.0	0.1		10.0	318.0	0.1	
	T1-4	A/D	46.4571	-84.9152	Trihedral	240		33.3	322.0	1.4		10.0	318.0	0.2	

Local Day	Friday	
Local Date	7-Oct	8-Oct
Local Time	12:50:46	12:29:40
		AirSAR Data

October 1994 Mission
Launch scheduled for 7:16 am on September 30
Local magnetic declination is 6.138° W

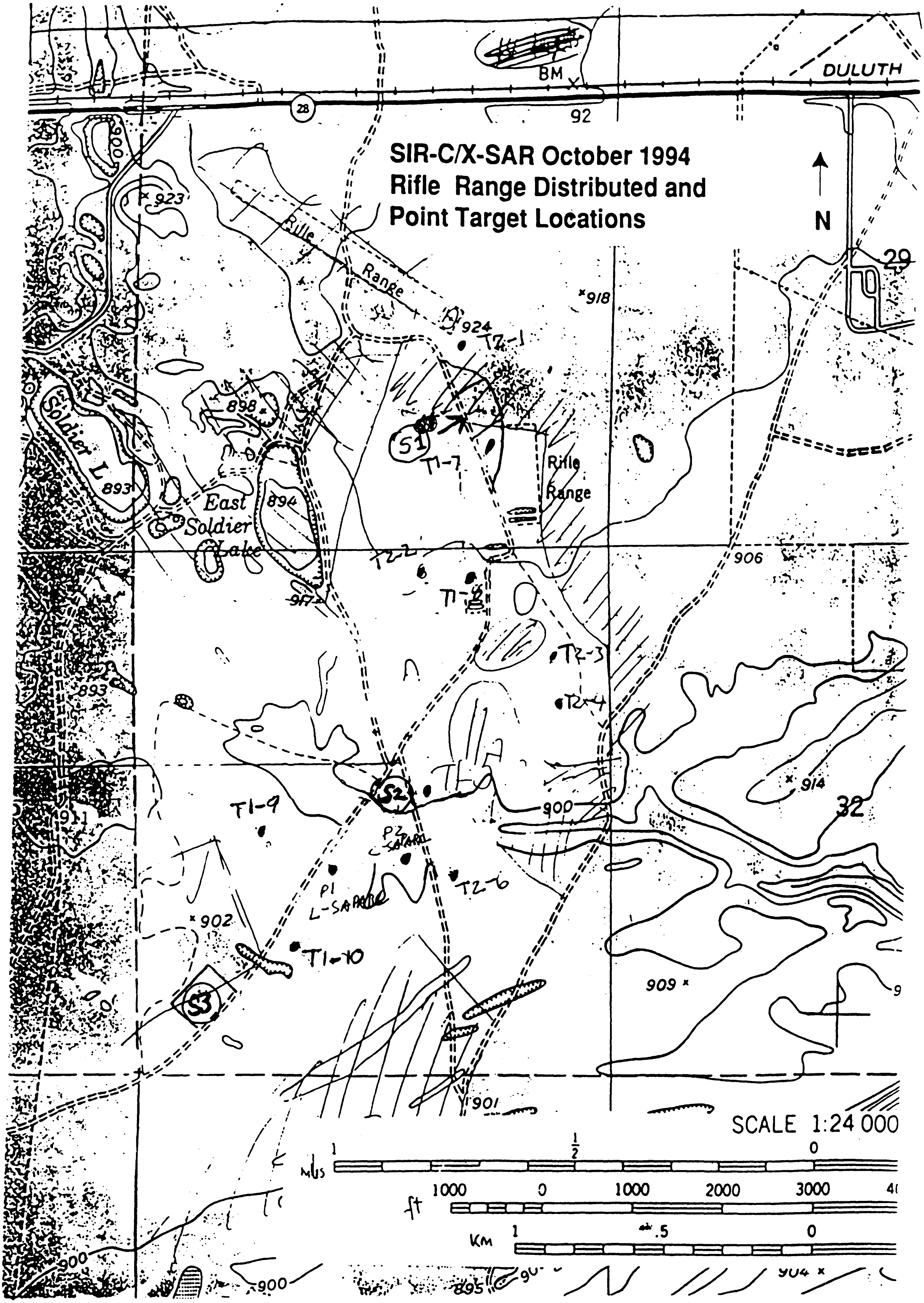
All PARCs:	1	1
	-1	-1

MET (dd)	9	10
MET (hh:mm:ss)	4:51:57	4:30:20
Orbit No.	150	166
Data-Take No.	150.2	166.1
Ascending/Descending	D	D
North/South Looking (from Shuttle)	N	N
Look Angle (relative to SIR-C)	39.596	39.596
Local Incidence Angle	41.248	41.248
SIR-C Azimuth Heading (True North)	132.424	132.424
Target Azimuth (True North)	311.862	311.862
Target Looking (N/S)	S	S
Target Azimuth (Mag. North)	318	318

			Location												
Site	Target Name	Ascending/ Descending	Latitude	Longitude	Target Type	Size (cm)	Max RCS (dBm^2)	Elevation Angles (From horizontal)	Azimuth (from true north)	Level (degrees)	Temp (°C) or Atten. (dB)	Elevation Angles (From horizontal)	Azimuth (from true north)	Level (degrees)	Temp (°C) or Atten (dB)
Rifle Range	P1	A/D	46.3481	-84.8487	L-SAPARC			41.2	318.0	0.0	4.5°	41.2	318.0	0.0	5°, 3 dB pad XMIT
	P2	A/D	46.3369	-84.8519	C-SAPARC			41.2	318.0	0.1	5°	41.2	318.0	0.0	5°, 3 dB pad RCV
	T1-7	A/D	46.3360	-84.8575	Trihedral	240		12.4	321.5	0.3		10.3	318.0	0.1	
	T1-8	A/D	46.3453	-84.8497	Trihedral	240		9.9	317.5	0.0		9.9	318.0	0.0	
	T1-9	A/D	46.3368	-84.8595	Trihedral	240		9.9	317.5	0.1		10.1	317.5	0.0	
	T1-10	A/D	46.3506	-84.8500	Trihedral	240		10.2	316.0	0.1		10.6	318.0	0.2	
	T2-1	A/D	46.3337	-84.8593	Trihedral	107		10.0	318.0	0.1		10.0	318.5	0.1	
	T2-2	A/D	46.3452	-84.8512	Trihedral	107		10.0	317.5	0.1		9.9	317.5	0.1	
	T2-3	A/D	46.3422	-84.8461	Trihedral	107		10.0	318.0	0.0		10.0	318.0	0.1	
	T2-4	A/D	46.3406	-84.8457	Trihedral	107		9.9	318.0	0.2		10.0	318.0	0.1	
	T2-5	A/D	46.3393	-84.8519	Trihedral	107		9.9	318.0	0.2		9.9	318.0	0.0	
	T2-6	A/D	46.3365	-84.8503	Trihedral	107		9.8	318.0	0.1		9.9	318.0	0.0	
Raco Airfield	P3	A/D	46.3568	-84.8048	C-PARC #1		44.5	41.2	318.0	0.4		41.2	318.0	0.5	
	P4	A/D	46.3508	-84.8196	C-PARC #2		42.4	41.2	318.0	0.9		41.2	318.0	0.3	
Cryderman	T1-1	A/D	46.4591	-84.9070	Trihedral	240		10.0	318.0	0.2		10.1	318.0	0.1	
	T1-2	A/D	46.4562	-84.9093	Trihedral	240		10.1	318.0	0.1		10.2	318.0	0.1	
	T1-3	A/D	46.4561	-84.9130	Trihedral	240		10.0	318.0	0.1		9.9	318.0	0.1	
	T1-4	A/D	46.4571	-84.9152	Trihedral	240		10.0	318.0	0.1		10.1	318.0	0.0	
			Local Day						Sunday				Monday		
			Local Date						9-Oct				10-Oct		
			Local Time						12:07:57				11:46:20		
									AirSAR Data						

2.2 DISTRIBUTED TARGETS

During the 11-day mission, a polarimetric scatterometer was used to collect data at L, C, and X-bands in conjunction with each SIR-C/X-SAR overpass. This data is used to define the average Mueller matrix of distributed targets. Three distributed targets, or surfaces, were defined and located at the rifle range. These were approximately 100 m X 100 m. Each plot (S1 to S3) had a distinctive surface roughness with RMS roughness ranging from 2 to 6 cm. (Tables 8 and 9). The locations of the distributed targets are documented on the map *SIR-C/X-SAR October 1994 Rifle Range Distributed and Point Target Locations*. Scatterometer analysis is not included in this report but is documented elsewhere.



SIR-C/X-SAR October 1994 Rifle Range Distributed and Point Target Locations

3 Surface Observations

For the October mission, surface observations included surface roughness, both small and large scale as appropriate, and soil moisture characterization. These were based on the hypotheses and methods presented in the following table.

Table 7: Surface Observations: Hypotheses, Objectives, and Methods

Hypothesis	Objective	Method
1. There are large scale variations in surface height in the forest test stands and clearings.	1. Take measurements which will capture the large scale surface rms height	1. Surveying methods using meter tape, transit and Philadelphia rod.
2. There are small scale variations in surface height in the agricultural fields and clearings.	2. Take measurements which will capture the small scale surface rms height	1. Use spray paint method, supplemented by photographic method.
3. Soil moisture content will be unique to the mission period and will vary by soil type supporting different vegetation.	3a. Measure soil moisture and bulk density in forest stands, clearings, and agricultural fields. Select these to provide a cross-section of the forest communities and ages, and herbaceous vegetation cover at the site. 3b. Obtain soil dielectric properties for selected forest stands and cal sites	3a. Take soil cores at several locations in each of 13 forest stands , 21 agricultural fields, and clearings representative of the test site. Do for each site several times during the mission. 3b. Use portable dielectric probe. 10 stands plus cal sites.

3.1 ROUGHNESS

In contrast to the April SIR-C mission where snow covered the ground, the October time frame presented a variety of exposed ground or soil surfaces of varying degrees of roughness. To more completely describe and quantify the surface term with respect to radar backscatter, surface roughness must be measured in addition to soil moisture conditions as proposed in the preceding table.

Surface roughness is a relative term, as it is the degree of surface roughness relative to wavelength and incidence angle that influences radar backscatter. For example, a useful first-order estimation for whether a surface looks "smooth" to an incident radar beam is often given by the Rayleigh Criterion

$$(1) \quad \sigma < \frac{\lambda}{8\cos\theta}$$

where σ is the rms surface height, λ is the transmitted wavelength, and θ is the angle of incidence and the surface is considered smooth if the left-hand side of the equation is less than the right-hand. (Also used is the Fraunhofer criterion which is more stringent, with 32 substituting for 8 in the right-hand denominator). A general rule of thumb is to sample roughness at a spatial scale of $\lambda / 10$.

In order to decide at what spatial frequency (small to large scale) to take ground measurements, the following should be considered: a) the transmitted wavelengths, especially those most likely to be important in reaching the surface underneath agricultural and forest canopies, and b) the surface under scrutiny and the presence and size of any regular or even periodic undulations. Longer wavelengths would be expected to have a higher probability in reaching a forest floor, and thus measurements in forested areas concentrated on large scale roughness with consideration also given to the size of apparent local structure. Small scale measurements were also not made in the forested areas because of difficulties in exhuming the undisturbed mineral soil surface. Short wavelengths would be expected to be important in surfaces such as pasture which were at the same time less likely to have large scale undulations due to level lake plain substrate and agricultural management. Therefore, small scale roughness measurements were emphasized in agricultural fields.

The two parameters used for characterizing surface roughness are rms height (σ), the standard deviation of the surface height, and the surface correlation length (l). The rms height is given by,

$$(2) \quad \sigma = R.M.S.Height = \sqrt{\frac{1}{n}\sum_{i=1}^{n} z_i^{\,2}}$$

where Z_i is the displacement of the ith height from the height at meter 0.0. As a further refinement to the rms height, the data is generally leveled, or detrended, to arrive at a detrended rms height (σ_d) which reflects the measured roughness independently of any general trend in slope. Detrending is accomplished by computing the coefficients of the regression of Z_j (cm above or below the first measurement on the transect) on j (measurement point distance in meters from meter 0.0), finding the residuals $z'_j = z_j - \hat{z}_j$. and then recomputing the rms height based on Z_j'

The normalized autocorrelation function of a surface profile $z(x)$ gives a measure of the similarity between height z at point x as a function of displacement in x. The correlation function is given by:

$$(3) \quad \rho(x') = \frac{\sum_{i=1}^{N+1-j} z_i z_{j+i-1}}{\sum_{i=1}^{N} z_i^2}$$

where $x'=(j-1)\Delta x$, Δx is the horizontal displacement and j is an integer ≥ 1. The surface correlation length l is defined as the displacement x' for which $l(x')= 1/e.$ [2]

3.1.1 Forested Areas: Large Scale Roughness

For the SIR-C/X-SAR mission large scale roughness measurements were made in 12 forest stands and at two calibration target areas covered with herbaceous vegetation: the Rifle Range and Cryderman Field. Large scale roughness measurements capture larger or low frequency surface undulations which may or may not be periodic. In unmanaged forest stands, roughness is unlikely to be periodic. However, in managed forest stands, forestry practices of preparing the substrate for planting can introduce periodic structure. The frequency of measurement points was determined based on visual observation of the general frequency of surface undulations. In the two non-forested areas, transects were 50 m. in length. The number of observations along each transect was 26, 51, or 101 depending on the surface. In the forested areas, transect length varied from 10 to 50 m and number of observations per transect from 26 to 101, also depending on the surface. These criteria are given for each location in Table 8: *Summary table for Large Scale Roughness.* In both cases, measurements were made using a transit/tripod in conjunction with a fiberglass tape and Philadelphia rod. Measurements of height above the surface in feet were taken by moving the rod at regular intervals down the transect, beginning with meter 0.0 and continuing for the predetermined length of the measurement transect.

The mean height in cm, rms height, and detrended rms height were calculated, and are also given for each location in Table 8: *Summary table for Large Scale Roughness.* In addition to the results in Table 8, plots of the surface roughness for each location are given in Appendix A.

3.1.2 Agricultural Fields

Small Scale Roughness

The agricultural fields measured during the SIR-C/X-SAR mission consisted of pasture and hayfields. These are less likely to present pronounced periodic patterns typically found in row-tilled cropland. Therefore, the agricultural fields measured can be fairly reliably characterized by small scale roughness as the original mean surface (lake plain) is quite flat, any possible large scale undulations have largely been removed by agricultural management practices, and new large periodic structures have not been introduced. Again, the desired outcome of the small scale roughness measurements is rms surface height (cm) and correlation length.

Surface Profile Measurement: To characterize the surface profile of the agricultural fields, two methods were implemented:(1) a spray paint technique, and (2) a photographic technique. The photographic technique is much faster to implement in the field. Both techniques were used on the same transects in order to evaluate the intercomparability of the two methods. What follows is a brief description of the two methods and the associated results of surface rms height and correlation length.

Table 8: Summary Table for Large Scale Roughness

Date	Location or Forest Stand	Tree Type	Transect #	Transect Length (m)	Number of Observations	Mean Height (cm)	RMS Height (cm)	RMS Height (Detrended) (cm)
8/17/94	Rifle Range Surface 1		1	50	26	-8.09	5.64	1.81
			2	50	26	1.90	2.76	1.71
8/17/94	Rifle Range Surface 2		1	50	51	8.79	7.19	6.58
			2	50	51	-14.16	10.76	4.63
8/18/94	Rifle Range Surface 3		1	50	26	12.71	8.76	4.95
			2	50	26	-0.13	4.88	4.58
8/18/94	Cryderman Field		1	50	26	9.92	4.80	4.75
			2	50	26	-34.72	17.61	5.89
10/3/94	Rifle Range Clearcut		1	50	101	-10.07	7.02	6.89
			2	50	101	4.05	9.72	7.64
8/19/94	22	Sapling/Pole Red Pine (Plantation)	1	50	26	-13.78	5.51	5.09
			2	50	26	-15.19	10.33	2.77
10/10/94	23	Mature Red & White Pine (Plantation)	1	25	101	13.76	11.35	9.96
8/19/94	24	Pole Jack Pine (Plantation)	1	50	26	28.48	12.41	6.42
			2	50	26	7.76	15.06	9.04
8/18/94	31	Pole Northern Hardwood	1	50	26	-18.90	9.77	6.96
			2	50	26	-13.22	5.85	5.66
8/18/94	32	Mature Northern White-Cedar	1	50	26	3.35	5.79	5.35
8/19/94			2	50	26	42.99	59.30	56.44

Date	Location or Forest Stand	Tree Type	Transect #	Transect Length (m)	Number of Observations	Mean Height (cm)	RMS Height (cm)	RMS Height (Detrended) (cm)
8/18/94	33	Aspen Saplings	1	50	26	-21.11	13.26	9.51
			2	50	26	31.18	25.89	12.42
10/11/94	43	Mature Red Pine (Plantation)	1	20	101	-10.67	10.05	9.40
8/18/94	44	Black Spruce	1	50	26	-6.66	9.57	9.34
8/19/94			2	50	26	85.92	46.94	10.84
10/10/94	51	Sapling Red Pine (Plantation)	1	10	101	-21.35	13.39	6.80
10/11/94	75	Mature White Pine (Plantation)	1	19.2	97	-7.52	12.35	10.50
10/10/94	78	Seedling Red Pine (Plantation)	1	10	101	7.41	11.07	10.04
10/10/94	80	SeedlingRed Pine (Plantation)	1	10	101	-5.53	11.49	7.60

Both the spray paint technique and photographic technique require that a long, thin (1.2 m. long X 0.46 m. high X 0.0032 m. thick) aluminum plate be driven into the soil without disturbing the surface in front. To accomplish this task a number of steps must be taken to prepare the testing site. The first step is to clear the nearby area of large vegetative growth using shears. Once the majority is removed, any remaining stubble which may interfere with the measurement of the soil surface profile is burned away with a propane torch. Finally, the plate may be inserted into the ground and hammered into a level position. The main problem with both techniques is that the insertion of the panel into the ground can cause deformation of the surface to be measured.

Spray Paint Technique: The spray paint technique consists of wrapping a section of graph paper from a scroll around the metallic plate which is then driven into the ground. Once the plate is situated so that the lower edge of the graph paper is below the soil surface, the profile is contrasted onto the graph paper by spraying the soil-plate interface with a light coating of dark spray paint. After drying the plate is removed from the ground and the graph paper stored and returned to the laboratory for further processing. This further processing consists of tracing the shadowed soil profile left on the graph paper using a digitizing table.

Difficulties that may occur with this method are 1.) spray paint maybe applied too weakly or too strongly (causing dripping) in different areas, 2.) shadowing may occur if there are unremoved intervening obstacles between the spray paint can and the surface profile, 3.) digitization of the profile is a time consuming process, and 4.) the one-dimensional profile is all that remains of the characterization.

Photographic Technique: A photograph is taken of the entire plate (which has been previously calibrated with a scale). Best results have been obtained by using a 50mm lens at a distance of about 3 meters with a low angle of incidence. Care should be taken to remove all intervening debris between the lens and the surface being measured, with additional attention being given to contrast between the paper background and the soil surface (the sun situated behind the camera worked best). A large, flimsy, piece of sheet metal was used to mat down any tall grasses that may have intervened between the camera and the surface profile.

Once the photographs have been processed, they are digitized into a gray-scale image. The digitization resolution is found by first determining the spatial resolution desired in the plot and then converting this resolution into units of pixels per photograph inch. For instance, using a 3.5" x 5" photographic print of the 1.2 meter wide plate, and assuming we want at least 1mm resolution, the number of pixels per inch (ppi) is calculated by:

$$(4) \quad ppi = \frac{1.2m.}{(1mm.*5.0in.)} \approx 240\, pixels\, /\, in.$$

Digitized representation of the scene should be stored in a .TIFF file format which can be read by the 'xv' and 'matlab' programs in UNIX. To reduce file size, it may be desirable to separate the image into components of just the soil/plate interface and the ruled portion of the plate.

The surface edge is detected by first convolving the image with a sobel vertical edge detection mask and then implementing a search algorithm to determine the location of greatest change in the convolved image. This method works very well although there are often difficulties that occur when spurious pieces of grass or shadows caused by the graph paper are mistaken for the soil surface. These corrections can be made on-line by low pass filtering the data or direct editing of the surface points. Finally, the ruled portion of the photograph may then be used to warp the image to remove any scaling inconsistencies due to photographic distortion.

Possible difficulties that may occur with this method are: 1.) poor contrast between the soil surface and the plate background, 2.) overabundance of intervening grasses between the camera and the surface profile being measured, 3.) excessive warping due to the camera position and lens distortion, and 4.) poor resolution due to the negative and lens quality.

Once the soil profile has been obtained via either one of the above two methods, the parameters that characterize the surface can then be calculated. The following *Table 9: Summary Table for Small Scale Roughness* contains the derived measures of rms height and correlation length obtained from both the photographic and spray-paint methods. For the profiles measured in common by the two techniques the results are correlated with $r^2 = 0.78$ and $s = 0.111$ cm for σ and $r^2 = 0.98$ and $s = 0.396$ cm for l. Hence, the photographic technique is found to be a suitable substitute for the more traditional "spray paint" method.

Table 9: Summary Table for Small Scale Roughness

Location	RMS Height (cm)		Correlation Length (cm)		Slope (%)
	Spray Paint/ Digitizing Method	Photo Method	Spray Paint/ Digitizing Method	Photo Method	Spray Paint/ Digitizing Method
Cryderman S-1	1.565		12.555		0.325
Cryderman S-2	0.668		6.474		0.334
Field A		0.597		7.651	
Field C		0.644		18.39	
Field G	0.711	0.811	8.941	9.987	0.282
Field I	1.293	1.319	11.382	12.78	0.315
Field J		1.24		18.4	
Field K	0.902	0.948		16.40	0.336
Field M	0.808	0.702	11.249	12.45	0.302
Field N		0.802		20.04	
Field O	1.243	1.074	4.377	5.832	0.660
Field Q	1.025	1.018	10.864	11.57	0.393
Field S	1.005	0.867	7.216	7.817	0.324
Field T		0.5728		12.39	
Field Z	0.563		4.747		0.402
Rifle Range S1-1	0.720		14.834		0.282
Rifle Range S1-2	1.373		23.306		0.187
Rifle Range S1-3	4.343		25.690		0.261
Rifle Range S2-1	1.075		23.145		0.254
Rifle Range S2-2	3.476		23.941		0.243
Rifle Range S2-3	7.348		25.522		0.377
Rifle Range S3-1	3.256		14.105		0.363
Rifle Range S3-2	0.746		9.501		0.271
Rifle Range S3-3	3.732		14.283		0.365

3.2 SOIL MOISTURE

3.2.1 Forested Stands and Clearings

Soil properties identified for study during the October SIR-C/X-SAR project and expected to have implications for radar backscatter include moisture and bulk density. Since there is a very close association between soil type and forest community type, soil properties could be subsampled by measurement of the forest stands and clearings used by other measurements. The locations, vegetation cover types, and age classes examined, are listed in Table 10: *Soil Moisture in Forest Stands and Clearings: Locations and Vegetation Types.* Thirteen locations were examined. The notation for example TR1-1, refers to trihedral locations at Cryderman field, and S2 refers to extended surfaces at the Rifle Range.

For each forest stand or clearing examined, measurements were repeated on different days whenever possible to track any change in soil moisture at a location over the time of the mission. Several samples were taken at each site. In the forests, typically one or two samples were taken at each of 3 previously established plots along an established transect, netting either 3 or 6 samples per forest stand per measurement day. In the clearings, samples were taken at trihedral locations or from the corners of the extended-target plots (s1,s2,s3). The 0-5 cm layer of the mineral soil was sampled at each location using an oakfield soil tube with radius = 0.96 cm. Typically, three cores were taken at a given location and combined as a single sample. All mineral soil samples were taken on a gravimetric basis, and most were also taken on a volumetric basis (i.e. the total volume of the soil sample is known). The organic horizons were sampled at a selection of the locations. Organic horizon samples were taken on a gravimetric basis. The type of sampling done at each location can be determined by consulting Table 11: *Summary Table for Soil Moisture in Forest Stands and Clearings.*

All of the soil samples collected were weighed immediately after collection. Next, the samples were baked to equilibrium weight in an oven at 110° C to remove the moisture, then re-weighed. In this way water mass fraction and, for the volumetric samples, volumetric water content were computed for the soil samples.

Table 10: Soil Moisture in Forest Stands and Clearings: Locations and Vegetation Types

Location	Vegetation Type	Dates of Observation
Cryderman field (TR1-1)	Short grass - (Hayfield)	9/30, 10/1, 10/9, 10/10
Cryderman field (TR1-2)	Short grass - (Hayfield)	9/30, 10/1, 10/4, 10/5, 10/6, 10/7, 10/8, 10/10
Cryderman field (TR1-3)	Short grass - (Hayfield)	9/30, 10/1, 10/4, 10/5, 10/6, 10/7, 10/8, 10/9, 10/10
Cryderman field (TR1-23)	Short grass - (Hayfield)	10/4, 10/5, 10/6, 10/7, 10/8, 10/9
Raco Airfield	Short shrub/grass < 1m (Clearcut)	9/30, 10/1, 10/4, 10/5, 10/6, 10/7, 10/8, 10/9, 10/10
Rifle Range (S1)	Short grass	9/30, 10/1, 10/4, 10/5, 10/6, 10/7, 10/8, 10/9, 10/10
Rifle Range (S2)	Short grass	9/30, 10/1, 10/4, 10/5, 10/6, 10/7, 10/8, 10/9, 10/10
Rifle Range (S3)	Short grass	9/30, 10/1, 10/4, 10/5, 10/6, 10/7, 10/8, 10/9, 10/10
Stand 22	Red Pine plantation - pole	9/30, 10/5, 10/7, 10/9
Stand 24	Jack Pine - mature	10/4, 10/6, 10/8, 10/10
Stand 31	Northern Hardwoods - pole/mature	9/30, 10/5, 10/7, 10/9
Stand 32	Northern White-cedar - mature	10/1
Stand 33	Aspen - sapling	10/4, 10/6, 10/8
Stand 34	Aspen - overmature	9/30, 10/5, 10/7, 10/9
Stand 37	Jack Pine - seedling	10/4, 10/6, 10/8, 10/9, 10/10
Stand 38	Jack Pine - sapling	10/4, 10/6, 10/9, 10/10
Stand 43	Red Pine - mature	10/1, 10/5, 10/7, 10/9
Stand 44	Black Spruce - mature	10/1

Table 11: *Summary Table for Soil Moisture in Forest Stands and Clearings* also provides the summary results for each stand or clearing. Included are the sample location wet wt. (g), dry wt. (g), gravimetric moisture (dry wt. g/g), bulk density (g/cm^3), and volumetric moisture (cm^3/cm^3) where available. Appendix B contains a more detailed record of the soil moisture measurements, any comments/notes recorded in the field, along with a key to the abbreviations. Calculation of the soil moisture parameters were as follows:

Average soil bulk density (g/cm^3)

$$(5) \quad Db = \frac{1}{n}\sum_{i=1}^{n}\left[\frac{MDi}{l * \pi * r^2 * ci}\right]$$

where n = the number of sample points, MDi = soil sample dry wt. (g), l = length of soil core (cm), r = radius of soil core (cm), and ci = n of cores in sample

Average soil gravimetric moisture (dry wt. g/g)

$$(6) \quad Mg = \frac{1}{n}\sum_{i=1}^{n}\left[\frac{MWi\text{-}MDi}{MDi}\right]$$

where MWi = soil sample wet wt. (g), and n = the number of sample points

Soil water volume fraction (cm^3/cm^3)

$$(7) \quad \theta = \left[\frac{MWi\text{-}MDi}{l * \pi * r^2 * ci}\right]$$

Table 11: Summary Table for Soil Moisture in Forest Stands and Clearings

		Humus/Organic Layer		Mineral Soil					
Stand	Date	Mean Depth (cm)	Mean Gravimetric Moisture (g/g)	Gravimetric Moisture (g/g)		Bulk Density (g/cm3)		Volumetric Moisture (cm3/cm3)	
				Mean	Stdev	Mean	Stdev	Mean	Stdev
Cryderman	Sept. 30			0.33	0.09	1.22	0.19	0.4	0.11
	Oct. 1			0.34	0.13	1.15	0.09	0.38	0.14
	Oct. 4			0.27	0.06	1.24	0.02	0.33	0.06
	Oct. 5			0.28	0.01	1.25	0.08	0.35	0.04
	Oct. 6			0.28	0	1.24	0.09	0.35	0.03
	Oct. 7			0.28	0.02	1.08	0.16	0.31	0.07
	Oct. 8			0.3	0	1.18	0.11	0.35	0.04
	Oct. 9			0.31	0.04	1.23	0.04	0.39	0.07
	Oct. 10			0.37	0.05	1.07	0.07	0.39	0.03
Mean				***0.31***	***0.04***	***1.18***	***0.09***	***0.36***	***0.07***
Stdev				***0.03***	***0.04***	***0.07***	***0.05***	***0.03***	***0.04***
Raco Air	Sept. 30			0.16	0.04	1.54	0.04	0.25	0.06
	Oct. 1			0.2	0.03	1.42	0.06	0.28	0.04
	Oct. 4			0.19	0.02	1.44	0.06	0.27	0.03
	Oct. 5			0.18	0.04	1.34	0.11	0.24	0.04
	Oct. 6			0.17	0.05	1.31	0.1	0.23	0.06
	Oct. 7			0.19	0.05	1.37	0.05	0.25	0.06
	Oct. 8			0.17	0.03	1.46	0.08	0.24	0.04
	Oct. 9			0.23	0.07	1.34	0.13	0.3	0.06
	Oct. 10			0.24	0.04	1.4	0.26	0.33	0.03
Mean				***0.19***	***0.04***	***1.40***	***0.10***	***0.27***	***0.05***
Stdev				***0.03***	***0.01***	***0.07***	***0.07***	***0.03***	***0.02***
RR S1	Sept. 30			0.11	0.04	1.36	0.15	0.15	0.04
	Oct. 1			0.13	0.05	1.44	0.11	0.18	0.05
	Oct. 4			0.1	0.01	1.32	0.06	0.13	0.01
	Oct. 5			0.12	0.02	1.25	0.12	0.15	0.04
	Oct. 6			0.11	0.02	1.22	0.02	0.14	0.02
	Oct. 7			0.13	0.03	1.21	0.08	0.16	0.02
	Oct. 8			0.15	0.01	1.18	0.02	0.17	0.02
	Oct. 9			0.26	0.1	1.05	0.11	0.27	0.07
	Oct. 10			0.2	0.03	1.12	0.06	0.22	0.02
Mean				***0.15***	***0.03***	***1.24***	***0.08***	***0.17***	***0.03***
Stdev				***0.05***	***0.03***	***0.12***	***0.05***	***0.04***	***0.02***

Table 11: Summary Table for Soil Moisture in Forest Stands and Clearings

		Humus/Organic Layer		Mineral Soil					
Stand	Date	Mean Depth (cm)	Mean Gravimetric Moisture (g/g)	Gravimetric Moisture (g/g)		Bulk Density (g/cm3)		Volumetric Moisture (cm3/cm3)	
				Mean	Stdev	Mean	Stdev	Mean	Stdev
RR S2	Sept. 30			0.1	0.04	1.38	0.24	0.14	0.04
	Oct. 1			0.08	0.03	1.29	0.04	0.1	0.03
	Oct. 4			0.1	0.02	1.1	0.12	0.11	0.02
	Oct. 5			0.08	0.01	1.14	0.07	0.09	0.02
	Oct. 6			0.12	0.03	1.2	0.08	0.15	0.04
	Oct. 7			0.1	0.01	1.17	0.13	0.12	0.01
	Oct. 8			0.12	0.01	1.08	0.06	0.13	0.01
	Oct. 9			0.17	0.02	1.15	0.11	0.19	0.02
	Oct. 10			0.18	0.02	1.16	0.06	0.2	0.03
Mean				***0.12***	***0.02***	***1.19***	***0.10***	***0.14***	***0.02***
Stdev				***0.04***	***0.01***	***0.09***	***0.06***	***0.04***	***0.01***
RR S3	Sept. 30			0.15	0.02	1.04	0.13	0.16	0.01
	Oct. 1			0.14	0.01	1.17	0.08	0.16	0.01
	Oct. 4			0.1	0.01	1.17	0.05	0.12	0.01
	Oct. 5			0.09	0.04	0.99	0.06	0.09	0.04
	Oct. 6			0.1	0.04	1.05	0.15	0.1	0.04
	Oct. 7			0.12	0.06	1.09	0.2	0.13	0.06
	Oct. 8			0.13	0.06	1.05	0.15	0.13	0.04
	Oct. 9			0.22	0.13	1.06	0.2	0.22	0.06
	Oct. 10			0.18	0.07	1.14	0.2	0.2	0.04
Mean				***0.14***	***0.05***	***1.08***	***0.14***	***0.15***	***0.04***
Stdev				***0.04***	***0.04***	***0.06***	***0.06***	***0.04***	***0.02***
Stand 22	Sept. 30	1	0.46	0.18	0.04	1.32	0.14	0.24	0.07
	Oct. 1								
	Oct. 4								
	Oct. 5			0.13	0.07	1.32	0.1	0.17	0.08
	Oct. 6								
	Oct. 7			0.12	0.07	1.35	0.07	0.15	0.08
	Oct. 8								
	Oct. 9	4	1.61	0.18	0.11	1.4	0.08	0.24	0.14
	Oct. 10								
Mean		***3***	***1.04***	***0.15***	***0.07***	***1.35***	***0.10***	***0.20***	***0.09***
Stdev		***2***	***0.81***	***0.03***	***0.03***	***0.04***	***0.03***	***0.05***	***0.03***

Table 11: Summary Table for Soil Moisture in Forest Stands and Clearings

		Humus/Organic Layer		Mineral Soil					
Stand	Date	Mean Depth (cm)	Mean Gravimetric Moisture (g/g)	Gravimetric Moisture (g/g)		Bulk Density (g/cm3)		Volumetric Moisture (cm3/cm3)	
				Mean	Stdev	Mean	Stdev	Mean	Stdev
Stand 24	Sept. 30								
	Oct. 1								
	Oct. 4			0.22	0.05	0.84	0.08	0.19	0.03
	Oct. 5								
	Oct. 6			0.22	0.08	1.01	0.2	0.21	0.04
	Oct. 7								
	Oct. 8	3	1.03	0.19	0.07	1.04	0.09	0.19	0.08
	Oct. 9								
	Oct. 10	4	2.32	0.18	0.07	1.24	0.18	0.22	0.04
Mean		***4***	***1.68***	***0.20***	***0.07***	***1.03***	***0.14***	***0.20***	***0.04***
Stdev		***1***	***0.91***	***0.02***	***0.01***	***0.16***	***0.08***	***0.01***	***0.01***
Stand 31	Sept. 30	2	1.07	0.21	0.08	0.92	0.22	0.18	0.04
	Oct. 1								
	Oct. 4								
	Oct. 5	3	1.8	0.15	0.03	1.17	0.13	0.17	0.01
	Oct. 6								
	Oct. 7	2	1.08	0.19	0.08	1.11	0.21	0.2	0.04
	Oct. 8								
	Oct. 9	4	2.19	0.23	0.07	1.11	0.17	0.25	0.03
	Oct. 10								
Mean		***3***	***1.54***	***0.20***	***0.07***	***1.08***	***0.18***	***0.20***	***0.03***
Stdev		***1***	***0.55***	***0.03***	***0.02***	***0.11***	***0.04***	***0.04***	***0.01***
Stand 32	Sept. 30	21	3.45						
	Oct. 1								
	Oct. 4								
	Oct. 5								
	Oct. 6								
	Oct. 7								
	Oct. 8								
	Oct. 9								
	Oct. 10								
Mean		***21***	***3.45***						
Stdev									

Table 11: Summary Table for Soil Moisture in Forest Stands and Clearings

		Humus/Organic Layer		Mineral Soil					
Stand	Date	Mean Depth (cm)	Mean Gravimetric Moisture (g/g)	Gravimetric Moisture (g/g)		Bulk Density (g/cm3)		Volumetric Moisture (cm3/cm3)	
				Mean	Stdev	Mean	Stdev	Mean	Stdev
Stand 33	Sept. 30								
	Oct. 1								
	Oct. 4			0.22	0.02	1.02	0.05	0.22	0.02
	Oct. 5								
	Oct. 6	3	1.09	0.21	0.1	1.13	0.19	0.22	0.07
	Oct. 7								
	Oct. 8	2	0.91	0.15	0.1	1.24	0.19	0.17	0.06
	Oct. 9								
	Oct. 10	2	1.52	0.21	0.05	1.21	0.07	0.25	0.06
Mean		*2*	*1.17*	*0.20*	*0.07*	*1.15*	*0.13*	*0.22*	*0.06*
Stdev		*1*	*0.31*	*0.03*	*0.04*	*0.10*	*0.08*	*0.03*	*0.03*
Stand 34	Sept. 30	4	1.33	0.21	0.07	1.35	0	0.27	0.13
	Oct. 1								
	Oct. 4								
	Oct. 5	3	0.7	0.18	0.04	1.13	0.11	0.2	0.03
	Oct. 6								
	Oct. 7	4	1.24	0.23	0.16	1.16	0.29	0.24	0.09
	Oct. 8								
	Oct. 9			0.18	0	1.32	0	0.24	0
	Oct. 10								
Mean		*4*	*1.09*	*0.20*	*0.07*	*1.24*	*0.10*	*0.24*	*0.06*
Stdev		*1*	*0.34*	*0.02*	*0.07*	*0.11*	*0.14*	*0.03*	*0.06*
Stand 37	Sept. 30								
	Oct. 1								
	Oct. 4			0.17	0	1.05	0.08	0.17	0.02
	Oct. 5								
	Oct. 6			0.14	0.02	1.13	0.11	0.16	0.02
	Oct. 7								
	Oct. 8			0.15	0.04	1.03	0.15	0.15	0.02
	Oct. 9			0.25	0.09	1.07	0.18	0.26	0.06
	Oct. 10			0.25	0.06	1.06	0.14	0.26	0.03
Mean				*0.18*	*0.04*	*1.07*	*0.13*	*0.19*	*0.03*
Stdev				*0.05*	*0.04*	*0.04*	*0.04*	*0.05*	*0.02*

Table 11: Summary Table for Soil Moisture in Forest Stands and Clearings

		Humus/Organic Layer		Mineral Soil					
Stand	Date	Mean Depth (cm)	Mean Gravimetric Moisture (g/g)	Gravimetric Moisture (g/g)		Bulk Density (g/cm3)		Volumetric Moisture (cm3/cm3)	
				Mean	Stdev	Mean	Stdev	Mean	Stdev
Stand 38	Sept. 30								
	Oct. 1								
	Oct. 4			0.08	0.04	1.21	0.01	0.1	0.05
	Oct. 5								
	Oct. 6			0.06	0.03	1.32	0.05	0.08	0.05
	Oct. 7								
	Oct. 8								
	Oct. 9			0.14	0.04	1.25	0.05	0.18	0.05
	Oct. 10			0.16	0.08	1.12	0.23	0.17	0.06
Mean				*0.11*	*0.05*	*1.23*	*0.09*	*0.13*	*0.05*
Stdev				*0.05*	*0.02*	*0.08*	*0.10*	*0.05*	*0.00*
Stand 43	Sept. 30								
	Oct. 1			0.26	0.13	1.04	0.19	0.25	0.07
	Oct. 4								
	Oct. 5			0.19	0.03	1.13	0.17	0.21	0.01
	Oct. 6								
	Oct. 7	3	0.69	0.14	0.02	1.23	0.1	0.17	0.01
	Oct. 8								
	Oct. 9			0.2	0.08	1.19	0.17	0.23	0.04
	Oct. 10								
Mean		*3*	*0.69*	*0.20*	*0.06*	*1.15*	*0.16*	*0.22*	*0.03*
Stdev				*0.05*	*0.05*	*0.08*	*0.04*	*0.03*	*0.03*
Stand 44	Sept. 30								
	Oct. 1	5	2.72	0.51	0.42	0.79	0.44	0.26	0.17
	Oct. 4								
	Oct. 5								
	Oct. 6								
	Oct. 7								
	Oct. 8								
	Oct. 9								
	Oct. 10								
Mean		*5*	*2.72*	*0.51*	*0.42*	*0.79*	*0.44*	*0.26*	*0.17*
Stdev									

3.2.2 Agricultural Fields

As with the forest stands and clearings, for each agricultural field examined, measurements were repeated on successive days whenever possible to track any change in soil moisture at a location over the time of the mission. In the agricultural fields, three soil cores were taken at each of three locations randomly chosen in a field, netting nine cores per field per day. All samples were taken on both gravimetric and volumetric bases as can be seen in Table 12: *Summary Table for Agricultural Fields Soil Moisture.*

All of the soil samples collected were weighed immediately after collection. Next, the samples were baked to equilibrium weight in an oven at 110° C to remove the moisture, then re-weighed. In this way water mass fraction and the volumetric water content were computed for the soil samples.

Table 12: *Summary Table for Agricultural Fields Soil Moisture* provides a summary of the results for each field Included are the sample location gravimetric moisture (dry wt. g/g), bulk density (g/cm^3), and volumetric moisture (cm^3/cm^3). Calculations of the soil moisture parameters were identical to those in equations 5-7 in the previous section.

Table 12: Summary Table for Agricultural Fields Soil Moisture

Field	Date	Avg. Bulk Density (g/cm3)	Avg. Gravimetric Moisture (dr wt. g/g)	Avg. Volumetric Moisture (cm3/cm3)	Field	Date	Avg. Bulk Density (g/cm3)	Avg. Gravimetric Moisture (dr wt. g/g)	Avg. Volumetric Moisture (cm3/cm3)
A	5-Oct	1.37	0.15	0.21	L	5-Oct	1.55	0.07	0.11
	6-Oct	1.30	0.12	0.16		6-Oct	1.21	0.27	0.32
	7-Oct	1.28	0.17	0.21		7-Oct	1.21	0.29	0.35
	8-Oct	1.39	0.14	0.19		8-Oct	1.17	0.29	0.34
	9-Oct	1.30	0.25	0.32		9-Oct	1.22	0.38	0.47
	10-Oct	1.29	0.28	0.36		10-Oct	1.25	0.40	0.50
	Mean	***1.32***	***0.19***	***0.24***		***Mean***	***1.27***	***0.28***	***0.35***
	Stdev	***0.04***	***0.07***	***0.08***		***Stdev***	***0.14***	***0.12***	***0.14***
B	5-Oct	1.29	0.18	0.23	M	5-Oct	0.98	0.35	0.34
	6-Oct	1.33	0.17	0.22		6-Oct	1.24	0.24	0.29
	7-Oct	1.27	0.18	0.23		7-Oct	1.14	0.34	0.38
	8-Oct	1.37	0.18	0.25		8-Oct	1.11	0.36	0.39
	9-Oct	1.27	0.25	0.32		9-Oct	1.15	0.38	0.43
	10-Oct	1.26	0.25	0.32		10-Oct	1.16	0.44	0.49
	Mean	***1.30***	***0.20***	***0.26***		***Mean***	***1.13***	***0.35***	***0.39***
	Stdev	***0.04***	***0.04***	***0.04***		***Stdev***	***0.08***	***0.07***	***0.07***
C	5-Oct	1.27	0.30	0.38	N	5-Oct	1.21	0.27	0.32
	6-Oct	1.39	0.26	0.35		6-Oct	1.38	0.24	0.32
	7-Oct	1.30	0.23	0.30		7-Oct	1.35	0.24	0.33
	8-Oct	1.37	0.22	0.30		8-Oct	1.36	0.24	0.33
	9-Oct	1.33	0.29	0.39		9-Oct	1.39	0.32	0.45
	10-Oct	1.31	0.30	0.39		10-Oct	1.32	0.35	0.46
	Mean	***1.33***	***0.27***	***0.35***		***Mean***	***1.34***	***0.28***	***0.37***
	Stdev	***0.05***	***0.04***	***0.04***		***Stdev***	***0.06***	***0.05***	***0.07***
D	5-Oct	1.58	0.23	0.36	O	5-Oct	1.40	0.25	0.35
	6-Oct	1.46	0.25	0.37		6-Oct	1.21	0.25	0.30
	7-Oct	1.60	0.22	0.35		7-Oct	1.29	0.24	0.31
	8-Oct	1.45	0.22	0.32		8-Oct	1.29	0.25	0.32
	9-Oct	1.45	0.28	0.41		9-Oct	1.32	0.35	0.46
	10-Oct	1.37	0.30	0.41		10-Oct	1.25	0.37	0.47
	Mean	***1.48***	***0.25***	***0.37***		***Mean***	***1.29***	***0.28***	***0.37***
	Stdev	***0.09***	***0.03***	***0.03***		***Stdev***	***0.06***	***0.06***	***0.08***
E	5-Oct	0.99	0.29	0.29	P	5-Oct	0.88	0.45	0.39
	6-Oct	1.19	0.31	0.37		6-Oct	1.10	0.34	0.37
	7-Oct	1.29	0.28	0.36		7-Oct	1.07	0.36	0.38
	8-Oct	1.29	0.30	0.39		8-Oct	1.09	0.35	0.38
	9-Oct	1.29	0.32	0.41		9-Oct	1.05	0.44	0.46
	10-Oct	1.17	0.37	0.43		10-Oct	1.06	0.43	0.46
	Mean	***1.20***	***0.31***	***0.37***		***Mean***	***1.04***	***0.39***	***0.41***
	Stdev	***0.12***	***0.03***	***0.05***		***Stdev***	***0.08***	***0.05***	***0.04***
F	5-Oct	1.38	0.28	0.38	Q	5-Oct	1.21	0.32	0.38
	6-Oct	1.39	0.27	0.37		6-Oct	1.17	0.29	0.33
	7-Oct	1.32	0.29	0.38		7-Oct	1.22	0.27	0.33
	8-Oct	1.26	0.29	0.36		8-Oct	1.37	0.25	0.34
	9-Oct	1.34	0.34	0.46		9-Oct	1.29	0.34	0.44
	10-Oct	1.27	0.35	0.45		10-Oct	1.23	0.35	0.43
	Mean	***1.33***	***0.30***	***0.40***		***Mean***	***1.25***	***0.30***	***0.38***
	Stdev	***0.05***	***0.04***	***0.04***		***Stdev***	***0.07***	***0.04***	***0.05***
G	5-Oct	1.38	0.25	0.35	R	5-Oct	1.14	0.31	0.35
	6-Oct	1.31	0.29	0.38		6-Oct	1.22	0.30	0.37
	7-Oct	1.45	0.24	0.35		7-Oct	1.26	0.31	0.39
	8-Oct	1.39	0.25	0.35		8-Oct	1.27	0.29	0.37
	9-Oct	1.43	0.30	0.42		9-Oct	1.26	0.34	0.42
	10-Oct	1.34	0.29	0.39		10-Oct	1.23	0.42	0.51
	Mean	***1.38***	***0.27***	***0.37***		***Mean***	***1.23***	***0.33***	***0.40***
	Stdev	***0.05***	***0.02***	***0.03***		***Stdev***	***0.05***	***0.05***	***0.06***

Table 12: Summary Table for Agricultural Fields Soil Moisture

Field	Date	Avg. Bulk Density (g/cm3)	Avg. Gravimetric Moisture (dry wt. g/g)	Avg. Volumetric Moisture (cm3/cm3)	Field	Date	Avg. Bulk Density (g/cm3)	Avg. Gravimetric Moisture (dry wt. g/g)	Avg. Volumetric Moisture (cm3/cm3)
H	5-Oct	1.35	0.24	0.32	S	5-Oct	1.24	0.32	0.40
	6-Oct	1.05	0.34	0.35		6-Oct	1.34	0.33	0.45
	7-Oct	1.35	0.25	0.34		7-Oct	1.14	0.34	0.38
	8-Oct	1.31	0.28	0.37		8-Oct	1.00	0.36	0.36
	9-Oct	1.29	0.38	0.49		9-Oct	0.94	0.46	0.42
	10-Oct	1.32	0.30	0.39		10-Oct	1.07	0.45	0.48
	Mean	***1.28***	***0.30***	***0.38***		***Mean***	***1.12***	***0.38***	***0.41***
	Stdev	***0.11***	***0.05***	***0.06***		***Stdev***	***0.15***	***0.06***	***0.04***
I	5-Oct	1.30	0.17	0.22	T	5-Oct	0.94	0.38	0.36
	6-Oct	1.38	0.22	0.31		6-Oct	0.93	0.35	0.32
	7-Oct	1.33	0.24	0.32		7-Oct	1.16	0.30	0.35
	8-Oct	1.35	0.25	0.33		8-Oct	1.11	0.30	0.33
	9-Oct	1.40	0.30	0.42		9-Oct	1.17	0.36	0.42
	10-Oct	1.30	0.32	0.41		10-Oct	1.25	0.41	0.51
	Mean	***1.34***	***0.25***	***0.34***		***Mean***	***1.09***	***0.35***	***0.38***
	Stdev	***0.04***	***0.06***	***0.08***		***Stdev***	***0.13***	***0.04***	***0.07***
J	5-Oct	1.46	0.22	0.32	U	5-Oct	1.11	0.35	0.39
	6-Oct	1.26	0.22	0.27		6-Oct	1.09	0.30	0.33
	7-Oct	1.48	0.19	0.28		7-Oct	1.27	0.31	0.39
	8-Oct	1.44	0.18	0.26		8-Oct	1.19	0.33	0.38
	9-Oct	1.36	0.29	0.39		9-Oct	1.21	0.40	0.48
	10-Oct	1.28	0.30	0.39		10-Oct	1.24	0.40	0.50
	Mean	***1.38***	***0.23***	***0.32***		***Mean***	***1.18***	***0.35***	***0.41***
	Stdev	***0.10***	***0.05***	***0.06***		***Stdev***	***0.07***	***0.04***	***0.06***
K	5-Oct	1.20	0.34	0.41					
	6-Oct	1.22	0.32	0.39					
	7-Oct	1.28	0.31	0.39					
	8-Oct								
	9-Oct	1.39	0.31	0.43					
	10-Oct	1.26	0.34	0.43					
	Mean	***1.27***	***0.32***	***0.41***					
	Stdev	***0.08***	***0.02***	***0.02***					

3.3 DIELECTRIC MEASUREMENTS OF FORESTED AREA SOILS

Soil dielectric measurements were taken in forest stands in concert with soil moisture core sampling. In situ dielectric measurements were made with portable dielectric probes (Applied Microwave Corp. PDP) using 0.25 in diameter coaxial probe tips inserted no more than 1 cm into the mineral soil. In forest stands, typically three dielectric measurements were taken at each of five sample locations per stand, netting 15 dielectric measurements. Sampling at the Rifle Range was done at locations on the distributed calibration surfaces (s1,s2, and s3), at the Raco Airport in the large grassy area, and at Cryderman Field at the Trihedral locations. Again a total of 15 samples were taken per plot. The means and standard deviations of the real and imaginary parts of the dielectric constant were calculated by stand or plot on a daily basis. Forest stands were sampled from 1 to 4 times over the mission period, with most stands being sampled at least twice. Sampling at the Rifle Range, the Raco Airport, and Cryderman Field was slightly more intensive, and was done on Oct. 1, and each day from Oct. 5 through Oct. 9. All of the above was done using the P-band probe (P-148). Additionally, Cryderman Field, the Raco Airport and two forest stands were sampled on Sept. 30 at L-band. These were the only L-band soil dielectric measurements made.

Results of dielectric measurements for each stand or clearing for each day are presented in Table 13: *Summary Table of Forest Soil Dielectrics.* Measurements presented are those described in the previous paragraph.

Table 13: Summary Table of Forest Soil Dielectrics

Location	Date	Time	P-band			
			e' - mean	e' - stdev	e" - mean	e" - stdev
22	5-Oct	10.49	22.43	15.31	1.77	3.91
	7-Oct	11.01	6.65	4.15	0.50	2.04
24	6-Oct	10.43	25.24	13.18	2.47	3.63
	Oct 8	4.46	28.91	10.72	3.20	3.27
31	5-Oct	14.05	31.44	10.24	3.20	3.20
	7-Oct	12.34	26.03	14.43	2.47	3.80
	9-Oct	10.43	31.33	11.62	1.11	3.41
32	1-Oct	12.12	47.67	28.93	3.95	5.38
33	6-Oct	13.11	17.31	9.87	2.47	3.14
	8-Oct	2.42	14.19	12.88	0.50	3.59
34	5-Oct	15.20	26.53	18.55	3.20	4.31
	7-Oct	12.09	22.74	18.50	2.47	4.30
	9-Oct	11.01	34.23	13.47	1.77	3.67
37	6-Oct	12.16	7.54	6.91	0.50	2.63
	9-Oct	13.15	26.20	14.08	2.47	3.75
38	6-Oct	11.49	4.53	2.45	0.00	1.57
	9-Oct	13.36	10.42	9.02	0.50	3.00
43	1-Oct	16.59	30.96	12.01	2.47	3.47
	5-Oct	16.04	16.58	7.70	1.77	2.77
	7-Oct	11.31	13.38	13.50	1.11	3.67
	9-Oct	11.31	27.57	14.43	1.11	3.80
44	1-Oct	10.38	34.73	17.28	3.95	4.16
Cryderman	1-Oct	12.55	25.71	11.46	3.95	3.39
	5-Oct	11.43	31.31	14.75	3.95	3.84
	6-Oct	14.48	25.48	13.05	3.20	3.61
	7-Oct	13.06	22.76	16.12	3.20	4.02
	8-Oct	1.32	33.63	11.35	3.95	3.37
	9-Oct	9.31	36.29	8.39	2.47	2.90
Raco Airport	1-Oct	14.31	11.82	6.50	1.11	2.55
	5-Oct	10.22	25.29	9.16	1.77	3.03
	6-Oct	10.12	21.97	8.77	3.20	2.96
	7-Oct	10.45	15.94	12.25	1.77	3.50
	8-Oct	4.23	22.41	6.01	2.47	2.45
	9-Oct	12.38	30.96	5.75	3.20	2.40

Table 13: Summary Table of Forest Soil Dielectrics

Rifle Range S1	1-Oct	15.07	6.03	6.93	0.50	2.63
	5-Oct	9.56	9.45	10.06	0.50	3.17
	6-Oct	9.15	4.09	4.58	0.50	2.14
	7-Oct	9.21	3.80	2.59	0.00	1.61
	8-Oct	3.27	16.55	8.70	1.11	2.95
	9-Oct	11.59	21.51	10.09	1.11	3.18
Rifle Range S2	1-Oct	15.38	3.56	4.07	0.50	2.02
	5-Oct	9.35	8.23	8.49	0.50	2.91
	6-Oct	9.33	6.03	5.33	0.00	2.31
	7-Oct	9.42	4.12	4.42	0.00	2.10
	8-Oct	3.37	10.71	10.22	1.11	3.20
	9-Oct	12.10	19.20	13.67	1.11	3.70
Rifle Range S3	1-Oct	16.12	6.81	5.59	0.50	2.36
	5-Oct	9.18	6.33	4.86	0.50	2.20
	6-Oct	9.48	5.95	6.93	0.50	2.63
	7-Oct	10.05	3.53	2.42	0.50	1.56
	8-Oct	3.54	19.35	21.64	1.11	4.65
	9-Oct	12.24	23.13	11.52	1.11	3.39

Location	Date	Time		L-band		
			e' - mean	e' - stdev	e" - mean	e" - stdev
31	30-Sep	11.37	18.48	14.03	2.45	3.75
34	30-Sep	13.30	19.25	8.41	4.08	2.90
Cryderman	30-Sep	12.55	18.61	10.48	4.89	3.24
Raco Airport	30-Sep	16.08	14.03	8.78	4.08	2.96

4 Vegetation Observations

Ancillary data for several sets of canopy properties were required for the SIR-C/X-SAR experiment: 1) those related to the quantity of biomass, 2) those related to moisture status and temperature, and 3) those related to leaf and herbaceous vegetation phenology. The biomass quantities were considered static within the October SIR-C/X-SAR mission and biomass data had been collected during summers 1992-94. Those properties related to moisture, temperature, and phenology are unique to any mission period and may be expected to vary over the period. Therefore, in order to describe the status of the vegetation canopy, measurements were taken during the October SIR-C/X-SAR mission as set forth in the following table.

Table 14: Vegetation Properties: Hypotheses, Objectives, and Methods

Hypothesis	Objective	Method
1. Vegetation canopy coverage shows phenological variation from season to season	Determine the canopy coverage during October 1994 mission in forest stands and fields	Use LI-COR leaf area index meter which calculates m^2/m^2 of leaf area in stands and fields
2. Vegetation moisture content will be unique to the mission period and will vary by cover type or species. Agricultural biomass will vary by season	Determine the wet & dry moisture and volume of woody tree species and herbaceous vegetation of interest. Quantify current biomass of agricultural veg.	Do destructive sampling. Take cuttings of herbaceous vegetation and tree foliage. Fell one tree of each species of interest & sample the bole and branches
3. Vegetation Dielectric properties related to moisture conditions will be unique to the mission period and will vary by:		
a: species and meteorological conditions	a. Determine the dielectric properties for all tree species of interest at the time of the mission.	a. Complete detailed dielectric profiles using dielectric probes. Do this for at least one tree each of the nine tree species of interest. Record air and tree temperature.
b. on a diurnal basis	b. Track e' over at least the time range of the overflights and over a 24-hour period if possible.	Attach dielectric probes to trees and program them to take continuous measurements over part or all of the diurnal cycle.

4.1 LEAF AREA INDEX

Leaf area index (LAI) is a measure of the net single-sided leaf area per unit area of ground in m^2/m^2. LAI can be measured a number of ways including leaf counts, litter traps or using optical transmittance of the canopy. The LI-COR 2000 instrument uses the latter approach at a wavelength of 490 μm, a chlorophyll absorption band. Measurements made below the canopy are ratioed to those made above the canopy to determine transmittance as a function of zenith angle. This function is used to estimate LAI assuming (1) green foliage has transmissivity = 0.0 at 490 μm, (2) the foliage is randomly distributed, (3) the foliage elements are small compared to the view area of each detector ring (five rings, each covering a zenith angle of approximately 13^o), and (4) the foliage is randomly oriented in azimuth.

The LI-COR 2000 was used to obtain estimates of LAI for both the forest stands within the Raco Supersite and also for 21 agricultural fields located southeast of the Raco Supersite in the vicinity of Rudyard, MI. A 50% view restrictor was used on the instruments during all measurements. The forest stands were measured during two periods: (1) from August 16-19 and (2) from October 1-6, 1994. The agricultural fields were all sampled on October 6, 1994. All locations sampled plus date and time are listed as part of Table 15: *Summary Table of Leaf Area Index Observations.*

The agricultural fields were sampled at three locations within a field (generally 16 ha in size). Six replicates of above and below canopy readings were made at each location. Hence, the reported LAI values are based upon a sample size of 18.

The pre-established forest sampling grid of 5 transects with 8 locations per transect was subsampled for LAI estimation. Typically, two to four transects were sampled with below canopy readings being obtained with three replicates per location. This makes the sample size three times the number of independent sample locations given in the table. Measurements made beneath the forest canopy are compared to those made (within +/- 7 seconds) by an independent, but cross-calibrated LI-COR 2000 located above the canopy or in a nearby clearing.

The mean LAI and standard deviations about the mean LAI are given in Table 15. However, these values do not account for two factors: (1) extinction caused by woody stems and (2) the non-random orientation of conifer needles on shoots. These effects are approximately corrected by the following:

(8) $$LAI_{corrected} = LAI_c + LAI_d$$

(9) $$LAI_c = R_c C(LAI_{raw} - W)$$

(10) $$LAI_d = (1 - C)(LAI_{raw} - W)$$

where the subscripts *c* and *d* denote coniferous and deciduous, R_c is a conifer needle correction factor, C is the percent of net basal area that is coniferous, and W is a woody stem correction factor. R_c is given by the ratio of projected needle area (quantity of interest) to the average projected shoot area (quantity measured by LI-COR 2000). This value has been found to range from 1.5 to 1.7 depending upon species.[3] A value of 1.67 is assumed appropriate for all conifer species in this study. The woody stem correction factor is determined for LI-COR measurements of deciduous stems (C < 5%) during leafless winter conditions. Measurements obtained at the Raco supersite have been used to generate an empirical dependence of W on basal area (B_a).

(11) $$W = 0.1344 B_a^{0.5522} \qquad (R^2=0.865)$$

Assuming that the woody stem correction factor for coniferous species is approximately that determined for deciduous species, Eq. 4 can be substituted into Eq. 2 and Eq. 3 yielding:

(12) $$LAI_{corrected} = \left(LAI_{raw} - 0.1344 B_a^{0.5522}\right)(1.0 + 0.67C)$$

This equation is used to calculated the corrected LAI values in Table 15: *Summary Table of Leaf Area Index Observations* using basal area values measured for each stand. No corrections are needed for the data collected in the agricultural fields.

Table 15: Summary Table of Leaf Area Index Observations

Forest Stands

Stand	Dominant Species	Month	Day	Start Time	Stop Time	No. Locations	LAI Mean (Uncorrected)	LAI Stand. Dev.	Mean Tip Angle	Total Basal Area (m^2/m^2)	Conifer Basal Area (m^2/m^2)	% Conifer	Wood Correction Factor	Corrected LA (m^2/m^2)
R22	red pine	Aug	17	17:48	18:17	26	3.45	0.59	51.2	20.00	20.00	100%	0.70	4.59
R23	red & white pine	Oct	5	12:34	13:06	27	2.86	0.30	55.2	38.70	35.67	92%	1.01	2.99
R25	red & white pine	Oct	5	13:30	13:56	25	2.74	0.44	51.0	33.06	31.06	94%	0.93	2.95
R27	jack pine	Oct	5	15:56	16:19	24	2.42	0.41	57.0	25.08	24.24	97%	0.80	2.67
R28	beech	Oct	2	11:06	11:50	26	3.87	0.37	39.9	40.33	4.08	10%	1.04	3.03
R29	red maple	Oct	2	12:10	12:50	25	3.76	0.43	40.0	35.34	2.72	8%	0.96	2.94
R31	red maple	Oct	1	11:04	11:42	24	3.77	0.32	44.2	27.33	0.02	0%	0.83	2.93
R32	white-cedar	Oct	3	13:21	13:51	23	3.41	0.50	50.1	59.30	58.13	98%	1.28	3.52
R33	trembling aspen	Oct	1	12:16	13:12	16	4.13	0.79	42.8	24.54	0.00	0%	0.79	3.34
R34	bigtooth aspen / red maple	Oct	1	13:33	14:08	24	4.11	0.30	41.9	29.03	0.18	1%	0.86	3.26
R35	jack pine	Aug	18	17:02	17:21	21	1.87	0.64	52.1	11.32	11.22	99%	0.51	2.26
R36	jack pine	Aug	19	11:18	11:47	22	1.94	1.74	43.6	6.27	6.11	98%	0.37	2.59
R38	jack pine	Aug	19	18:47	19:04	22	1.84	0.43	53.4	6.18	6.18	100%	0.37	2.45
R39	jack pine	Aug	16	15:50	16:26	19	0.90	0.35		0.05	0.04	97%	0.02	1.44
R41	red pine	Aug	19	15:30	15:57	20	2.56	0.64	45.0	8.40	7.47	89%	0.44	3.40
R42	jack pine	Aug	19	14:22	14:49	23	2.72	1.10	47.8	7.32	6.31	86%	0.40	3.65
R43	red pine	Aug	17	11:55	12:35	27	3.58	0.48	48.6	34.19	33.10	97%	0.94	4.35
R45	trembling aspen	Oct	1	14:55	16:10	16	1.47	0.49	58.9	9.63	0.30	3%	0.47	1.02
R46	red maple	Oct	3	11:46	12:14	24	4.25	0.43	40.8	43.30	8.77	20%	1.08	3.61
R47	trembling aspen	Oct	2	16:41	17:19	24	3.50	0.89	49.1	24.04	1.81	8%	0.78	2.86
R48	trembling aspen/red maple	Oct	2	15:47	16:13	24	3.53	0.51	44.6	28.17	5.37	19%	0.85	3.02
R49	trembling aspen	Oct	1	16:54	17:30	14	2.91	0.47	53.0	15.21	0.00	0%	0.60	2.31
R50	red pine	Oct	1	18:04	18:34	12	3.33	0.70	52.5	26.75	19.76	74%	0.83	3.74
R51	red pine	Aug	19	17:15	17:35	23	3.01	0.55	47.0	17.29	16.19	94%	0.65	3.84
R52	red pine	Aug	18	14:55	15:19	23	2.60	0.41	50.3	21.27	21.27	100%	0.73	3.13
R54	jack pine	Oct	3	14:54	15:10	23	1.15	0.32	62.7	4.99	4.99	100%	0.33	1.38
R55	jack pine	Aug	19	18:16	18:35	22	1.80	0.47	61.8	6.53	6.53	100%	0.38	2.37
R56	jack pine	Aug	18	16:16	16:37	25	2.77	0.64	45.4	5.70	5.70	100%	0.35	4.04
R58	jack pine	Aug	18	14:26	14:49	23	1.17	0.72	40.9	6.67	6.67	100%	0.38	1.31
R59	jack pine	Aug	17	13:23	13:48	19	1.27	0.52	50.2	4.56	4.56	100%	0.31	1.61
R60	jack pine	Aug	17	16:57	17:27	23	1.49	0.81	45.8	6.59	6.56	100%	0.38	1.85
R61	jack pine	Aug	17	14:54	15:28	25	2.64	0.54	47.6	18.86	18.86	100%	0.68	3.27
R62	jack pine	Aug	17	15:41	16:37	25	2.57	0.57	53.4	16.43	16.42	100%	0.63	3.24
R63	jack pine	Aug	17	13:58	14:35	25	2.12	0.42	43.2	9.94	9.94	100%	0.48	2.74
R64	jack pine	Aug	18	13:04	13:31	22	2.03	0.66	48.4	11.44	11.44	100%	0.52	2.53
R65	jack pine	Aug	18	15:37	16:03	24	2.99	0.43	52.6	16.71	16.71	100%	0.64	3.93
R66	jack pine	Oct	3	15:34	15:55	14	1.78	0.21	56.4	1.52	1.52	100%	0.17	2.68
R67	jack pine	Aug	16	13:35	14:17	28	0.77	0.29		22.52	22.51	100%	0.75	0.04

Table 15: Summary Table of Leaf Area Index Observations

Forest Stands

Stand	Dominant Species	Month	Day	Start Time	Stop Time	No. Locations	LAI Mean (Uncorrected)	LAI Stand. Dev.	Mean Tip Angle	Total Basal Area (m^2/m^2)	Conifer Basal Area (m^2/m^2)	% Conifer	Wood Correction Factor	Corrected LA (m^2/m^2)
R68	red pine	Aug	18	13:45	14:08	21	2.40	0.35	54.4	28.62	28.62	100%	0.86	2.58
R71	red pine	Oct	6	11:00	11:18	13	1.12	0.29	51.7	10.09	10.09	100%	0.48	1.06
R72	red pine	Oct	6	10:21	10:50	9	0.88	0.25	48.6	8.86	8.79	99%	0.45	0.71
R73	red pine	Oct	3	16:34	16:52	24	1.37	0.39	57.9	17.84	17.81	100%	0.66	1.18
R74	white pine	Oct	3	17:45	18:06	23	3.94	0.38	49.1	37.67	25.51	68%	1.00	4.28
R75	white pine	Oct	3	17:10	17:33	21	4.09	0.40	51.3	42.63	39.72	93%	1.07	4.91
R77	red pine	Aug	19	12:03	12:24	24	1.88	0.99	44.2	9.37	8.02	86%	0.46	2.23
R81	red pine	Aug	19	12:43	13:06	23	2.12	0.35	54.2	11.72	11.43	97%	0.52	2.64
R82	red pine	Aug	19	10:41	11:04	22	1.40	0.67	57.4	8.52	8.50	100%	0.44	1.60
R83	red pine	Aug	19	16:12	16:32	22	2.28	0.62	42.6	8.35	7.78	93%	0.43	2.99
R86	northern hardwoods	Oct	2	13:40	14:06	23	2.89	0.36	47.3	33.05	0.06	0%	0.93	1.96
R87	aspen, lowland	Oct	2	17:56	18:44	22	2.91	0.50	52.2	16.85	0.00	0%	0.64	2.27

Agricultural Fields

Field	Crop Type	Month	Day	Start Time	Stop Time	No. Locations	LAI Mean	LAI Stand. Dev.	Mean Tip Angle
RA		Oct	6	15:51	15:53	18	2.07	1.49	74.7
RB		Oct	6	15:59	16:01	18	3.12	0.94	59.7
RC		Oct	6	16:14	16:16	18	3.53	2.35	67.3
RD		Oct	6	16:08	16:13	18	2.57	1.39	67.3
RE		Oct	6	15:41	15:43	18	3.97	2.71	67.7
RF		Oct	6	15:32	15:34	18	3.14	0.98	65.7
RG		Oct	6	16:22	16:24	18	4.31	1.31	58.0
RH		Oct	6	16:53	16:54	18	2.05	1.45	78.7
RI		Oct	6	16:47	16:49	18	3.59	1.55	62.0
RJ		Oct	6	16:39	16:43	18	2.95	1.51	67.3
RK		Oct	6	16:32	16:34	18	3.44	1.45	74.3
RL		Oct	6	14:00	14:07	18	2.90	0.75	65.0
RM		Oct	6	15:08	15:09	18	0.66	0.16	82.3
RN		Oct	6	15:20	15:24	18	3.06	1.53	70.7
RO		Oct	6	14:15	14:17	18	2.71	0.75	65.7
RP		Oct	6	14:23	14:30	18	3.27	1.10	60.0
RQ		Oct	6	14:37	14:43	18	3.41	1.53	63.0
RR		Oct	6	14:50	14:52	18	2.95	1.57	60.3
RS		Oct	6	14:57	14:59	18	3.69	1.60	59.0
RT		Oct	6	13:36	13:38	18	2.54	1.66	77.7
RU		Oct	6	13:20	13:28	36	2.93	1.59	69.2

4.2 VEGETATION MOISTURE MEASUREMENT BY DESTRUCTIVE SAMPLING

Vegetation moisture status during the mission was obtained from two methods: destructive sampling and dielectric measurements. Destructive sampling was done for 10 trees including one each of the 10 major species found in the test site, all 21 agricultural fields, plus Cryderman field and the grassy area at the Raco Airport.

4.2.1 Forested Areas

The destructive sampling was done in order to characterize the moisture content and dry density of woody stems as functions of stem diameter. One tree of each of the following species was felled and sampled: red maple, sugar maple, American beech, bigtooth aspen, trembling aspen, red pine, jack pine, white pine, northern white-cedar, and black spruce. Individuals chosen were either large pole-size or mature for all species except the two aspens where large saplings were selected.

Trees were felled by chainsaw near the base of the trunk. The trunks were then marked at each centimeter change in diameter. Following this, slices or trunk cross-sections were then removed from the trunk at each marked centimeter increment. Slices taken ranged from about 3 cm to 15 cm in height and were centered on a particular diameter, with longer samples taken near the slender top of the tree so as to have a large enough mass and volume to obtain a reliable moisture estimate. Small branches and twigs were also sampled to fill out the smaller end of the diameter range. This methodology can be seen in Appendix A. For example, for red maple (Acer rubrum) samples were taken starting at 15 cm at the base of the cut trunk, and were taken every subsequent centimeter decrement, ending with samples of twigs at 1.0 and 0.5 cm. A sizable sample of leaves were also taken for each tree.

A portable electronic scale was taken into the forest and wet weights of all samples were immediately obtained. Larger trunk cross-sections were placed directly on the scale and measured. Information about the sample plus its wet weight was recorded on individual forms and these and the sample were then placed and sealed in zip-lock bags to preserve moisture. Short-term preservation of moisture was potentially important for water displacement method volume measurements which would be made upon return from the field.

For small twigs, numerous twigs were needed to constitute a reliable sample. These were collected, placed in previously weighed ziplock bags, measured, labeled, and sealed.

Later during the same day all woody and foliage samples were measured for volume using a water displacement method. This method is based on the equivalence between 1 g pure H_20 and 1 cm^3 at a constant temperature. The vegetation samples were submerged in a water filled vessel. The volume was estimated by weighing the displaced water on a scale accurate to 0.001 g. The volumes obtained would be used to compute bulk density and volumetric moisture of the trees sampled.

Next the samples were dried to determine dry weight. Samples were dried in portable drying ovens on-site and also at the University of Michigan Biological Station at Pellston, MI. Some samples which potentially still contained some moisture upon return to Ann Arbor, were dried further at the University of Michigan Botanical Gardens in Ann Arbor. Samples were weighed and weights recorded after sufficient drying.

After all measurements were completed the following calculations could be made:

Average tree gravimetric moisture (dry wt. g/g)

$$(13)\quad Mg = \frac{1}{n}\sum_{i=1}^{n}\left[\frac{MW_i - MD_i}{MD_i}\right]$$

where MW_i = wood sample wet wt. (g), MD_i = wood sample dry wt. (g), and n = the number of samples

Average tree bulk density (g/cm^3)

$$(14)\quad Db = \frac{1}{n}\sum_{i=1}^{n}\left[\frac{MD_i}{V_i}\right]$$

where MD_i = wood sample dry wt. (g), V_i = wood sample volume (cm^3), and n = the number of samples

Table 16: Summary Table of Vegetation Moisture in Forest Stands

Stand	Species	Date	Basal Diameter	Type	Avg. Gravimetric Moisture (dry wt. g/g)	Avg. Volumetric Moisture (cm3/cm3)	Avg. Bulk Density (g/cm3)
31	Red Maple	9/29/94	15.0	Wood	0.626	0.358	0.570
				Foliage	1.462	0.599	0.418
31	Sugar Maple	9/29/94	15.0	Wood	0.585	0.346	0.600
				Foliage	1.527	0.425	0.302
32	Black Spruce	10/1/94	13.0	Wood	0.836	0.439	0.546
				Foliage	1.071	1.405	1.313
31	American Beech	9/30/94	17.0	Wood	0.786	0.420	0.536
				Foliage	1.735	0.381	0.219
24	Jack Pine	10/1/94	17.0	Wood	1.192	0.505	0.434
				Foliage	1.573	0.621	0.395
22	Red Pine	10/1/94	16.0	Wood	1.580	0.607	0.392
				Foliage	1.284	4.146	3.228
75	Eastern White Pine	10/1/94	20.0	Wood	1.391	0.590	0.442
				Foliage	1.247	0.540	0.433
33	Bigtooth Aspen	9/30/94	9.0	Wood	0.944	0.494	0.523
				Foliage	1.641	0.673	0.410
33	Quaking Aspen	9/30/94	14.0	Wood	0.882	0.417	0.466
				Foliage	1.725	0.978	0.567
32	Northern White-Cedar	10/1/94	18.0	Wood	0.970	0.589	0.520
				Foliage	1.077	10.400	9.655

Average tree volumetric moisture (cm^3/cm^3)

$$(15)\quad \theta = \frac{1}{n}\sum_{i=1}^{n}\left[\frac{MWi - MDi}{Vi}\right]$$

where MWi = wood sample wet wt. (g), MDi = wood sample dry wt. (g), Vi = wood sample volume (cm3), and n = the number of samples

The same calculations could also be applied to leaf/needle measurements although the sample size which was usually one (one large bag of leaves or needles) did not require averaging as included in the above formulas.

These mean results plus individual measurements, location, and date/time, are in the Following Table 16: *Summary Table of Vegetation Moisture in Forest Stands.*

4.2.2 Agricultural Fields

Vegetation moisture by destructive sampling was also carried out for 20 agricultural fields plus Cryderman Field and the Raco Airfield. In agricultural fields samples of vegetation were taken by using shears to cut all herbaceous vegetation down to the ground in a 0.25 x 0.25 m plot. A paper or ziplock bag was weighed and recorded, then the vegetation was placed in it and the weight of vegetation plus bag was weighed and recorded. Later the vegetation was dried and re-weighed. From these measurements, the following were calculated:

Vegetation gravimetric moisture (wet wt. g/g)

$$(16)\quad Mg = \frac{MW - MD}{MW}$$

where MW= sample wet wt. (g), and MD = sample dry wt. (g)

Table 17: Summary Table of Vegetation Moisture and Biomass in Agricultural Fields

Field	Date	Time	Gravimetric Moisture (wet wt. g/g)	Wet Biomass (kg/m2)	Dry Biomass (kg/m2)
Cryderman Field	10/3/94	11:15	0.602	0.398	0.158
Raco Airfield	10/3/94		0.293	0.958	0.677
A	10/6/94	1:30	0.560	0.534	0.235
B	10/6/94	1:55	0.636	0.531	0.194
C	10/6/94	2:25	0.771	0.693	0.159
D	10/6/94	2:15	0.704	0.907	0.269
E	10/6/94		0.746	1.523	0.386
F	10/6/94	2:59	0.716	1.504	0.427
G	10/5/94	11:00	0.594	1.578	0.640
H	10/7/94	3:30	0.648	0.651	0.229
I	10/7/94	3:30	0.768	2.942	0.683
K	10/5/94		0.538	1.330	0.614
L	10/7/94	3:30	0.600	1.102	0.441
M	10/6/94	3:15	0.687	0.394	0.123
N	10/6/94	3:11	0.743	0.746	0.192
O	10/5/94	1:00	0.655	1.304	0.450
P	10/6/94	3:39	0.564	1.573	0.685
Q	10/6/94	3:54	0.571	1.066	0.457
R	10/6/94		0.777	0.744	0.166
S	10/5/94	2:00	0.568	1.931	0.834
T	10/7/94	3:00	0.615	0.974	0.375
U	10/7/94	2:00	0.567	1.150	0.498

Vegetation wet biomass (kg/m^2)

(17) $$BW = \frac{MW}{A * 1000}$$

where BW=sample wet biomass (kg/m2), MW = sample wet weight (g), and A=area of sample (m2)

Vegetation dry biomass (kg/m^2)

(18) $$BD = \frac{MD}{A * 1000}$$

where BD=sample dry biomass (kg/m2), MD = sample dry weight (g), and A=area of sample (m2)

These results are included, along with location, date, and time, in Table 17: *Summary Table of Vegetation Moisture and Biomass in Agricultural Fields.*

4.3 DIELECTRIC MEASUREMENTS OF FOREST TREES

Dielectric measurements of trees had been made at the Raco site during the past four years, and these provided the basis for the hypotheses in *Table 14: Vegetation Properties: Hypotheses, Objectives, and Methods* relating to dielectric measurement. Findings indicated that in early fall with most of the deciduous leaves still green as was the case in the early part of the October mission, deciduous trees were still transpiring and thus trunks and main stems were actively transporting water. Near the end of the mission deciduous leaves began to undergo fall color change, but advanced senescence had not occurred. Many of the deciduous forest stands measured were within several miles of the climate mitigating influence of Lake Superior.

Table 18: Tree Dielectric Measurements Completed During the August and October SIR-C/X-SAR Project

SIR-C Dielectric Measurements: August

Species	Size Class	e' vs. Depth		
		Date	Stand	Probe
Beech	pole	8/15/94	31	P148, C127
Bigtooth Aspen	mature	8/17/94	34	P148, L102, C127
Bigtooth Aspen	sapling	8/17/94	33	P148, L102, C127
Black Spruce	mature	8/17/94	88	P148, L102, C127
Jack Pine	mature	8/16/94	24	P148, C127
Jack Pine	sapling	8/16/94	38	P148, C127
N White Cedar	mature	8/17/94	88	P148, L102, C127
Red Maple	pole	8/15/94	31	P148, C127
Red Pine	mature	8/16/94	43	P148, C127
Red Pine	sapling	8/16/94	22	P148, C127
Sugar Maple	pole	8/15/94	31	P148, C127
White Pine	mature	8/16/94	25	P148, C127

SIR-C Dielectric Measurements: October

Species	Size Class	e' vs. Depth		
		Date	Stand	Probe
Beech	pole	9/28/94	31	P148, L102, C127
Bigtooth Aspen	mature	9/29/94	34	P148, L102, C127
Black Spruce	pole	9/29/94	32	P148, L102, C127
Jack Pine	mature	10/2/94	24	P148, C120
Jack Pine	sapling	10/2/94	86	P148, C120
N White Cedar	mature	9/29/94	32	P148, L102, C127
Red Maple	mature	9/28/94	31	P148, L102, C127
Red Pine	mature	10/2/94	23	P148, L102, C120
Red Pine	sapling	10/2/94	86	P148, C120
Sugar Maple	mature	9/28/94	31	P148, L102, C127
Trembling Aspen	mature	9/29/94	34	P148, L102, C127
Trembling Aspen	sapling	9/29/94	33	P148, L102, C127
White Pine	mature	10/2/94	23	P148, L102, C120

Species	Size Class	e' vs. Time		
		Date	Stand	Probe
Red Pine	pole	9/29/94	22	C120
Sugar Maple	pole	10/2/94	31	C120
Sugar Maple	pole	10/7/94	31	C120
Sugar Maple	pole	10/9/94	31	C120

4.3.1 Dielectric Depth Profiles

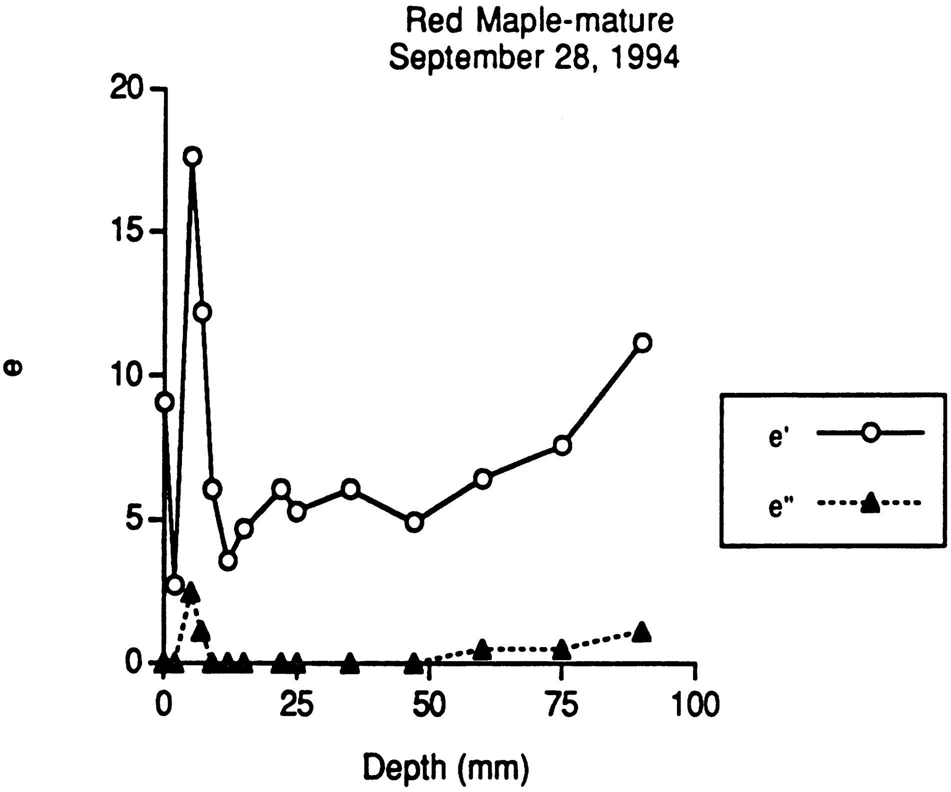
Two meet objective one under dielectric measurements in Table 14, dielectric measurements were made as a function of depth into tree trunks. These detailed profiles were carried out for one to two individuals each of nine tree species of interest (in nine different test stands) in August and ten in October. When two individuals of the same species were measured, they were sampled from different age classes (usually one mature, and one sapling). The species, stands, sampling dates, and probes used are listed in Table 18: *Tree Dielectric Measurements Completed During the August and October SIR-C/X-SAR Mission* in the columns "e' vs. Depth."

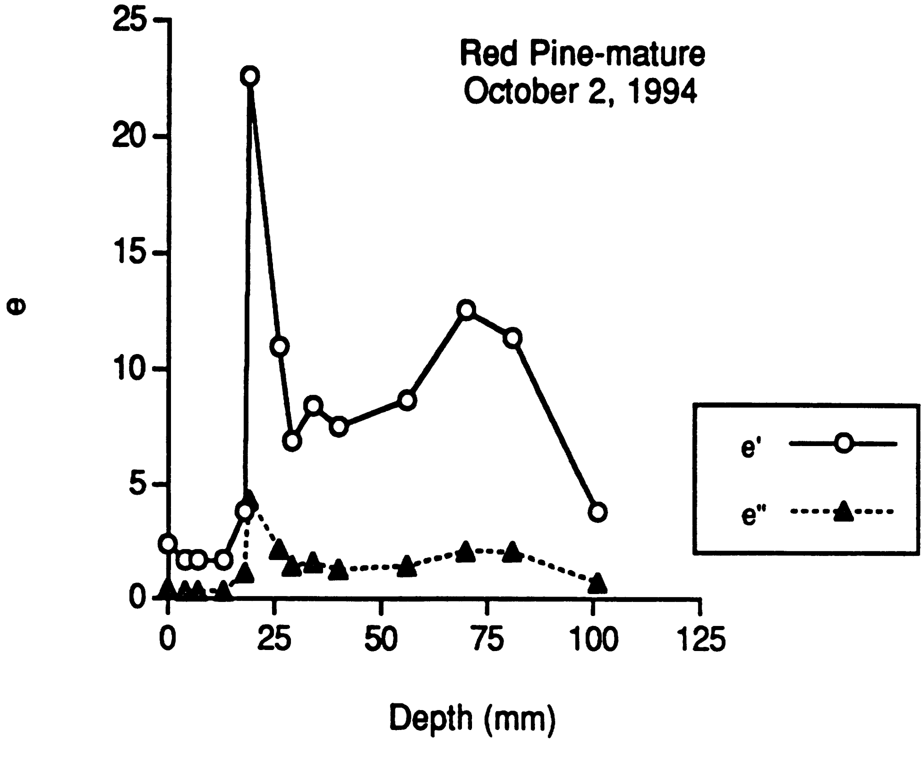
Measurements were made approximately at 1-2 mm intervals until several mm past the cambium, then every 5 mm, and increasing to every 10 mm for large individuals. For this and the other two sampling procedures, data were collected using portable dielectric probes (P, L, and C-bands) coupled with programmable HP calculators.[4] Each probe measurement results in an estimate of e' and e" the real and imaginary parts respectively of the complex dielectric constant. In this case data were taken in the field as reflection coefficients and later converted to e. Figure 1 gives the dielectric depth profile of red maple and red pine taken 9/28/94 and 10/2/94 respectively. Appendix D provides a complete set of the plots.

4.3.2 Temporal Variance in Dielectric

To meet objective two it was necessary to determine if the dielectric changed as a function of time at least through the time range of the overflights and, if possible, throughout a 24 hr. cycle. Because there was some diurnal change in air and soil temperature and humidity (warm sunny days, and significantly cooler nights), it was hypothesized that there might be a diurnal trend in bole moisture status in some species. If there was a significant change, other tree dielectric measurements would require adjustment with respect to time of day to reflect the moisture status at the time a particular overflight. To test this, dielectric probes were attached to trees and programmed to take measurements at regular intervals. Two trees, a large pole-size sugar maple, and a pole size red pine were monitored over a 24-hour cycle. Trees monitored for diurnal trends are listed in the third table (e' vs. Time) of Table 18. Plots for all temporal measurements can be found in Appendix E.

Figure 1: Dielectric Depth Profiles at P-Band





5 Weather Data

The SIR-C/X-SAR mission occurred during a time of changing weather conditions. To analyze a specific image or detect change over the mission time frame in several images, weather data, especially precipitation, would be needed as outlined in the following table.

Table 19: Weather Observations: Hypotheses, Objectives, and Methods

Hypothesis	Objective	Method
1. Precipitation will vary over the imaged area during any given precipitation event.	1. Acquire precipitation data at a level of detail sufficient for contouring incident total precipitation over the imaged area.	1. Deploy a network of 21 precipitation gauges and take measurements after each precipitation event.
2. Forest canopies intercept a percentage of total precipitation with interception percent dependent upon species composition.	2. Determine precipitation interception for each of five forest communities present in the test site.	2. Locate five rain gauges under each forest community and locate an additional five of the 21 gauges in adjacent open areas.
3. Other weather parameters will also vary over the mission duration and will be useful in image and ground data analysis.	3. Collect data on wind speed, air pressure, humidity, and precipitation.	3. Acquire daily weather radar maps plus hourly or daily reports (wind, pressure, humidity, and precipitation) .

The array of 21 gauges was designed with 16 deployed in a 4 x 4 array in clearings. The remaining 5 were placed such that one was within each type of forest community (red pine, jack pine, lowland conifer, northern hardwoods, and aspen) and paired with gauges in nearby or adjacent clearings. All gauge locations were chosen for ease of access by all weather roads and trails. Monitoring of the precipitation gauges extended over the period September 29 - October 10, 1994. The gauge locations are shown on the map *SIR-C/X-SAR Precipitation Gauge Network.*

Rain gauges were constructed prior to the October mission and were made by permanently attaching wide-mouth pvc funnels to the top of pvc bottles. PVC test tubes were mounted upside-down on the side of each bottle to allow easy mounting over a tall re-bar in the field. Forty-two rain gauges were constructed. Each bottle was pre-weighed to have a baseline bottle/cap empty weight. These were then mounted on top of 6' lengths of re-bar driven into the ground at 21 locations. Thus, after a precipitation event, a bottle containing precipitation could be quickly removed, capped, and brought back from the field for weighing, and a new bottle immediately placed on the re-bar. The time required to pick up all 21 cans was a minimum of 4 hours.

Summary data for the precipitation gauges is presented in Table 21: *Precipitation (mm of water) during the October SIR-C/X-SAR Experiment*, and includes GPS derived rain gauge coordinates, precipitation amounts for each precipitation event, and total precipitation for the only precipitation period, October 8-10. Table 20: *Intercepted Precipitation* provides the paired rain gauge locations and net difference in precipitation (gauge in clearing minus gauge in forest). Appendix F gives daily temperature, precipitation, and wind speed from the weather station at Sault Saint Marie (NOAA). Appendix G consists of daily weather data collected at the Pendills Creek and Sullivan Creek Fish Hatcheries (U.S. Fish and Wildlife Service). Appendix H consists of NOAA Michigan daily weather radar precipitation maps showing the geographical extent of any precipitation events during the mission period.

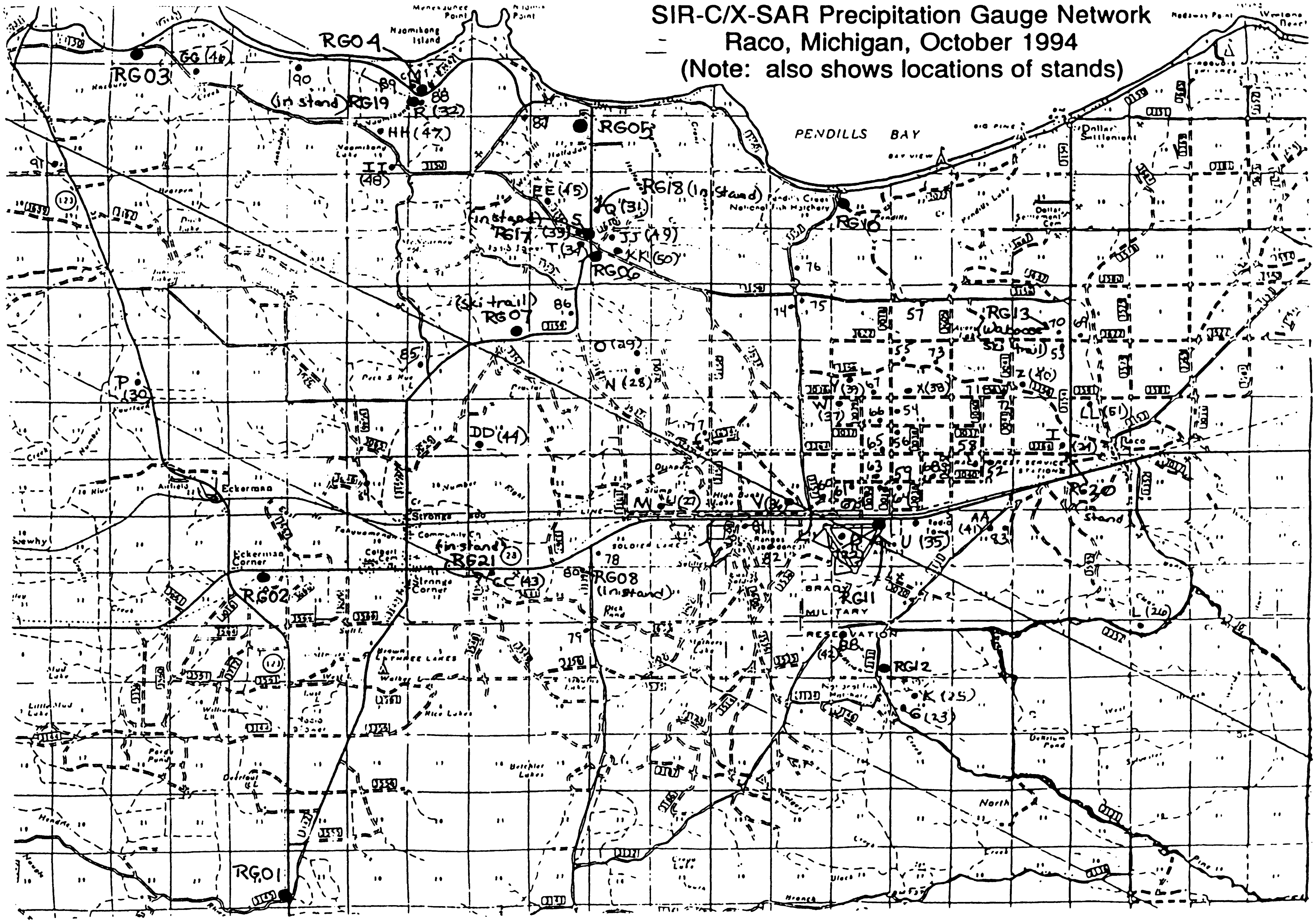
Table 20: Intercepted Precipitation

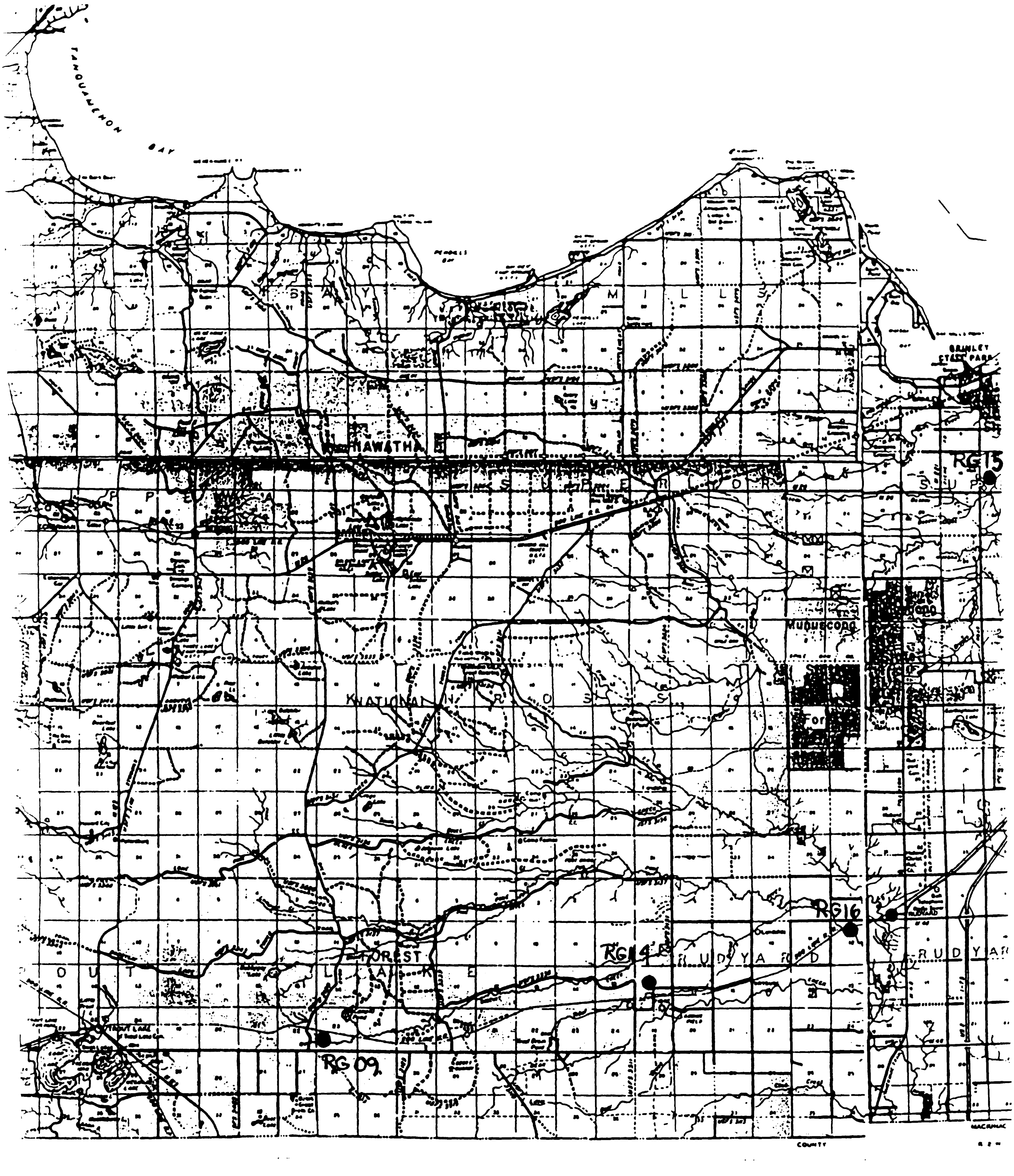
Gauge No. Under Canopy	Community Type	Stand #	Gauge No. in Associated Clearing	Net Difference in Total Precipitation (10/8-10/10) in mm
17	Aspen Sapling	33	6	-6.59
18	Northern Hardwoods	31	6	-2.34
19	Lowland Conifer	32	4	-9.11
20	Jack Pine	24	13	-6.83
21	Red Pine	43	8	-2.82

Table 21: Precipitation (mm of water) during the October SIR-C/X-SAR Experiment

Gauges in Clearings	UTM Coordinates		Daily Precipitation (mm)			Total Precipitation (mm) (9/29 to 10/10)
			10/8/94	10/9/94	10/10/94	
RG01	653398.85	5124818.76	1.50	9.71	4.30	15.51
RG02	652479.55	5134204.71	1.34	10.41	5.84	17.59
RG03	647640.57	5149001.97	1.67	10.64	5.55	17.86
RG04	656312.88	5148039.79	1.14	11.34	4.35	16.83
RG05	660790.98	5146916.28		11.99	3.92	15.91
RG06	660899.85	5143693.21	1.53	11.51	4.91	17.95
RG07	658619.88	5140909.63	1.73	10.87	5.37	17.97
RG08	661123.74	5134324.47	1.96	9.91	2.46	14.33
RG09	661386.03	5116773.78	0.00	10.30	2.20	12.50
RG10	670155.78	5146167.49	2.68	11.93	4.01	18.62
RG11	668914.72	5135953.98	1.72	8.42	4.25	14.39
RG12	668995.54	5131239.14	2.93	8.98	3.72	15.63
RG13	673771.39	5141224.64	2.36	12.98	5.48	20.82
RG14	675240.93	5119485.00	0.09	8.53	2.49	11.11
RG15	686741.88	5138593.63	0.75	9.82	4.02	14.59
RG16	683283.12	5122152.11	0.39	7.59	2.61	10.59
Average:			1.45	10.31	4.09	15.76
Std. Dev:			0.87	1.46	1.18	2.79
Guages in Forests	UTM Coordinates		10/8/94	10/9/94	10/10/94	Net Precipitation (mm) (10/8 to 10/10)
RG17	660858.63	5143738.68	0.93	7.88	2.55	11.36
RG18	660899.27	5143971.80	0.96	12.01	2.64	15.61
RG19	656312.07	5147989.56	0.00	6.51	1.21	7.72
RG20	673845.39	5138054.15	2.10	8.25	3.64	13.99
RG21	658462.38	5134211.05	1.50	8.60	1.41	11.51
Average:			1.10	8.65	2.29	12.04
Std. Dev:			0.78	2.04	0.99	3.00
All Gauges			10/8/94	10/9/94	10/10/94	Net Precipitation (mm) (10/8 to 10/10)
Average:			1.36	9.91	3.66	14.88
Std. Dev:			0.84	1.72	1.36	3.21

SIR-C/X-SAR Precipitation Gauge Network
Raco, Michigan, October 1994
(Note: also shows locations of stands)




TAHQUAMENON BAY
B A Y M I L L S
BRIMLEY STATE PARK
HIAWATHA
S U P E R I O R
S U P
RG15
NATIONAL FOREST
Mudusconq
RG16
RG14
R U D Y A R D
R U D Y A R
FOREST LAKE
RG09
COUNTY
MACKINAC

6 References

[1] Bergen, K.M., M.C. Dobson, T.L. Sharik, and I. Brodie, Final Report: Structure, Composition, and Above-ground Biomass of SIR-C/X-SAR and ERS-1 Forest Test Stands 1991-1994, Raco Michigan Site , Radiation Laboratory Final Report, 026511-7-F, 1995.

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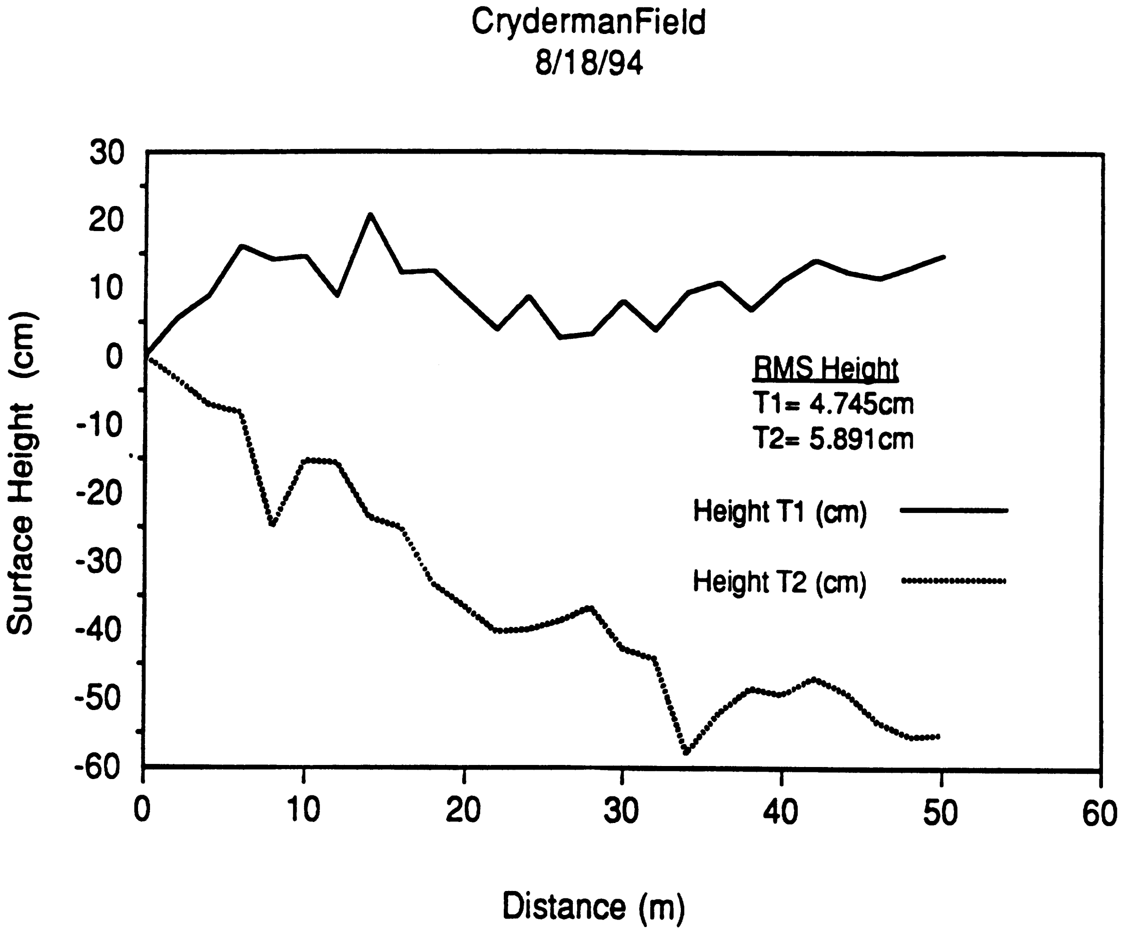
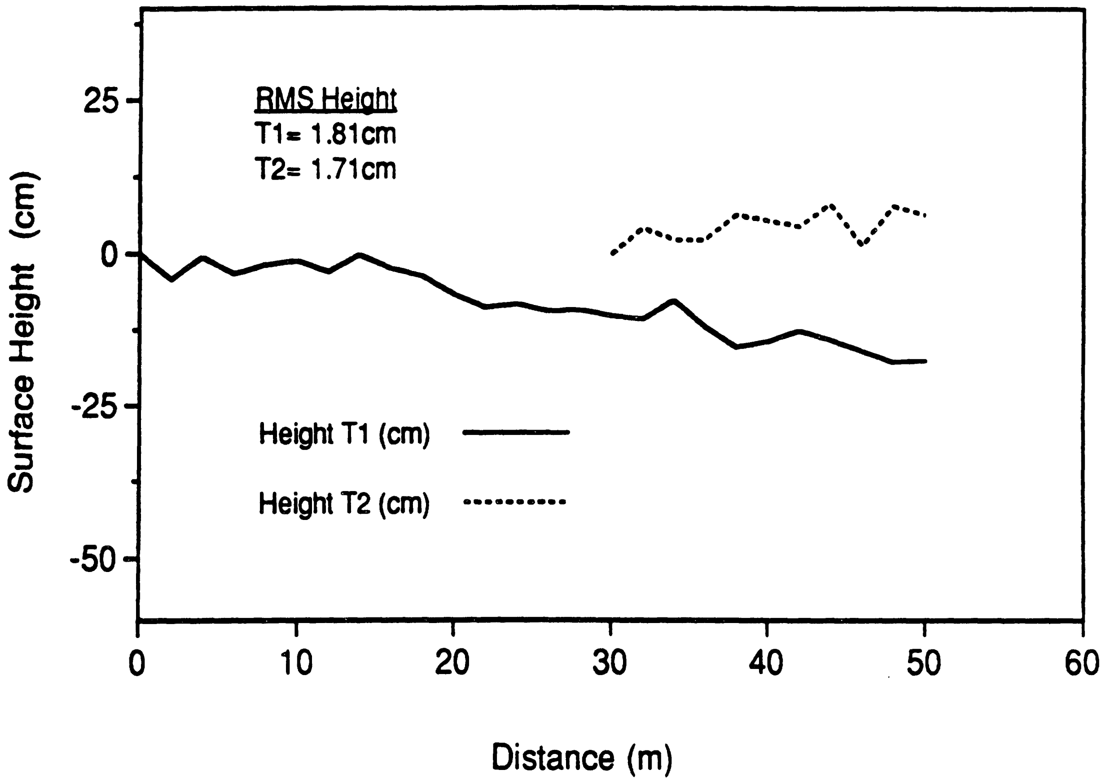
[3] Norman, J.M and Gower, S.T., "Rapid estimation of leaf area index in conifer and broadleaf plantations," Ecology, 72:1896-900, October 1991.

[4] Brunfeldt, D.R. Manual for portable dielectric probe, Applied Microwave Corp: Lawrence, KS, January 1989.

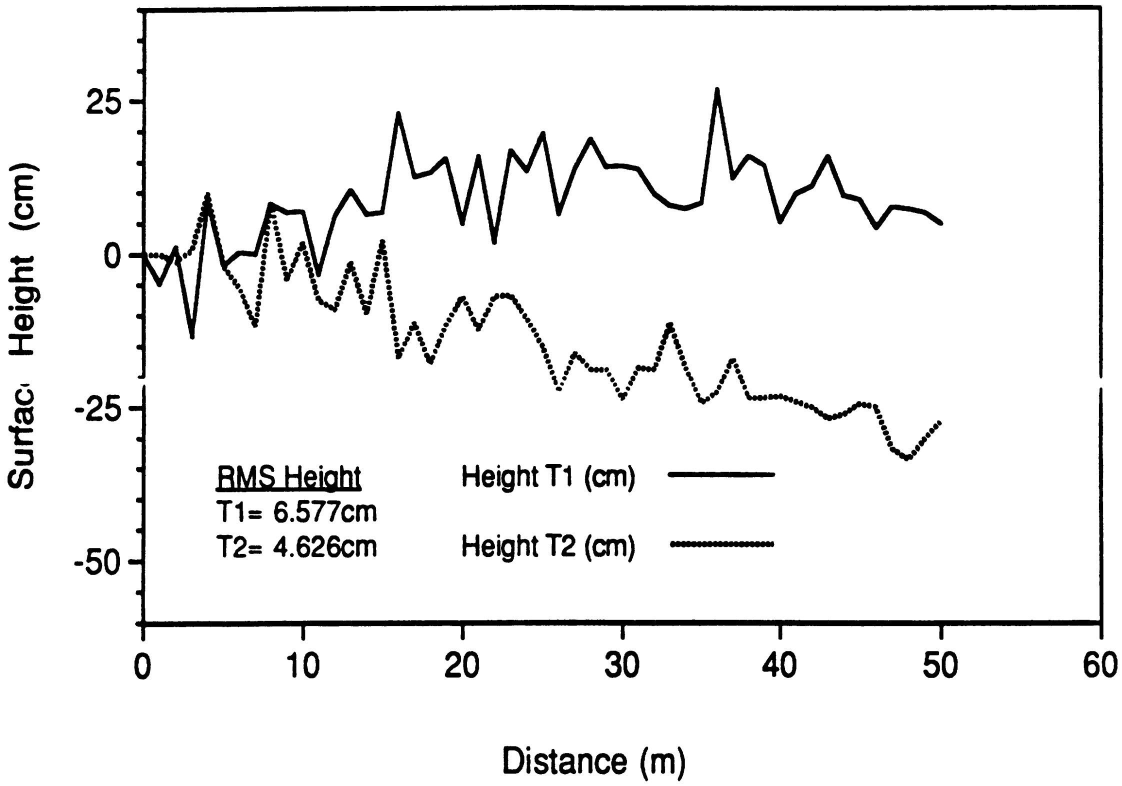
APPENDIX A:

FOREST LARGE SCALE ROUGHNESS PLOTS


CrydermanField
8/18/94
30
20
10
0
-10
-20
-30
-40
-50
-60
Surface Height (cm)
0
10
20
30
40
50
60
Distance (m)
RMS Height
T1= 4.745cm
T2= 5.891cm
Height T1 (cm)
Height T2 (cm)

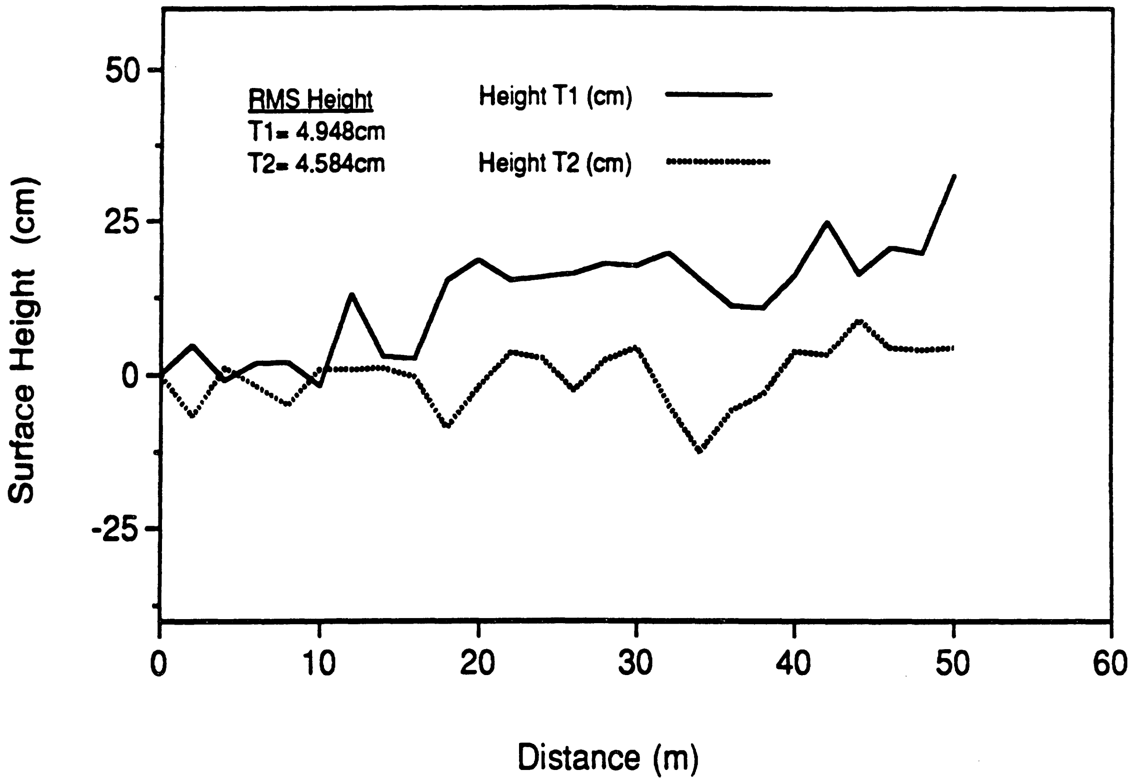


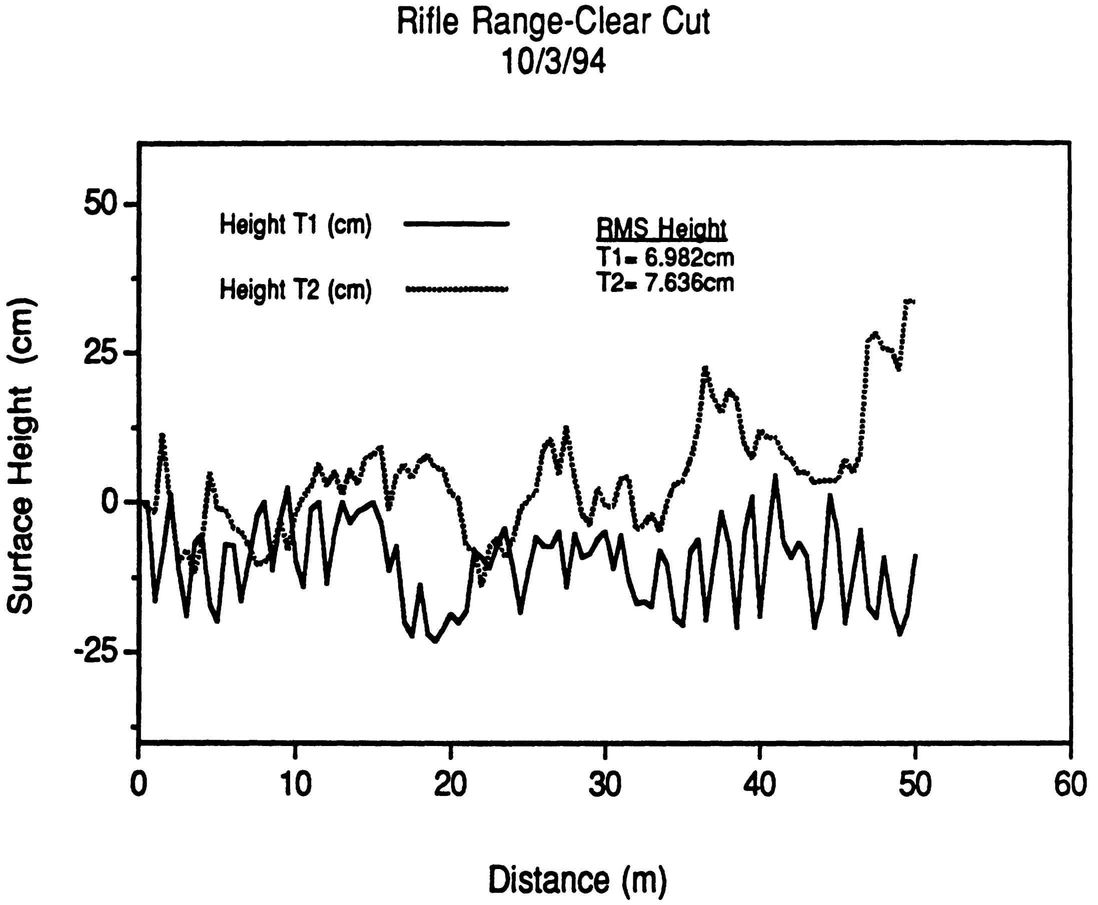
Rifle Range-Surface 1
8/17/94



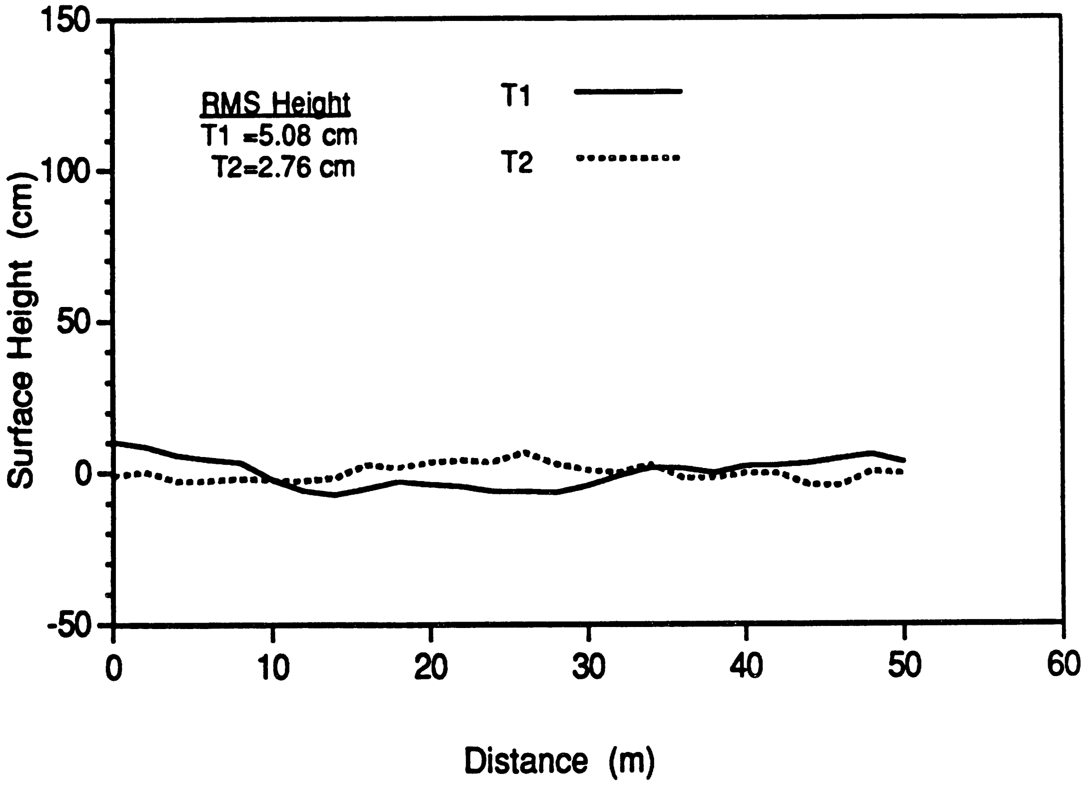
Rifle Range-Surface 2
8/17/94

Rifle Range-Surface 3
8/18/94

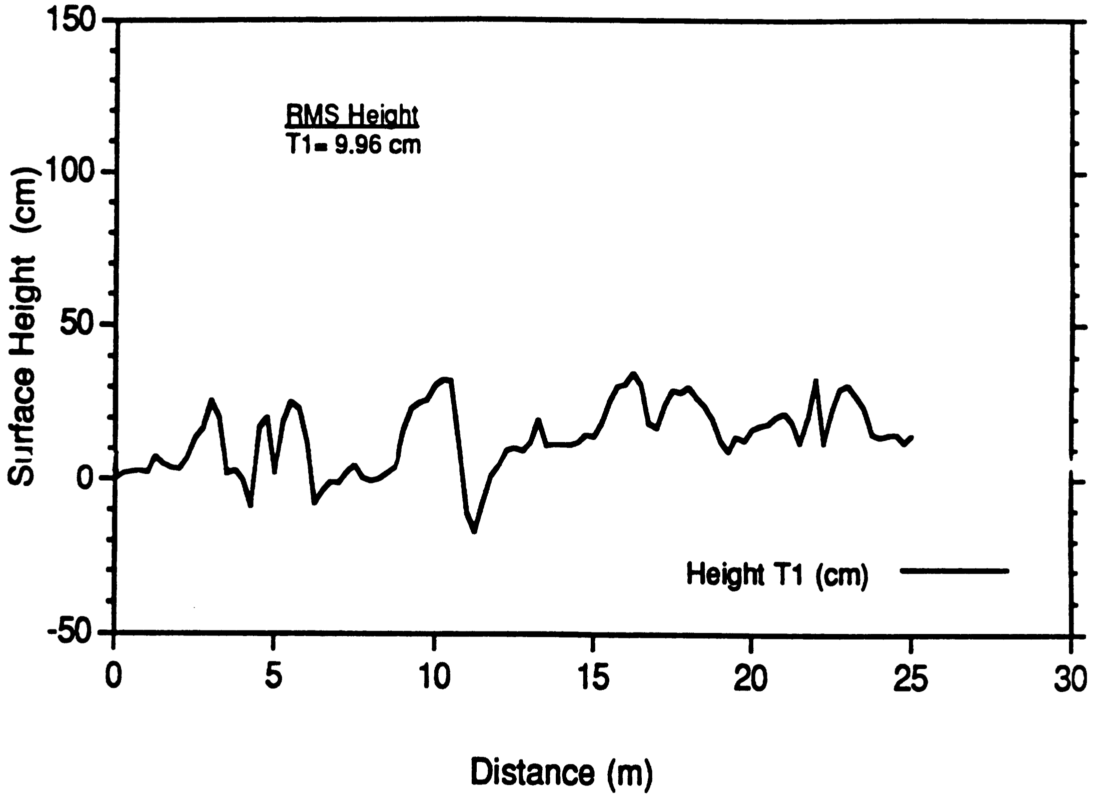


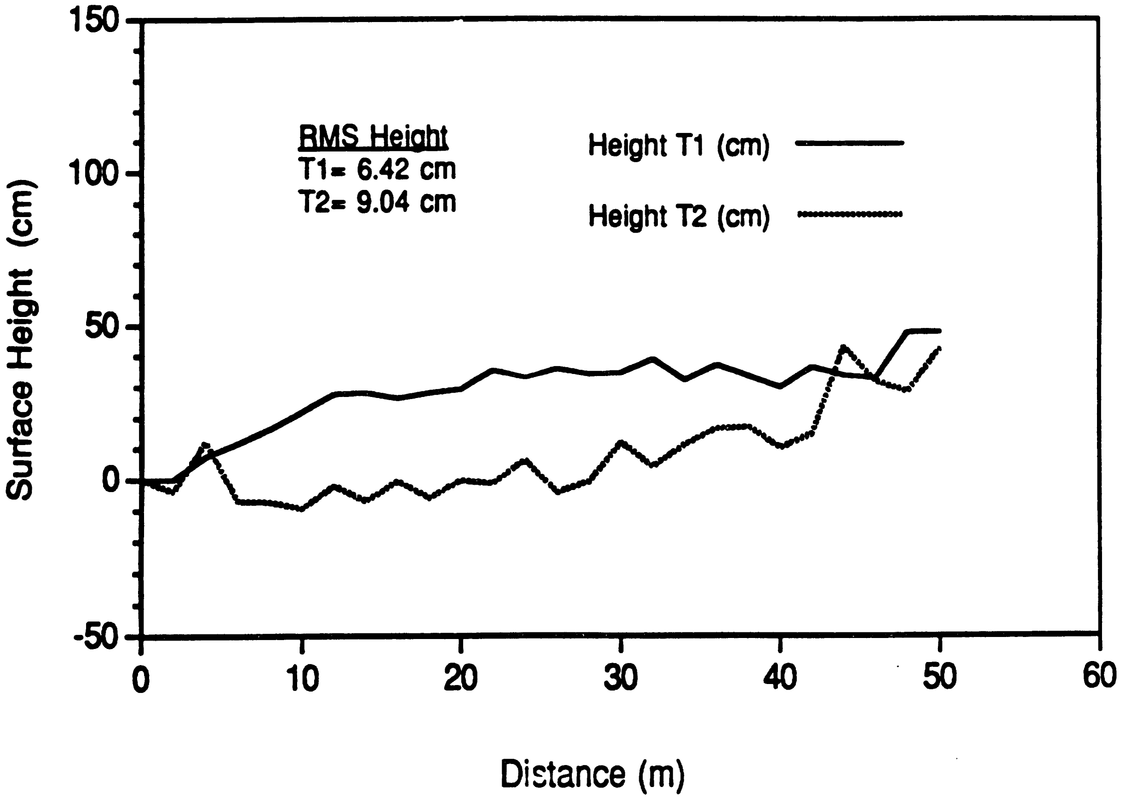

Rifle Range-Clear Cut
10/3/94
Height T1 (cm)
Height T2 (cm)
RMS Height
T1= 6.982cm
T2= 7.636cm
Surface Height (cm)
50
25
0
-25
0
10
20
30
40
50
60
Distance (m)

Stand 22
Red Pine Plantation
8/19/94

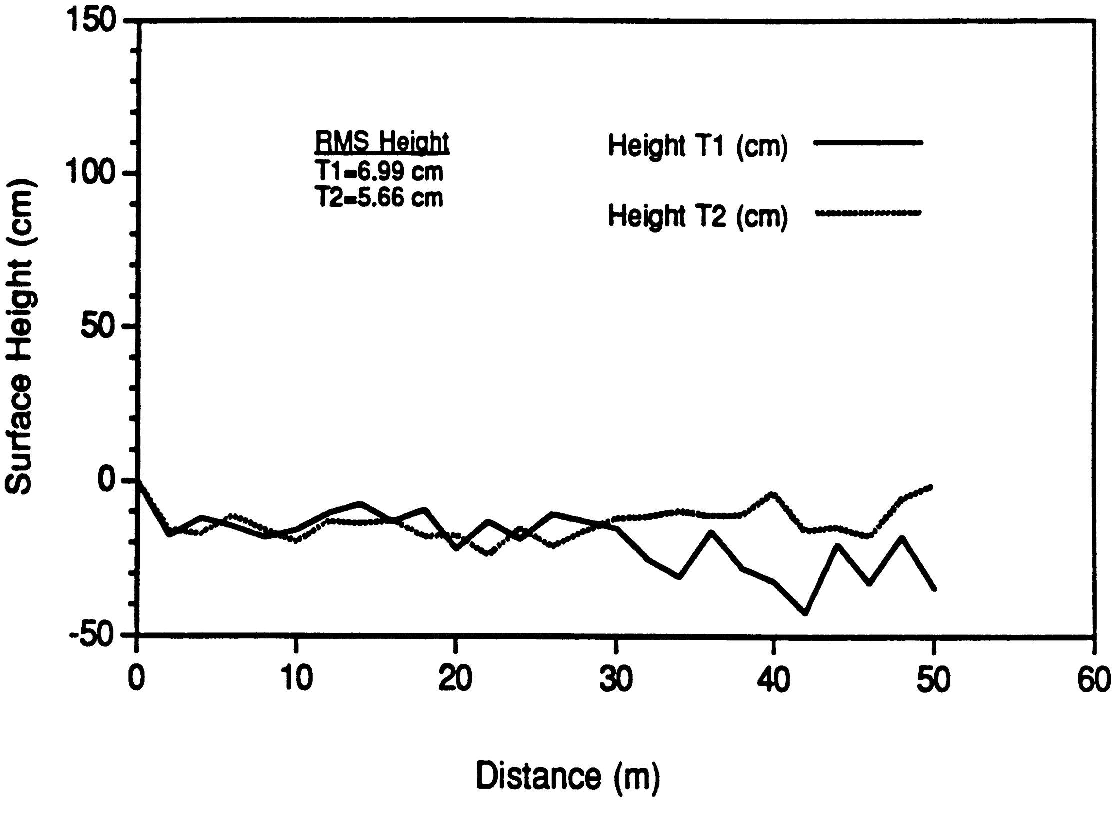


Stand 23
Mature Red and White Pine Plantation
10/10/94

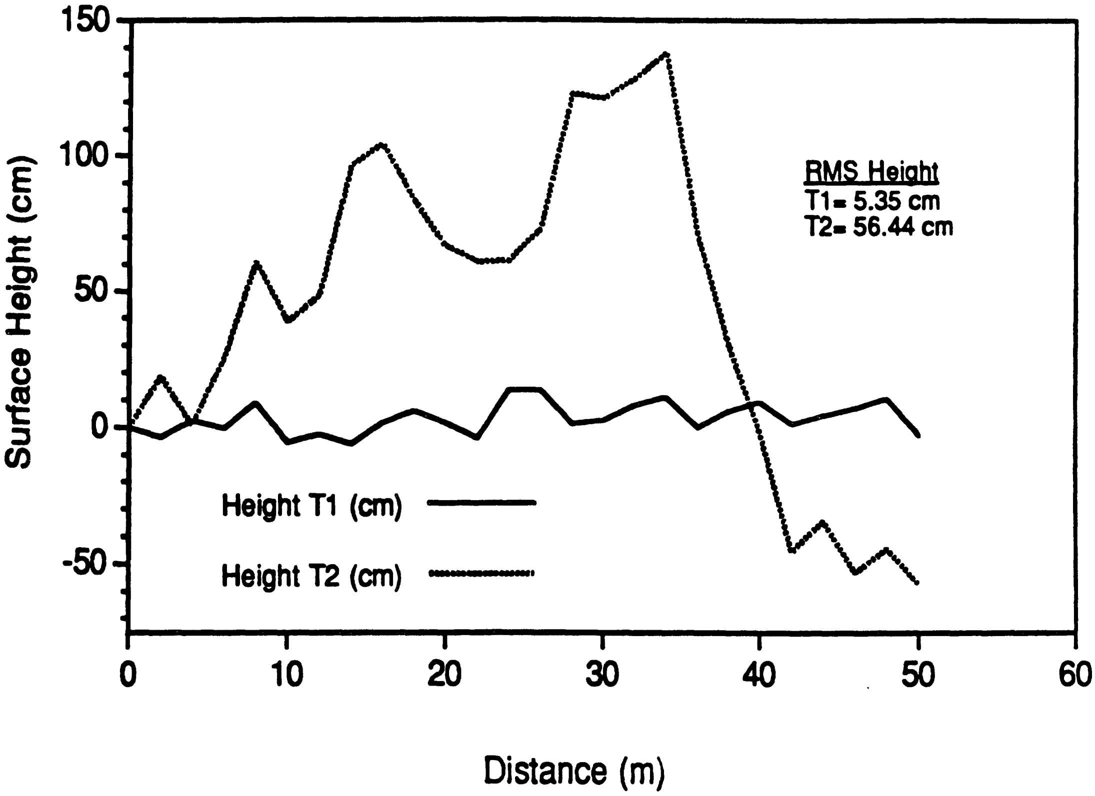




Stand 24
Pole Size Jack Pine Plantation
8/19/94



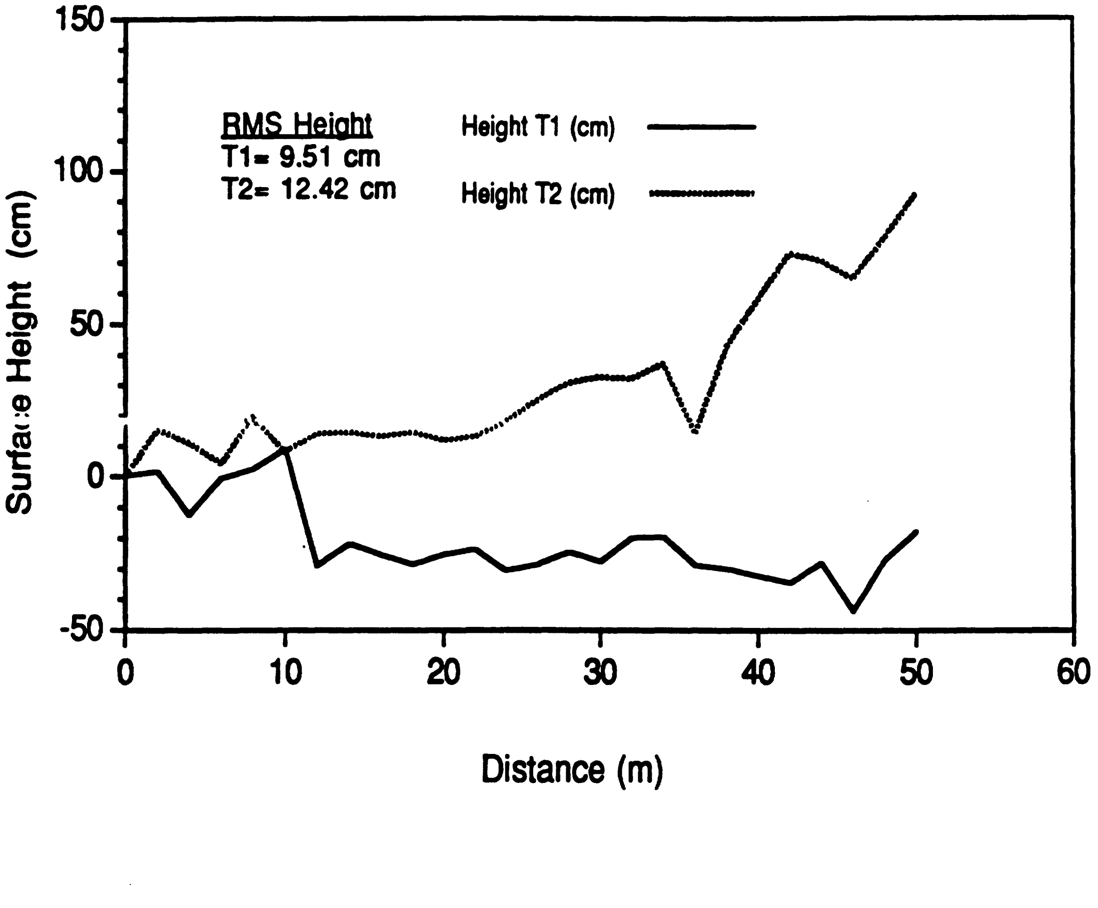
Stand 31
Pole Size Northern Hardwood
8/18/94



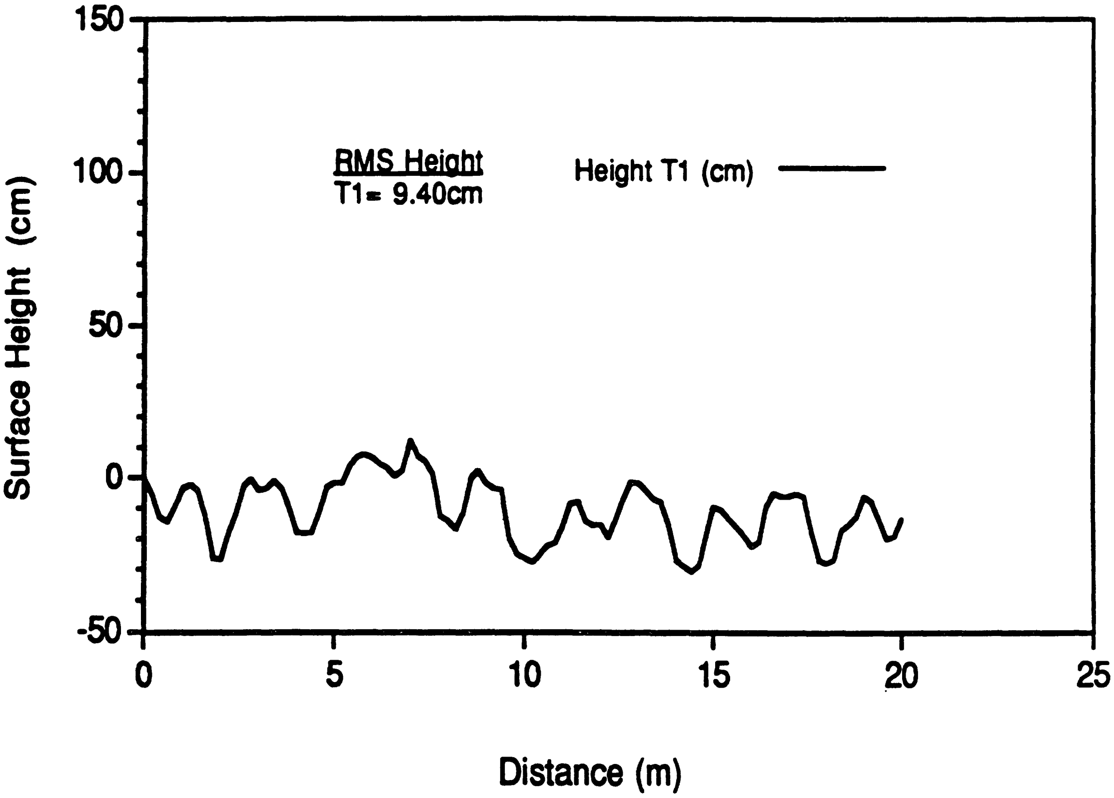
Stand 32
Mature Northern White-Cedar
8/18-8/19/94

RMS Height
T1= 5.35 cm
T2= 56.44 cm

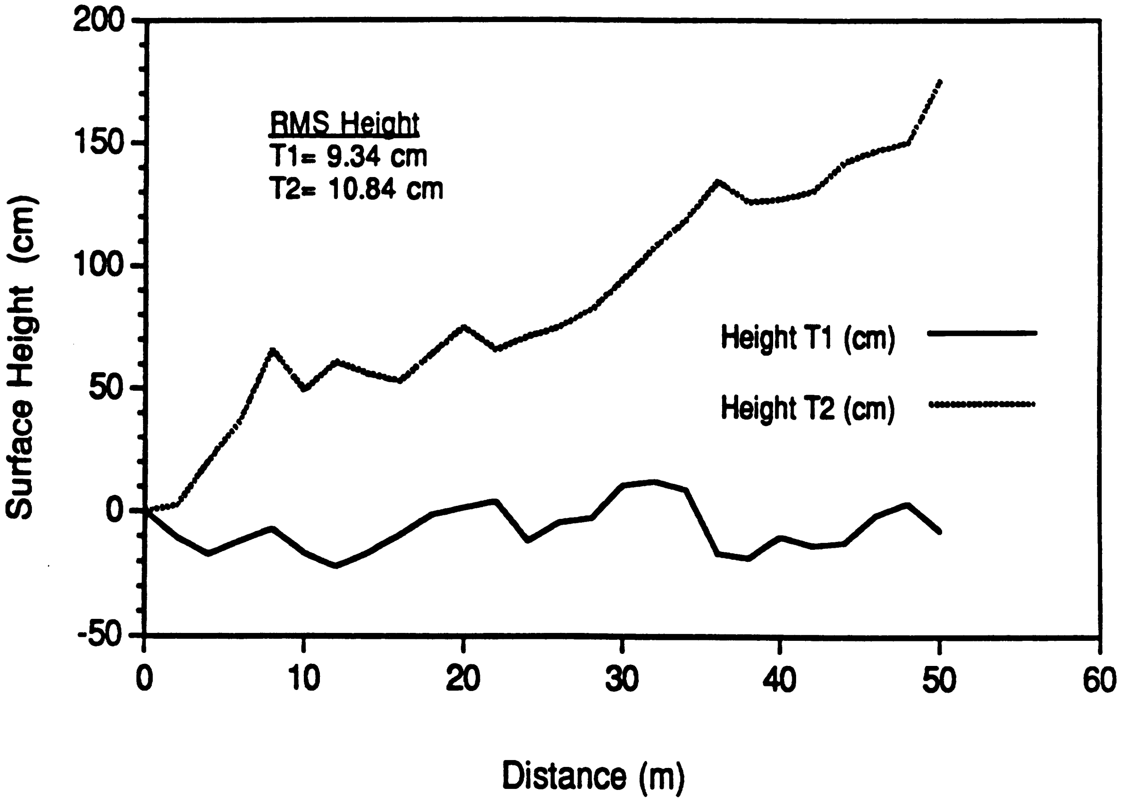
Stand 33
Aspen Sapling
8/18-8/19/94



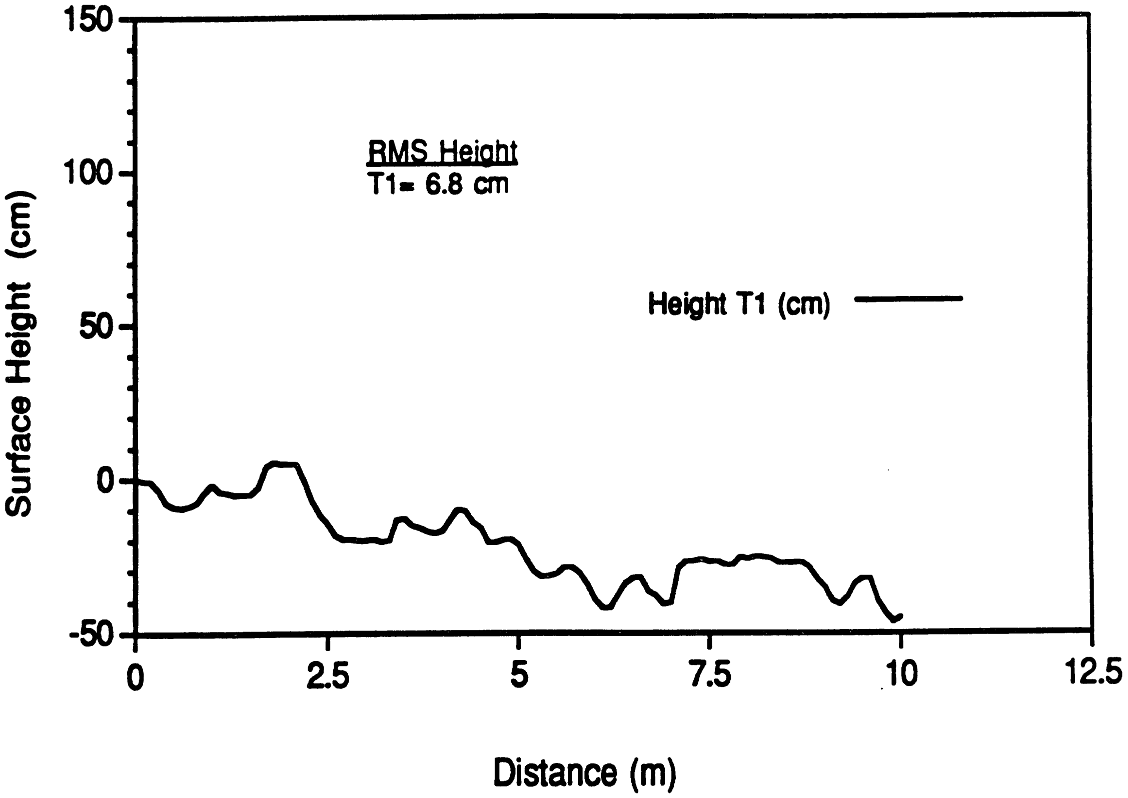
Stand 43
Mature Red Pine Plantation
10/11/94



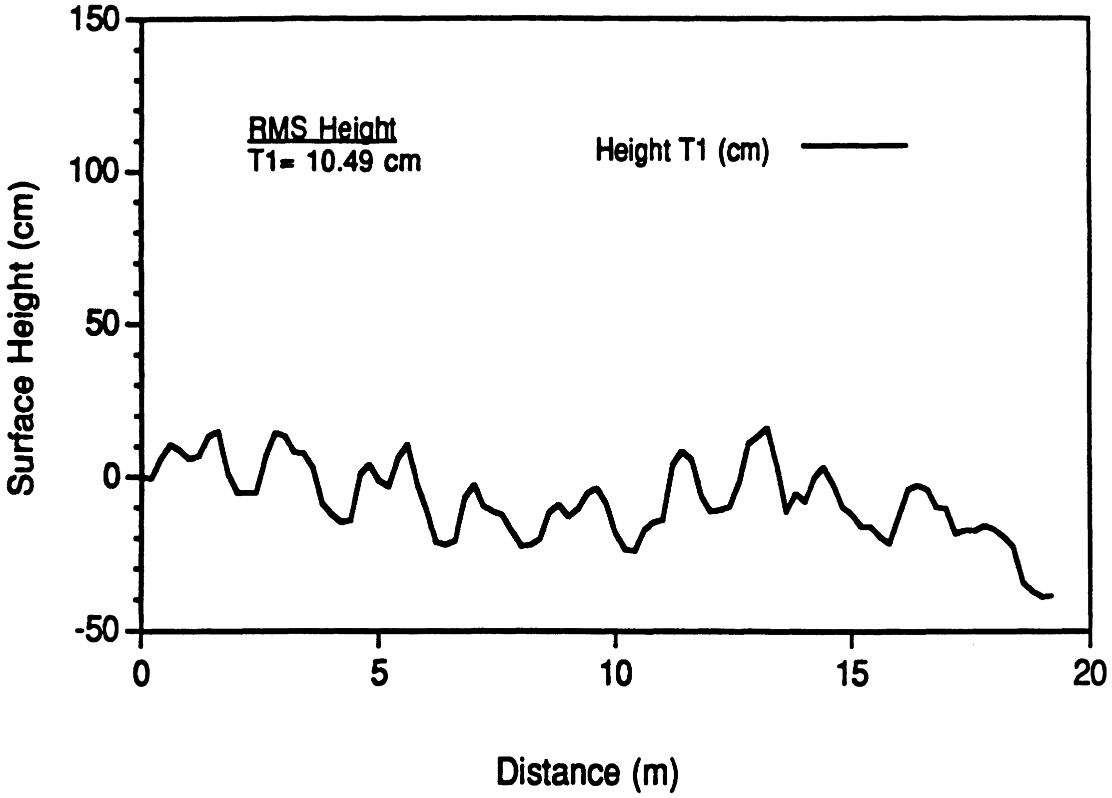
Stand 44
Mature Black Spruce
8/18-8/19/94



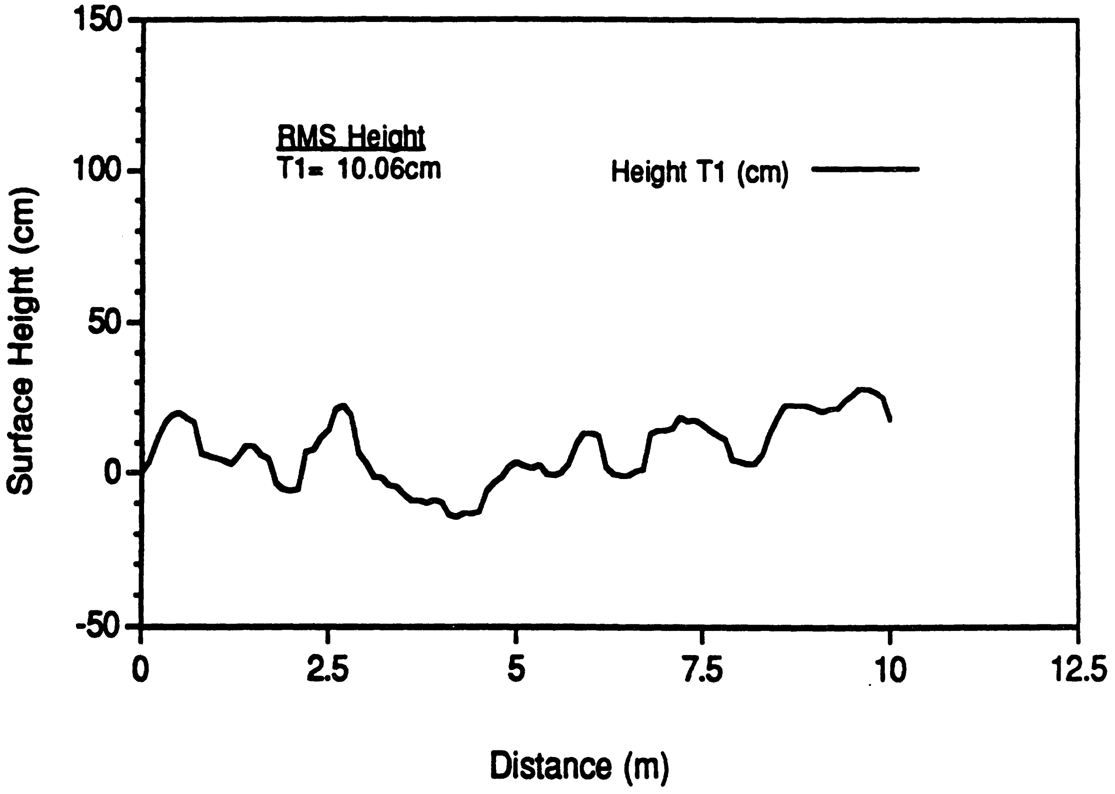
Stand 51
Sapling Red Pine Plantation
10/10/94

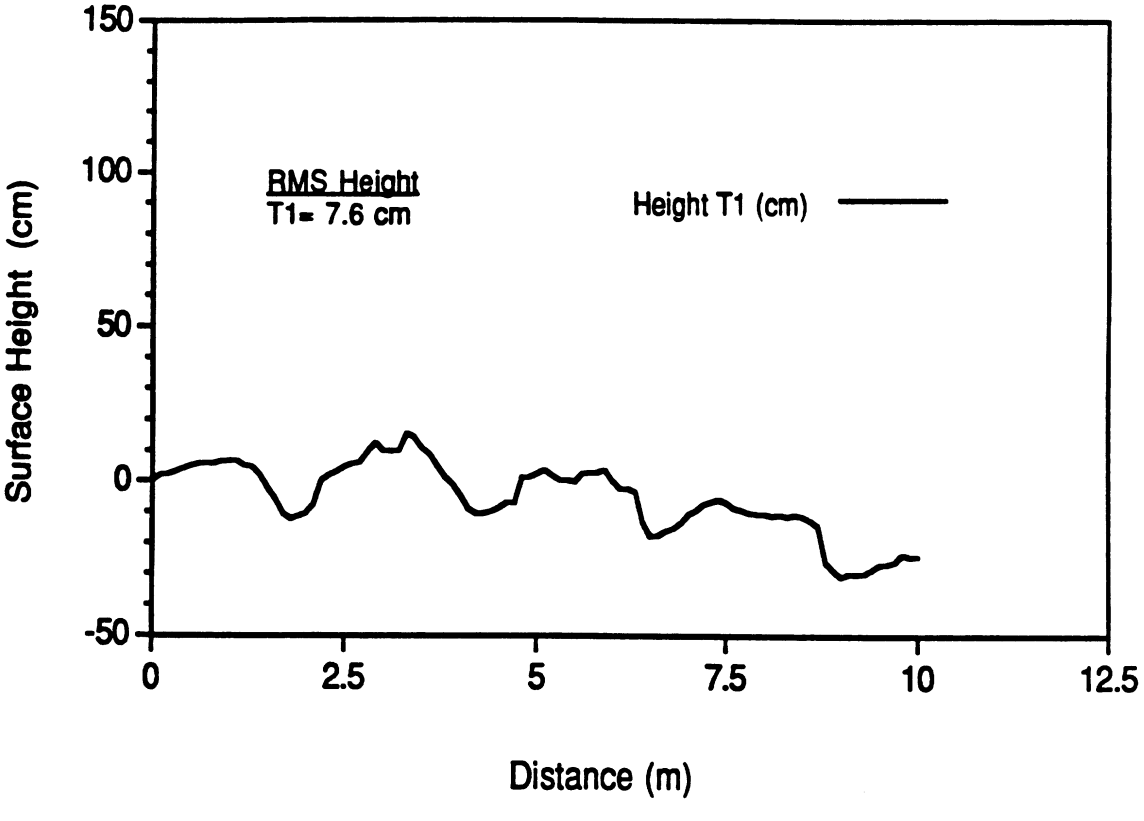


Stand 75
Mature White Pine Plantation
10/11/94



Stand 78
Seedling Red Pine Plantation
10/10/94





Stand 80
Seedling Red Pine Plantation
10/10/94

APPENDIX B:
SOIL MOISTURE IN FOREST STANDS AND CLEARINGS

Key to Abbreviations

Key of Abbreviations

n.c. = not collected

n.v. = non-volumetric

bcore = big core

minsoil = mineral soil

RR = Rifle Range

TR = Trihedral

T = Transect

n.l. = no litter

9/30/94

Location	Sample Cod	Wet Wt. (g)	Dry Wt. (g)	Core Volume	Comments	Organic Layer Depth (cm)	Organic Layer Gravimetric Moisture (dry wt g/g)	Mineral Soil Gravimetric Moisture (dry wt g/g)	Bulk Density (g/cm^3)	Volumetric Moisture (cm^3/cm^3)
Cryderman	TR1-1	82.30	62.50	43.42				0.32	1.44	0.46
Cryderman	TR1-2	59.50	47.80	43.42				0.24	1.10	0.27
Cryderman	TR1-3	69.40	48.60	43.42				0.43	1.12	0.48
Cryderman	TR1-23									
Mean		*70.40*	*52.97*					*0.33*	*1.22*	*0.40*
Stdev		*11.43*	*8.27*					*0.09*	*0.19*	*0.11*
Raco Air	1.00	77.00	68.90	43.42				0.12	1.59	0.19
Raco Air	2.00	77.50	65.60	43.42				0.18	1.51	0.27
Raco Air	3.00	79.20	66.70	43.42				0.19	1.54	0.29
Mean		*77.90*	*67.07*					*0.16*	*1.54*	*0.25*
Stdev		*1.15*	*1.68*					*0.04*	*0.04*	*0.05*
RRS1	1.00	61.40	53.40	43.42				0.15	1.23	0.18
RRS1	2.00	64.80	58.10	43.42				0.12	1.34	0.15
RRS1	3.00	70.80	66.00	43.42				0.07	1.52	0.11
Mean		*65.67*	*59.17*					*0.11*	*1.36*	*0.15*
Stdev		*4.76*	*6.37*					*0.04*	*0.15*	*0.04*
RRS2	1A	69.90	65.80	43.42				0.06	1.52	0.09
RRS2	1B									
RRS2	2A	54.80	48.00	43.42				0.14	1.11	0.16
RRS2	2B									
RRS2	3A	73.20	66.40	43.42				0.10	1.53	0.16
RRS2	3B									
Mean		*65.97*	*60.07*					*0.10*	*1.38*	*0.14*
Stdev		*9.81*	*10.45*					*0.04*	*0.24*	*0.04*
RRS3	1.00	56.30	50.00	43.42				0.13	1.15	0.15
RRS3	2.00	53.40	45.90	43.42				0.16	1.06	0.17
RRS3	3.00	45.90	39.20	43.42				0.17	0.90	0.15
Mean		*51.87*	*45.03*					*0.15*	*1.04*	*0.16*
Stdev		*5.37*	*5.45*					*0.02*	*0.13*	*0.01*

					9/30/94					
Location	Sample Code	Wet Wt. (g)	Dry Wt. (g)	Core Volume	Comments	Organic Layer Depth (cm)	Organic Layer Gravimetric Moisture (dry wt g/g)	Mineral Soil Gravimetric Moisture (dry wt g/g)	Bulk Density (g/cm^3)	Volumetric Moisture (cm^3/cm^3)
Stand 22	T1-1									
Stand 22	T1-3									
Stand 22	T1-5									
Stand 22	T1-5A									
Stand 22	T1-5B									
Stand 22	T4-1A	37.20	23.90		1cm hum., n.v.	1	0.56			
Stand 22	T4-1B	67.80	56.20	43.42	min. soil			0.21	1.29	0.27
Stand 22	T4-3A	59.10	52.10	43.42	min. soil			0.13	1.20	0.16
Stand 22	T4-3B									
Stand 22	T4-5A	29.70	21.90		1 cm hum n.v.	1	0.36			
Stand 22	T4-5B	77.20	64.10	43.42	min soi l			0.20	1.48	0.30
Mean		***54.20***	***43.64***			***1***	***0.46***	***0.18***	***1.32***	***0.24***
Stdev		***20.17***	***19.43***			***0***	***0.14***	***0.04***	***0.14***	***0.07***
Stand 31	T4-1A	46.10	25.00		2cm hum. n.v.	2	0.84			
Stand 31	T4-1B	127.50	107.00	125.80	5cm b. core, min. soil			0.19	0.85	0.16
Stand 31	T4-3A	46.60	22.00		2cm hum. , n.v.	2	1.12			
Stand 31	T4-3B	167.30	146.60	125.80	5cm b. core, min. soil			0.14	1.17	0.16
Stand 31	T4-5A	44.80	19.80		2.5cm hum. , n.v.	3	1.26			
Stand 31	T4-5B	121.80	93.20	125.80	5cm b. core, min. soil			0.31	0.74	0.23
Stand 31	T5-1A									
Stand 31	T5-1B									
Stand 31	T5-3									
Stand 31	T5-5A									
Stand 31	T5-5B									
Mean		***92.35***	***68.93***			***2***	***1.07***	***0.21***	***0.92***	***0.18***
Stdev		***53.32***	***54.07***			***0***	***0.21***	***0.08***	***0.22***	***0.04***
Stand 32	T1-1									
Stand 32	T1-3									
Stand 32	T1-5									
Mean										
Stdev										

9/30/94

Location	Sample Code	Wet Wt. (g)	Dry Wt. (g)	Core Volume	Comments	Organic Layer Depth (cm)	Organic Layer Gravimetric Moisture (dry wt g/g)	Mineral Soil Gravimetric Moisture (dry wt g/g)	Bulk Density (g/cm^3)	Volumetric Moisture (cm^3/cm^3)
Stand 34	T1-1A									
Stand 34	T1-1B									
Stand 34	T1-3									
Stand 34	T1-5									
Stand 34	T2-1A	85.30	49.60		2cm hum., n.v.	2	0.72			
Stand 34	T2-1B	66.20	58.70	43.42	min. soil			0.13	1.35	0.17
Stand 34	T2-3A	74.80	24.80		2cm hum., n.v.	2	2.02			
Stand 34	T2-3B	74.30	58.70	43.42	min. soil			0.27	1.35	0.36
Stand 34	T2-5A	130.70	58.30		7cm hum., n.v.	7	1.24			
Stand 34	T2-5B	91.50	73.50		min. soil, n.v.			0.24		
Stand 34	T5-1									
Stand 34	T5-3A									
Stand 34	T5-3B									
Stand 34	T5-5A									
Stand 34	T5-5B									
Mean		*87.13*	*53.93*			*4*	*1.33*	*0.21*	*1.35*	*0.27*
Stdev		*23.13*	*16.22*			*3*	*0.65*	*0.07*	*0.00*	*0.13*

					10/1/94					
Location	Sample Cod	Wet Wt. (g)	Dry Wt. (g)	Core Volume	Comments	Organic Layer Depth (cm)	Organic Layer Gravimetric Moisture	Mineral Soil Gravimetric Moisture (dry wt g/g)	Mineral Soil Bulk Density (g/cm^3	Mineral Soil Volumetric Moisture (cm^3/cm^3)
Cryderman	TR1-1	64.8	46.9	43.42				0.38	1.08	0.41
Cryderman	TR1-2	64.4	54.1	43.42				0.19	1.25	0.24
Cryderman	TR1-3	70.6	48.7	43.42				0.45	1.12	0.50
Cryderman	TR1-23									
Mean		***66.60***	***49.90***					***0.34***	***1.15***	***0.38***
Stdev		***3.47***	***3.75***					***0.13***	***0.09***	***0.14***
Haco Air	1 00	70.3	60	43.42				0.17	1.38	0.24
Raco Air	2 00	78.1	64.9	43.42				0.20	1.49	0.30
Haco Air	3 00	73.4	60.1	43.42				0.22	1.38	0.31
Mean		***73.93***	***61.67***					***0.20***	***1.42***	***0.28***
Stdev		***3.93***	***2.80***					***0.03***	***0.06***	***0.04***
RRS1	1 00	72.9	66.3	43.42				0.10	1.53	0.15
RRS1	2 00	71.6	64.7	43.42				0.11	1.49	0.16
RRS1	3.00	67.7	57.2	43.42				0.18	1.32	0.24
Mean		***70.73***	***62.73***					***0.13***	***1.44***	***0.18***
Stdev		***2.71***	***4.86***					***0.05***	***0.11***	***0.05***
RRS2	1A	62.7	58.7	43.42	ridge top			0.07	1.35	0.09
RRS2	1B	61	54.5	43.42	furrow bottom			0.12	1.26	0.15
RRS2	2A	59.5	56	43.42	top			0.06	1.29	0.08
RRS2	2B	60.9	55.6	43.42	bottom			0.10	1.28	0.12
RRS2	3A	57.9	54.6	43.42	top			0.06	1.26	0.08
RRS2	3B	59.4	54.3	43.42	bottom			0.09	1.25	0.12
Mean		***60.40***	***55.88***					***0.08***	***1.29***	***0.10***
Stdev		***1.80***	***1.70***					***0.03***	***0.04***	***0.03***
RRS3	1.00	55.3	47.9	43.42				0.15	1.10	0.17
RRS3	2 00	55.8	49.4	43.42				0.13	1.14	0.15
RRS3	3 00	62.1	54.9	43.42				0.13	1.26	0.17
Mean		***57.73***	***50.73***					***0.14***	***1.17***	***0.16***
Stdev		***3.79***	***3.69***					***0.01***	***0.08***	***0.01***

					10/1/94					
Location	**Sample Code**	**Wet Wt. (g)**	**Dry Wt. (g)**	**Core Volume**	**Comments**	**Organic Layer Depth (cm)**	**Organic Layer Gravimetric Moisture**	**Mineral Soil Gravimetric Moisture (dry wt g/g)**	**Mineral Soil Bulk Density (g/cm^3**	**Mineral Soil Volumetric Moisture (cm^3/cm^3)**
Stand 32	T1-1	73.5	17.8		organic, n.v	20	3.13			
Stand 32	T1-3	62.3	16.1		organic, n.v	21	2.87			
Stand 32	T1-5	86.2	16.1		organic, n.v	22	4.35			
Mean		***74.00***	***16.67***			***21***	***3.45***			
Stdev		***11.96***	***0.98***			***1***	***0.79***			
Stand 43	T5-1	58.1	49.6	43.42				0.17	1.14	0.20
Stand 43	T5-3	60.8	50.7	43.42				0.20	1.17	0.23
Stand 43	T5-5A	49.9	35.6	43.42				0.40	0.82	0.33
Stand 43	T5-5B									
Mean		***56.27***	***45.30***					***0.26***	***1.04***	***0.25***
Stdev		***5.68***	***8.42***					***0.13***	***0.19***	***0.07***
Stand 44	T1-1A	23.4	17.55	28.95	swampy, 2 @5 cm			0.33	0.40	0.13
Stand 44	T1-1B	52.7	48.2	28.95	2@5-10 cm			0.09	1.11	0.10
Stand 44	T1-2A	67.7	53.6	28.95	2@ top 5cm			0.26	1.23	0.32
Stand 44	T1-2B	38.3	18	28.95	5-10cm (2@)			1.13	0.41	0.47
Stand 44	T1-3A	79.3	45.7		not vol. below 40cm moss			0.74		
Stand 44	T1-3B	128.2	34.5		not vol. moss 5x	5	2.72			
Mean		***64.93***	***36.26***			***5***	***2.72***	***0.51***	***0.79***	***0.26***
Stdev		***36.88***	***15.61***					***0.42***	***0.44***	***0.17***

					10/4/94					
Location	Sample Cod	Wet Wt. (g)	Dry Wt. (g)	Core Volume	Comments	Organic Layer Depth (cm)	Organic Layer Gravimetric Moisture	Mineral Soil Gravimetric Moisture (dry wt g/g)	Mineral Soil Bulk Density (g/cm^3	Mineral Soil Volumetric Moisture (cm^3/cm^3)
Cryderman	TR1-1									
Cryderman	TR1-2	65.1	53.1	43.42				0.23	1.22	0.28
Cryderman	TR1-3	71.5	54.6	43.42				0.31	1.26	0.39
Cryderman	TR1-23	67.8	47.7	43.42				0.42	1.10	0.46
Mean		***68.30***	***53.85***					***0.27***	***1.24***	***0.33***
Stdev		***4.53***	***1.06***					***0.06***	***0.02***	***0.08***
Raco Air	1.00	77.6	65	43.42				0.19	1.50	0.29
Raco Air	2.00	70	59.8	43.42				0.17	1.38	0.23
Raco Air	3.00	75.2	62.3	43.42				0.21	1.43	0.30
Mean		***74.27***	***62.37***					***0.19***	***1.44***	***0.27***
Stdev		***3.89***	***2.60***					***0.02***	***0.06***	***0.03***
RR S1	1.00	62.5	57.4	43.42				0.09	1.32	0.12
RR S1	2.00	66.2	60	43.42				0.10	1.38	0.14
RR S1	3.00	60.8	54.9	43.42				0.11	1.26	0.14
Mean		***63.17***	***57.43***					***0.10***	***1.32***	***0.13***
Stdev		***2.76***	***2.55***					***0.01***	***0.06***	***0.01***
RR S2	1A	58.6	53.6	43.42				0.09	1.23	0.12
RR S2	1B									
RR S2	2A	50.2	46.5	43.42				0.08	1.07	0.09
RR S2	2B									
RR S2	3A	48.1	43.1	43.42				0.12	0.99	0.12
RR S2	3B									
Mean		***52.30***	***47.73***					***0.10***	***1.10***	***0.11***
Stdev		***5.56***	***5.36***					***0.02***	***0.12***	***0.02***
RR S3	1.00	55	49.7	43.42				0.11	1.14	0.12
RR S3	2.00	58.1	53.3	43.42				0.09	1.23	0.11
RR S3	3.00	54.4	49	43.42				0.11	1.13	0.12
Mean		***55.83***	***50.67***					***0.10***	***1.17***	***0.12***
Stdev		***1.99***	***2.31***					***0.01***	***0.05***	***0.01***

					10/4/94					
Location	Sample Cod	Wet Wt. (g)	Dry Wt. (g)	Core Volume	Comments	Organic Layer Depth (cm)	Organic Layer Gravimetric Moisture	Mineral Soil Gravimetric Moisture (dry wt g/g)	Mineral Soil Bulk Density (g/cm^3	Mineral Soil Volumetric Moisture (cm^3/cm^3)
Stand 24	T5-1	42.3	35.5	43.42				0.19	0.82	0.16
Stand 24	T5-3	43.4	33.8	43.42				0.28	0.78	0.22
Stand 24	T5-5A	48	40.1	43.42				0.20	0.92	0.18
Stand 24	T5-5B									
Mean		***44.57***	***36.47***					***0.22***	***0.84***	***0.19***
Stdev		***3.02***	***3.26***					***0.05***	***0.08***	***0.03***
Stand 33	T5-1	50.75	41.3	43.42	1-3 cm humus			0.23	0.95	0.22
Stand 33	T5-3	55.2	45.4	43.42				0.22	1.05	0.23
Stand 33	T5-5A	54.3	45.5	43.42	1-3 cm humus			0.19	1.05	0.20
Stand 33	T5-5B									
Stand 33	T6-1	55.6	45.1	43.42				0.23	1.04	0.24
Mean		***53.96***	***44.33***					***0.22***	***1.02***	***0.22***
Stdev		***2.21***	***2.02***					***0.02***	***0.05***	***0.02***
Stand 37	T1-3									
Stand 37	T5-1	52.1	44.9	43.42				0.16	1.03	0.17
Stand 37	T5-3	57.8	49.4	43.42				0.17	1.14	0.19
Stand 37	T5-5	49.5	42.5	43.42				0.16	0.98	0.16
Mean		***53.13***	***45.60***					***0.17***	***1.05***	***0.17***
Stdev		***4.25***	***3.50***					***0.00***	***0.08***	***0.02***
Stand 38	T3-1	55.1	53	43.42				0.04	1.22	0.05
Stand 38	T3-3	56.96	52.6	43.42				0.08	1.21	0.10
Stand 38	T3-5	59	52.5	43.42				0.12	1.21	0.15
Stand 38	T5-1									
Stand 38	T5-3									
Stand 38	T5-5									
Mean		***57.02***	***52.70***					***0.08***	***1.21***	***0.10***
Stdev		***1.95***	***0.26***					***0.04***	***0.01***	***0.05***

10/5/94

Location	Sample Cod	Wet Wt. (g)	Dry Wt. (g)	Core Volume	Comments	Organic Layer Depth (cm)	Organic Layer Gravimetric Moisture	Mineral Soil Gravimetric Moisture (dry wt g/g)	Mineral Soil Bulk Density (g/cm^3	Mineral Soil Volumetric Moisture (cm^3/cm^3)
Cryderman	TR1-1									
Cryderman	TR1-2	65.3	51.5	43.42				0.27	1.19	0.32
Cryderman	TR1-3	72.9	56.7	43.42				0.29	1.31	0.37
Cryderman	TR1-23	68	54.6	43.42				0.25	1.26	0.31
Mean		***69.10***	***54.10***					***0.28***	***1.25***	***0.35***
Stdev		***5.37***	***3.68***					***0.01***	***0.08***	***0.04***
Haco Air	1.00	63.7	52.7	43.42				0.21	1.21	0.25
Haco Air	2.00	69.1	60.6	43.42				0.14	1.40	0.20
Haco Air	3.00	73.8	61.6	43.42				0.20	1.42	0.28
Mean		***68.87***	***58.30***					***0.18***	***1.34***	***0.24***
Stdev		***5.05***	***4.88***					***0.04***	***0.11***	***0.04***
RR S1	1.00	67.6	59.1	43.42				0.14	1.36	0.20
RR S1	2.00	54.7	48.9	43.42				0.12	1.13	0.13
RR S1	3.00	60.6	55	43.42				0.10	1.27	0.13
Mean		***60.97***	***54.33***					***0.12***	***1.25***	***0.15***
Stdev		***6.46***	***5.13***					***0.02***	***0.12***	***0.04***
RR S2	1A									
RR S2	1B									
RR S2	2A	50.7	47.3	43.42				0.07	1.09	0.08
RR S2	2B									
RR S2	3A	56	51.6	43.42				0.09	1.19	0.10
RR S2	3B									
Mean		***53.35***	***49.45***					***0.08***	***1.14***	***0.09***
Stdev		***3.75***	***3.04***					***0.01***	***0.07***	***0.02***
RR S3	1.00	44.7	40.5	43.42				0.10	0.93	0.10
RR S3	2.00	51.5	45.5	43.42				0.13	1.05	0.14
RR S3	3.00	45.2	43.1	43.42				0.05	0.99	0.05
Mean		***47.13***	***43.03***					***0.09***	***0.99***	***0.09***
Stdev		***3.79***	***2.50***					***0.04***	***0.06***	***0.04***

10/5/94

Location	Sample Cod	Wet Wt. (g)	Dry Wt. (g)	Core Volume	Comments	Organic Layer Depth (cm)	Organic Layer Gravimetric Moisture	Mineral Soil Gravimetric Moisture (dry wt g/g)	Mineral Soil Bulk Density (g/cm^3	Mineral Soil Volumetric Moisture (cm^3/cm^3)
Stand 22	T1-1									
Stand 22	T1-3									
Stand 22	T1-5	67.1	61.7	43.42	2 cm humus			0.09	1.42	0.12
Stand 22	T1-5A	62.5	57.2	43.42	3 cm humus			0.09	1.32	0.12
Stand 22	T1-5B	64	52.8	43.42	4 cm humus			0.21	1.22	0.26
Stand 22	T4-1A									
Stand 22	T4-1B									
Stand 22	T4-3A									
Stand 22	T4-3B									
Stand 22	T4-5A									
Stand 22	T4-5B									
Mean		*64.53*	*57.23*					*0.13*	*1.32*	*0.17*
Stdev		*2.35*	*4.45*					*0.07*	*0.10*	*0.08*
Stand 31	T4-1A									
Stand 31	T4-1B									
Stand 31	T4-3A									
Stand 31	T4-3B									
Stand 31	T4-5A									
Stand 31	T4-5B									
Stand 31	T5-1A	58.3	51.2	43.42	2-5 cm humus			0.14	1.18	0.16
Stand 31	T5-1B	105.8	37.8		2-5cm hum n.v.	3	1.80			
Stand 31	T5-3	53.1	44.9	43.42	2-5 cm humus			0.18	1.03	0.19
Stand 31	T5-5A	63.2	55.8	43.42				0.13	1.29	0.17
Stand 31	T5-5B									
Mean		*70.10*	*47.43*			*3*	*1.80*	*0.15*	*1.17*	*0.17*
Stdev		*24.15*	*7.82*					*0.03*	*0.13*	*0.01*

					10/5/94					
Location	Sample Cod	Wet Wt. (g)	Dry Wt. (g)	Core Volume	Comments	Organic Layer Depth (cm)	Organic Layer Gravimetric Moisture	Mineral Soil Gravimetric Moisture (dry wt g/g)	Mineral Soil Bulk Density (g/cm^3	Mineral Soil Volumetric Moisture (cm^3/cm^3)
Stand 34	T1-1A	54.7	45.5	43.42	2-5 cm humus			0.20	1.05	0.21
Stand 34	T1-1B	91.8	53.9		2-5cm hum n.v.	3	0.70			
Stand 34	T1-3	62.2	54.6	43.42	2-5 cm humus			0.14	1.26	0.18
Stand 34	T1-5	57	47.2	43.42	2-5 cm humus			0.21	1.09	0.23
Stand 34	T2-1A									
Stand 34	T2-1B									
Stand 34	T2-3A									
Stand 34	T2-3B									
Stand 34	T2-5A									
Stand 34	T2-5B									
Stand 34	T5-1									
Stand 34	T5-3A									
Stand 34	T5-3B									
Stand 34	T5-5A									
Stand 34	T5-5B									
Mean		***66.43***	***50.30***			***3***	***0.70***	***0.18***	***1.13***	***0.20***
Stdev		***17.21***	***4.62***					***0.04***	***0.11***	***0.03***
Stand 43	T5-1	66.2	57.6	43.42				0.15	1.33	0.20
Stand 43	T5-3	54.2	44.5	43.42				0.22	1.02	0.22
Stand 43	T5-5A	54.2	45.6	43.42				0.19	1.05	0.20
Stand 43	T5-5B									
Mean		***58.20***	***49.23***					***0.19***	***1.13***	***0.21***
Stdev		***6.93***	***7.27***					***0.03***	***0.17***	***0.01***

					10/6/94					
Location	**Sample Code**	**Wet Wt. (g)**	**Dry Wt. (g)**	**Core Volume**	**Comments**	**Organic Layer Depth (cm)**	**Organic Layer Gravimetric Moisture**	**Mineral Soil Gravimetric Moisture (dry wt g/g)**	**Mineral Soil Bulk Density (g/cm^3**	**Mineral Soil Volumetric Moisture (cm^3/cm^3)**
Cryderman	TR1-1									
Cryderman	TR1-2	65.1	50.8	43.2				0.28	1.18	0.33
Cryderman	TR1-3	72.4	56.5	43.2				0.28	1.31	0.37
Cryderman	TR1-23	63.9	50.9	43.2				0.26	1.18	0.30
Mean		***68.75***	***53.65***					***0.28***	***1.24***	***0.35***
Stdev		***5.16***	***4.03***					***0.00***	***0.09***	***0.03***
Raco Air	1.00	64.7	55.5	43.2				0.17	1.28	0.21
Raco Air	2.00	69.6	61.6	43.2				0.13	1.43	0.19
Raco Air	3.00	65.3	53.2	43.2				0.23	1.23	0.28
Mean		***66.53***	***56.77***					***0.17***	***1.31***	***0.23***
Stdev		***2.67***	***4.34***					***0.05***	***0.10***	***0.05***
RRS1	1.00	60.3	53.4	43.2				0.13	1.24	0.16
RRS1	2.00	57.4	51.7	43.2				0.11	1.20	0.13
RRS1	3.00	58	52.9	43.2				0.10	1.22	0.12
Mean		***58.57***	***52.67***					***0.11***	***1.22***	***0.14***
Stdev		***1.53***	***0.87***					***0.02***	***0.02***	***0.02***
RRS2	1A	61.2	52.9	43.2				0.16	1.22	0.19
RRS2	1B									
RRS2	2A	60.6	54.8	43.2				0.11	1.27	0.13
RRS2	2B									
RRS2	3A	53.8	48.4	43.2				0.11	1.12	0.13
RRS2	3B									
Mean		***58.53***	***52.03***					***0.12***	***1.20***	***0.15***
Stdev		***4.11***	***3.29***					***0.03***	***0.08***	***0.04***
RRS3	1.00	44.1	40.7	43.2				0.08	0.94	0.08
RRS3	2.00	49.1	43	43.2				0.14	1.00	0.14
RRS3	3.00	56.5	53	43.2				0.07	1.23	0.08
Mean		***49.90***	***45.57***					***0.10***	***1.05***	***0.10***
Stdev		***6.24***	***6.54***					***0.04***	***0.15***	***0.04***

					10/6/94					
Location	Sample Cod	Wet Wt. (g)	Dry Wt. (g)	Core Volume	Comments	Organic Layer Depth (cm)	Organic Layer Gravimetric Moisture	Mineral Soil Gravimetric Moisture (dry wt g/g)	Mineral Soil Bulk Density (g/cm^3	Mineral Soil Volumetric Moisture (cm^3/cm^3)
Stand 24	T5-1	50.4	42.2	43.2				0.19	0.98	0.19
Stand 24	T5-3	46.4	35.4	43.2				0.31	0.82	0.25
Stand 24	T5-5A	61.3	52.7	43.2	6cm hum layer			0.16	1.22	0.20
Stand 24	T5-5B									
Mean		*52.70*	*43.43*					*0.22*	*1.01*	*0.21*
Stdev		*7.71*	*8.72*					*0.08*	*0.20*	*0.04*
Stand 33	T5-1	59.6	50.4	43.2				0.18	1.17	0.21
Stand 33	T5-3	52.3	39.6	43.2				0.32	0.92	0.29
Stand 33	T5-5A	62.9	55.9	43.2				0.13	1.29	0.16
Stand 33	T5-5B	62.3	29.8		2-3cm humus n.v.	3	1.09			
Stand 33	T6-1									
Mean		*59.28*	*43.93*			*3*	*1.09*	*0.21*	*1.13*	*0.22*
Stdev		*4.87*	*11.60*					*0.10*	*0.19*	*0.07*
Stand 37	T1-3									
Stand 37	T5-1	50.1	44.1	43.2				0.14	1.02	0.14
Stand 37	T5-3	56.5	48.6	43.2				0.16	1.13	0.18
Stand 37	T5-5	59.9	53.3	43.2				0.12	1.23	0.15
Mean		*55.50*	*48.67*					*0.14*	*1.13*	*0.16*
Stdev		*4.98*	*4.60*					*0.02*	*0.11*	*0.02*
Stand 38	T3-1	56	54.6	43.2				0.03	1.26	0.03
Stand 38	T3-3	60.1	56.8	43.2				0.06	1.31	0.08
Stand 38	T3-5	64.5	59.2	43.2				0.09	1.37	0.12
Stand 38	T5-1									
Stand 38	T5-3									
Stand 38	T5-5									
Mean		*60.20*	*56.87*					*0.06*	*1.32*	*0.08*
Stdev		*4.25*	*2.30*					*0.03*	*0.05*	*0.05*

					10/7/94					
Location	Sample Code	Wet Wt. (g)	Dry Wt. (g)	Core Volume	Comments	Organic Layer Depth (cm)	Organic Layer Gravimetric Moisture	Mineral Soil Gravimetric Moisture (dry wt g/g)	Mineral Soil Bulk Density (g/cm^3	Mineral Soil Volumetric Moisture (cm^3/cm^3)
Cryderman	TR1-1									
Cryderman	TR1-2	53	41.8	43.42				0.27	0.96	0.26
Cryderman	TR1-3	67.3	51.7	43.42				0.30	1.19	0.36
Cryderman	TR1-23	61.6	48.3	43.42				0.28	1.11	0.31
Mean		*60.15*	*46.75*					*0.28*	*1.08*	*0.31*
Stdev		*10.11*	*7.00*					*0.02*	*0.16*	*0.07*
Raco Air	1.00	68	57.2	43.42				0.19	1.32	0.25
Raco Air	2.00	69.9	61.3	43.42				0.14	1.41	0.20
Raco Air	3.00	73.1	59.4	43.42				0.23	1.37	0.32
Mean		*70.33*	*59.30*					*0.19*	*1.37*	*0.25*
Stdev		*2.58*	*2.05*					*0.05*	*0.05*	*0.06*
RRS1	1.00	61.5	54.2	43.42				0.13	1.25	0.17
RRS1	2.00	56.2	48.4	43.42				0.16	1.11	0.18
RRS1	3.00	60.9	55.1	43.42				0.11	1.27	0.13
Mean		*59.53*	*52.57*					*0.13*	*1.21*	*0.16*
Stdev		*2.90*	*3.64*					*0.03*	*0.08*	*0.02*
RRS2	1A	54.4	49.1	43.42				0.11	1.13	0.12
RRS2	1B									
RRS2	2A	62.6	57	43.42				0.10	1.31	0.13
RRS2	2B									
RRS2	3A	50.7	46.3	43.42				0.10	1.07	0.10
RRS2	3B									
Mean		*55.90*	*50.80*					*0.10*	*1.17*	*0.12*
Stdev		*6.09*	*5.55*					*0.01*	*0.13*	*0.01*
RRS3	1.00	61.9	54.8	43.42				0.13	1.26	0.16
RRS3	2.00	44.6	38	43.42				0.17	0.88	0.15
RRS3	3.00	51.7	48.7	43.42				0.06	1.12	0.07
Mean		*52.73*	*47.17*					*0.12*	*1.09*	*0.13*
Stdev		*8.70*	*8.50*					*0.06*	*0.20*	*0.05*

					10/7/94					
Location	Sample Code	Wet Wt. (g)	Dry Wt. (g)	Core Volume	Comments	Organic Layer Depth (cm)	Organic Layer Gravimetric Moisture	Mineral Soil Gravimetric Moisture (dry wt g/g)	Mineral Soil Bulk Density (g/cm^3	Mineral Soil Volumetric Moisture (cm^3/cm^3)
Stand 22	T1-1	66.8	61.4	43.42				0.09	1.41	0.12
Stand 22	T1-3	62.2	58.3	43.42				0.07	1.34	0.09
Stand 22	T1-5									
Stand 22	T1-5A	66.4	55.6	43.42				0.19	1.28	0.25
Stand 22	T1-5B									
Stand 22	T4-1A									
Stand 22	T4-1B									
Stand 22	T4-3A									
Stand 22	T4-3B									
Stand 22	T4-5A									
Stand 22	T4-5B									
Mean		*65.13*	*58.43*					*0.12*	*1.35*	*0.15*
Stdev		*2.55*	*2.90*					*0.07*	*0.07*	*0.08*
Stand 31	T4-1A									
Stand 31	T4-1B									
Stand 31	T4-3A									
Stand 31	T4-3B									
Stand 31	T4-5A									
Stand 31	T4-5B									
Stand 31	T5-1A	63.8	55.7	43.42	2 cm humus			0.15	1.28	0.19
Stand 31	T5-1B									
Stand 31	T5-3	58.8	51.3	43.42	2 cm humus			0.15	1.18	0.17
Stand 31	T5-5A	48.7	37.9	43.42	2 cm humus			0.28	0.87	0.25
Stand 31	T5-5B	58.1	27.9		2cm hum layer n.v.	2	1.08			
Mean		*57.35*	*43.20*			*2*	0.33	*0.19*	*1.11*	*0.20*
Stdev		*6.30*	*12.70*					*0.08*	*0.21*	*0.04*

					10/7/94					
Location	Sample Code	Wet Wt. (g)	Dry Wt. (g)	Core Volume	Comments	Organic Layer Depth (cm)	Organic Layer Gravimetric Moisture	Mineral Soil Gravimetric Moisture (dry wt g/g)	Mineral Soil Bulk Density (g/cm^3	Mineral Soil Volumetric Moisture (cm^3/cm^3)
Stand 34	T1-1A									
Stand 34	T1-1B									
Stand 34	T1-3									
Stand 34	T1-5									
Stand 34	T2-1A									
Stand 34	T2-1B									
Stand 34	T2-3A									
Stand 34	T2-3B									
Stand 34	T2-5A									
Stand 34	T2-5B									
Stand 34	T5-1	68.1	61	43.42	4 cm humus			0.12	1.40	0.16
Stand 34	T5-3A	62.7	53.6	43.42	4 cm humus			0.17	1.23	0.21
Stand 34	T5-3B									
Stand 34	T5-5A	51	36.2	43.42	4 cm humus			0.41	0.83	0.34
Stand 34	T5-5B	54.8	24.5		hum layer 3-5 nv	4	1.24			
Mean		*59.15*	*43.83*			*4*	*1.24*	*0.23*	*1.16*	*0.24*
Stdev		*7.70*	*16.55*					*0.16*	*0.29*	*0.09*
Stand 43	T5-1	65.1	58	43.42	2-3cm humus			0.12	1.34	0.16
Stand 43	T5-3	60.2	52.9	43.42	2-3cm humus			0.14	1.22	0.17
Stand 43	T5-5A	57.1	49	43.42	2-3cm humus			0.17	1.13	0.19
Stand 43	T5-5B	38.9	23		2-3cm hum n.v.	3	0.69			
Mean		*55.33*	*45.73*			*3*	*0.69*	*0.14*	*1.23*	*0.17*
Stdev		*11.43*	*15.59*					*0.02*	*0.10*	*0.01*

10/8/94

Location	Sample Code	Wet Wt. (g)	Dry Wt. (g)	Core Volume	Comments	Organic Layer Depth (cm)	Organic Layer Gravimetric Moisture	Mineral Soil Gravimetric Moisture (dry wt g/g)	Mineral Soil Bulk Density (g/cm^3	Mineral Soil Volumetric Moisture (cm^3/cm^3)
Cryderman	TR1-1									
Cryderman	TR1-2	62.5	48.2	43.42				0.30	1.11	0.33
Cryderman	TR1-3	71.2	54.7	43.42				0.30	1.26	0.38
Cryderman	TR1-23	62.5	48.4	43.42				0.29	1.11	0.32
Mean		66.85	51.45					0.30	1.18	0.35
Stdev		6.15	4.60					0.00	0.11	0.04
Raco Air	1 00	70 2	59 3	43.42	drizzling			0.18	1.37	0.25
Raco Air	2 00	73.2	64.5	43.42				0.13	1.49	0.20
Raco Air	3 00	77.9	65.8	43.42				0.18	1.52	0.28
Mean		73.77	63.20					0.17	1.46	0.24
Stdev		3.88	3.44					0.03	0.08	0.04
RR S1	1 00	59	51.9	43.42	drizzling			0.14	1.20	0.16
RR S1	2 00	57.3	50.3	43.42				0.14	1.16	0.16
RR S1	3 00	59.7	51.5	43.42				0.16	1.19	0.19
Mean		58.67	51.23					0.15	1.18	0.17
Stdev		1.23	0.83					0.01	0.02	0.02
RR S2	1A	50.3	44.2	43.42	drizzling			0.14	1.02	0.14
RR S2	1B									
RR S2	2A	55.9	49.8	43.42				0.12	1.15	0.14
RR S2	2B									
RR S2	3A	52.4	47.2	43.42				0.11	1.09	0.12
RR S2	3B									
Mean		52.87	47.07					0.12	1.08	0.13
Stdev		2.83	2.80					0.01	0.06	0.01
RR S3	1 00	56.2	51.1	43.42	drizzling			0.10	1.18	0.12
RR S3	2 00	46.4	38.8	43.42				0.20	0.89	0.18
RR S3	3 00	52	47.5	43.42				0.09	1.09	0.10
Mean		51.53	45.80					0.13	1.05	0.13
Stdev		4.92	6.32					0.06	0.15	0.04

10/8/94

Location	Sample Code	Wet Wt. (g)	Dry Wt. (g)	Core Volume	Comments	Organic Layer Depth (cm)	Organic Layer Gravimetric Moisture	Mineral Soil Gravimetric Moisture (dry wt g/g)	Mineral Soil Bulk Density (g/cm^3	Mineral Soil Volumetric Moisture (cm^3/cm^3)
Stand 24	T5-1	50.1	42.6	43.42	1-5 cm humus			0.18	0.98	0.17
Stand 24	T5-3	54.2	42.7	43.42	1-5 cm humus			0.27	0.98	0.26
Stand 24	T5-5A	56.1	49.7	43.42	1-5 cm humus			0.13	1.14	0.15
Stand 24	T5-5B	91.6	45.2		hum layer, n.v.	3	1.03			
Mean		***63.00***	***45.05***			***3***	***1.03***	***0.19***	***1.04***	***0.19***
Stdev		***19.23***	***3.33***					***0.07***	***0.09***	***0.06***
Stand 33	T5-1	56.5	44.7	43.42	2cm hum layre n.c.			0.26	1.03	0.27
Stand 33	T5-3	61.8	56.7	43.42	2cm hum layre n.c.			0.09	1.31	0.12
Stand 33	T5-5A	65.9	60.1	43.42	2cm hum layre n.c.			0.10	1.38	0.13
Stand 33	T5-5B	42.7	22.3		hum layer n.v.	2	0.91			
Stand 33	T6-1									
Mean		***56.73***	***45.95***			***2***	***0.91***	***0.15***	***1.24***	***0.17***
Stdev		***10.11***	***17.09***					***0.10***	***0.19***	***0.08***
Stand 37	T1-3									
Stand 37	T5-1	57.6	51.6	43.42				0.12	1.19	0.14
Stand 37	T5-3	51.2	44.9	43.42				0.14	1.03	0.15
Stand 37	T5-5	45.6	38.2	43.42				0.19	0.88	0.17
Mean		***51.47***	***44.90***					***0.15***	***1.03***	***0.15***
Stdev		***6.00***	***6.70***					***0.04***	***0.15***	***0.02***

					10/9/94					
Location	Sample Code	Wet Wt. (g)	Dry Wt. (g)	Core Volume	Comments	Organic Layer Depth (cm)	Organic Layer Gravimetric Moisture	Mineral Soil Gravimetric Moisture (dry wt g/g)	Mineral Soil Bulk Density (g/cm^3	Mineral Soil Volumetric Moisture (cm^3/cm^3)
Cryderman	TR1-1	66.9	52.2	43.42				0.28	1.20	0.34
Cryderman	TR1-2									
Cryderman	TR1-3	73.8	54.92	43.42				0.34	1.26	0.43
Cryderman	TR1-23	64.8	46.9	43.42				0.38	1.08	0.41
Mean		***70.35***	***53.56***					***0.31***	***1.23***	***0.39***
Stdev		***4.88***	***1.92***					***0.04***	***0.04***	***0.07***
Haco Air	1.00	65.5	53.4	43.42				0.23	1.23	0.28
Haco Air	2.00	74.9	64.75	43.42				0.16	1.49	0.23
Haco Air	3.00	73.9	56.96	43.42				0.30	1.31	0.39
Mean		***71.43***	***58.37***					***0.23***	***1.34***	***0.30***
Stdev		***5.16***	***5.80***					***0.07***	***0.13***	***0.08***
RR S1	1.00	56.6	46.11	43.42	started drizzling			0.23	1.06	0.24
RR S1	2.00	55.9	40.7	43.42				0.37	0.94	0.35
RR S1	3.00	60.2	50.55	43.42				0.19	1.16	0.22
Mean		***57.57***	***45.79***					***0.26***	***1.05***	***0.27***
Stdev		***2.31***	***4.93***					***0.10***	***0.11***	***0.07***
RR S2	1A	62.7	53.6	43.42	no rain			0.17	1.23	0.21
RR S2	1B									
RR S2	2A	59.4	51.86	43.42				0.15	1.19	0.17
RR S2	2B									
RR S2	3A	53.3	44.87	43.42				0.19	1.03	0.19
RR S2	3B									
Mean		***58.47***	***50.11***					***0.17***	***1.15***	***0.19***
Stdev		***4.77***	***4.62***					***0.02***	***0.11***	***0.02***
RR S3	1.00	61	52.3	43.42				0.17	1.20	0.20
RR S3	2.00	55.6	49.39	43.42				0.13	1.14	0.14
RR S3	3.00	49.3	36.15	43.42				0.36	0.83	0.30
Mean		***55.30***	***45.95***					***0.22***	***1.06***	***0.22***
Stdev		***5.86***	***8.61***					***0.13***	***0.20***	***0.08***

10/9/94

Location	Sample Cod	Wet Wt. (g)	Dry Wt. (g)	Core Volume	Comments	Organic Layer Depth (cm)	Organic Layer Gravimetric Moisture	Mineral Soil Gravimetric Moisture (dry wt g/g)	Mineral Soil Bulk Density (g/cm^3	Mineral Soil Volumetric Moisture (cm^3/cm^3)
Stand 22	T1-1	71	63.83	43.42				0.11	1.47	0.17
Stand 22	T1-3	69	62.28	43.42				0.11	1.43	0.15
Stand 22	T1-5									
Stand 22	T1-5A	74.2	56.82	43.42				0.31	1.31	0.40
Stand 22	T1-5B	58.4	22.38		2-4 cm hum. n.v.	4	1.61			
Stand 22	T4-1A									
Stand 22	T4-1B									
Stand 22	T4-3A									
Stand 22	T4-3B									
Stand 22	T4-5A									
Stand 22	T4-5B									
Mean		***68.15***	***51.33***			***4***	***1.61***	***0.18***	***1.40***	***0.24***
Stdev		***6.84***	***19.53***					***0.11***	***0.08***	***0.14***
Stand 31	T4-1A									
Stand 31	T4-1B									
Stand 31	T4-3A									
Stand 31	T4-3B									
Stand 31	T4-5A									
Stand 31	T4-5B									
Stand 31	T5-1A	52.3	39.9	43.42	2-4 cm humus			0.31	0.92	0.29
Stand 31	T5-1B									
Stand 31	T5-3	61.5	51.9	43.42	2-4 cm humus			0.18	1.20	0.22
Stand 31	T5-5A	64.2	53.13	43.42	2-4 cm humus			0.21	1.22	0.25
Stand 31	T5-5B	89.8	28.15		humus 2-4 cm n.v.	4	2.19			
Mean		***66.95***	***43.27***			***4***	***2.19***	***0.23***	***1.11***	***0.25***
Stdev		***16.06***	***11.71***					***0.07***	***0.17***	***0.03***

					10/9/94					
Location	Sample Cod	Wet Wt. (g)	Dry Wt. (g)	Core Volume	Comments	Organic Layer Depth (cm)	Organic Layer Gravimetric Moisture	Mineral Soil Gravimetric Moisture (dry wt g/g)	Mineral Soil Bulk Density (g/cm^3	Mineral Soil Volumetric Moisture (cm^3/cm^3)
Stand 34	T1-1A									
Stand 34	T1-1B									
Stand 34	T1-3									
Stand 34	T1-5									
Stand 34	T2-1A									
Stand 34	T2-1B									
Stand 34	T2-3A									
Stand 34	T2-3B									
Stand 34	T2-5A									
Stand 34	T2-5B									
Stand 34	T5-1									
Stand 34	T5-3A									
Stand 34	T5-3B	67.8	57.3	43.42				0.18	1.32	0.24
Stand 34	T5-5A									
Stand 34	T5-5B									
Mean		*67.80*	*57.30*					*0.18*	*1.32*	*0.24*
Stdev										
Stand 37	T1-3	63.5	55.06	43.42				0.15	1.27	0.19
Stand 37	T5-1	53.7	40.17	43.42				0.34	0.93	0.31
Stand 37	T5-3									
Stand 37	T5-5	55.5	43.66	43.42				0.27	1.01	0.27
Mean		*57.57*	*46.30*					*0.25*	*1.07*	*0.26*
Stdev		*5.22*	*7.79*					*0.09*	*0.18*	*0.06*
Stand 38	T3-1									
Stand 38	T3-3									
Stand 38	T3-5									
Stand 38	T5-1	57.5	52.25	43.42	2cm n.c. litter			0.10	1.20	0.12
Stand 38	T5-3	65.5	56.96	43.42				0.15	1.31	0.20
Stand 38	T5-5	63.1	53.92	43.42				0.17	1.24	0.21
Mean		*62.03*	*54.38*					*0.14*	*1.25*	*0.18*
Stdev		*4.11*	*2.39*					*0.04*	*0.05*	*0.05*
Stand 43	T5-1	68.1	59.83	43.42				0.14	1.38	0.19
Stand 43	T5-3	57.2	45.5	43.42	2cm nc litter			0.26	1.05	0.27
Stand 43	T5-5A	59.8	49.53	43.42	2cm n.c. litter			0.21	1.14	0.24
Stand 43	T5-5B									
Mean		*61.70*	*51.62*					*0.20*	*1.19*	*0.23*
Stdev		*5.69*	*7.39*					*0.06*	*0.17*	*0.04*

					10/10/94					
Location	Sample Cod	Wet Wt. (g)	Dry Wt. (g)	Core Volume	Comments	Organic Layer Depth (cm)	Organic Layer Gravimetric Moisture	Mineral Soil Gravimetric Moisture (dry wt g/g)	Mineral Soil Bulk Density (g/cm^3	Mineral Soil Volumetric Moisture (cm^3/cm^3)
Cryderman	TR1-1	60.6	44.13	43.42				0.37	1.02	0.38
Cryderman	TR1-2	63.6	45.06	43.42				0.41	1.04	0.43
Cryderman	TR1-3	65.6	49.88	43.42				0.32	1.15	0.36
Cryderman	TR1-23									
Mean		***63.27***	***46.36***					***0.37***	***1.07***	***0.39***
Stdev		***2.52***	***3.09***					***0.05***	***0.07***	***0.03***
Raco Air	1.00	61.2	47.51	43.42				0.29	1.09	0.32
Raco Air	2.00	80	66.37	43.42				0.21	1.53	0.31
Raco Air	3.00	83.9	68.16	43.42				0.23	1.57	0.36
Mean		***75.03***	***60.68***					***0.24***	***1.40***	***0.33***
Stdev		***12.14***	***11.44***					***0.04***	***0.26***	***0.03***
RR S1	1.00	56.4	45.74	43.42				0.23	1.05	0.25
RR S1	2.00	57.3	48.36	43.42				0.18	1.11	0.21
RR S1	3.00	60.3	51.25	43.42				0.18	1.18	0.21
Mean		***58.00***	***48.45***					***0.20***	***1.12***	***0.22***
Stdev		***2.04***	***2.76***					***0.03***	***0.06***	***0.02***
RR S2	1A	62.1	51.8	43.42				0.20	1.19	0.24
RR S2	1B									
RR S2	2A	60.3	51.76	43.42				0.16	1.19	0.20
RR S2	2B									
RR S2	3A	54.7	47.07	43.42				0.16	1.08	0.18
RR S2	3B									
Mean		***59.03***	***50.21***					***0.18***	***1.16***	***0.20***
Stdev		***3.86***	***2.72***					***0.02***	***0.06***	***0.03***
RR S3	1.00	62.8	54.6	43.42				0.15	1.26	0.19
RR S3	2.00	49.7	39.3	43.42				0.26	0.91	0.24
RR S3	3.00	61.2	53.95	43.42				0.13	1.24	0.17
Mean		***57.90***	***49.28***					***0.18***	***1.14***	***0.20***
Stdev		***7.15***	***8.65***					***0.07***	***0.20***	***0.04***

10/10/94

Location	Sample Cod	Wet Wt. (g)	Dry Wt. (g)	Core Volume	Comments	Organic Layer Depth (cm)	Organic Layer Gravimetric Moisture	Mineral Soil Gravimetric Moisture (dry wt g/g)	Mineral Soil Bulk Density (g/cm^3	Mineral Soil Volumetric Moisture (cm^3/cm^3)
Stand 24	T5-1	66.1	57.4	43.42	4 cm humus			0.15	1.32	0.20
Stand 24	T5-3	56.4	44.89	43.42	5 cm humus			0.26	1.03	0.27
Stand 24	T5-5A	67.1	59.09	43.42	6 cm humus			0.14	1.36	0.18
Stand 24	T5-5B	93.3	28.11		hum layer n.v.	4	2.32			
Mean		***70.73***	***47.37***			***4***	***2.32***	***0.18***	***1.24***	***0.22***
Stdev		***15.80***	***14.32***					***0.07***	***0.18***	***0.04***
Stand 33	T5-1	61.7	49.01	43.42	1-3 cm humus			0.26	1.13	0.29
Stand 33	T5-3	64.1	54.95	43.42	1-3 cm humus			0.17	1.27	0.21
Stand 33	T5-5A	65.2	53.54	43.42	1-3 cm humus			0.22	1.23	
Stand 33	T5-5B	65.6	26		hum layer n.v.	2	1.52			
Stand 33	T6-1									
Mean		***64.15***	***45.88***			***2***	***1.52***	***0.21***	***1.21***	***0.25***
Stdev		***1.75***	***13.49***					***0.05***	***0.07***	***0.06***
Stand 37	T1-3									
Stand 37	T5-1	58.7	47.35	43.42				0.24	1.09	0.26
Stand 37	T5-3	52.8	40.43	43.42				0.31	0.93	0.28
Stand 37	T5-5	62.3	52.38	43.42				0.19	1.21	0.23
Mean		***57.93***	***46.72***					***0.25***	***1.08***	***0.26***
Stdev		***4.80***	***6.00***					***0.06***	***0.14***	***0.03***
Stand 38	T3-1	64.1	59.29	43.42				0.08	1.37	0.11
Stand 38	T3-3	49.1	39.97	43.42				0.23	0.92	0.21
Stand 38	T3-5	55.2	46.67	43.42				0.18	1.07	0.20
Stand 38	T5-1									
Stand 38	T5-3									
Stand 38	T5-5									
Mean		***56.13***	***48.64***					***0.16***	***1.12***	***0.17***
Stdev		***7.54***	***9.81***					***0.08***	***0.23***	***0.05***

APPENDIX C:

TABLES AND PLOTS OF VEGETATION MOISTURE MEASUREMENTS BY DESTRUCTIVE SAMPLING IN FOREST STANDS

Stand 31
Red Maple
9/29/94

Stem Diameter (cm)	Gravimetric Moisture (dry wt. g/g)	Bulk Density (g/cm3)	Volumetric Moisture (cm3/cm3)
0.5	0.788	0.164	0.129
1.0 .	0.734	1.123	0.825
2.0	0.720	0.636	0.458
3.0	0.679	0.571	0.388
4.0	0.716	0.590	0.423
5.0	0.696	0.539	0.375
6.0	0.659	0.517	0.341
7.0	0.570	0.535	0.305
8.0	0.577	0.554	0.320
9.0	0.560	0.539	0.302
10.0	0.583	0.538	0.314
11.0	0.529	0.542	0.287
12.0	0.519	0.563	0.293
13.0	0.557	0.554	0.309
14.0	0.580	0.566	0.328
15.0	0.554	0.589	0.326
leaves	1.321	0.511	0.675
leaves	1.603	0.326	0.522
Mean of Wood=	0.626	0.570	0.358
SD of Wood=	0.085	0.180	0.143
Mean of Leaves=	1.462	0.418	0.599

Stand 31
Sugar Maple
9/29/94

Stem Diameter (cm)	Gravimetric Moisture (dry wt. g/g)	Bulk Density (g/cm3)	Volumetric Moisture (cm3/cm3)
0.5	0.784	0.280	0.219
1.0	0.664	0.411	0.273
2.0	0.716	0.682	0.488
3.0	0.760	0.651	0.495
4.0	0.658	0.656	0.431
5.0	0.647	0.610	0.395
6.0	0.616	0.628	0.386
7.0	0.540	0.604	0.327
8.0	0.575	0.621	0.357
9.0	0.557	0.615	0.342
10.0	0.514	0.613	0.315
11.0	0.468	0.640	0.300
12.0	0.436	0.637	0.278
13.0	0.478	0.626	0.299
14.0	0.516	0.635	0.327
15.0	0.433	0.686	0.297
leaves	1.904	0.207	0.395
leaves	1.150	0.397	0.456
Mean of Wood=	0.585	0.600	0.346
SD of Wood=	0.112	0.105	0.077
Mean of Leaves=	1.527	0.302	0.425

Stand 32
Black Spruce
10/1/94

Stem Diameter (cm)	Gravimetric Moisture (dry wt. g/g)	Bulk Density (g/cm3)	Volumetric Moisture (cm3/cm3)
4.0	1.145	0.487	0.558
5.0	1.026	0.513	0.527
6.0	0.992	0.460	0.457
7.0	0.858	0.442	0.379
8.0	0.787	0.466	0.367
9.0	0.680	0.474	0.322
10.0	0.623	0.490	0.305
11.0	0.642	0.470	0.302
12.0	0.545	0.510	0.278
13.0	0.563	0.510	0.287
0.5	0.770	0.052	0.040
1.0	0.701	1.996	1.399
2.0	1.149	0.134	0.154
3.0	1.225	0.635	0.778
leaves	1.071	1.313	1.405
Mean of Wood=	0.836	0.546	0.439
SD of Wood=	0.231	0.445	0.329
Mean of Leaves=	1.071	1.313	1.405

Stand 32
Northern White-cedar
10/1/94

Stem Diameter (cm)	Gravimetric Moisture (dry wt. g/g)	Bulk Density (g/cm3)	Volumetric Moisture (cm3/cm3)
0.5	0.842	0.677	0.570
1.0	0.702	3.720	2.613
2.0	1.159	0.333	0.386
3.0	1.176	0.474	0.557
4.0	1.151	0.444	0.511
5.0	1.214	0.407	0.494
6.0	1.182	0.412	0.487
7.0	1.160	0.385	0.446
8.0	1.072	0.356	0.381
9.0	1.023	0.354	0.362
10.0	0.960	0.357	0.343
11.0	0.847	0.361	0.306
12.0	0.822	0.353	0.290
13.0	0.788	0.359	0.283
14.0	0.766	0.354	0.271
15.0	0.770	0.335	0.258
18.0	0.861	0.335	0.288
leaves	1.077	9.655	10.400
Mean of Wood=	0.970	0.589	0.520
SD of Wood=	0.180	0.811	0.549
Mean of Leaves=	1.077	9.655	10.400

Stand 24
Jack Pine
10/1/94

Stem Diameter (cm)	Gravimetric Moisture (dry wt. g/g)	Bulk Density (g/cm3)	Volumetric Moisture (cm3/cm3)
0.5	1.003	0.412	0.414
1.0	1.040	1.434	1.492
2.0	1.208	0.468	0.566
3.0	1.274	0.389	0.495
4.0	1.374	0.393	0.539
5.0	1.668	0.339	0.565
6.0	1.697	0.361	0.613
7.0	1.661	0.342	0.568
8.0	1.620	0.364	0.589
9.0	1.362	0.354	0.482
10.0	1.238	0.359	0.444
11.0	1.053	0.347	0.365
12.0	0.974	0.344	0.335
13.0	0.891	0.347	0.310
14.0	0.851	0.371	0.316
15.0	0.859	0.378	0.325
16.0	0.801	0.419	0.336
17.0	0.879	0.391	0.343
needles	1.573	0.395	0.621
Mean of Wood=	1.192	0.434	0.505
SD of Wood=	0.312	0.252	0.269
Mean of Leaves=	1.573	0.395	0.621

Stand 22
Red Pine
10/1/94

Stem Diameter (cm)	Gravimetric Moisture (dry wt. g/g)	Bulk Density (g/cm3)	Volumetric Moisture (cm3/cm3)
0.5	1.000	0.319	0.319
1.0	1.077	0.767	0.826
2.0	1.420	0.589	0.836
3.0	1.704	0.575	0.980
4.0	1.892	0.346	0.655
5.0	1.906	0.347	0.662
6.0	1.621	0.366	0.594
7.0	1.830	0.314	0.575
8.0	1.833	0.318	0.582
9.0	1.791	0.329	0.590
10.0	1.719	0.333	0.573
11.0	1.631	0.345	0.563
12.0	1.609	0.328	0.527
13.0	1.513	0.344	0.521
14.0	1.527	0.340	0.519
15.0	1.441	0.339	0.489
16.0	1.355	0.370	0.502
needles	1.284	3.228	4.146
Mean of Wood=	1.580	0.392	0.607
SD of Wood=	0.263	0.127	0.154
Mean of Leaves=	1.284	3.228	4.146

Stand 31
American Beech
9/30/94

Stem Diameter (cm)	Gravimetric Moisture (dry wt. g/g)	Bulk Density (g/cm3)	Volumetric Moisture (cm3/cm3)
0.5	0.797	0.654	0.521
1.0	0.867	0.197	0.171
2.0	0.751	0.188	0.141
3.0	0.917	0.528	0.484
4.0	0.778	0.547	0.426
5.0	0.830	0.576	0.478
6.0	0.856	0.595	0.509
7.0	0.792	0.566	0.449
8.0	0.766	0.582	0.446
9.0	0.793	0.559	0.444
10.0	0.789	0.588	0.464
11.0	0.783	0.581	0.455
12.0	0.803	0.556	0.446
13.0	0.769	0.591	0.454
14.0	0.763	0.562	0.428
16.0	0.695	0.635	0.441
17.0	0.618	0.610	0.377
leaves	1.735	0.219	0.381
Mean of Wood=	0.786	0.536	0.420
SD of Wood=	0.066	0.133	0.104
Mean of Leaves=	1.735	0.219	0.381

Stand 75
Eastern White Pine
10/1/94

Stem Diameter (cm)	Gravimetric Moisture (dry wt. g/g)	Bulk Density (g/cm3)	Volumetric Moisture (cm3/cm3)
0.5	0.998	0.170	0.169
1.0	1.138	1.535	1.747
2.0	1.142	1.016	1.160
3.0	1.895	0.324	0.613
4.0	1.804	0.445	0.803
5.0	1.731	0.325	0.562
6.0	1.156	0.335	0.387
7.0	1.471	0.339	0.498
8.0	1.430	0.348	0.497
10.0	1.493	0.304	0.453
11.0	1.187	0.352	0.418
12.0	1.616	0.297	0.481
14.0	1.493	0.304	0.453
16.0	1.455	0.296	0.431
18.0	1.279	0.328	0.420
20.0	0.965	0.357	0.344
needles	1.247	0.433	0.540
Mean of Wood=	1.391	0.442	0.590
SD of Wood=	0.282	0.343	0.378
Mean of Leaves=	1.247	0.433	0.540

Stand 33
Bigtooth Aspen
9/30/94

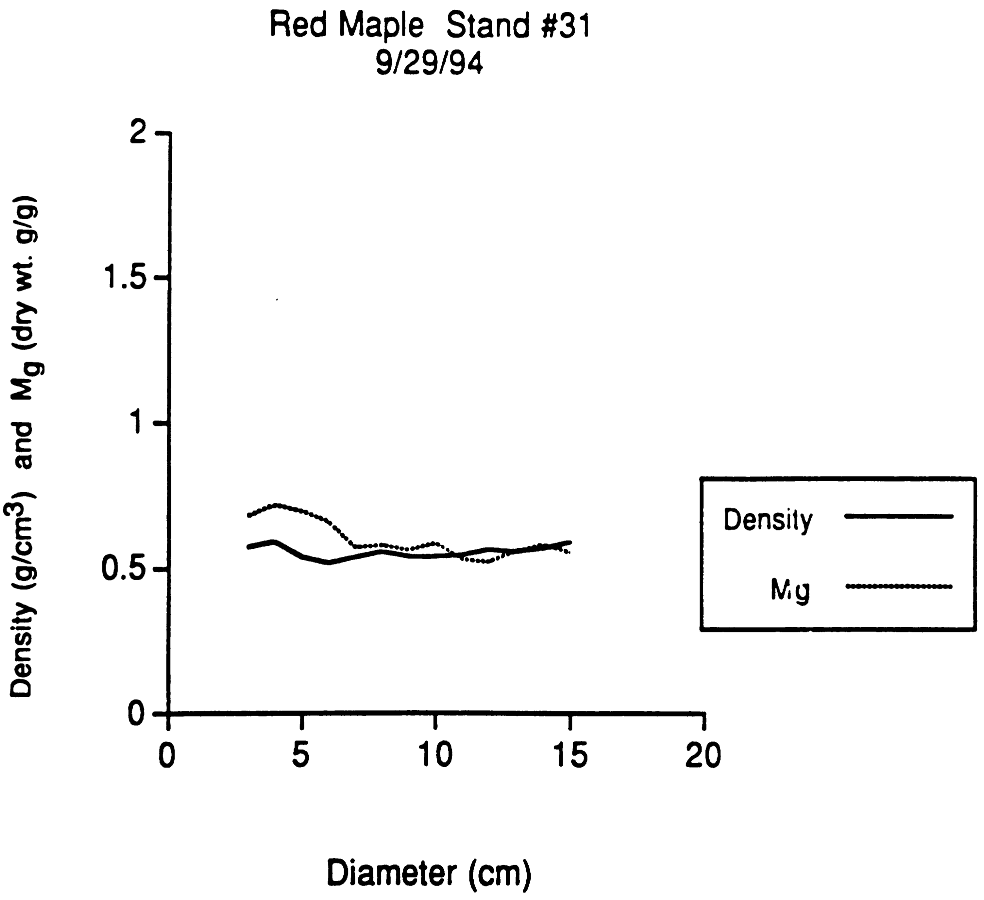
Stem Diameter (cm)	Gravimetric Moisture (dry wt. g/g)	Bulk Density (g/cm3)	Volumetric Moisture (cm3/cm3)
0.5	0.956	0.561	0.536
1.0	0.916	0.934	0.855
2.0	0.997	0.729	0.726
3.0	1.033	0.442	0.456
3.5	1.180	0.418	0.493
5.0	0.976	0.417	0.407
6.0	0.950	0.429	0.408
7.0	0.788	0.383	0.301
8.0	0.790	0.442	0.349
9.0	0.851	0.477	0.406
leaves	1.641	0.410	0.673
Mean of Wood=	0.944	0.523	0.494
SD of Wood=	0.118	0.176	0.173
Mean of Leaves=	1.641	0.410	0.673

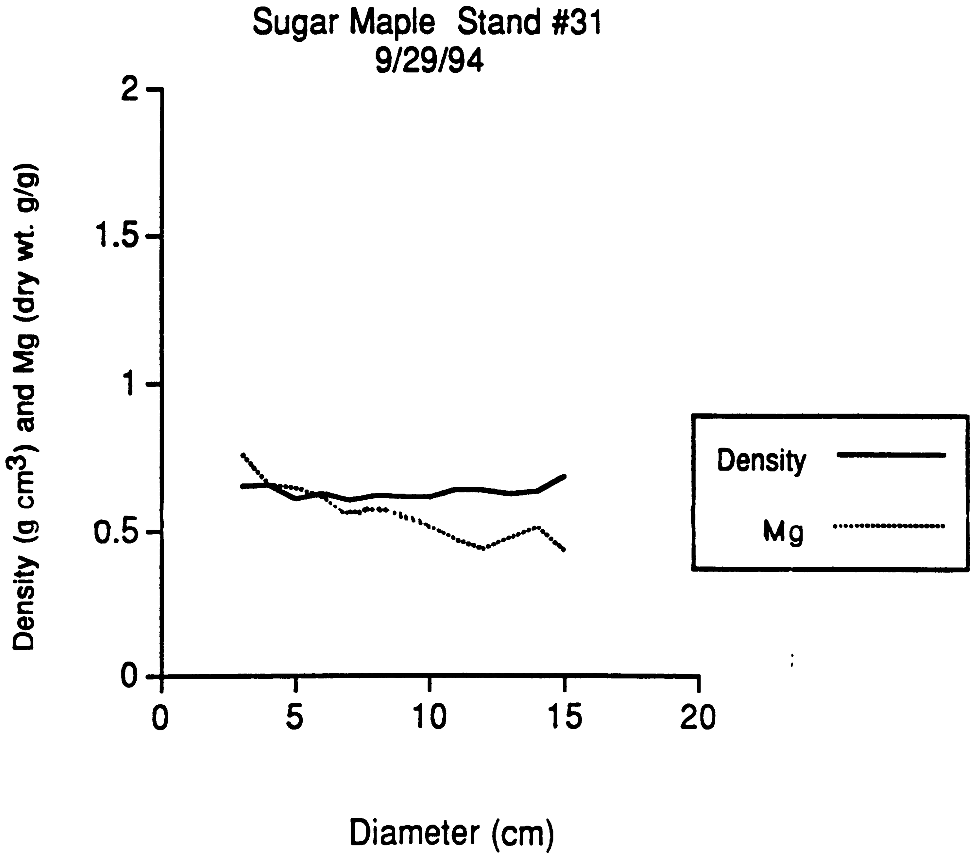
Stand 33
Quaking Aspen
9/30/94

Stem Diameter (cm)	Gravimetric Moisture (dry wt. g/g)	Bulk Density (g/cm3)	Volumetric Moisture (cm3/cm3)
0.5	0.992	0.040	0.040
1.0	0.972	0.244	0.238
2.0	1.054	1.269	1.338
3.0	1.020	0.502	0.512
4.0	1.096	0.438	0.480
5.0	0.983	0.401	0.394
6.0	0.887	0.491	0.436
7.0	0.883	0.430	0.380
8.0	0.811	0.464	0.376
9.0	0.855	0.487	0.416
10.0	0.691	0.435	0.300
11.0	0.667	0.439	0.293
12.0	0.698	0.447	0.312
13.0	0.777	0.461	0.358
14.0	0.841	0.450	0.378
leaves	1.725	0.567	0.978
Mean of Wood=	0.882	0.466	0.417
SD of Wood=	0.136	0.252	0.278
Mean of Leaves=	1.725	0.567	0.978

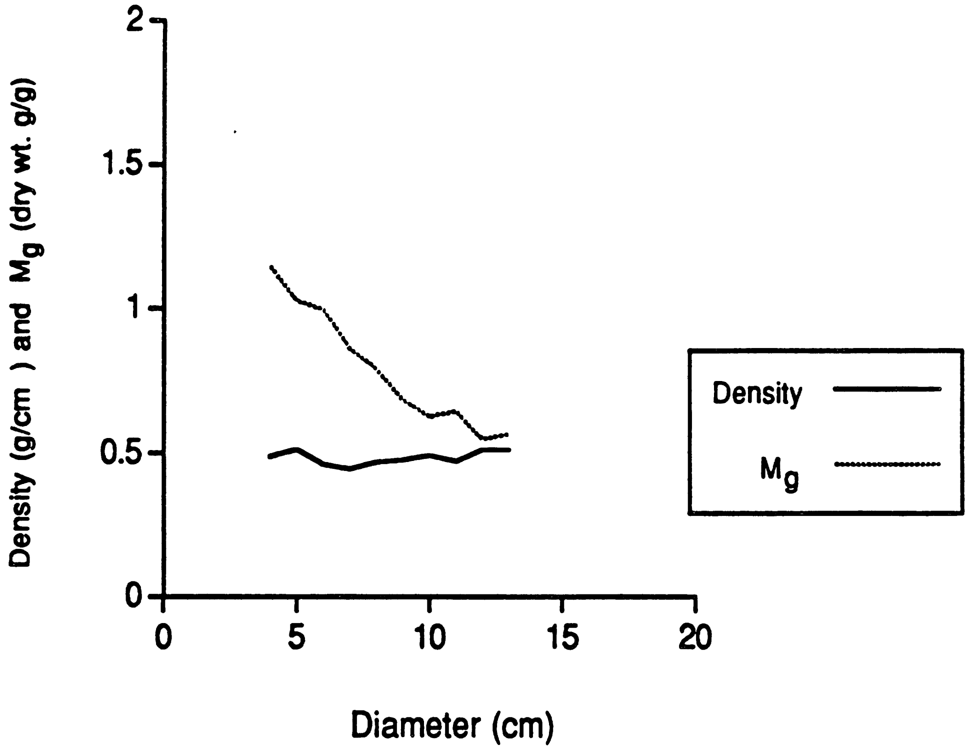
Stand 32
Northern White-cedar
10/1/94

Stem Diameter (cm)	Gravimetric Moisture (dry wt. g/g)	Bulk Density (g/cm3)	Volumetric Moisture (cm3/cm3)
0.5	0.842	0.677	0.570
1.0	0.702	3.720	2.613
2.0	1.159	0.333	0.386
3.0	1.176	0.474	0.557
4.0	1.151	0.444	0.511
5.0	1.214	0.407	0.494
6.0	1.182	0.412	0.487
7.0	1.160	0.385	0.446
8.0	1.072	0.356	0.381
9.0	1.023	0.354	0.362
10.0	0.960	0.357	0.343
11.0	0.847	0.361	0.306
12.0	0.822	0.353	0.290
13.0	0.788	0.359	0.283
14.0	0.766	0.354	0.271
15.0	0.770	0.335	0.258
18.0	0.861	0.335	0.288
leaves	1.077	9.655	10.400
Mean of Wood=	0.970	0.589	0.520
SD of Wood=	0.180	0.811	0.549
Mean of Leaves=	1.077	9.655	10.400

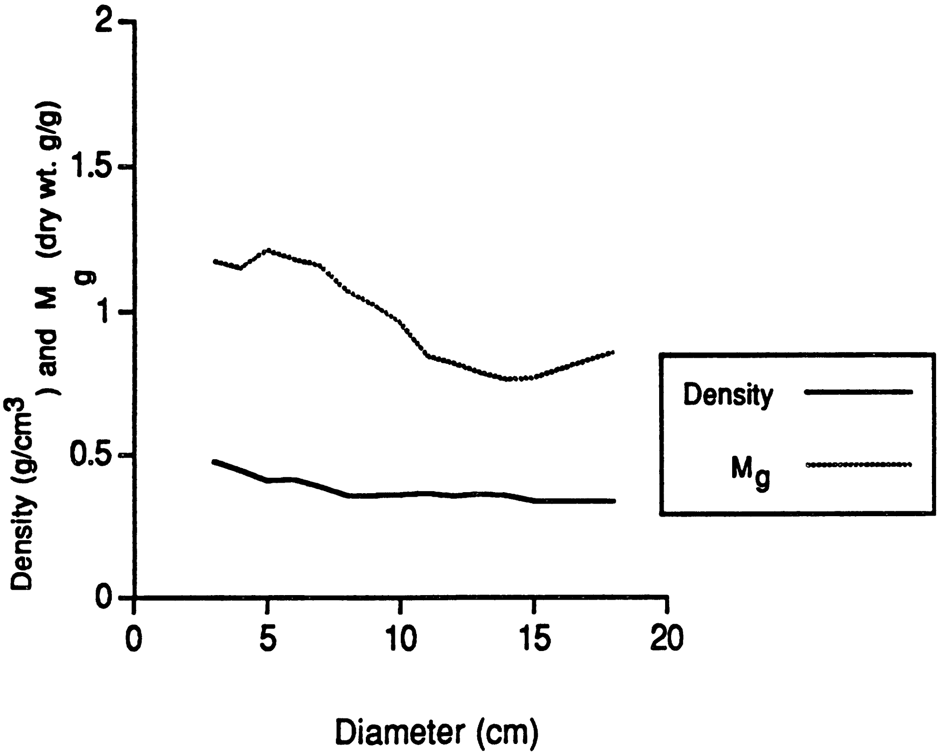

Red Maple Stand #31
9/29/94
Density (g/cm3) and Mg (dry wt. g/g)
2
1.5
1
0.5
0
0
5
10
15
20
Diameter (cm)
Density
Mg

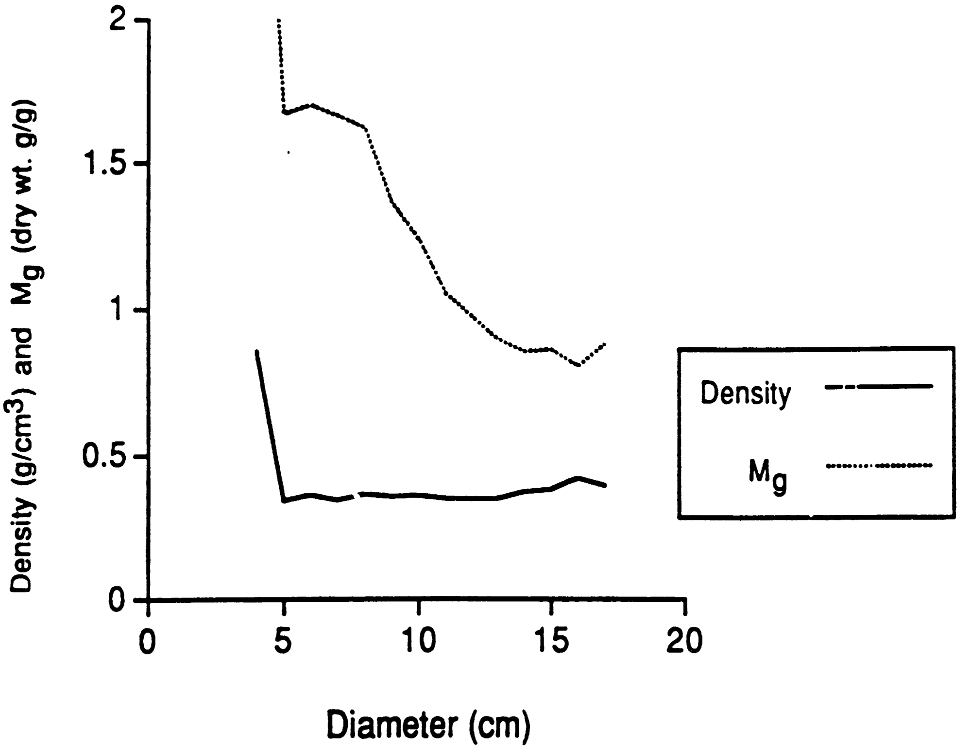

Sugar Maple Stand #31
9/29/94
Density (g cm3) and Mg (dry wt. g/g)
2
1.5
1
0.5
0
0
5
10
15
20
Diameter (cm)
Density
Mg

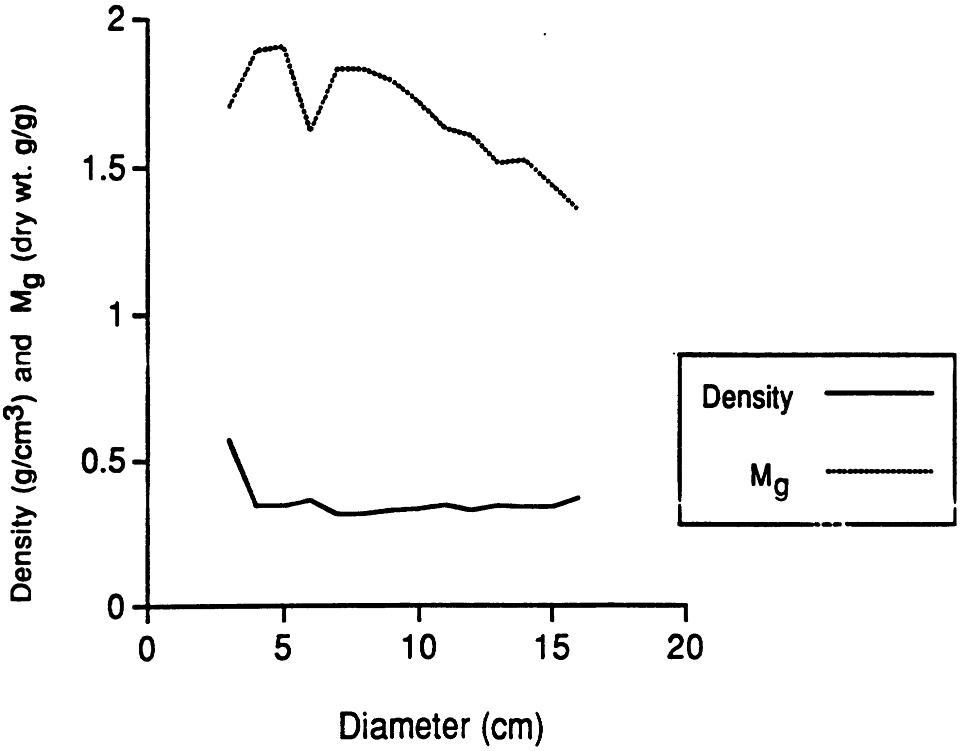
Black Spruce Stand #32
10/1/94

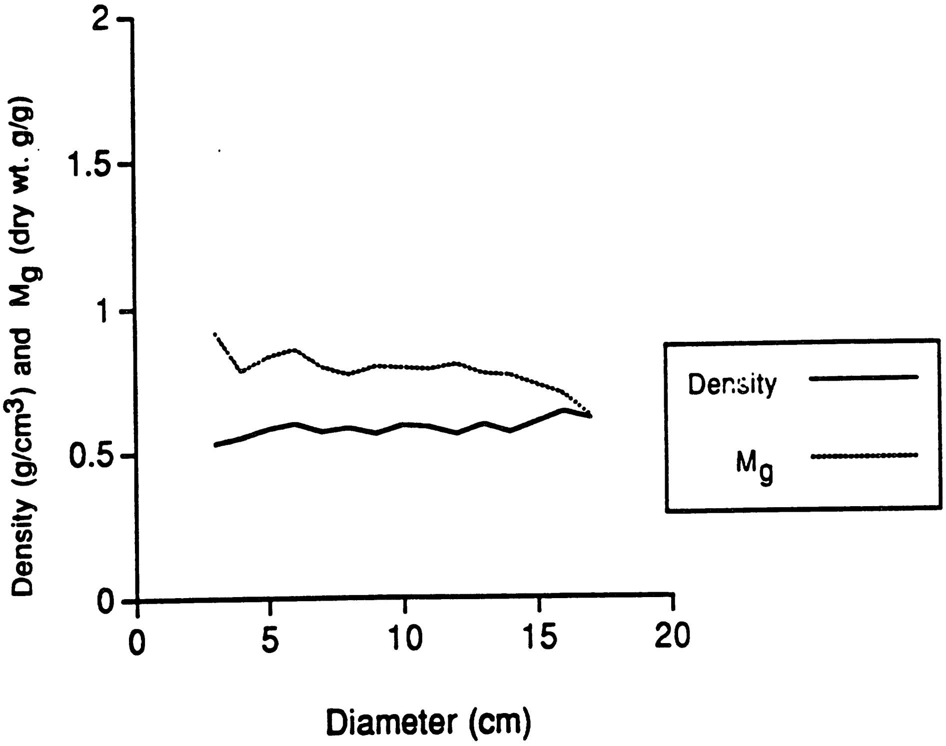


N White Cedar Stand #32
10/1/94

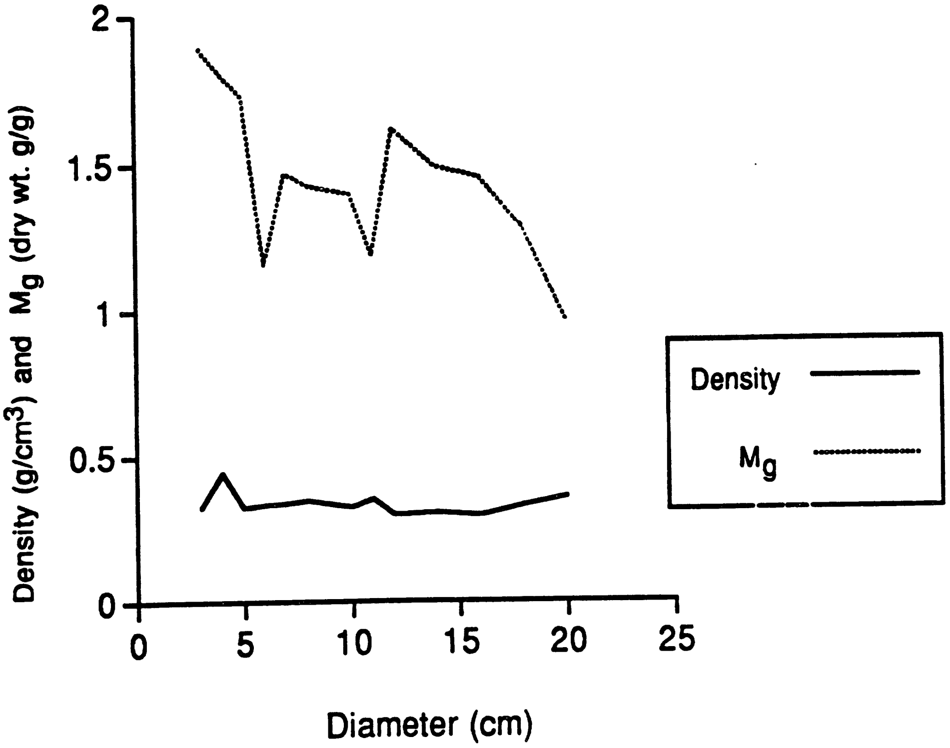



Jack Pine Stand #24
10/1/94


Red Pine Stand #22
10/1/94

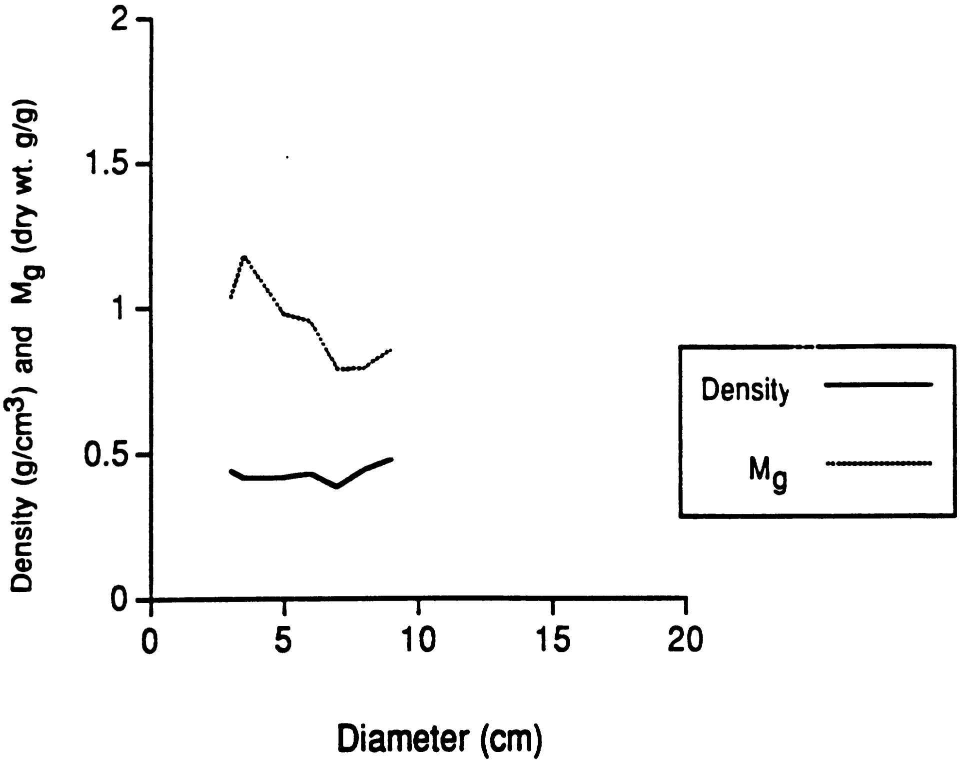


Beech Stand #31
9/30/94

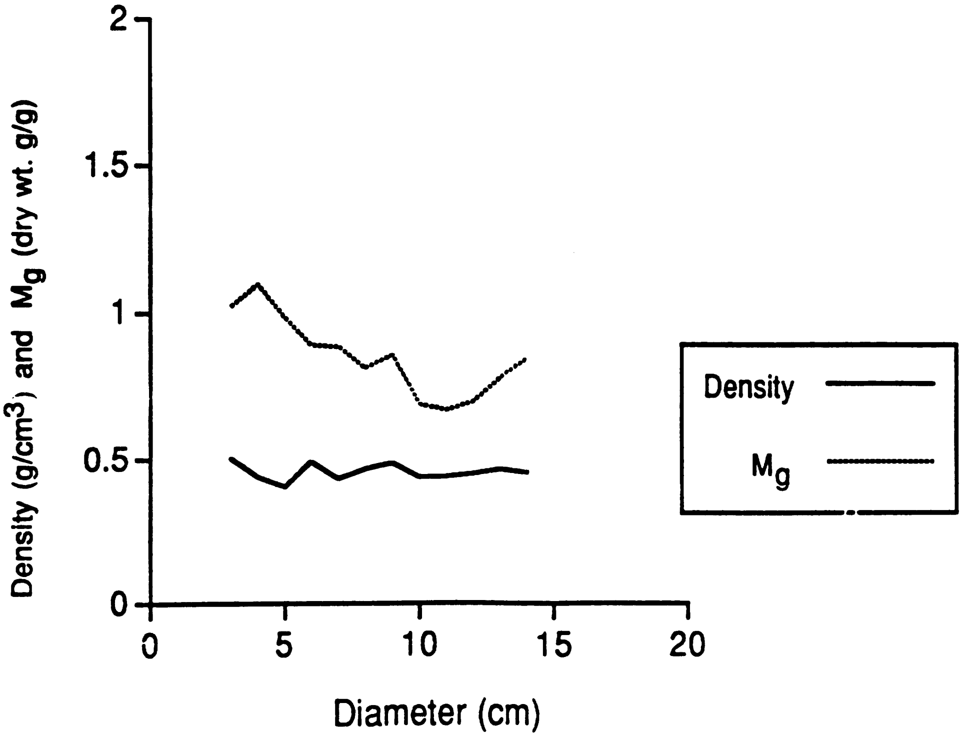


White Pine Stand #75
10/1/94

Bigtooth Aspen Stand #33
9/30/94

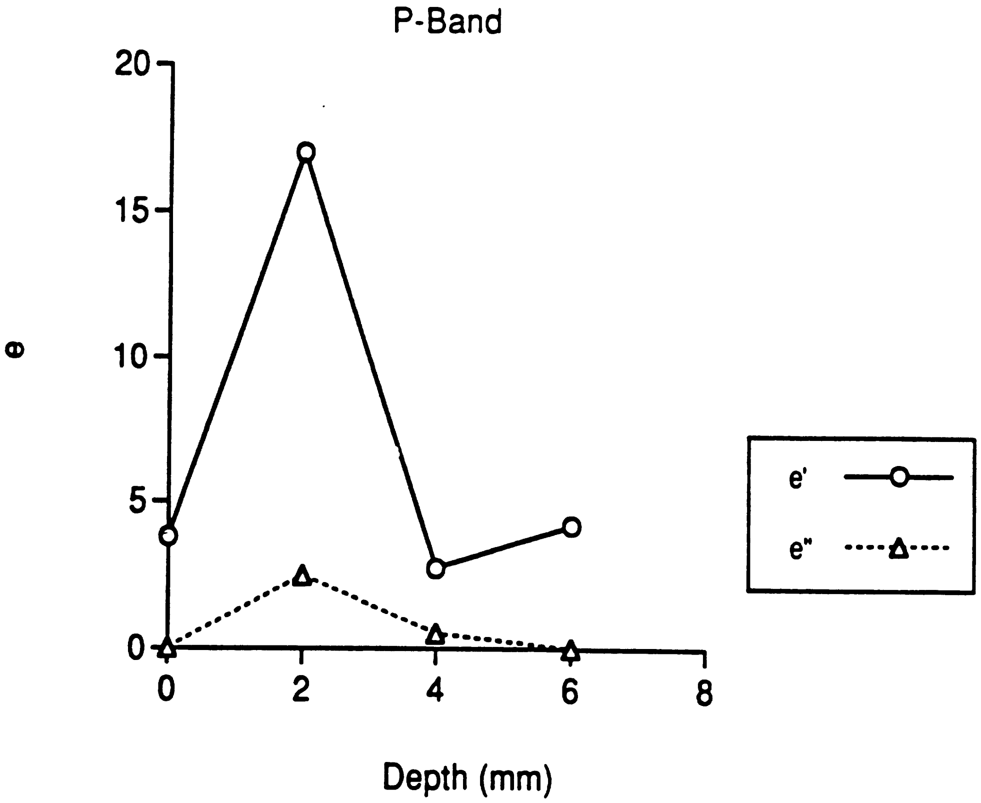


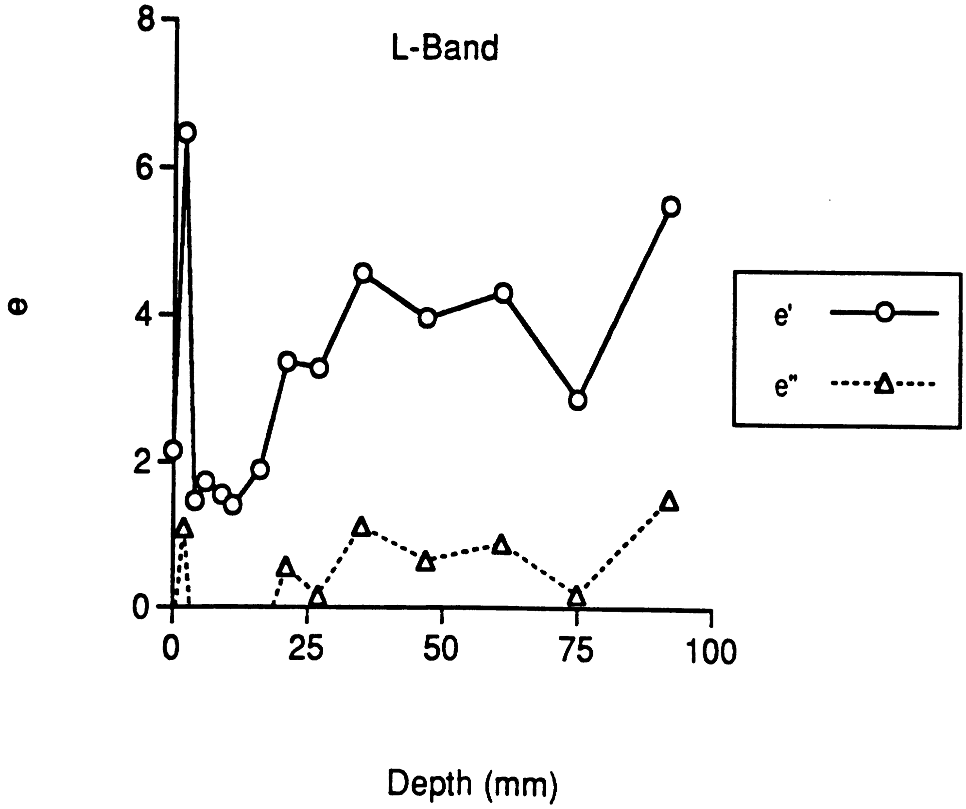
Trembling Aspen Stand #33
9/30/94



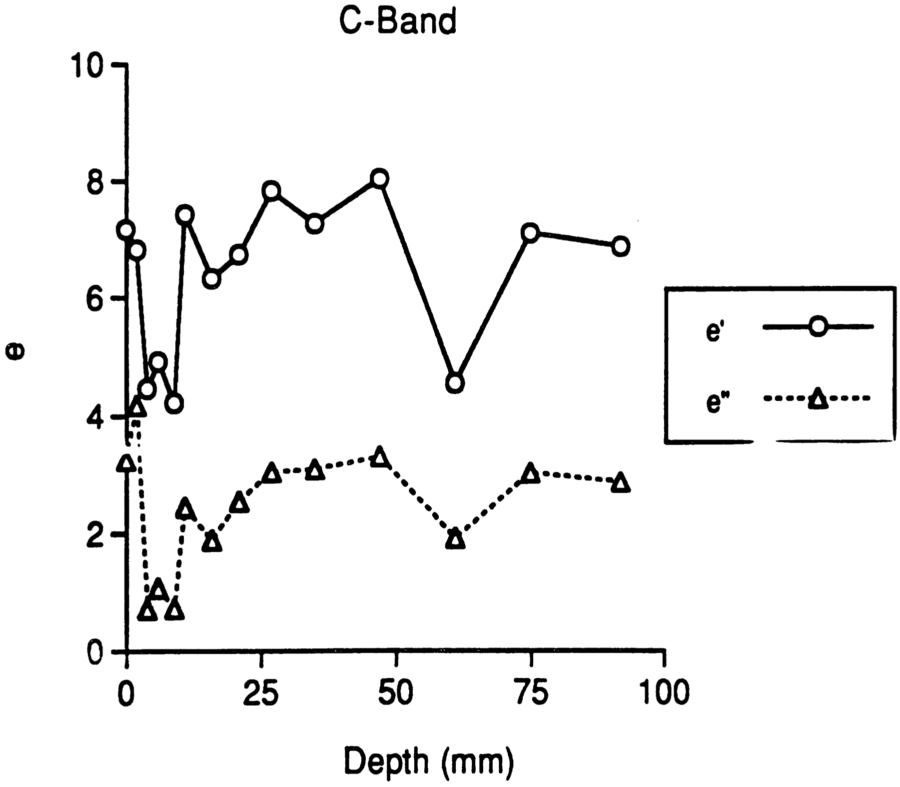
APPENDIX D:
VEGETATION DIELECTRIC PLOTS: e' vs. Depth

Dielectric Depth Profile
September 28, 1994
Beech-pole
dbh=20 cm



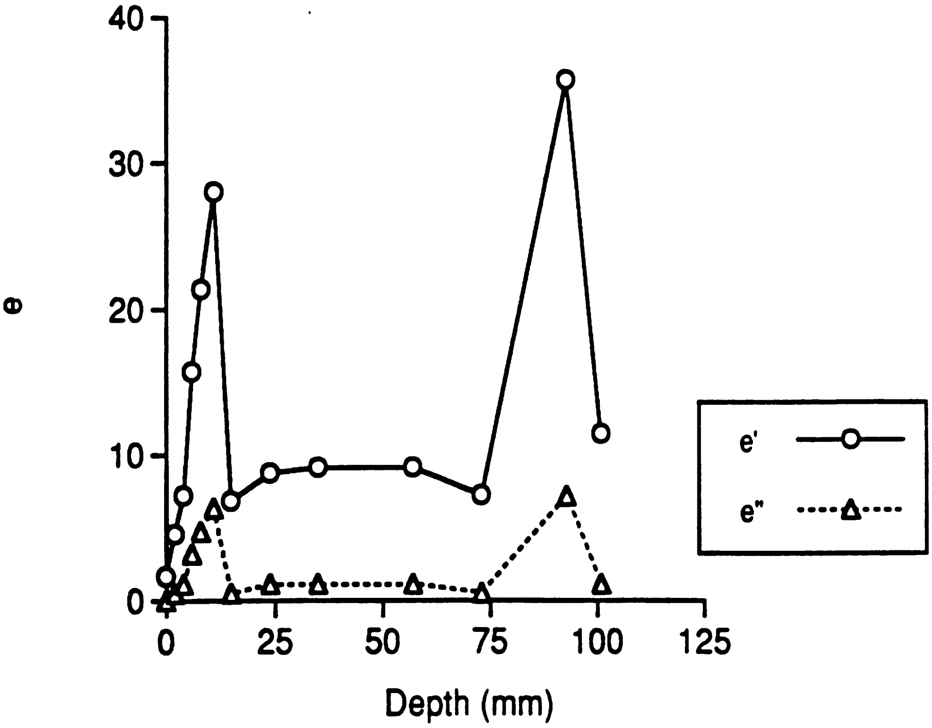


Dielectric Depth Profile
September 28,1994
Beech-pole
dbh=20 cm

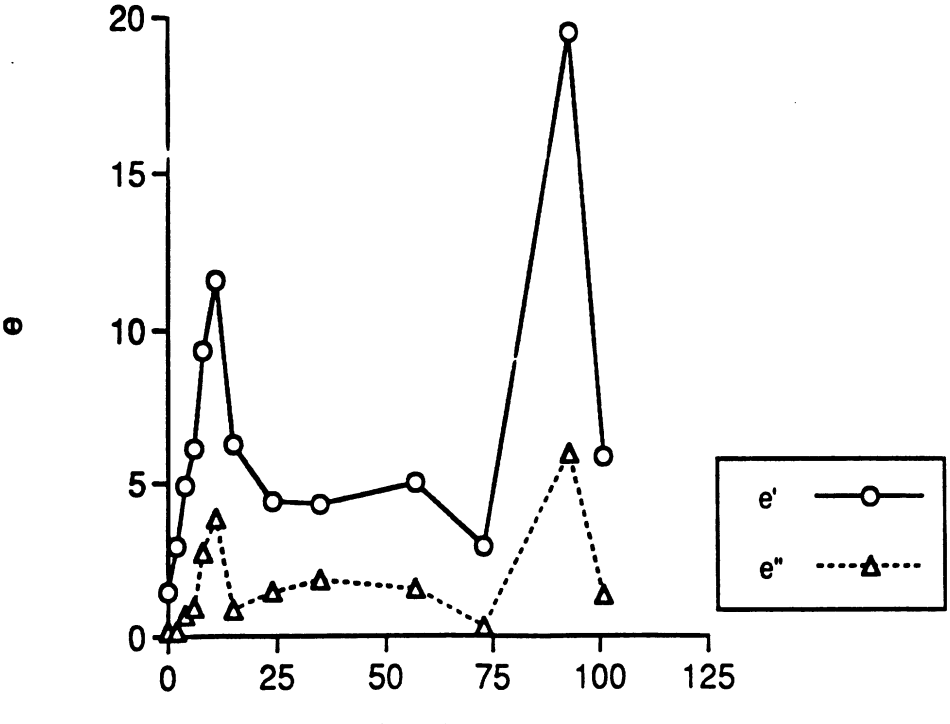


Dielectric Depth Profiles
September 29, 1994
Bigtooth Aspen-mature
dbh=30 cm

P-Band

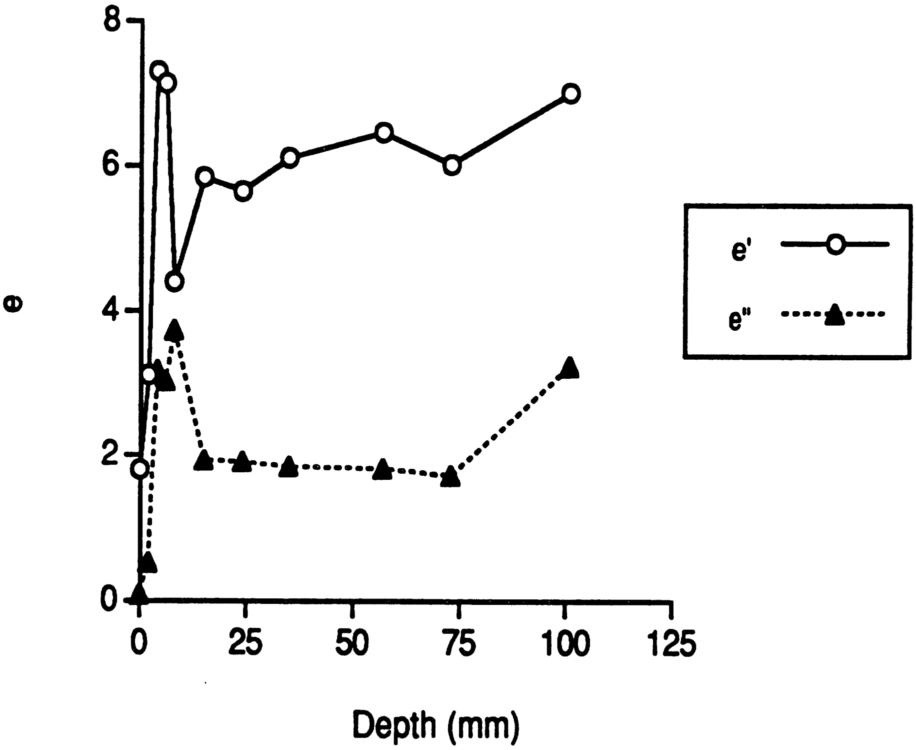


L-Band

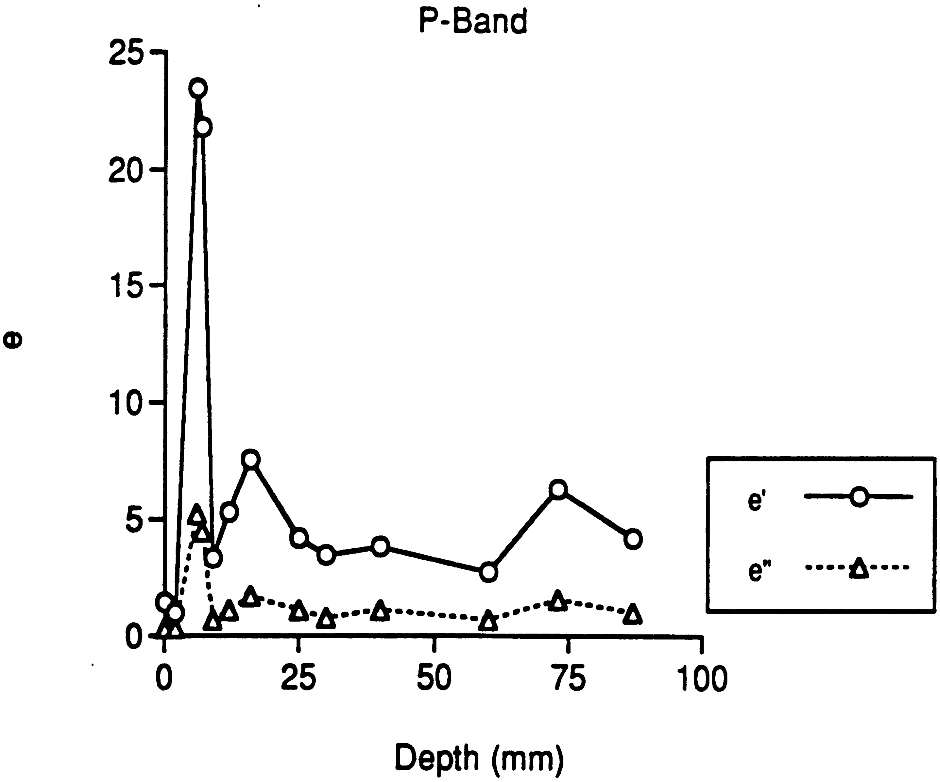


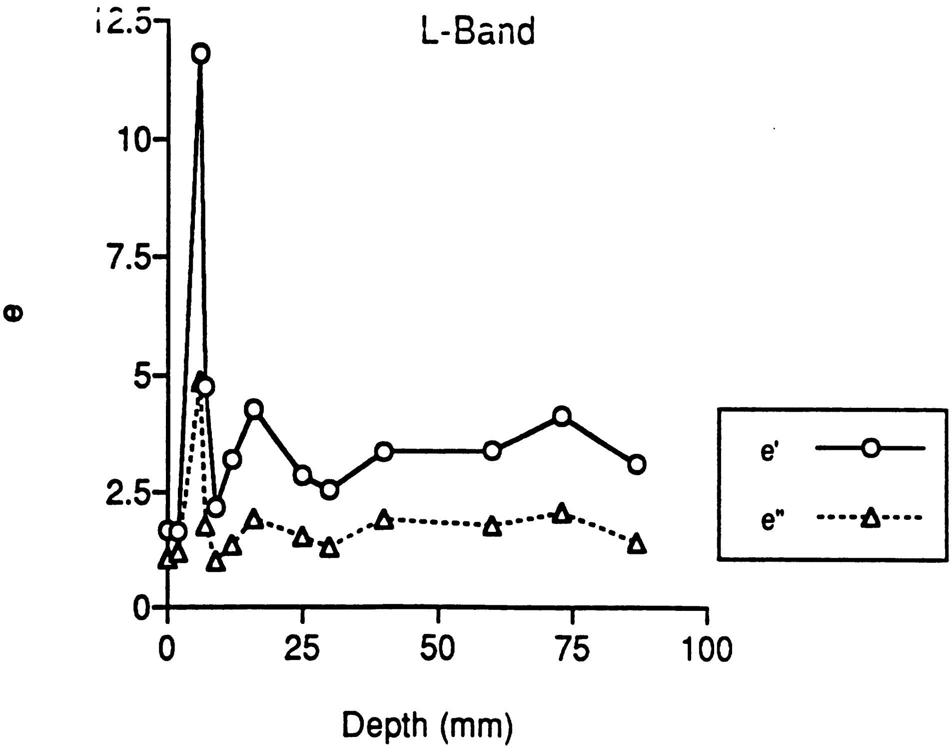
Dielectric Depth Profiles
September 29,1994
Bigtooth Aspen-mature
dbh=30 cm

C-Band



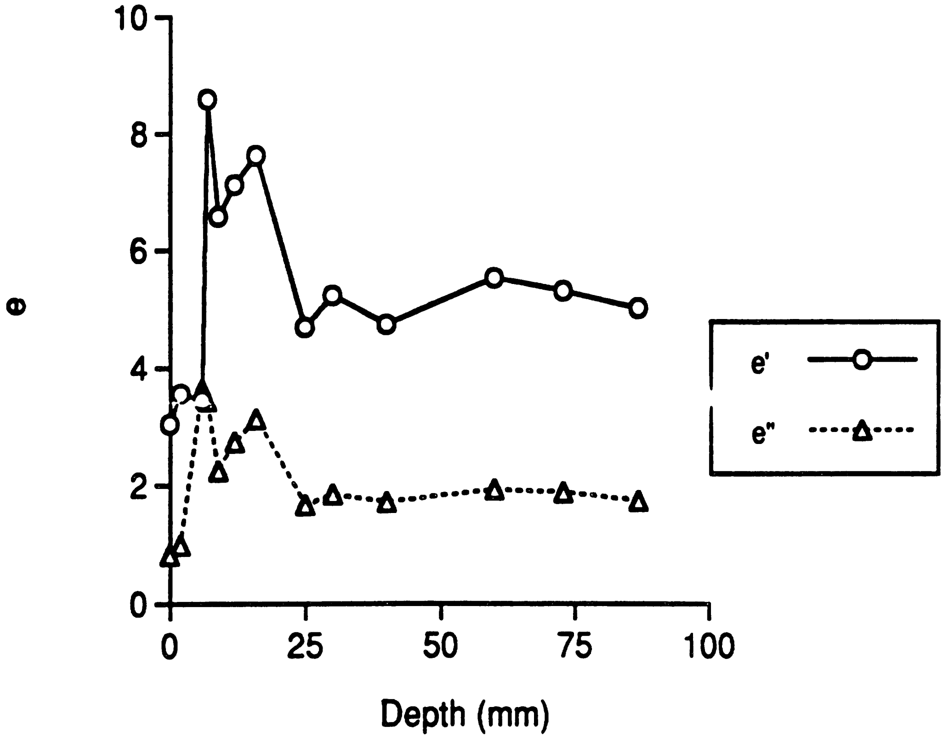
Dielectric Depth Profiles
Black Spruce-Pole
September 29,1994
dbh= 20cm





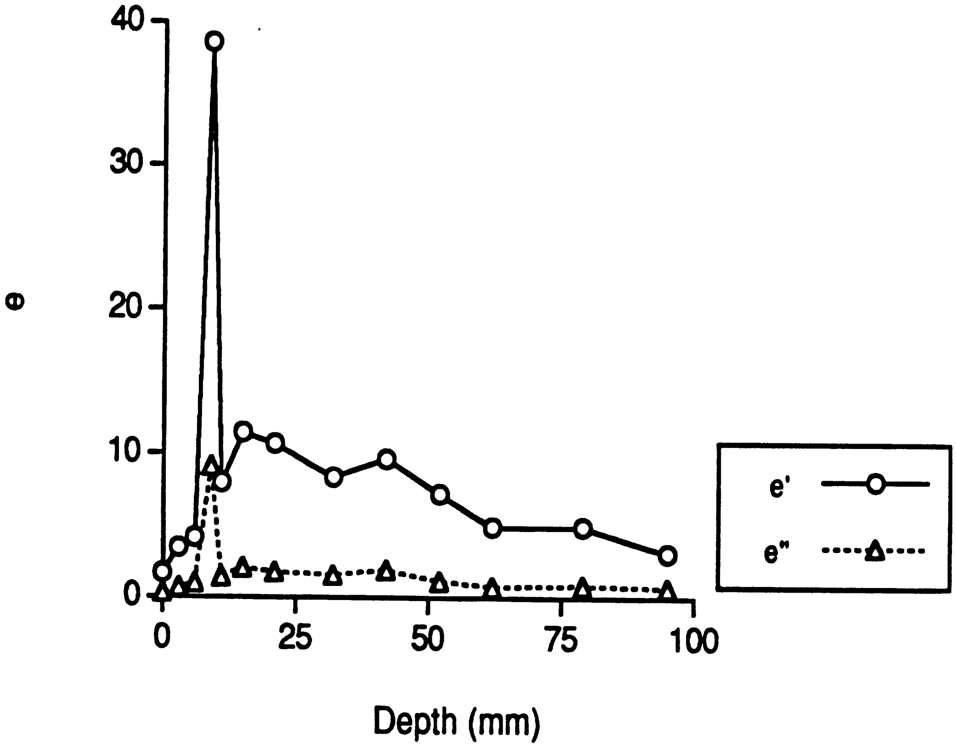
Dielectric Depth Profiles
September 29, 1994
Black Spruce-pole
dbh=20 cm

C-Band

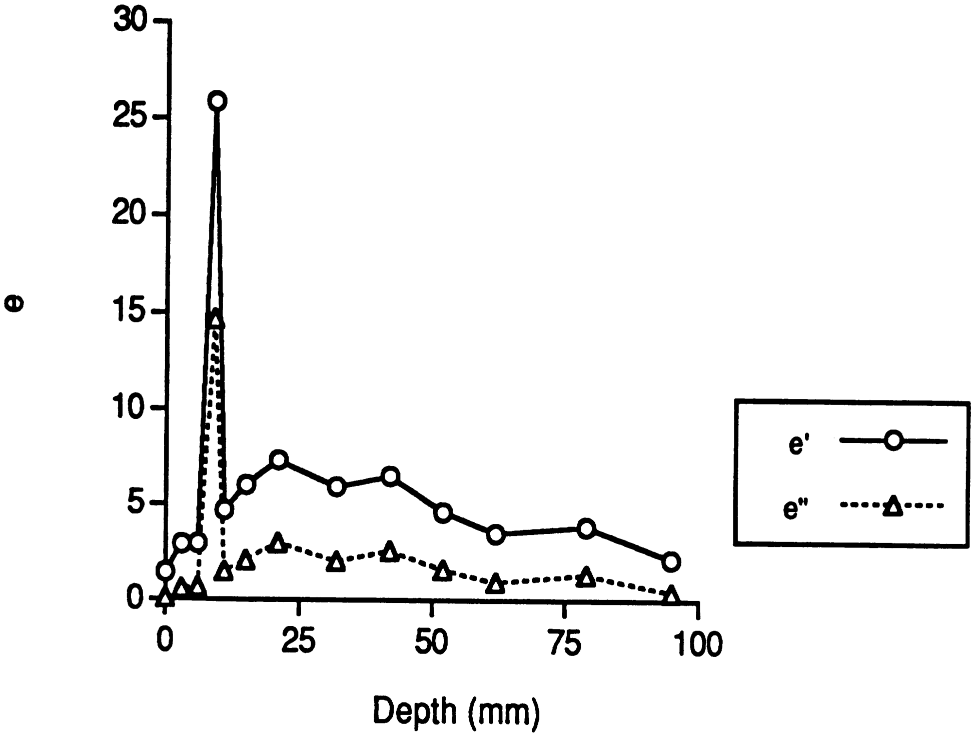


Dielectric Depth Profiles
October 2, 1994
Jack Pine-mature
dbh=24 cm

P-Band

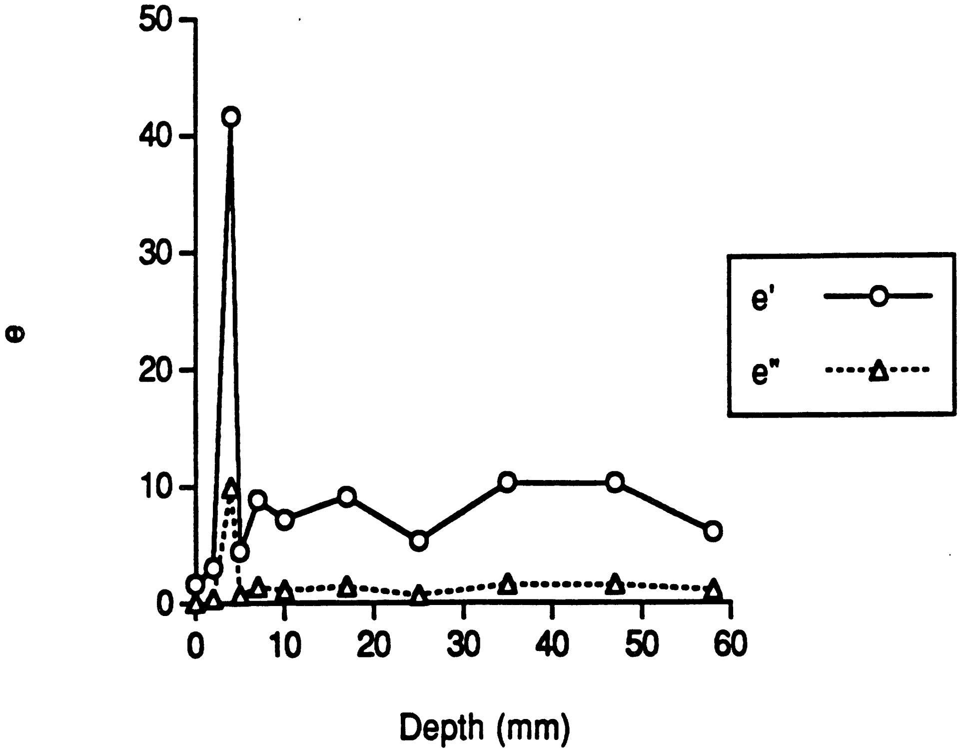


C-Band

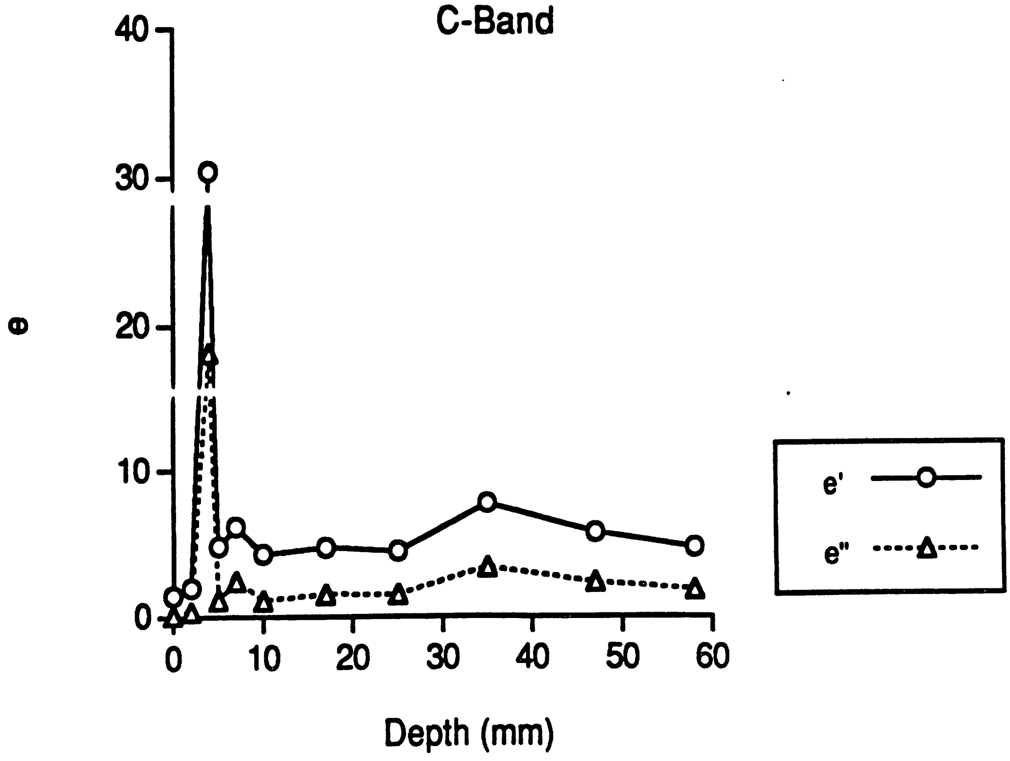


Dielectric Depth Profiles
October 2, 1994
Jack Pine-sapling
dbh= 12.6 cm

P-Band

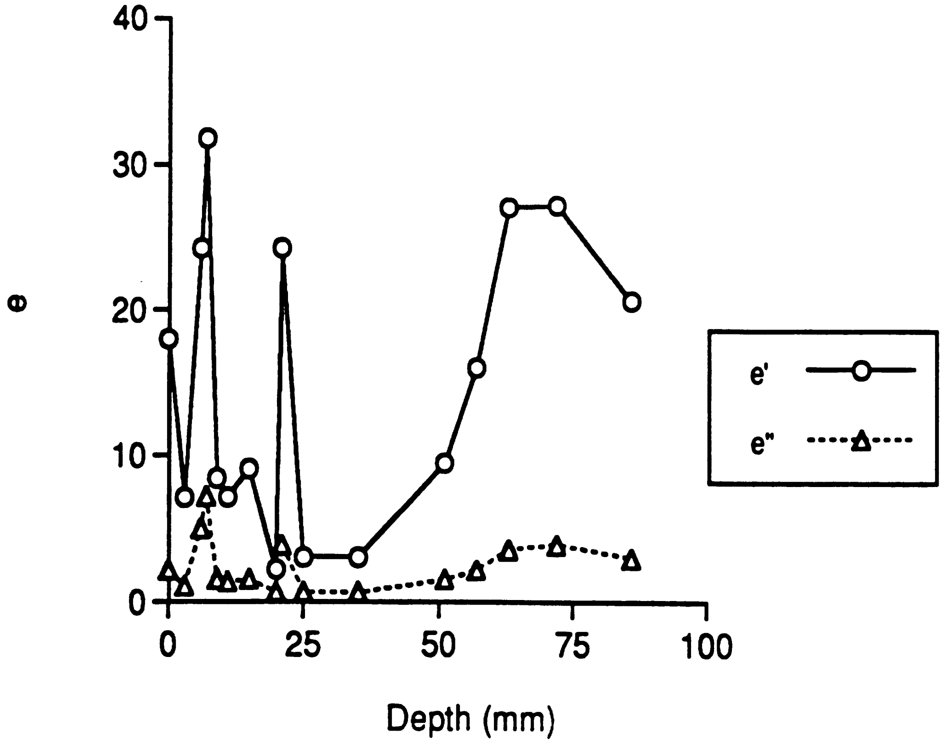


C-Band

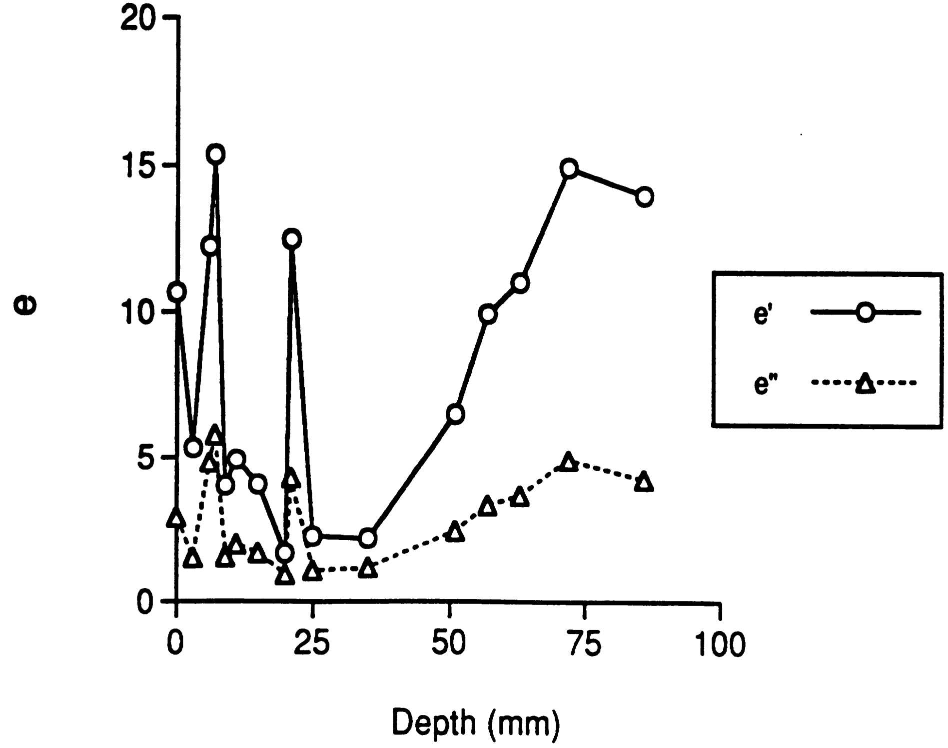


Dielectric Depth Profiles
September 29, 1994
N White Cedar-mature
dbh=35cm

P-Band

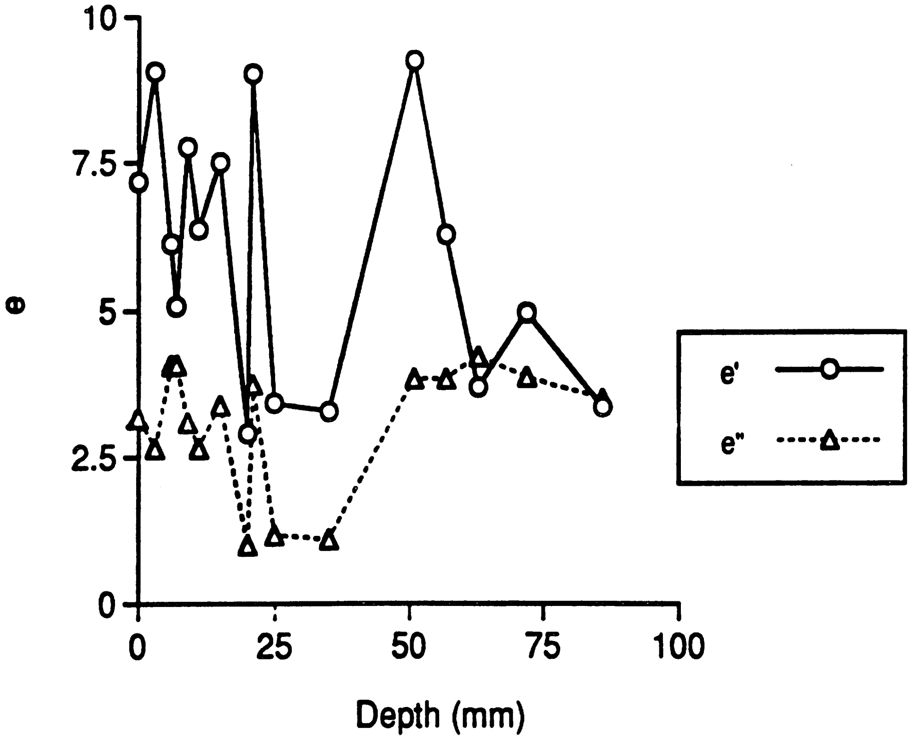


L-Band



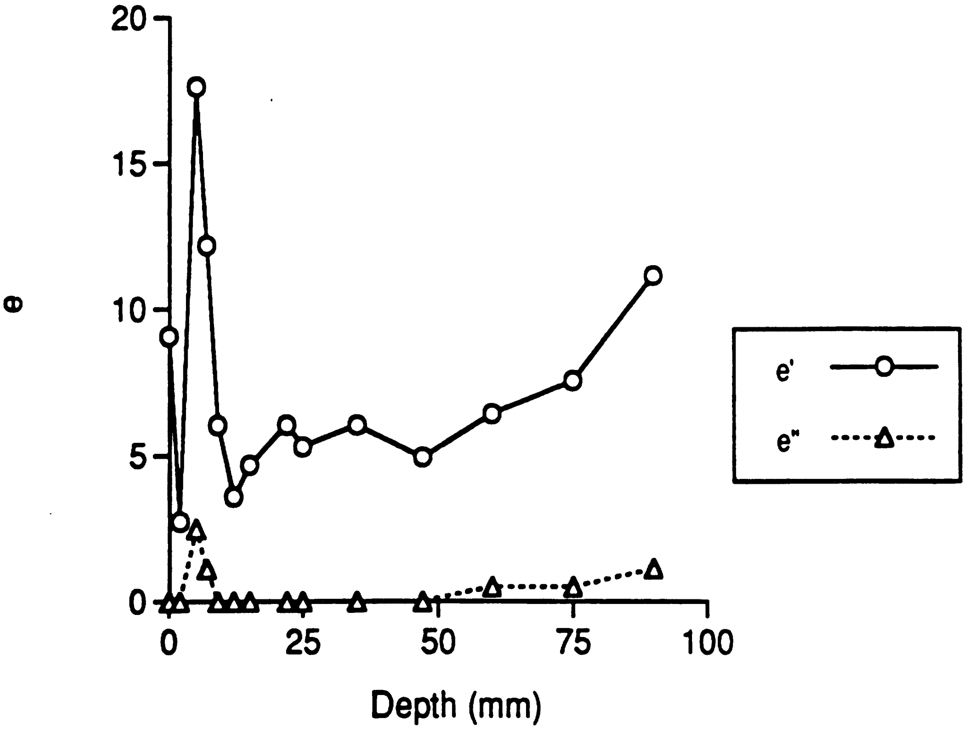
Dielectric Depth Profiles
September 29, 1994
N White Cedar-mature
dbh=35 cm

C-Band

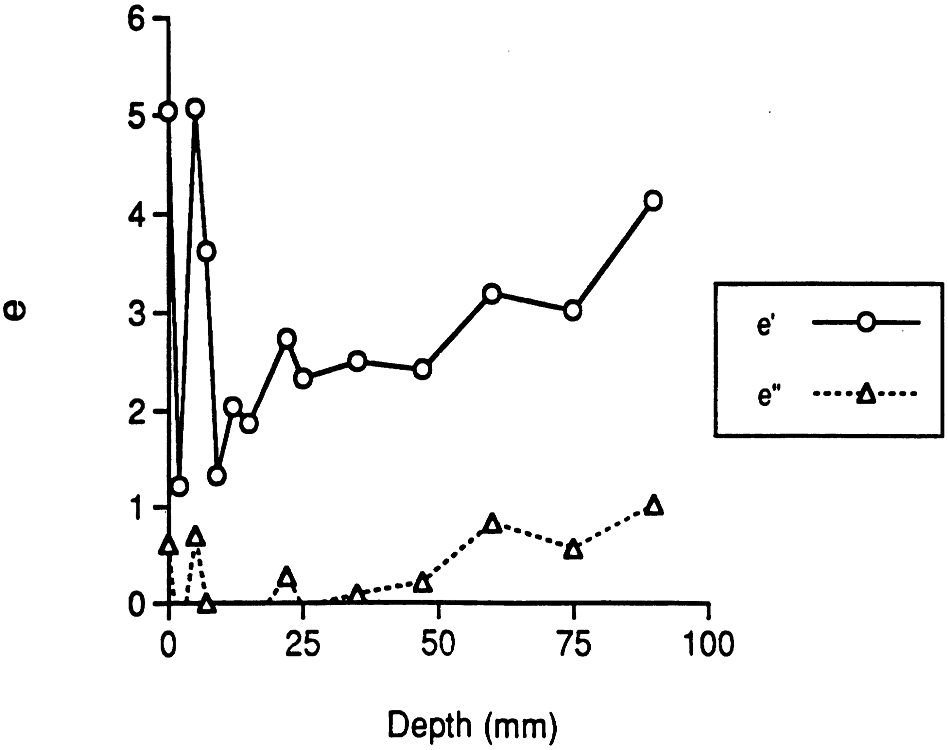


Dielectric Depth Profiles
Red Maple-mature
September 28,1994
dbh= 26.5cm

P-Band

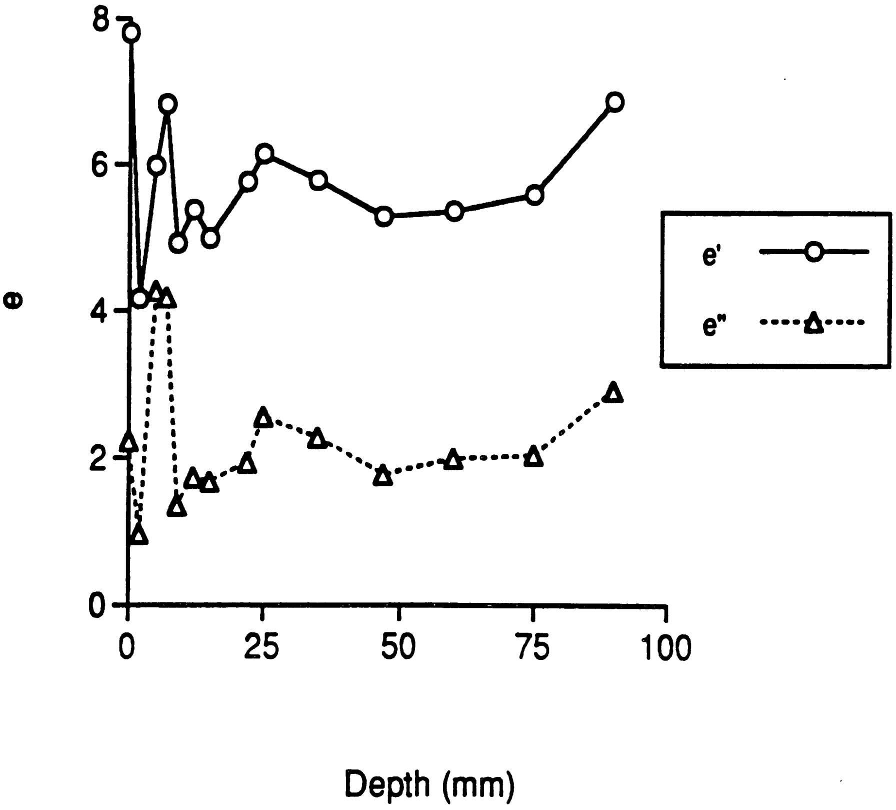


L-Band

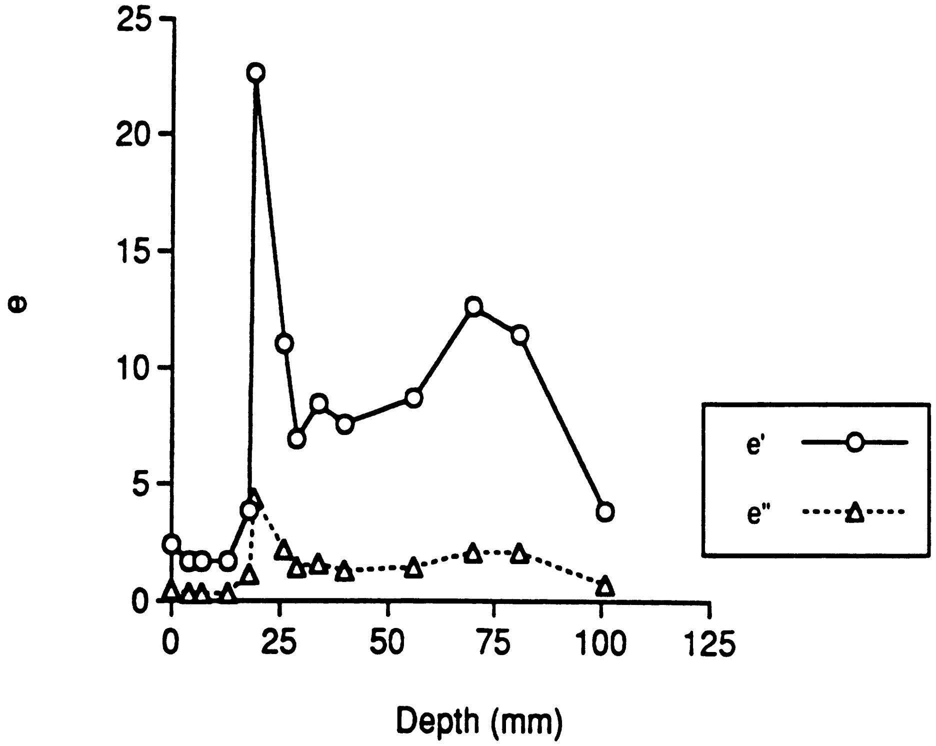


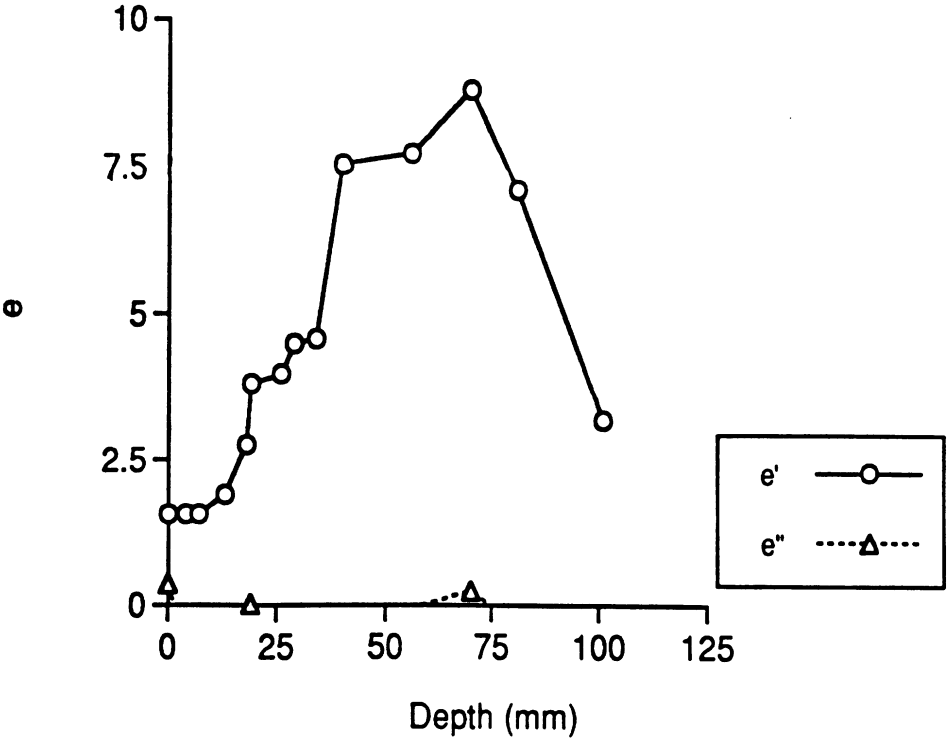
Dielectric Depth Profile
September 28, 1994
Red Maple-mature
dbh=26. 5cm

C-Band



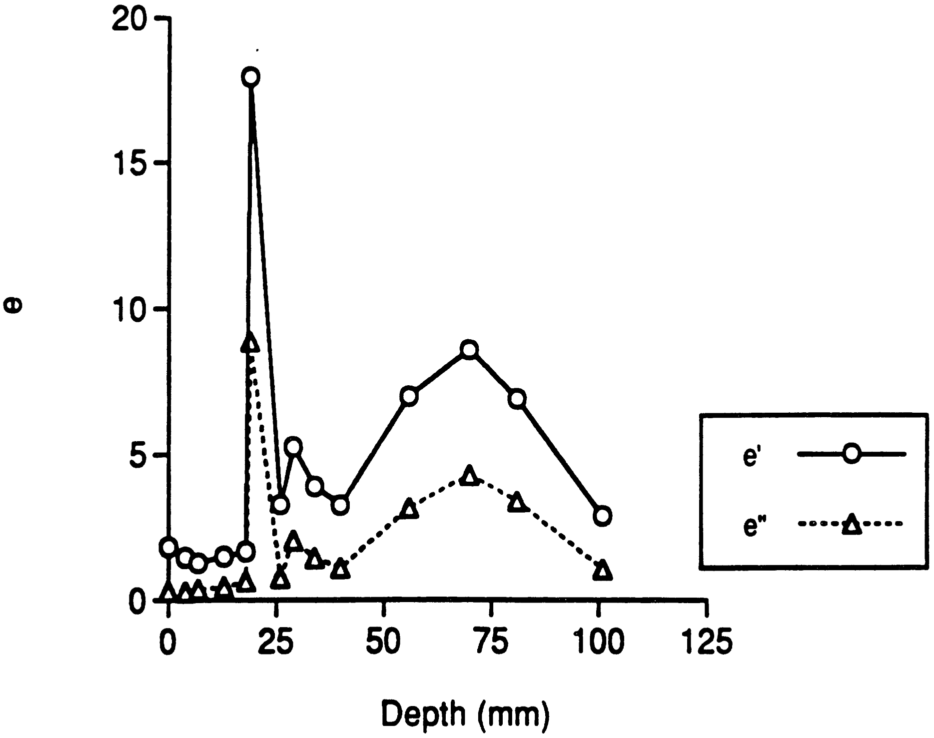
Dielectric Depth Profiles
October 2, 1994
Red Pine-mature


P-Band


L-Band

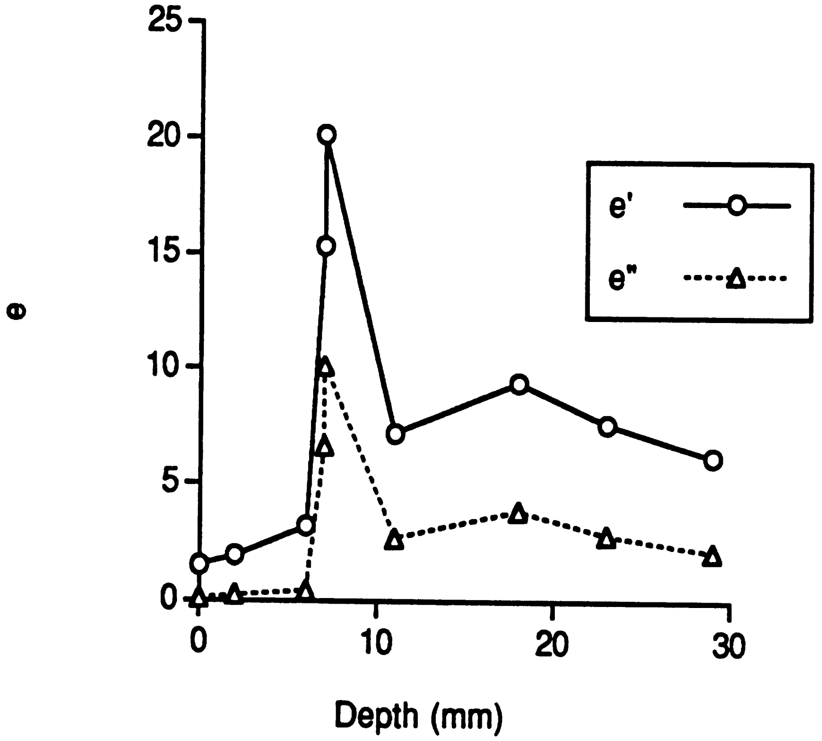
Dielectric Depth Profiles
October 2, 1994
Red Pine-mature

C-Band



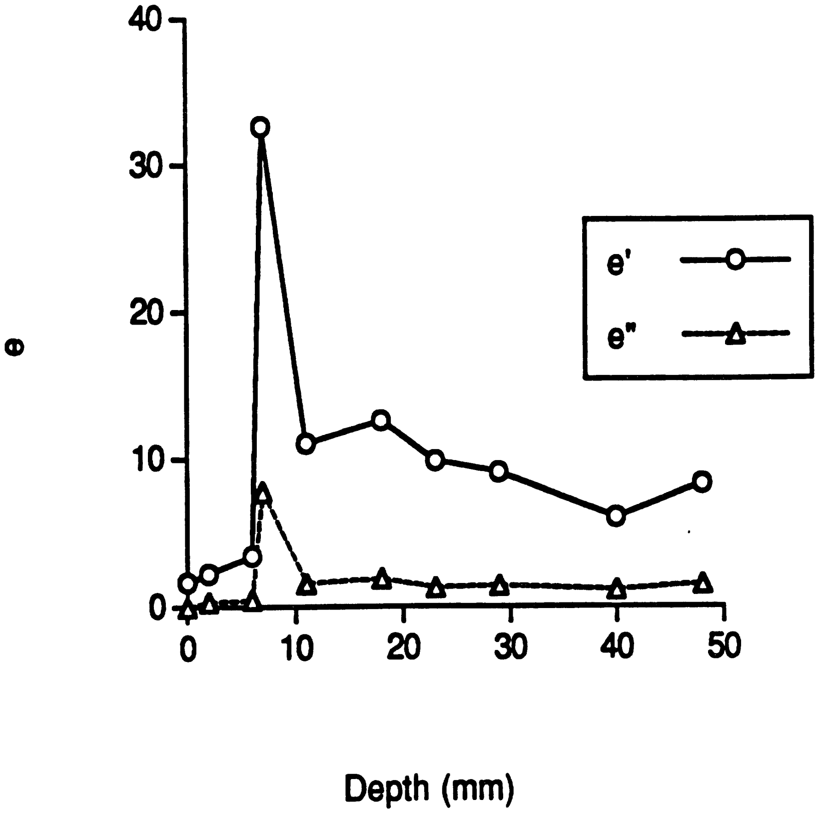
Dielectric Depth Profile
October 10, 1994
Red Pine - sapling

C-Band

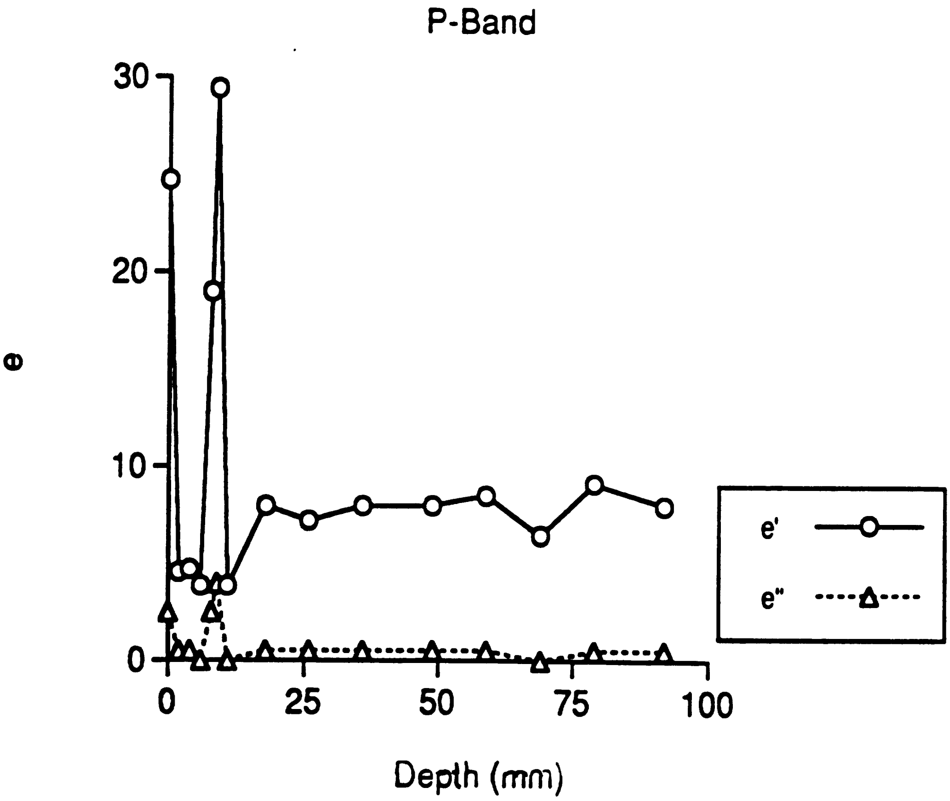


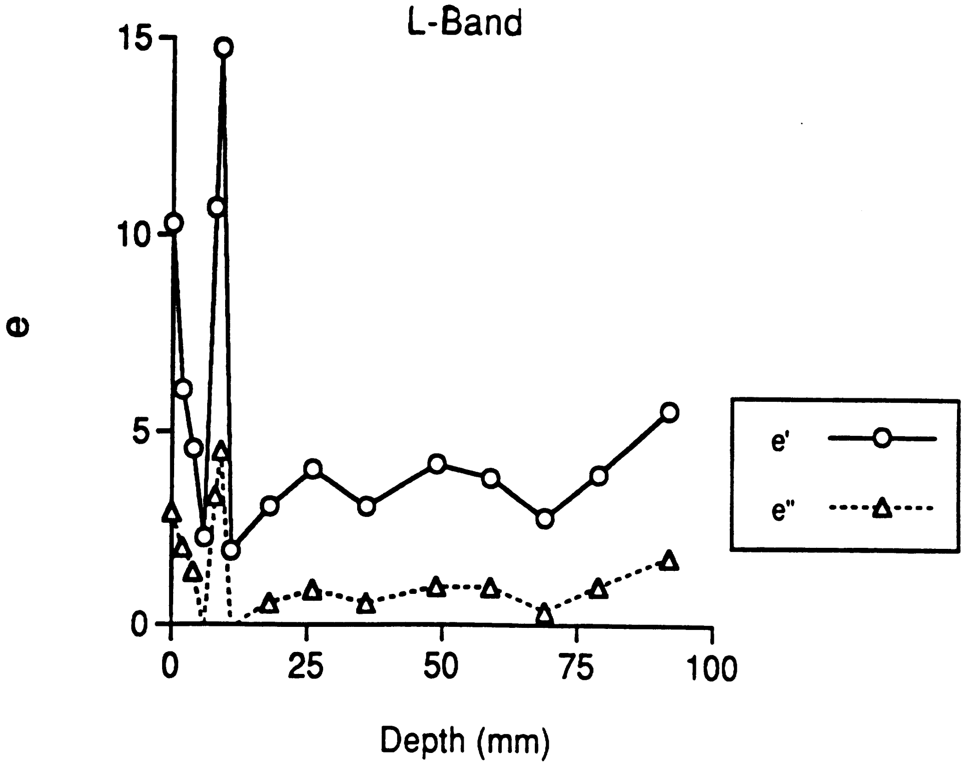
Dielectric Depth Profiles
October 2, 1994
Red Pine-sapling

P-Band



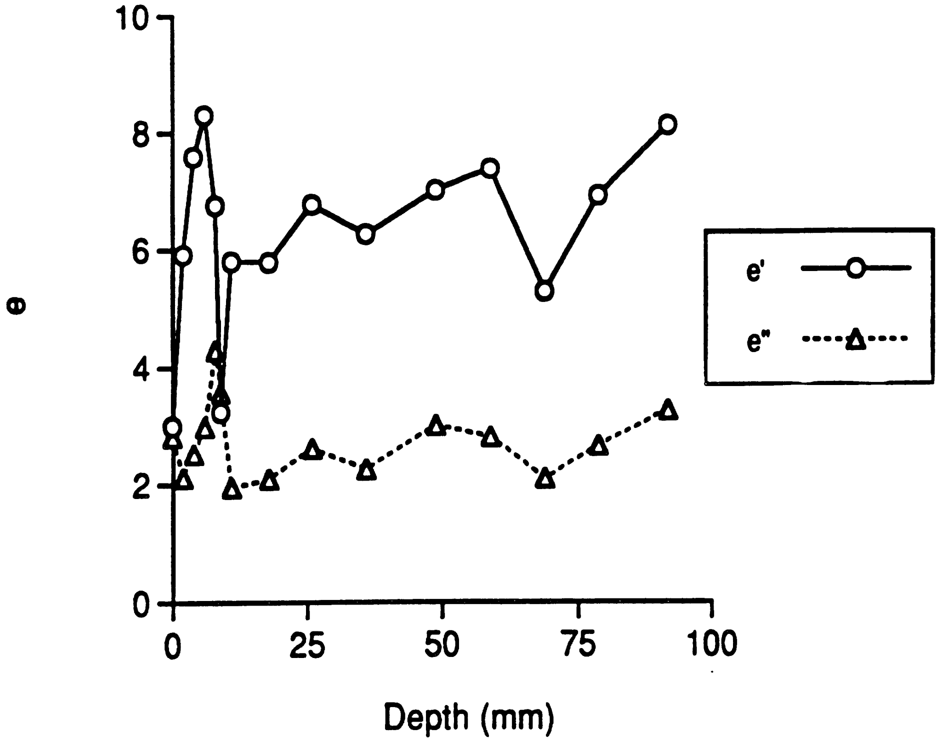
Dielectric Depth Profiles
September 28, 1994
Sugar Maple-mature
dbh=25 cm



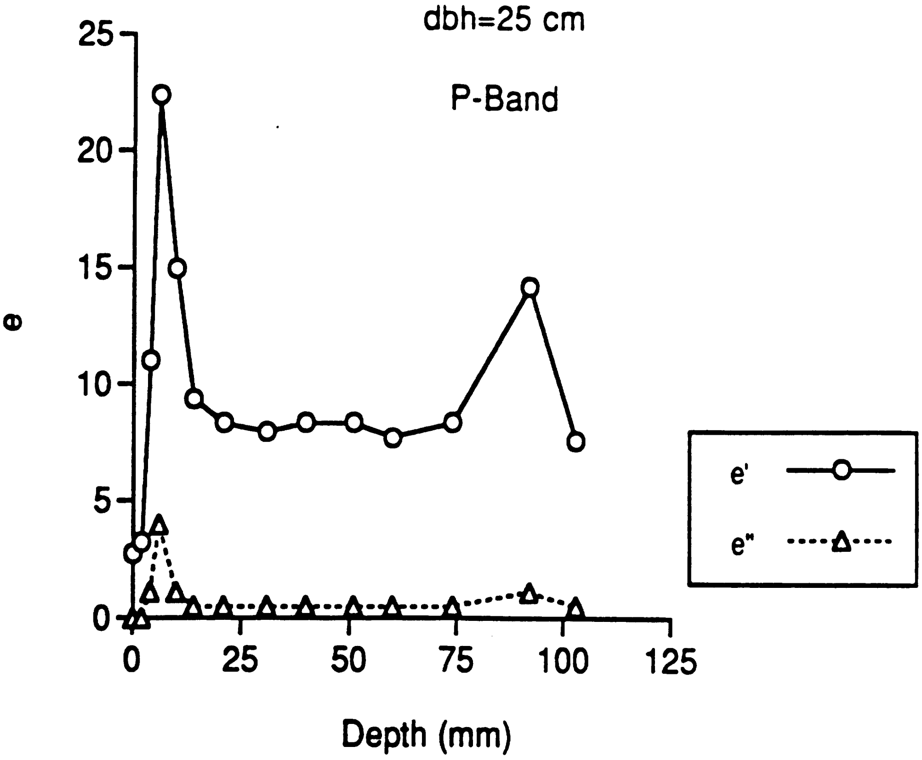


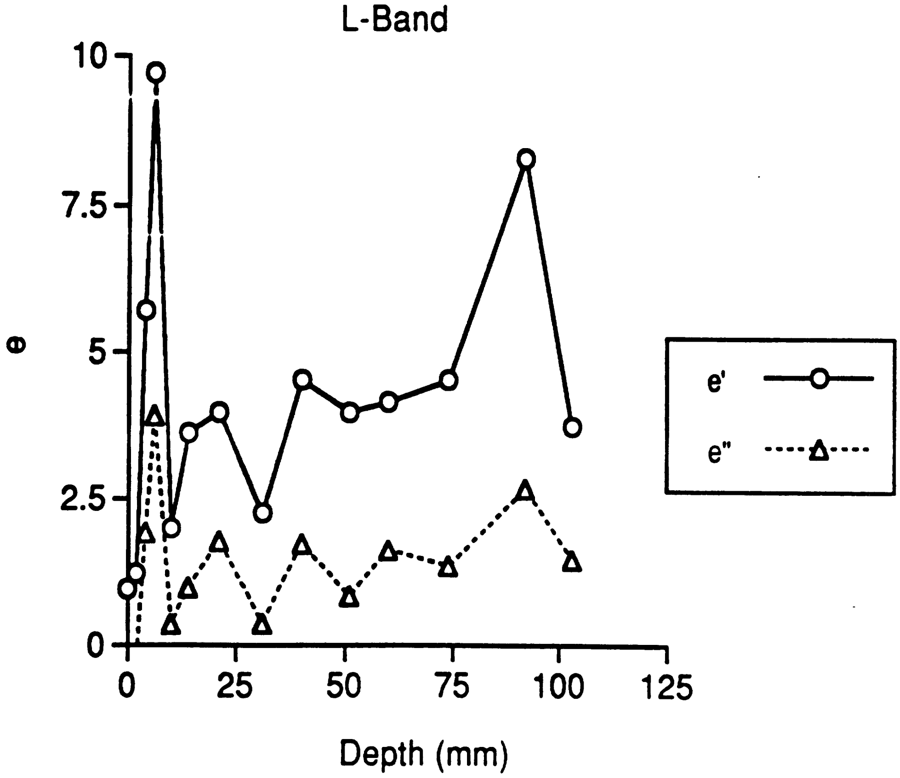
Dielectric Depth Profiles
September 28, 1994
Sugar Maple-mature
dbh=25 cm

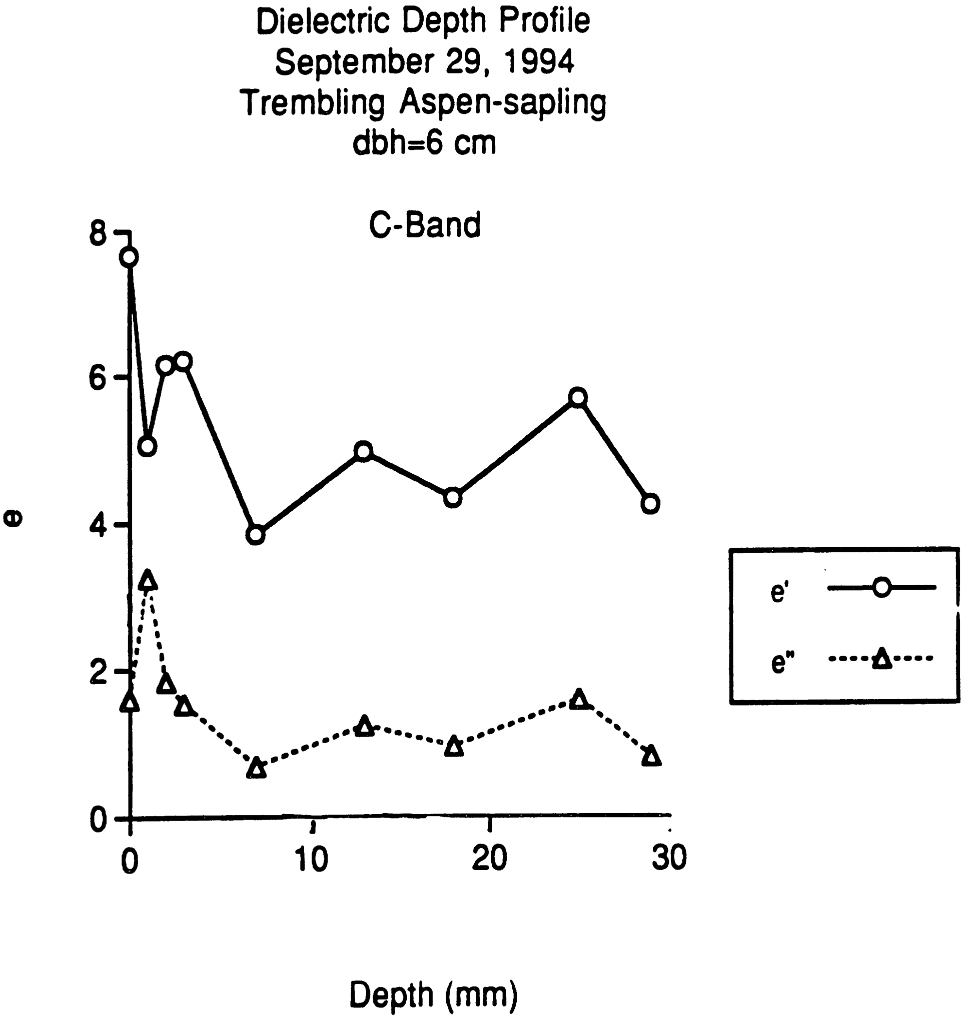
C-Band



Dielectric Depth Profiles
Trembling Aspen-mature
September 29, 1994
dbh=25 cm



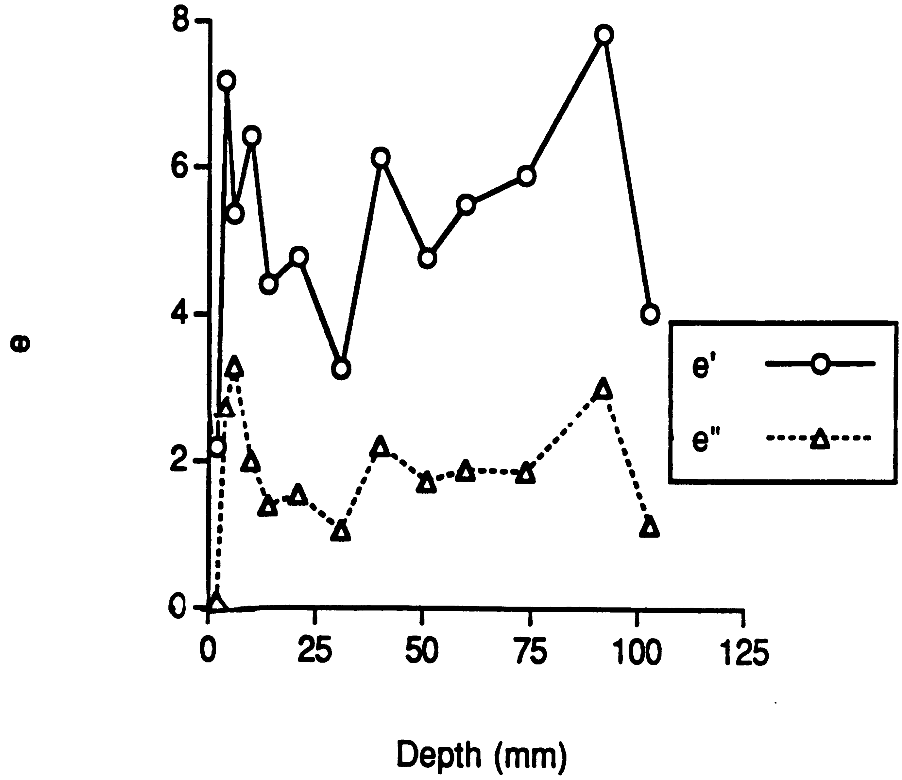




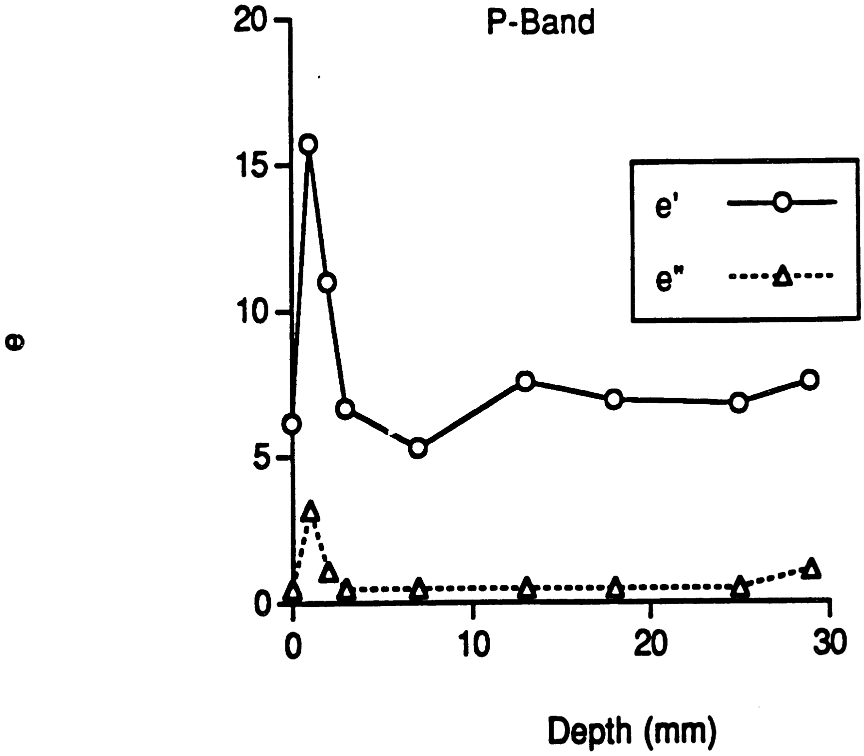
Dielectric Depth Profile
September 29, 1994
Trembling Aspen-sapling
dbh=6 cm

Dielectric Depth Profiles
Trembling Aspen-mature
September 29, 1994
dbh=25 cm

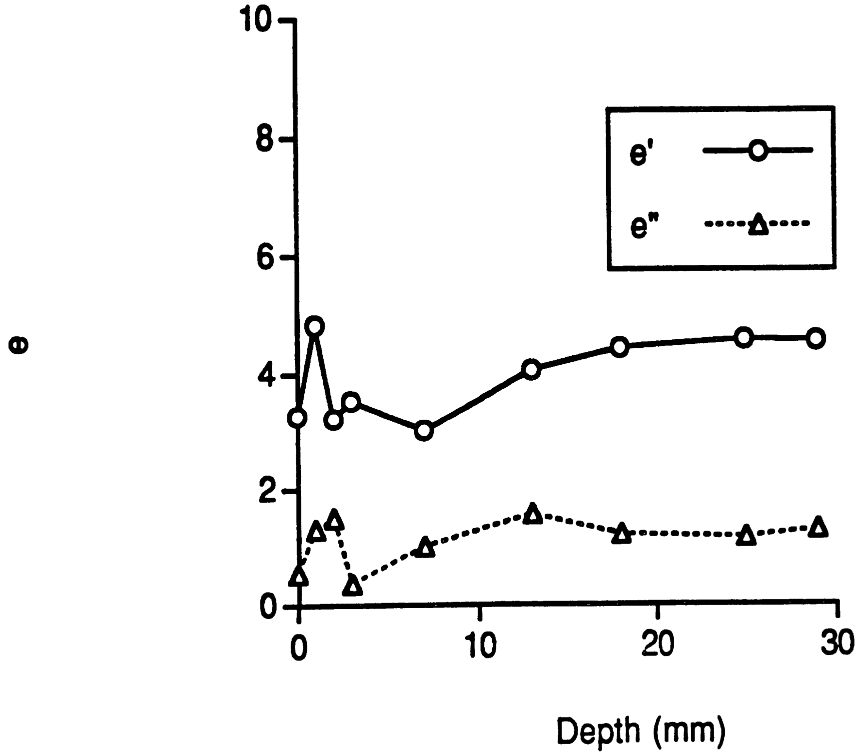
C-Band



Dielectric Depth Profiles
Trembling Aspen-sapling
September 29, 1994
dbh=6 cm

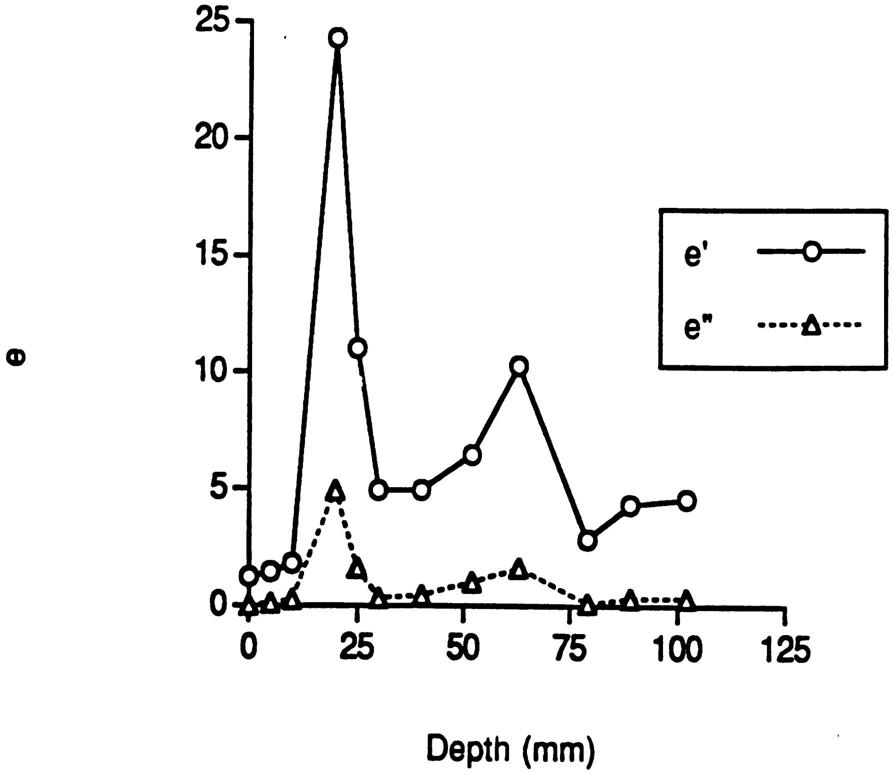


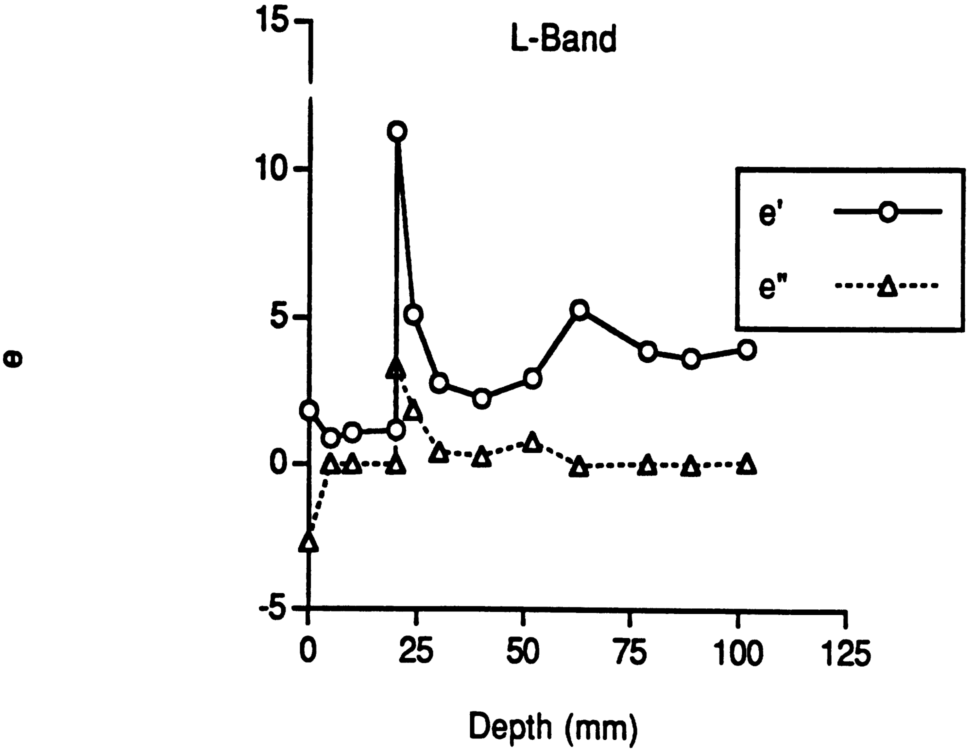
L-Band

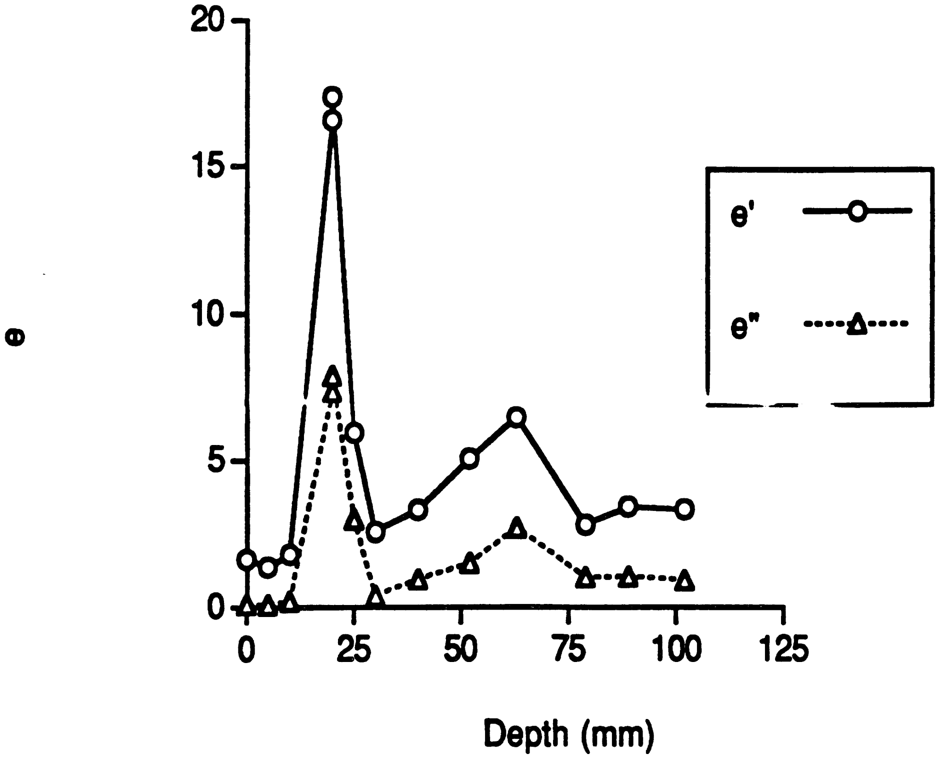


Dielectric Depth Profile
October 2, 1994
White Pine-mature

P-Band



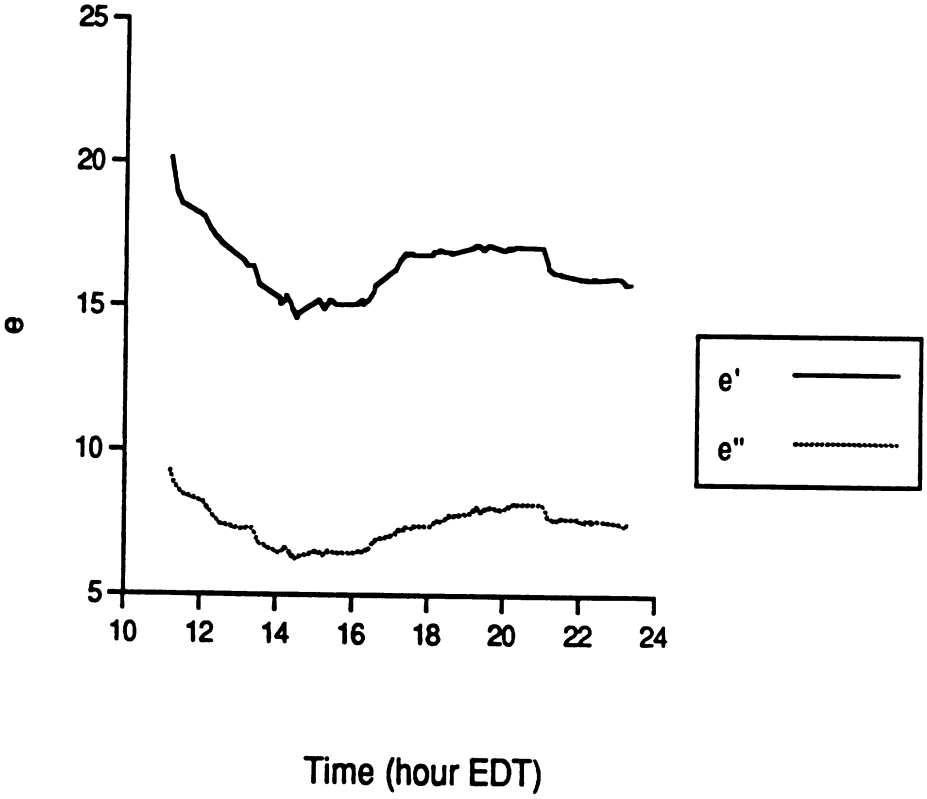




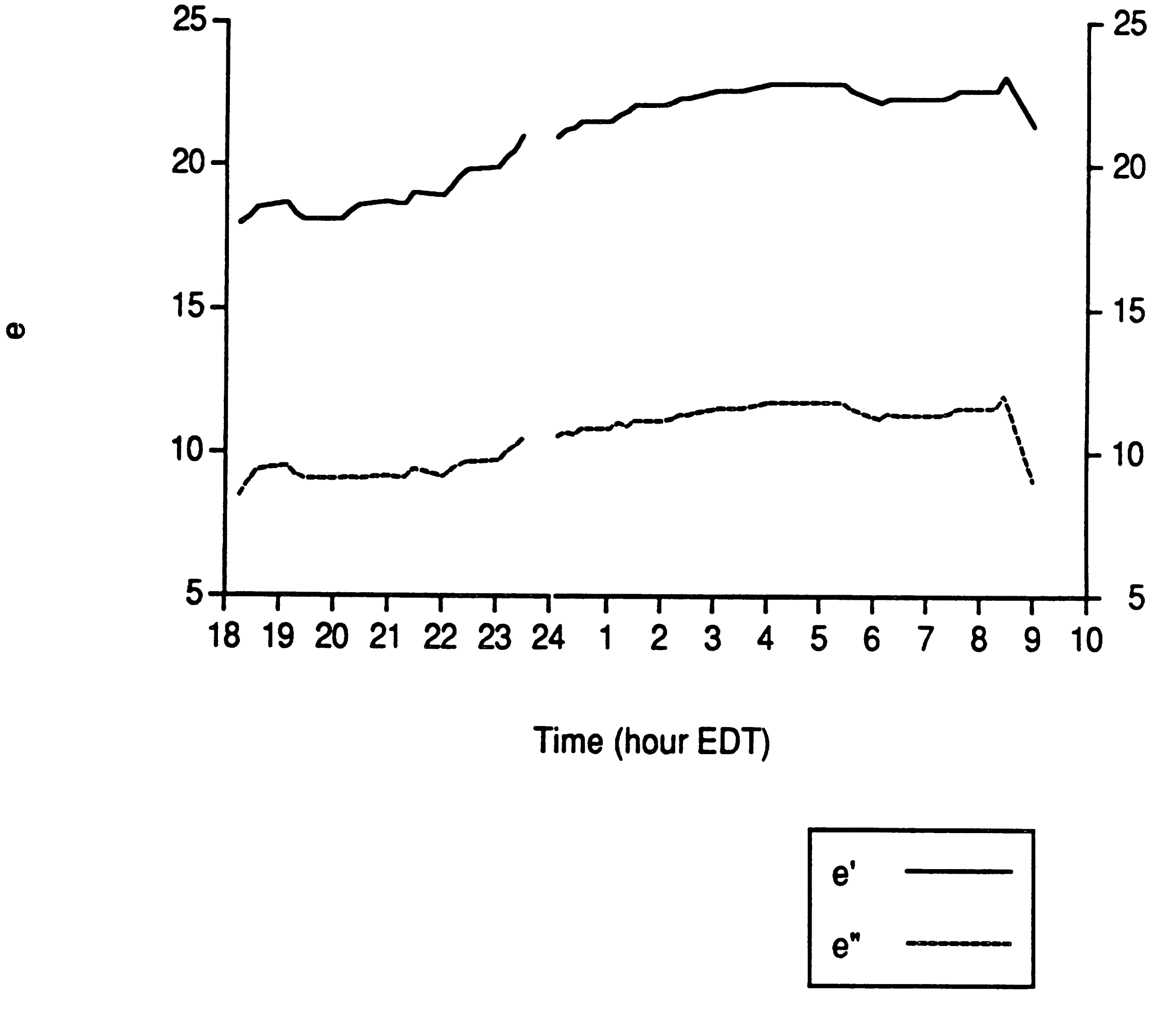
Dielectric Depth Profile
October 2, 1995
White Pine - mature

C-Band

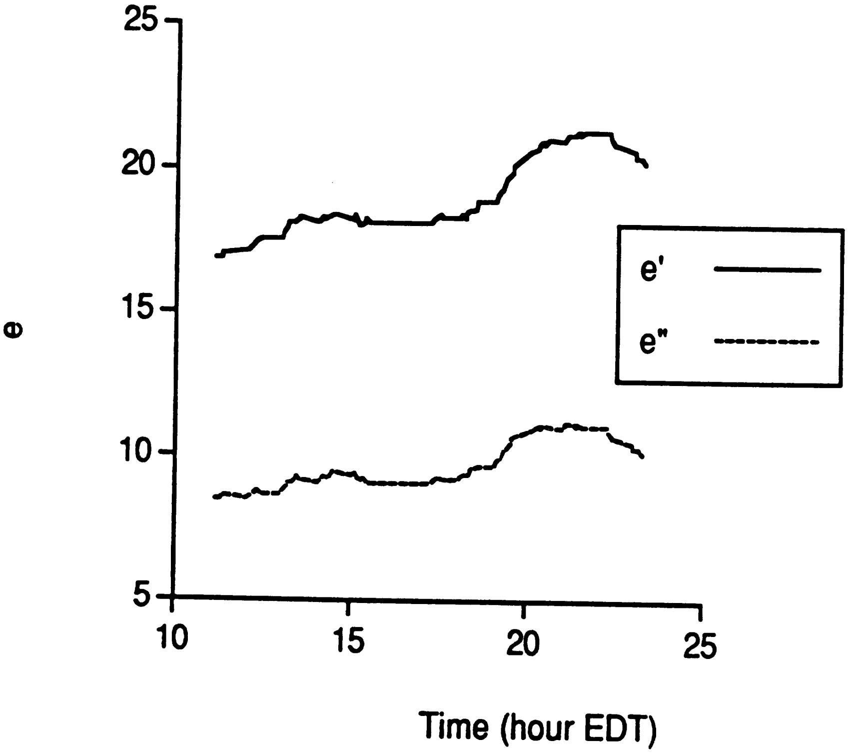
APPENDIX E:
VEGETATION DIELECTRIC PLOTS: e' vs. Time



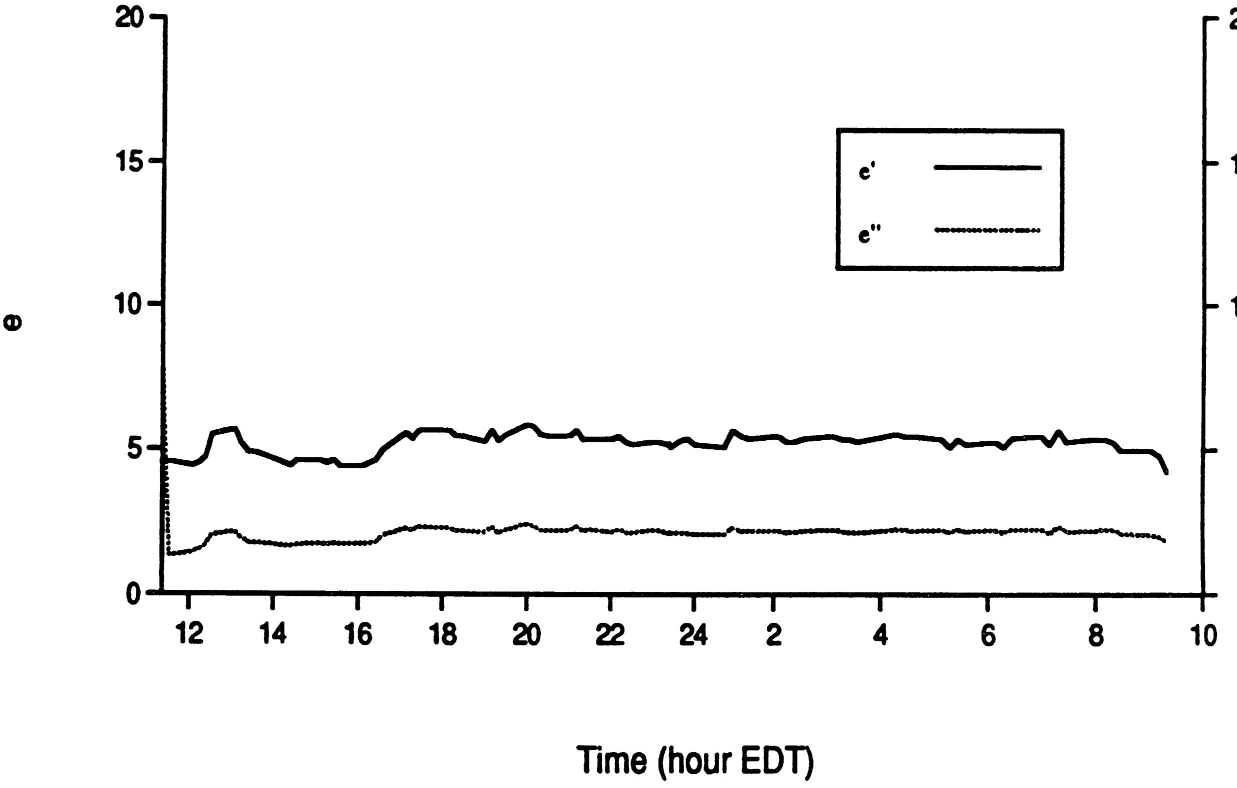
Temporal Variance in Tree Dielectric
Red Pine Stand #22
September 30, 1994
C-Band


Temporal Variance in Tree Dielectric
Sugar Maple Stand #31
C-Band
10/2/94

Temporal Variance in Tree Dielectric
Sugar Maple Stand #31
C-Band
10/7/94



Temporal Variance in Tree Dielectric
Sugar Maple Stand #31
C-Band
10/9/94



APPENDIX F:
DAILY WEATHER DATA: SAULT STE. MARIE WEATHER STATION

SEP 1994
SAULT STE. MARIE, MI
NWS OFFICE, NOAA
214 WEST 14TH AVENUE

INQUIRIES/COMMENTS CALL
(704) 271-4800 VOICE
271-4010 TDD/271-4876 FAX

SUBURBAN OFFICE

LOCAL CLIMATOLOGICAL DATA
MONTHLY SUMMARY

EP 1994
SAULT STE. MARIE, MI

LATITUDE 46° 28'N LONGITUDE 84 22'W ELEVATION (GROUND) 718 FEET TIME ZONE EASTERN 14847

DATE	TEMPERATURE °F MAXIMUM	MINIMUM	AVERAGE	DEPARTURE FROM NORMAL	AVERAGE DEW POINT	DEGREE DAYS BASE 65 °F HEATING	COOLING	WEATHER TYPES 1 FOG 2 HEAVY FOG 3 THUNDERSTORMS 4 ICE PELLETS 5 HAIL 6 GLAZE 7 DUSTSTORM 8 SMOKE, HAZE 9 BLOWING SNOW	SNOW/ICE ON GRD AT 0700 (IN.)	PRECIPITATION (INCHES) WATER EQUIVALENT	SNOW ICE PELLETS	AVERAGE STATION PRESSURE (INCHES OF Hg) ELEV. 724 (FT. MSL)	WIND (M.P.H.) RESULTANT DIR	RESULTANT SPEED	AVERAGE SPEED	PEAK GUST SPEED	PEAK GUST DIR	FASTEST 1-MIN SPEED	FASTEST 1-MIN DIR	SUNSHINE MINUTES	PERCENT POSSIBLE	SKY COVER TENTHS SUNRISE TO SUNSET	MIDNIGHT TO MIDNIGHT
1	2	3	4	5	6	7A	7B	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
01	59	37	48	-11	42	17	0		0	0.00	0.0	29.470	31	7.6	8.0	23	NW	15	31	701	88	3	2
02	64	35	50	-9	44	15	0	1	0	0.00	0.0	29.555	31	2.5	3.7	12	W	8	34	577	72	5	4
03	64	43	54	-4	46	11	0		0	0.00	0.0	29.600	36	1.2	4.7	14	NE	8	24	714	90	3	4
04	64	44	54	-4	49	11	0	2	0	0.00	0.0	29.580	12	8.2	8.8	18	SE	13	15	347	44	9	8
05	66	48	57	-1	49	8	0	1	0	T	0.0	29.380	12	10.2	10.7	25	SE	18	14	242	31	9	9
06	62	50	56	-2	53	9	0	1	0	T	0.0	29.190	31	7.0	9.4	22	NW	16	30	77	10	10	9
07	64	44	54	-4	51	11	0	1	0	0.01	0.0	29.180	29	5.6	6.0	18	W	14	29	524	67	5	3
08	67	40	54	-3	47	11	0	1	0	0.00	0.0	29.210	30	5.1	5.7	20	NW	14	30	733	94	5	3
09	60	45	53	-4	46	12	0	1	0	0.00	0.0	29.350	32	5.9	7.6	18	NW	14	29	776	100	0	0
10	65	38	52	-5	44	13	0		0	0.00	0.0	29.490	10	3.8	5.1	12	SE	7	16	770	100	0	0
11	71	43	57	1	53	8	0	2	0	0.00	0.0	29.490	12	5.6	6.4	14	SE	10	15	337	44	7	5
12	76	52	64	8	60	1	0	1 8	0	0.00	0.0	29.330	22	2.4	5.7	16	SW	10	24	490	64	7	6
13	74	57	66	10	63	0	1	1 8	0	0.53	0.0	29.180	27	4.0	6.2	13	W	10	30	393	52	10	9
14	65	58	62	6	60	3	0	1	0	T	0.0	29.270	11	4.6	6.8	14	SE	12	10	0	0	10	10
15	64	59	62	7	61	3	0	2	0	0.11	0.0	29.140	11	9.6	9.7	17	SE	14	11	0	0	10	10
16	74	59	67*	12	64	0	2	1 8	0	0.11	0.0	28.980	23	4.5	8.2	22	NW	13	30	110	15	9	9
17	61	49	55	0	52	10	0	1	0	T	0.0	29.170	31	10.9	11.4	25	NW	18	32	623	83	4	4
18	67	43	55	1	49	10	0	1	0	0.00	0.0	29.280	30	8.6	9.5	28	NW	21	31	744	100	0	1
19	72	45	59	5	50	6	0		0	0.00	0.0	29.320	28	5.4	6.2	18	W	14	29	741	100	0	0
20	77*	47	62	8	57	3	0	23	0	0.00	0.0	29.290	25	0.6	4.1	12	NW	9	34	423	57	4	3
21	74	56	65	11	59	0	0	1	0	0.00	0.0	29.250	11	7.1	7.6	15	SE	12	15	348	47	10	8
22	74	56	65	12	57	0	0	1	0	0.00	0.0	29.185	12	9.5	10.1	22	SE	16	14	347	47	9	7
23	72	56	64	11	58	1	0	1	0	0.00	0.0	29.250	11	8.5	9.0	16	SE	14	11	363	50	6	8
24	68	51	60	7	56	5	0	1	0	0.00	0.0	29.280	10	4.4	5.0	8	E	7	14	195	27	10	9
25	60	49	55	3	56	10	0	1	0	0.11	0.0	29.150	07	5.9	7.2	23	NE	16	04	0	0	10	10
26	54	47	51	-1	48	14	0		0	0.09	0.0	29.010	07	11.5	11.7	25	NE	16	06	0	0	10	10
27	58	49	54	2	53	11	0	1	0	0.10	0.0	28.880	05	3.0	5.0	14	NW	9	32	0	0	10	10
28	51	45	48	-3	47	17	0	1	0	0.44	0.0	28.805	31	14.6	14.9	30	NW	22	32	0	0	10	10
29	51	41	46	-5	39	19	0	1	0	T	0.0	29.100	32	14.2	14.6	32	NW	23	31	236	33	8	5
30	58	34*	46*	-5	41	19	0		0	0.00	0.0	29.210	32	3.0	6.4	17	NW	13	26	511	72	6	6

SUM	SUM				TOTAL	TOTAL	NUMBER OF DAYS	TOTAL	TOTAL	FOR THE MONTH :								TOTAL	% FOR MONTH	SUM	SUM
1956	1420				258	3		1.50	0.0	29.250	01	1.9	7.8	32	NW	23	31	11322		199	182
AVG.	AVG.	AVG.	DEP.	AVG.	DEP.	DEP.	PRECIPITATION	DEP.						DATE:29		DATE:29		POSS		AVG	AVG
65.2	47.3	56.3	1.2	51.7	-42	3	≥ .01 INCH 8	-2.19										22566	50	6.6	6.1

NUMBER OF DAYS				SEASON TO DATE TOTAL	TOTAL	SNOW, ICE PELLETS ≥ 1.0 INCH 0	GREATEST IN 24 HOURS AND DATES				GREATEST DEPTH ON GROUND OF SNOW, ICE PELLETS OR ICE AND DATE
MAXIMUM TEMP.		MINIMUM TEMP.		520	99	THUNDERSTORMS 1	PRECIPITATION		SNOW, ICE PELLETS		
≥ 90°	≤ 32°	≤ 32°	≤ 0°	DEP.	DEP.	HEAVY FOG 4	0.53	13	0.0		0
0	0	0	0	0	-32	CLEAR 6 PARTLY CLOUDY 9 CLOUDY 15					

* EXTREME FOR THE MONTH - LAST OCCURRENCE IF MORE THAN ONE.
T TRACE AMOUNT.
+ ALSO ON EARLIER DATE(S).
HEAVY FOG: VISIBILITY 1/4 MILE OR LESS.
BLANK ENTRIES DENOTE MISSING OR UNREPORTED DATA.

DATA IN COLS 6 AND 12-15 ARE BASED ON 21 OR MORE OBSERVATIONS AT HOURLY INTERVALS. RESULTANT WIND IS THE VECTOR SUM OF WIND SPEEDS AND DIRECTIONS DIVIDED BY THE NUMBER OF OBSERVATIONS.
COLS 16 & 17 : PEAK GUST - HIGHEST INSTANTANEOUS WIND SPEED.
ONE OF TWO WINDS IS GIVEN UNDER COLS 18 & 19 : FASTEST MILE- HIGHEST RECORDED SPEED FOR WHICH A MILE OF WIND PASSES STATION (DIRECTION IN COMPASS POINTS). FASTEST OBSERVED ONE MINUTE WIND - HIGHEST ONE MINUTE SPEED (DIRECTION IN TENS OF DEGREES).
ERRORS WILL BE CORRECTED IN SUBSEQUENT PUBLICATIONS.

I CERTIFY THAT THIS IS AN OFFICIAL PUBLICATION OF THE NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION, AND IS COMPILED FROM RECORDS ON FILE AT THE NATIONAL CLIMATIC DATA CENTER.

Kenneth D Hadeen
DIRECTOR
NATIONAL CLIMATIC DATA CENTER

noaa NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL ENVIRONMENTAL SATELLITE, DATA, AND INFORMATION SERVICE
NATIONAL CLIMATIC DATA CENTER ASHEVILLE, NORTH CAROLINA

OBSERVATIONS AT 3-HOUR INTERVALS

SEP 1994 14847
SAULT STE. MARIE, MI

HOUR L.S.T	SKY COVER (TENTHS)	CEILING IN HUNDREDS OF FEET	VISIBILITY		WEATHER	TEMPERATURE			REL. HUMIDITY %	WIND		SKY COVER (TENTHS)	CEILING IN HUNDREDS OF FEET	VISIBILITY		WEATHER	TEMPERATURE			REL. HUMIDITY %	WIND		SKY COVER (TENTHS)	CEILING IN HUNDREDS OF FEET	VISIBILITY		WEATHER	TEMPERATURE			REL. HUMIDITY %	WIND	
			WHOLE MILES	16THS MILE		AIR F	WET BULB F	DEW POINT F		DIRECTION	SPEED (KNOTS)			WHOLE MILES	16THS MILE		AIR F	WET BULB F	DEW POINT F		DIRECTION	SPEED (KNOTS)			WHOLE MILES	16THS MILE		AIR F	WET BULB F	DEW POINT F		DIRECTION	SPEED (KNOTS)
	SEP 01											SEP 02											SEP 03										
01	0	UNL	12			43	42	41	93	35	6	0	UNL	15			43	42	41	93	30	5	5	UNL	10			50	49	47	90	06	3
04	3	UNL	10			41	41	41	100	02	3	0	UNL	10			39	39	38	96	00	0	9	80	10			48	48	47	96	36	3
07	4	UNL	20			42	42	42	100	30	4	3	UNL	3		F	40	40	39	96	11	3	3	UNL	15			43	43	43	100	00	0
10	7	30	20			55	50	46	72	31	8	3	UNL	20			55	49	42	62	28	6	7	25	20			58	54	50	75	07	5
13	3	UNL	20			58	50	42	56	31	12	5	UNL	20			60	52	45	58	00	0	6	25	15			62	53	44	52	30	6
16	0	UNL	20			57	49	41	55	32	12	10	70	20			60	53	47	62	34	7	2	UNL	15			63	52	42	46	24	7
19	0	UNL	20			51	46	41	69	32	9	3	UNL	20			56	52	49	78	34	5	0	UNL	15			55	50	45	69	31	5
22	0	UNL	15			43	43	42	96	28	4	4	UNL	15			46	46	46	100	32	4	0	UNL	7			48	47	46	93	09	4
	SEP 04											SEP 05											SEP 06										
01	0	UNL	1	4	F	48	48	48	100	07	6	7	200	10			51	50	48	90	11	8	10	25	15			55	52	50	83	12	5
04	7	30	1	8	F	46	46	46	100	00	0	5	UNL	7			49	49	48	96	09	7	10	19	15			54	53	52	93	11	4
07	10	2	0	3	F	49	49	49	100	12	6	10	30	6		F	50	50	50	100	09	8	10	12	10			55	55	54	97	00	0
10	9	7	6		F	56	54	53	90	10	7	8	60	10			61	57	54	78	14	10	10	14	10			60	58	57	90	28	8
13	9	25	15			63	55	49	61	13	10	9	60	15			64	55	48	56	14	15	10	16	10			58	56	54	87	31	12
16	10	200	20			63	54	45	52	15	11	10	80	20			60	54	49	67	13	12	10	20	7			57	55	53	87	31	14
19	10	220	20			57	52	48	72	13	8	10	50	15		R	57	53	50	78	14	9	10	50	7			57	54	52	84	30	14
22	8	200	15			53	50	48	83	13	8	10	90	15			56	51	47	72	12	8	8	50	8			55	53	51	87	30	11
	SEP 07											SEP 08											SEP 09										
01	0	UNL	8			50	49	48	93	30	5	0	UNL	5		F	46	46	46	100	00	0	0	UNL	7			51	51	50	96	30	6
04	0	UNL	8			48	48	48	100	26	3	2	UNL	0	8	F	45	45	45	100	00	0	3	UNL	7			49	49	48	96	31	5
07	0	UNL	8			47	47	47	100	31	4	4	UNL	0	6	F	42	42	42	100	00	0	0	UNL	15			47	45	42	83	01	4
10	5	UNL	20			63	57	52	68	30	6	10	UNL	10			62	58	55	78	30	3	0	UNL	20			55	50	44	67	34	7
13	9	40	10		RW	58	56	55	90	28	7	2	UNL	20			66	56	48	53	27	11	0	UNL	20			60	53	46	60	30	12
16	5	UNL	15			61	58	55	81	29	12	2	UNL	20			65	55	46	50	32	9	0	UNL	20			58	52	47	67	29	12
19	5	UNL	15			60	58	57	90	27	4	3	UNL	15			56	51	47	72	33	6	0	UNL	15			51	49	46	83	28	5
22	0	UNL	7			50	50	50	100	00	0	0	UNL	10			50	49	48	93	30	5	0	UNL	10			48	47	45	89	09	4
	SEP 10											SEP 11											SEP 12										
01	0	UNL	7			42	42	41	96	00	0	0	UNL	4		F	45	45	45	100	07	3	5	UNL	7			55	55	54	97	10	3
04	0	UNL	7			42	41	40	93	07	5	0	UNL	1	8	F	44	44	44	100	08	3	6	250	2	8	F	53	53	53	100	00	0
07	0	UNL	15			42	41	40	93	07	5	10	1	0	4	F	48	48	48	100	09	4	9	35	0	12	F	53	53	53	100	14	[illegible]
10	0	UNL	15			54	49	44	69	14	6	8	7	5		F	55	54	53	93	11	6	9	150	5		F	66	64	63	90	04	[illegible]
13	1	UNL	15			61	53	46	58	07	4	2	UNL	12			67	61	57	70	15	9	10	UNL	10			72	67	64	76	28	[illegible]
16	0	UNL	15			64	54	46	52	08	5	10	40	10			69	64	60	73	14	8	5	UNL	10			75	69	65	71	25	6
19	0	UNL	15			56	52	49	78	17	4	8	UNL	10			61	58	56	84	13	7	7	UNL	6		H	67	65	63	87	24	7
22	0	UNL	10			45	44	43	93	03	3	6	UNL	10			56	55	54	93	11	4	7	UNL	4		H	63	62	61	93	21	5
	SEP 13											SEP 14											SEP 15										
01	6	UNL	0	12	F	58	58	58	100	00	0	7	30	2		F	59	59	59	100	29	4	10	16	4		F	60	59	59	97	12	6
04	10	40	1		F	59	59	59	100	15	3	10	17	2		F	60	60	60	100	31	4	10	35	5		RWF	59	59	59	100	11	8
07	10	7	0	12	RWF	63	63	63	100	23	6	10	16	4		F	61	61	61	100	00	0	10	7	7		L	59	58	58	97	11	12
10	10	80	5		F	66	65	65	97	25	6	10	6	5		F	64	63	62	93	10	7	10	7	5		LF	60	59	59	97	11	12
13	10	120	10			73	68	65	76	28	9	10	6	5		F	64	62	61	90	11	8	10	2	2		LF	62	62	62	100	12	9
16	8	UNL	7			73	69	67	82	32	8	10	10	7			64	61	59	84	13	7	10	2	0	14	RWF	64	64	64	100	11	7
19	10	30	4		F	66	65	64	93	24	5	10	10	5		F	61	59	58	90	10	7	10	1	0	6	F	64	64	64	100	11	9
22	10	30	4		F	63	62	62	97	29	6	10	5	4		F	60	59	58	93	11	6	10	0	0	1	F	63	63	63	100	11	7
	SEP 16											SEP 17											SEP 18										
01	9	140	0	6	F	62	62	62	100	07	6	10	5	5		F	61	60	60	97	30	12	7	70	10			54	54	53	96	31	6
04	8	120	3		F	61	61	61	100	14	4	10	4	4		LF	57	57	57	100	32	10	0	UNL	8			48	48	48	100	16	3
07	10	16	3		F	64	64	64	100	18	5	5	UNL	15			55	54	53	93	33	8	0	UNL	12			44	44	44	100	30	3
10	10	5	1	4	F	68	67	67	97	22	9	1	UNL	20			59	54	50	72	32	8	0	UNL	20			62	58	55	78	29	10
13	9	9	2	8	F	72	69	67	84	21	11	5	UNL	20			59	53	48	67	31	13	0	UNL	20			66	56	48	53	33	15
16	9	14	5		H	73	69	67	82	19	10	4	UNL	15			61	56	51	70	32	14	0	UNL	20			64	55	48	56	30	16
19	10	14	7		RW	63	62	62	97	29	8	1	UNL	15			53	52	51	93	29	6	0	UNL	20			57	52	48	72	31	7
22	4	UNL	5		F	61	61	61	100	27	5	0	UNL	15			52	52	51	96	29	8	0	UNL	15			50	50	49	96	27	3

MAXIMUM SHORT DURATION PRECIPITATION

TIME PERIOD (MINUTES)	5	10	15	20	30	45	60	80	100	120	150	180
PRECIPITATION (INCHES)	0.08	0.15	0.17	0.17	0.20	0.24	0.33	0.38	0.39	0.40	0.42	0.49
ENDED: DATE	13	13	13	13	13	13	13	13	13	13	13	13
ENDED: TIME (LST)	0736	0738	0739	0739	0739	0739	0739	0739	0739	0739	0739	0739

THE PRECIPITATION AMOUNTS FOR THE INDICATED TIME INTERVALS MAY OCCUR AT ANY TIME DURING THE MONTH. THE TIME INDICATED IS THE ENDING TIME OF THE INTERVAL. DATE AND TIME ARE NOT ENTERED FOR TRACE AMOUNTS.

OBSERVATIONS AT 3-HOUR INTERVALS

SEP 1994 14847
SAULT STE. MARIE MI

HOUR L.S.T.	SKY COVER (TENTHS)	CEILING IN HUNDREDS OF FEET	VISIBILITY		WEATHER	TEMPERATURE			REL. HUMIDITY %	WIND		SKY COVER (TENTHS)	CEILING IN HUNDREDS OF FEET	VISIBILITY		WEATHER	TEMPERATURE			REL. HUMIDITY %	WIND		SKY COVER (TENTHS)	CEILING IN HUNDREDS OF FEET	VISIBILITY		WEATHER	TEMPERATURE			REL. HUMIDITY %	WIND	
			WHOLE MILES	16THS MILE		AIR °F	WET BULB °F	DEW POINT °F		DIRECTION	SPEED (KNOTS)			WHOLE MILES	16THS MILE		AIR °F	WET BULB °F	DEW POINT °F		DIRECTION	SPEED (KNOTS)			WHOLE MILES	16THS MILE		AIR °F	WET BULB °F	DEW POINT °F		DIRECTION	SPEED (KNOTS)
	SEP 19											SEP 20											SEP 21										
01	0	UNL	10			50	49	48	93	26	4	0	UNL	10			54	54	53	96	27	5	2	UNL	10			57	57	57	100	07	3
04	0	UNL	10			51	50	49	93	32	6	0	UNL	5		F	50	50	50	100	08	4	7	UNL	8			57	57	57	100	08	6
07	0	UNL	15			46	46	46	100	00	0	10	2	0	2	F	51	51	51	100	00	0	8	130	7			57	57	57	100	10	5
10	0	UNL	20			62	55	50	65	30	6	0	UNL	7			64	62	60	87	05	3	10	UNL	10			68	64	61	78	13	8
13	0	UNL	20			69	58	50	51	27	11	2	UNL	15			76	68	63	64	32	8	10	UNL	10			73	65	60	64	15	10
16	0	UNL	20			71	59	49	46	32	5	7	UNL	15			75	66	60	60	23	4	10	UNL	10			72	65	60	66	12	7
19	0	UNL	20			58	55	52	81	23	5	5	UNL	15			66	62	60	81	21	6	10	200	10			64	63	62	93	12	5
22	0	UNL	20			56	54	52	87	23	5	2	UNL	15			59	58	57	93	08	3	7	200	10			59	58	58	97	11	6
	SEP 22											SEP 23											SEP 24										
01	5	UNL	3		F	59	58	58	97	08	7	10	80	7			61	56	56	84	09	9	7	UNL	7			55	55	54	97	07	5
04	2	UNL	2		F	57	57	57	100	09	6	10	80	7			59	57	56	90	10	7	8	UNL	5		F	51	51	51	100	06	4
07	9	UNL	2		F	57	56	56	97	10	7	5	UNL	3		F	58	57	57	97	10	8	10	200	3		F	52	52	51	96	09	4
10	8	UNL	7			65	62	60	84	11	11	10	8	5		F	62	60	59	90	13	11	10	200	5		F	59	57	56	90	09	5
13	8	UNL	10			71	63	57	61	14	13	0	UNL	8			70	65	61	73	15	10	9	200	8			67	61	57	70	11	5
16	9	100	10			71	63	57	61	14	11	10	UNL	8			70	63	59	68	13	10	10	100	10			67	62	58	73	14	6
19	10	100	10			64	59	56	75	11	8	10	UNL	8			61	59	57	87	12	6	9	120	10			61	59	58	90	14	4
22	10	80	7			61	59	57	87	10	7	10	UNL	7			57	56	55	93	08	5	10	100	8			59	58	58	97	11	5
	SEP 25											SEP 26											SEP 27										
01	7	90	7			57	57	57	100	07	3	10	25	10			49	48	46	90	06	14	10	7	7			51	51	51	100	09	6
04	10	1	0	8	F	57	57	57	100	15	4	10	25	10		R	48	47	45	89	06	8	10	4	2		F	52	52	52	100	05	6
07	10	3	0	14	F	58	58	58	100	11	3	9	45	15			48	48	47	96	06	14	10	6	3		F	51	51	51	100	06	6
10	10	12	5		RF	59	58	58	97	09	3	10	30	15			49	48	47	93	07	11	10	5	2	8	F	54	54	53	96	06	5
13	10	11	5		RWF	59	59	59	100	09	6	10	8	15			51	50	48	90	07	9	10	8	3		F	57	56	55	93	05	4
16	10	6	2	8	F	60	59	59	97	10	4	10	12	15			53	51	49	86	08	9	10	30	3		F	56	55	55	97	00	0
19	10	3	3		LF	55	55	55	100	03	10	10	10	10			51	50	49	93	09	8	10	5	1	8	RF	54	54	53	96	30	6
22	10	15	7			51	50	48	90	05	13	8	7	8			50	50	49	96	07	7	10	23	4		RF	51	51	51	100	00	0
	SEP 28											SEP 29											SEP 30										
01	10	25	4		RF	51	51	51	100	29	5	7	30	8			46	45	43	89	32	12	0	UNL	10			36	36	35	96	17	4
04	10	25	7		R	49	48	47	93	31	11	4	UNL	10			44	42	39	83	33	14	2	UNL	10			38	38	38	100	12	3
07	10	25	8		R	49	49	48	96	30	10	7	90	12			44	42	40	86	31	9	8	50	10			39	39	38	96	08	4
10	10	6	4		RF	50	50	50	100	32	12	8	25	15			48	44	40	74	32	12	4	UNL	15			52	48	43	72	06	3
13	10	7	4		RF	49	49	48	96	30	16	10	25	15			49	44	39	69	30	15	3	UNL	20			57	51	45	64	35	5
16	10	5	2		LF	48	48	47	96	31	16	7	30	20			47	43	39	74	31	17	8	UNL	20			55	50	44	67	30	10
19	10	10	4		LF	47	46	45	93	31	17	5	UNL	20			45	42	39	80	31	12	10	250	20			47	44	40	77	32	7
22	10	22	5		RF	47	46	44	89	31	14	2	UNL	20			44	42	40	86	31	9	10	200	15			44	42	40	86	33	7

SUMMARY BY HOURS

HOUR L.S.T.	AVERAGES								RESULTANT WIND	
	SKY COVER (TENTHS)	STATION PRESSURE (INCHES)	TEMPERATURE			REL HUMIDITY %	SPEED (MPH)	DIRECTION	SPEED (MPH)
			AIR °F	WET BULB F	DEW POINT F				
01	5	29.250	52	51	51	95	6.2	03	1.9
04	6	29.250	51	50	50	97	5.5	05	2.1
07	7	29.265	50	50	50	97	5.6	07	2.1
10	7	29.270	59	56	54	83	8.4	05	1.2
13	6	29.260	63	58	53	71	10.8	28	2.1
16	7	29.235	63	57	53	71	10.6	29	2.4
19	7	29.240	57	55	53	85	8.4	30	1.7
22	6	29.250	53	52	51	93	6.7	02	1.0

WEATHER CODES AND NOTES

&	TORNADO	S	SNOW	IF	ICE FOG
&C	FUNNEL CLOUD	SW	SNOW SHOWERS	GF	GROUND FOG
&W	WATER SPOUT	SG	SNOW GRAINS	BD	BLOWING DUST
T	THUNDERSTORM	SP	SNOW PELLETS	BN	BLOWING SAND
R	RAIN	IC	ICE CRYSTALS	BS	BLOWING SNOW
RW	RAIN SHOWERS	IP	ICE PELLETS	BY	BLOWING SPRAY
ZR	FREEZING RAIN	IPW	ICE PELLET SHOWERS	K	SMOKE
L	DRIZZLE	A	HAIL	H	HAZE
ZL	FREEZING DRIZZLE	F	FOG	D	DUST

CEILING: UNL INDICATES UNLIMITED
WIND DIRECTION: DIRECTIONS ARE THOSE FROM WHICH THE WIND IS BLOWING, INDICATED IN TENS OF DEGREES FROM TRUE NORTH: I.E. 09 FOR
EAST, 18 FOR SOUTH, 27 FOR WEST. AN ENTRY OF 00 INDICATES CALM.
SPEED: THE OBSERVED AVERAGE ONE-MINUTE VALUE (MPH=KNOTS X 1.15).

-HAPPY HOLIDAYS- AUL 288 12/20/94 PM

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HOURLY PRECIPITATION (WATER EQUIVALENT IN INCHES)

DATE	A.M. HOUR ENDING AT												P.M. HOUR ENDING AT												DATE
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	
01																									01
02																									02
03																									03
04																									04
05															T				T	T					05
06																	T								06
07											T	0.01	T	T											07
08																									08
09																									09
10																									10
11																									11
12																									12
13					0.10	0.02	0.21	0.18	0.01	0.01															13
14											T														14
15				T	T		T	T	T	T	T	0.01	0.02	T		0.07	0.01								15
16								T	0.04	0.02								T	0.04	0.01					16
17			T	T	T																				17
18																									18
19																									19
20																									20
21																									21
22																									22
23																									23
24																									24
25									T	T	T	0.03	0.03	0.05	T	T	T	T	T	T					25
26				T	T	0.04	T				0.03	0.02													26
27			0.01	0.01									0.01		0.02		0.01	0.01	T	T		T	0.01	0.02	27
28	0.02	0.03	0.04	0.03	0.01	0.01	T	0.02	0.10	0.11	T	T	T	T	0.02	0.02	0.01	T	T	T		0.01	0.01		28
29									T	T															29
30																									30

OCT 1994
SAULT STE. MARIE, MI
NWS OFFICE, NOAA
214 WEST 14TH AVENUE

INQUIRIES/COMMENTS CALL
(704) 271-4800 VOICE
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SUBURBAN OFFICE

ISSN # 0198-2680

LOCAL CLIMATOLOGICAL DATA

MONTHLY SUMMARY

SAULT STE. MARIE, MI OCT 1994

LATITUDE 46° 28'N LONGITUDE 84° 22'W ELEVATION (GROUND) 718 FEET TIME ZONE EASTERN 14847

	TEMPERATURE °F					DEGREE DAYS BASE 65 °F		WEATHER TYPES	SNOW/ ICE ON GRD AT 0700 (IN.)	PRECIPITATION (INCHES)		AVERAGE STATION PRESSURE (INCHES OF Hg) ELEV. 724 (FT.MSL)	WIND (M.P.H.)							SUNSHINE		SKY COVER TENTHS	
								1 FOG 2 HEAVY FOG 3 THUNDERSTORMS 4 ICE PELLETS 5 HAIL 6 GLAZE 7 DUSTSTORM 8 SMOKE, HAZE 9 BLOWING SNOW								PEAK GUST		FASTEST 1-MIN					
DATE	MAXIMUM	MINIMUM	AVERAGE	DEPARTURE FROM NORMAL	AVERAGE DEW POINT	HEATING	COOLING			WATER EQUIVALENT	SNOW ICE PELLETS		RESULTANT DIR	RESULTANT SPEED	AVERAGE SPEED	SPEED	DIR	SPEED	DIR	MINUTES	PERCENT POSSIBLE	SUNRISE TO SUNSET	MIDNIGHT TO MIDNIGHT
1	2	3	4	5	6	7A	7B	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
01	53	39	46	-4	36	19	0		0	0.00	0.0	29.190	33	9.0	10.3	28	NW	20	32	550	78	2	2
02	52	29	41	-9	32	24	0		0	0.00	0.0	29.330	32	8.3	9.3	26	NW	18	30	699	100	2	2
03	52	34	43	-7	34	22	0		0	0.00	0.0	29.490	36	4.8	7.4	23	N	15	31	657	94	3	2
04	49	35	42	-7	35	23	0		0	0.00	0.0	29.455	34	6.6	8.1	21	NW	15	31	303	44	8	7
05	54	35	45	-4	38	20	0		0	0.00	0.0	29.260	24	4.9	6.0	15	W	12	24	385	56	8	7
06	68*	42	55	6	50	10	0	1	0	0.00	0.0	29.180	16	5.0	7.0	20	SW	14	22	369	54	7	5
07	65	52	59	10	53	6	0	1	0	0.04	0.0	29.100	13	11.3	12.2	26	SE	21	13	267	39	10	9
08	65	45	55	7	51	10	0	1	0	0.35	0.0	29.020	25	5.8	8.4	22	SW	13	23	0	0	10	9
09	46	36	41	-7	38	24	0	1 4	0	0.24	T	29.070	30	15.0	16.1	43	NW	32	29	219	32	8	8
10	49	32	41	-6	35	24	0		0	0.01	0.0	29.490	32	8.7	9.4	28	N	17	32	512	76	6	4
11	58	30	44	-3	39	21	0	2	0	0.00	0.0	29.580	16	5.1	6.2	20	S	14	18	532	80	3	4
12	62	38	50	3	42	15	0	1	0	0.00	0.0	29.550	13	5.6	6.9	16	SE	13	17	610	92	1	1
13	64	39	52	6	45	13	0	1	0	0.00	0.0	29.510	09	5.7	6.6	18	E	15	06	632	95	7	5
14	56	40	48	2	42	17	0		0	0.00	0.0	29.580	12	8.0	9.1	21	SE	13	15	620	94	3	2
15	60	40	50	4	42	15	0		0	0.00	0.0	29.620	11	8.1	8.3	16	SE	13	11	374	57	5	5
16	60	40	50	5	43	15	0		0	0.00	0.0	29.590	11	8.9	9.1	21	SE	16	12	140	21	10	10
17	53	48	51	6	50	14	0	1	0	0.16	0.0	29.350	11	9.3	9.4	17	E	14	10	0	0	10	10
18	56	52	54	9	55	11	0	1	0	0.77	0.0	29.080	13	7.4	7.6	13	SE	10	14	0	0	10	10
19	66	54	60*	16	55	5	0	1	0	0.04	0.0	28.910	21	8.3	10.1	31	SW	18	23	305	47	5	8
20	54	47	51	7	48	14	0	1	0	0.03	0.0	29.060	29	11.0	11.7	30	NW	21	31	17	3	10	10
21	56	44	50	6	46	15	0		0	0.00	0.0	29.180	17	2.8	5.9	12	SW	9	28	42	7	10	8
22	62	44	53	10	50	12	0	1	0	0.02	0.0	29.040	12	10.4	10.8	21	SE	16	11	161	25	7	7
23	53	42	48	5	44	17	0	1	0	0.21	0.0	28.870	25	7.4	9.4	35	SW	20	28	183	29	7	7
24	46	35	41	-2	35	24	0		0	0.06	0.0	28.940	25	10.2	10.5	21	W	14	26	0	0	10	8
25	47	36	42	0	38	23	0		0	0.20	0.0	29.070	30	8.5	10.3	23	NW	16	31	222	36	7	8
26	45	29	37*	-5	35	28	0		0	T	0.0	29.350	33	4.6	6.2	18	NW	15	31	149	24	10	7
27	54	28*	41	0	38	24	0	1	0	0.00	0.0	29.240	17	5.1	8.2	25	SW	17	23	362	58	3	3
28	57	38	48	7	43	17	0		0	T	0.0	28.960	18	8.9	10.8	33	SW	20	21	1	0	10	8
29	57	36	47	6	43	18	0		0	0.04	0.0	29.000	26	6.6	8.3	26	NW	18	31	307	50	6	5
30	56	37	47	7	32	18	0		0	0.00	0.0	29.200	24	9.9	10.1	25	SW	16	24	530	87	1	1
31	49	31	40	0	32	25	0		0	0.00	0.0	29.180	33	4.3	7.1	17	NW	14	34	165	27	9	7
	SUM	SUM				TOTAL	TOTAL	NUMBER OF DAYS		TOTAL	TOTAL	FOR THE MONTH :								TOTAL	% FOR MONTH	SUM	SUM
	1724	1207				543	0			2.17	T	29.240	23	1.3	8.9	43	NW	32	29	9313		208	189
	AVG.	AVG.	AVG.	DEP.	AVG.	DEP.	DEP.	PRECIPITATION ≥ .01 INCH	13	DEP.						DATE: 9		DATE: 9		POSS		AVG	AVG
	55.6	38.9	47.3	2.0	41.8	-68	0			-1.06										20241	46	6.7	6.1

NUMBER OF DAYS				SEASON TO DATE		SNOW, ICE PELLETS ≥ 1.0 INCH	0	GREATEST IN 24 HOURS AND DATES				GREATEST DEPTH ON GROUND OF SNOW, ICE PELLETS OR ICE AND DATE	
				TOTAL	TOTAL								
MAXIMUM TEMP.		MINIMUM TEMP.		1063	99	THUNDERSTORMS	0	PRECIPITATION		SNOW, ICE PELLETS			
≥ 90°	≤ 32°	≤ 32°	≤ 0°	DEP.	DEP.	HEAVY FOG	1	0.89	17-18	trace	09	0	
0	0	6	0	-68	-32	CLEAR 8 PARTLY CLOUDY 9 CLOUDY 14							

* EXTREME FOR THE MONTH - LAST OCCURRENCE IF MORE THAN ONE.
T TRACE AMOUNT.
+ ALSO ON EARLIER DATE(S).
HEAVY FOG: VISIBILITY 1/4 MILE OR LESS.
BLANK ENTRIES DENOTE MISSING OR UNREPORTED DATA.

DATA IN COLS 6 AND 12-15 ARE BASED ON 21 OR MORE OBSERVATIONS AT HOURLY INTERVALS. RESULTANT WIND IS THE VECTOR SUM OF WIND SPEEDS AND DIRECTIONS DIVIDED BY THE NUMBER OF OBSERVATIONS.
COLS 16 & 17 : PEAK GUST - HIGHEST INSTANTANEOUS WIND SPEED.
ONE OF TWO WINDS IS GIVEN UNDER COLS 18 & 19 : FASTEST MILE- HIGHEST RECORDED SPEED FOR WHICH A MILE OF WIND PASSES STATION (DIRECTION IN COMPASS POINTS). FASTEST OBSERVED ONE MINUTE WIND - HIGHEST ONE MINUTE SPEED (DIRECTION IN TENS OF DEGREES).
ERRORS WILL BE CORRECTED IN SUBSEQUENT PUBLICATIONS.

I CERTIFY THAT THIS IS AN OFFICIAL PUBLICATION OF THE NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION, AND IS COMPILED FROM RECORDS ON FILE AT THE NATIONAL CLIMATIC DATA CENTER.

Kenneth D Hadeen
DIRECTOR
NATIONAL CLIMATIC DATA CENTER

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OBSERVATIONS AT 3-HOUR INTERVALS

OCT 1994 1484
SAULT STE. MARIE, MI

HOUR L.S.T.	SKY COVER (TENTHS)	CEILING IN HUNDREDS OF FEET	VISIBILITY		WEATHER	TEMPERATURE			REL HUMIDITY %	WIND		SKY COVER (TENTHS)	CEILING IN HUNDREDS OF FEET	VISIBILITY		WEATHER	TEMPERATURE			REL HUMIDITY %	WIND		SKY COVER (TENTHS)	CEILING IN HUNDREDS OF FEET	VISIBILITY		WEATHER	TEMPERATURE			REL HUMIDITY	WIND	
			WHOLE MILES	16THS MILE		AIR °F	WET BULB °F	DEW POINT °F		DIRECTION	SPEED (KNOTS)			WHOLE MILES	16THS MILE		AIR °F	WET BULB °F	DEW POINT °F		DIRECTION	SPEED (KNOTS)			WHOLE MILES	16THS MILE		AIR °F	WET BULB °F	DEW POINT °F		DIRECTION	SPEED (KNOTS)
					OCT 01											OCT 02											OCT 03						
01	10	200	15			45	43	41	86	33	8	0	UNL	15			40	38	35	82	26	3	0	UNL	15			38	36	32	79	05	4
04	4	UNL	15			43	42	40	89	34	9	0	UNL	12			32	32	31	96	00	0	0	UNL	15			36	34	32	85	07	4
07	7	UNL	15			39	37	35	86	01	4	0	UNL	15			35	34	32	89	28	5	0	UNL	15			35	33	31	85	05	6
10	0	UNL	20			49	42	34	56	35	9	0	UNL	20			49	42	32	52	33	11	0	UNL	20			45	40	33	63	07	6
13	0	UNL	20			52	44	35	53	31	14	1	UNL	20			51	42	31	47	31	14	2	UNL	20			50	43	35	57	32	9
16	0	UNL	20			50	44	36	59	32	17	6	UNL	20			49	42	32	52	32	15	2	UNL	20			49	44	38	66	31	11
19	0	UNL	15			43	40	35	74	32	7	5	UNL	15			43	39	34	71	32	9	3	UNL	15			42	40	38	86	33	6
22	0	UNL	15			42	40	38	86	30	5	0	UNL	15			41	38	33	73	36	7	0	UNL	15			40	37	33	76	06	3
					OCT 04											OCT 05											OCT 06						
01	10	40	15			37	37	36	96	32	4	8	35	15			41	39	37	86	00	0	9	60	10			43	43	42	96	15	3
04	10	40	15			41	38	35	79	04	6	7	40	15			37	37	36	96	23	3	0	UNL	15			43	43	43	100	08	3
07	10	45	15			40	38	34	79	02	6	7	40	15			40	38	36	86	23	5	9	80	5		F	45	45	45	100	10	3
10	9	120	15			42	39	35	76	03	7	8	140	15			47	42	35	63	26	7	8	40	6		F	55	53	52	90	08	5
13	9	25	15			46	41	34	63	31	10	7	120	15			51	45	37	59	24	10	7	UNL	8			65	60	56	73	19	11
16	5	UNL	20			47	42	36	66	31	11	8	UNL	20			52	45	38	59	26	5	3	UNL	15			66	59	53	63	21	8
19	7	UNL	15			42	39	36	79	32	9	10	UNL	15			48	44	40	74	20	6	2	UNL	20			57	53	50	78	14	5
22	1	UNL	15			38	37	36	93	27	3	3	UNL	15			43	42	41	93	20	5	0	UNL	12			53	52	51	93	12	7
					OCT 07											OCT 08											OCT 09						
01	0	UNL	10			53	53	52	96	12	7	3	UNL	10			62	60	58	87	22	9	10	20	10			45	45	44	96	30	6
04	5	UNL	10			54	52	51	90	12	8	9	100	10			57	54	52	84	22	6	10	15	3		RLF	44	44	44	100	29	8
07	10	80	10			55	52	50	83	12	10	10	40	10			56	54	53	90	20	5	9	15	10			42	42	42	100	25	8
10	9	UNL	10			59	55	51	75	13	13	10	28	7		L	56	54	52	87	26	9	8	14	10		RW	44	42	39	83	28	18
13	10	UNL	10			63	57	52	68	13	18	10	55	12		R	55	53	52	90	21	6	7	14	12		RW	42	40	38	86	30	17
16	10	60	7			62	58	54	75	12	12	10	7	4		RF	52	52	52	100	21	10	8	18	15			42	39	35	76	31	22
19	10	30	7		RW	60	58	56	87	14	10	10	5	3		RF	48	48	48	100	34	6	8	20	10		RW	39	37	34	82	30	16
22	10	35	6		F	61	59	57	87	15	12	10	5	4		LF	47	47	47	100	31	10	6	25	12			37	36	34	89	34	9
					OCT 10											OCT 11											OCT 12						
01	6	25	10			37	36	35	93	28	6	0	UNL	3		F	31	31	31	100	00	0	0	UNL	10			40	40	40	100	14	4
04	3	UNL	10			36	34	32	85	30	6	6	UNL	0	6	F	31	31	31	100	00	0	0	UNL	1	8	F	40	40	40	100	09	4
07	10	25	15			39	36	32	76	33	12	10	0	0	2	F	36	36	36	100	08	5	5	UNL	0	8	F	38	38	38	100	08	4
10	5	UNL	20			43	39	34	71	34	10	2	UNL	10			46	43	40	80	20	9	1	UNL	20			50	48	46	86	13	4
13	7	25	20			45	41	37	74	32	13	1	UNL	20			56	48	40	55	18	10	0	UNL	20			62	52	43	50	18	10
16	3	UNL	20			45	41	37	74	32	10	2	UNL	20			56	48	39	53	19	9	0	UNL	20			60	50	39	46	17	11
19	2	UNL	20			39	38	36	89	32	4	3	UNL	20			46	45	43	89	14	4	0	UNL	20			46	44	42	86	14	7
22	0	UNL	20			34	34	34	100	00	0	0	UNL	15			43	43	42	96	13	3	0	UNL	20			45	45	44	96	09	6
					OCT 13											OCT 14											OCT 15						
01	4	UNL	2		F	46	46	46	100	08	5	2	UNL	10			44	43	41	89	07	9	0	UNL	10			41	39	36	83	10	7
04	7	4	2		F	44	44	44	100	07	5	2	UNL	10			43	42	40	89	08	9	0	UNL	10			41	38	33	73	09	7
07	3	UNL	5		F	40	40	40	100	06	4	0	UNL	10			40	40	39	96	09	6	1	UNL	15			40	38	36	86	11	8
10	7	UNL	15			50	49	47	90	09	5	4	UNL	20			47	45	42	83	10	9	4	UNL	20			50	47	43	77	12	11
13	8	UNL	20			61	55	49	65	06	5	4	UNL	20			54	50	45	72	13	8	5	UNL	20			58	53	48	70	13	5
16	7	UNL	20			62	55	48	60	15	5	3	UNL	20			56	50	44	64	15	11	10	UNL	20			56	51	46	69	12	9
19	5	UNL	15			53	48	43	69	11	6	3	UNL	20			46	43	40	80	12	6	10	UNL	15			48	47	45	89	12	6
22	0	UNL	15			49	46	43	80	06	13	0	UNL	15			42	42	41	96	12	5	10	UNL	15			46	46	45	96	10	6
					OCT 16											OCT 17											OCT 18						
01	10	250	10			43	43	43	100	09	5	10	120	10			49	47	45	86	10	7	10	10	1	8	RF	53	53	53	100	13	5
04	10	200	8			41	41	41	100	08	4	10	55	10		R	49	48	46	90	08	7	10	10	1		RF	54	54	54	100	12	6
07	10	200	10			42	41	39	89	09	8	10	40	10		R	48	48	47	96	10	8	10	10	1		F	53	53	53	100	12	7
10	10	110	20			51	49	46	83	10	11	10	50	12			52	50	49	90	13	9	10	2	0	12	RF	54	54	54	100	12	9
13	9	100	20			59	53	47	65	12	11	10	35	5		RWF	52	52	51	96	13	6	10	1	0	8	F	55	55	55	100	13	8
16	9	80	20			56	50	44	64	12	14	10	8	5		RWF	52	52	52	100	12	10	10	2	0	8	LF	56	56	56	100	14	8
19	10	150	15			51	46	41	69	12	8	10	4	4		F	52	52	52	100	11	11	10	2	0	12	LF	55	55	55	100	12	7
22	10	150	15			50	46	41	71	11	8	10	4	3		RF	52	52	52	100	12	8	10	2	1		LF	55	55	55	100	15	6

MAXIMUM SHORT DURATION PRECIPITATION

TIME PERIOD (MINUTES)	5	10	15	20	30	45	60	80	100	120	150	180
PRECIPITATION (INCHES)	0.05	0.07	0.10	0.10	0.14	0.18	0.24	0.26	0.30	0.33	0.38	0.49
ENDED: DATE	18	18	18	18	18	18	18	18	18	18	18	18
ENDED: TIME (LST)	0142	0122	0124	0124	0142	0152	0159	0227	0248	0306	0336	0411

THE PRECIPITATION AMOUNTS FOR THE INDICATED TIME INTERVALS MAY OCCUR AT ANY TIME DURING THE MONTH. THE TIME INDICATED IS THE ENDING TIME OF THE INTERVAL. DATE AND TIME ARE NOT ENTERED FOR TRACE AMOUNTS.

OBSERVATIONS AT 3-HOUR INTERVALS

OCT 1994 14847
SAULT STE. MARIE, MI

HOUR L.S.T.	SKY COVER (TENTHS)	CEILING IN HUNDREDS OF FEET	VISIBILITY		WEATHER	TEMPERATURE			REL HUMIDITY %	WIND		SKY COVER (TENTHS)	CEILING IN HUNDREDS OF FEET	VISIBILITY		WEATHER	TEMPERATURE			REL HUMIDITY %	WIND		SKY COVER (TENTHS)	CEILING IN HUNDREDS OF FEET	VISIBILITY		WEATHER	TEMPERATURE			REL HUMIDITY %	WIND	
			WHOLE MILES	16THS MILE		AIR °F	WET BULB °F	DEW POINT °F		DIRECTION	SPEED (KNOTS)			WHOLE MILES	16THS MILE		AIR °F	WET BULB °F	DEW POINT °F		DIRECTION	SPEED (KNOTS)			WHOLE MILES	16THS MILE		AIR °F	WET BULB °F	DEW POINT °F		DIRECTION	SPEED (KNOTS)
	OCT 19											OCT 20											OCT 21										
01	10	2	0	8	LF	56	56	56	100	11	4	10	28	15			53	52	51	93	25	5	10	20	15			49	48	47	93	28	7
04	10	3	0	12	LF	56	56	56	100	16	6	10	25	15			53	51	50	90	25	8	10	20	15			48	47	45	89	24	5
07	10	4	0	6	F	57	57	57	100	09	3	10	5	1		LF	51	51	51	100	32	9	10	25	15			47	46	44	89	14	3
10	10	15	5		F	60	59	58	93	21	11	9	12	15			50	49	48	93	30	11	10	30	15			50	49	47	90	18	6
13	3	UNL	10			65	60	57	76	22	15	10	12	15			51	49	47	86	30	16	10	30	15			52	50	48	86	20	4
16	10	30	15			60	56	52	75	24	12	10	15	15			50	48	46	86	30	15	9	30	20			53	50	48	83	12	6
19	10	30	15			56	53	51	83	21	9	9	17	20			48	47	45	89	30	10	6	30	20			48	48	47	96	13	5
22	10	35	10			54	54	53	96	22	6	10	15	15			48	47	46	93	28	8	0	UNL	15			45	45	45	100	11	4
	OCT 22											OCT 23											OCT 24										
01	0	UNL	7			44	44	44	100	09	5	10	25	5		RF	50	50	50	100	13	7	4	UNL	15			41	39	37	86	25	10
04	10	75	6		F	47	47	47	100	09	4	10	25	5		RF	47	47	47	100	30	8	0	UNL	15			36	35	34	93	23	8
07	6	80	6		F	47	47	47	100	10	6	7	100	6		F	44	44	44	100	24	5	10	50	15			39	36	32	76	25	6
10	9	70	8			52	51	50	93	14	10	6	70	15			50	49	47	90	16	8	10	50	15			42	39	34	73	25	11
13	9	UNL	10			61	57	53	75	12	11	6	25	20			50	47	43	77	24	12	10	50	15			45	41	36	71	24	11
16	5	UNL	10			59	56	54	84	13	13	8	23	10		RW	45	44	42	89	28	17	10	30	15			45	40	34	66	26	9
19	6	50	10			53	51	50	90	11	14	7	23	10			44	43	41	89	24	5	10	30	10			41	38	35	79	28	7
22	7	50	7			51	51	50	96	12	11	3	UNL	15			43	42	40	89	26	7	10	25	6		R	37	37	37	100	24	9
	OCT 25											OCT 26											OCT 27										
01	10	7	5		R	37	37	37	100	25	8	7	25	15			39	37	35	86	35	5	0	UNL	15			30	30	30	100	00	0
04	10	13	6		R	39	39	39	100	26	9	10	23	15			37	36	34	89	34	3	7	UNL	0	12	F	32	32	32	100	09	5
07	10	13	5		R	38	38	38	100	25	11	10	25	15			38	37	36	93	03	3	9	30	0	12	F	34	34	34	100	09	5
10	6	12	15			40	40	39	96	30	8	10	25	15			40	38	36	86	31	6	3	UNL	8			45	44	43	93	19	9
13	7	20	20			44	41	36	74	33	12	8	25	20			42	41	39	89	35	8	4	UNL	12			53	48	43	69	22	12
16	6	20	15			44	41	38	80	31	14	8	130	15			42	39	35	76	33	10	0	UNL	20			54	48	42	64	21	10
19	9	20	15			40	38	36	86	33	7	2	UNL	15			37	36	34	89	31	4	0	UNL	20			44	41	38	80	13	6
22	6	25	15			39	39	38	96	30	5	0	UNL	10			32	32	32	100	19	4	0	UNL	15			42	40	38	86	15	6
	OCT 28											OCT 29											OCT 30										
01	0	UNL	15			40	39	38	93	11	5	10	40	10		R	52	49	47	83	22	13	0	UNL	15			42	37	29	60	24	9
04	0	UNL	15			42	42	41	96	11	4	7	40	10			51	49	46	83	24	8	0	UNL	15			42	37	29	60	24	8
07	8	UNL	8			44	43	42	93	16	8	8	120	10			48	47	45	89	25	9	0	UNL	15			37	33	27	67	24	7
10	10	150	12			51	48	45	80	17	8	9	120	15			51	49	47	86	26	5	0	UNL	15			48	41	32	54	25	8
13	10	130	15			54	49	45	72	20	12	3	UNL	15			56	51	47	72	30	15	0	UNL	20			55	46	35	47	24	10
16	10	120	20			56	49	42	60	20	12	4	UNL	20			53	48	43	69	31	7	2	UNL	20			54	45	35	49	22	10
19	10	120	15			54	49	44	69	15	5	2	UNL	15			42	41	40	93	19	4	2	UNL	20			47	41	33	58	22	9
22	10	40	10		R	53	49	44	72	20	12	0	UNL	15			40	38	35	82	24	4	3	UNL	15			45	41	37	74	26	6
	OCT 31																																
01	4	UNL	15			37	35	33	86	23	6																						
04	0	UNL	15			35	33	30	82	24	4																						
07	9	UNL	15			31	31	30	96	00	0																						
10	7	UNL	15			46	42	38	74	27	11																						
13	9	30	20			46	40	33	61	31	8																						
16	10	200	20			44	38	30	58	32	9																						
19	10	200	15			39	36	32	76	32	6																						
22	10	150	15			39	36	31	73	04	6																						

SUMMARY BY HOURS

HOUR L.S.T.	AVERAGES							RESULTANT WIND	
	SKY COVER (TENTHS)	STATION PRESSURE (INCHES)	TEMPERATURE			REL HUMIDITY %	SPEED (MPH)	DIRECTION	SPEED (MPH)
			AIR °F	WET BULB °F	DEW POINT °F				
01	5	29.240	44	43	41	91	6.5	20	1.1
04	6	29.240	43	42	40	92	6.5	19	0.4
07	7	29.250	43	41	40	92	7.0	12	0.9
10	7	29.260	49	46	43	81	10.2	21	1.8
13	6	29.240	53	48	43	71	12.3	25	4.2
16	6	29.220	52	48	43	70	12.7	26	3.8
19	6	29.230	47	44	42	83	8.3	18	0.8
22	4	29.240	45	43	42	90	7.6	15	1.5

WEATHER CODES AND NOTES

&	TORNADO	S	SNOW	IF	ICE FOG
&C	FUNNEL CLOUD	SW	SNOW SHOWERS	GF	GROUND FOG
&W	WATER SPOUT	SG	SNOW GRAINS	BD	BLOWING DUST
T	THUNDERSTORM	SP	SNOW PELLETS	BN	BLOWING SAND
R	RAIN	IC	ICE CRYSTALS	BS	BLOWING SNOW
RW	RAIN SHOWERS	IP	ICE PELLETS	BY	BLOWING SPRAY
ZR	FREEZING RAIN	IPW	ICE PELLET SHOWERS	K	SMOKE
L	DRIZZLE	A	HAIL	H	HAZE
ZL	FREEZING DRIZZLE	F	FOG	D	DUST

CEILING: UNL INDICATES UNLIMITED
WIND DIRECTION: DIRECTIONS ARE THOSE FROM WHICH THE WIND IS BLOWING, INDICATED IN TENS OF DEGREES FROM TRUE NORTH: I.E. 09 FOR
EAST, 18 FOR SOUTH, 27 FOR WEST. AN ENTRY OF 00 INDICATES CALM.
SPEED: THE OBSERVED AVERAGE ONE-MINUTE VALUE (MPH=KNOTS X 1.15).

NATIONAL CLIMATIC DATA CENTER
ROOM 120
151 PATTON AVENUE
ASHEVILLE, NORTH CAROLINA 28801-5001

OFFICIAL BUSINESS
PENALTY FOR PRIVATE USE $300

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OCT 1994 14847
SAULT STE. MARIE, MI
USCOM - NOAA - ASHEVILLE, NC 125

HOURLY PRECIPITATION (WATER EQUIVALENT IN INCHES)

DATE	A.M. HOUR ENDING AT												P.M. HOUR ENDING AT												DATE
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	
01																									01
02																									02
03																									03
04																									04
05																									05
06																									06
07																		T	0.03	T			0.01	T	07
08										T	T	T	0.01	0.03	0.05	0.03	0.06	0.09	0.06	0.01	0.01	T	T	T	08
09	T	T	T	0.07	0.01	0.01		0.03	0.01	0.01	T	0.01	0.02	T	T	0.01	0.01	0.01	0.02	T	0.01	T		0.01	09
10	T	0.01																							10
11																									11
12																									12
13																									13
14																									14
15																									15
16																									16
17			T	T	T	T	0.01	0.01				T	0.07	0.05	0.01	0.01	T					T	T		17
18	0.04	0.24	0.09	0.13	0.10	0.04	0.03	T	0.03	0.03	0.02					T	T	0.01	T	T	T	T	0.01	T	18
19	T	0.01	0.01	0.02	T	T												T	T	T	T	T			19
20		T	T			T	0.01	0.02																	20
21																									21
22			0.01	0.01																					22
23	0.02	0.05	0.06	0.04	0.01					T			T		T	0.02	0.01	T		T					23
24																				T	T	0.02	0.03	0.01	24
25	0.02	T	0.01	T	T	T	0.01	0.11	0.02	0.01						T		0.01	0.01	T	T				25
26													T		T	T	T	T							26
27																									27
28																					T	T	T	T	28
29	0.01	0.01	T	T											0.02										29
30																									30
31																									31

APPENDIX G:
DAILY WEATHER DATA: U.S. FISH AND WILDLIFE SERVICE

(Note: Temperatures are given in °F
Precipitation is given in inches)

Sullivan Creek

RECORD OF AIR AND WATER TEMPERATURES

STATION: Hiawatha Forest WF+1 **MONTH:** September, 1994

	AIR			WEATHER	POND WATER					WATER			REMARKS
DAY	LOW	HIGH	MEAN		12:00	8:00	Noon	4:00	Mean	LOW	HIGH	MEAN	
1	36	59	47.5	Cool + sunny	47	46	47	50	47.50				
2	28	67	47.5	sunny	46	43	45	50	46.00				
3	34	68	51.0	Ptly Cldy	47	46	47	52	48.00				
4	33	20	51.5	Cldy	45	47	47	51	47.5				
5	33	69	51.0	Ptly Cldy	48	46	48	50	48.0				
6	49	66	57.5	cloudy	48	47	49	51	48.75				
7	44	68	56.0	rainy	48	46	48	50	48.0				.03 Day Rain
8	48	74	61.0	sunny!	47	45	47	52	47.75				
9	34	65	49.5	Sunny!	47	45	47	52	47.75				
10	28	65	46.5	Clear	46	43	45	51	46.25				
11	32	75	53.5	Clear	46	45	47	52	47.50				
12	46	79	62.5	Ptly sunny	48	47	49	51	48.75				
13	54	78	66.0	cloudy	49	48	49	53	49.75				.18 night rain .30 day rain
14	57	65	61.0	cloudy	50	49	50	52	50.25				
15	57	74	65.5	Rain	50	49	49	50	49.50				.02 rain
16	64	76	70.0	cloudy	50	49	50	51	50.00				.06 day rain
17	53	68	60.5	ptly cloudy	50	49	50	53	50.50				.2 night rain
18	38	72	55.0	clear	49	47	48	53	49.25				
19	37	78	57.5	clear	48	45	48	52	48.25				
20	41	82	61.5	clear	43	41	48	53	46.25				
21	48	77	62.5	cloudy	48	47	49	52	49.00				
22	46	79	62.5	ptly cloudy	49	47	49	53	49.50				
23	51	77	64.0	Clear	50	47	47	52	50.00				
24	45	72	58.5	FAIR	49	47	48	52	49.0				
25	49	63	56.0	cloudy	49	48	49	49	48.75				.07 rain
26	45	59	52.0	cloudy	48	47	47	48	47.50				.04 night rain .06 day rain
27	51	65	58.0	cloudy	47	47	47	49	47.5				
28	44	51	47.50	clear	47	47	47	48	47.25				.45 night rain .03 day rain
29	40	56	48.00	ptly sunny	46	44	45	48	45.75				
30	27	63	45.00	ptly sunny	44	42	48	53	46.75				
31	—	—	—		----	----	----	----	----				
	TOTAL MEAN						TOTAL MEAN	1446.50 48.22		TOTAL MEAN			1.45" rain

Sullivan Creek

PEL FILES

RECORD OF AIR AND WATER TEMPERATURES

STATION: Hiawatha NFH

MONTH: October 1994

DAY	AIR			WEATHER	POND WATER					WATER			REMARKS
	LOW	HIGH	MEAN		12:00	8:00	Noon	4:00	Mean	LOW	HIGH	MEAN	
1	30	60	45.0	clear!	45	44	45	48	45.50				
2	26	56	41.0	clear!	47	44	43	47	45.25				
3	25	53	39.0	clear	43	41	43	46	43.25				
4	33	46	39.5	cloudy	43	43	44	45	43.75				.03 rain
5	33	58	45.5	ptly cldy	44	43	44	47	44.5				
6	40	69	54.5	ptly cldy	45	44	46	50	46.25				
7	43	70	56.5	cldy	46	47	48	50	47.75				
8	54	58	56.0	CLDY	49	48	48	49	48.5				
9	39	45	42.0	PTLY CLDY	47	46	46	48	46.75				0.33
10	26	54	40.0	cldy	44	42	43	45	43.50				0.08
11	23	60	41.50	ptly cldy	42	40	41	45	42.00				
12	31	67	49.00	sunny	43	42	44	47	44.00				
13	29	70	49.50	clear	44	43	45	48	45.00				
14	33	58	45.50	clear	45	43	44	46	44.5				
15	26	64	45.00	ptly cloudy	43	41	42	46	43.0				
16	30	63	46.5	cloudy	44	42	43	47	44.0				
17	46	54	50.00	cloudy	46	45	46	46	45.75				.04 night rain .06 Day rain
18	50	60	55.00	overcast	46	46	47	47	46.50				.44 night rain .10 day rain
19	55	66	60.50	overcast	48	48	48	50	48.50				.03 night rain Trace night rain
20	49	53	51.00	overcast	48	48	48	48	48.00				Trace night rain Trace Day rain
21	42	53	47.50	CLDY	47	46	46	48	46.75				
22	43	68	55.50	Ptly cldy	44	44	45	48	45.25				
23	40	54	47.00	" "	46	45	45	47	45.75				.23 Night rain
24	30	47	38.50	" "	44	42	44	45	43.75				.07 Night rain
25	34	50	42.00	" "	43	43	43	[illegible]	42.75				.04 Night rain
26	29	48	33.51	" "	42	41	42	44	42.25				Trace rain
27	21	58	39.5	" "	41	40	43	44	42.0				FAIR
28	24	59	41.5	" "	42	43	44	47	44.0				WINDY
29	42	62	52.0	" "	46	45	45	47	45.75				
30	26	57	41.5	CLEAR	44	42	42	44	43.00				
31	23	57	40.0	Clear	42	40	41	43	41.50				
	TOTAL 1436.0 MEAN 46.30F				TOTAL ✓1389.00 MEAN 44.80					TOTAL MEAN			1.45" Total Rain

RECORD OF AIR AND WATER TEMPERATURES

STATION Pendills Creek NFH **MONTH** SEPT. 1994

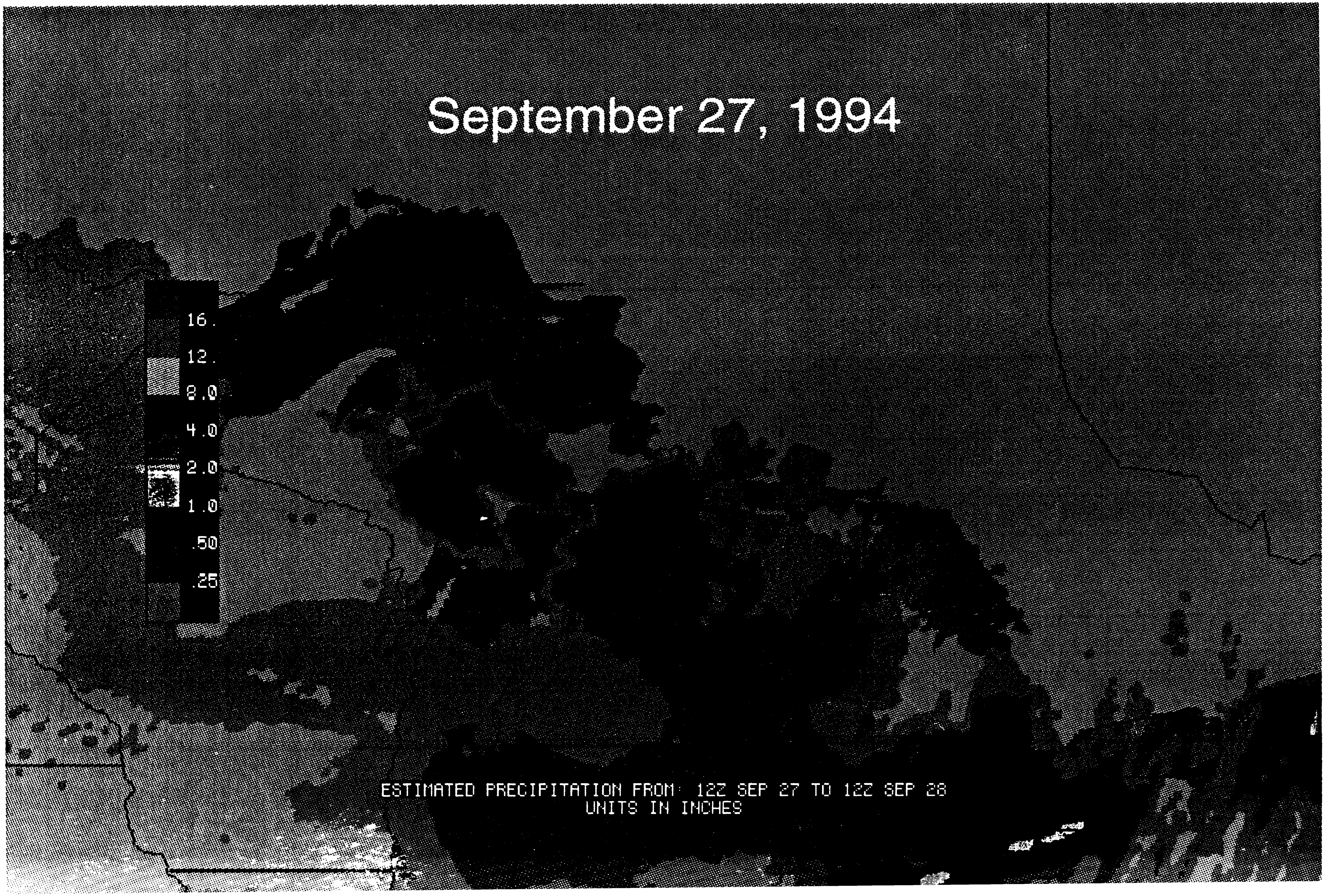
DAY	AIR			WEATHER	POND WATER					WATER			REMARKS
	LOW	HIGH	MEAN		12:00	LOW	NOON	HIGH	MEAN	LOW	HIGH	MEAN	
1	39	61	50.0	Clear	51	50	52	54	51.75				.15 RAIN
2	35	62	48.5	Clear	50	48	50	53	50.25				
3	41	65	53.0	PtlyCld	49	49	49	51	49.50				
4	37	67	52.0	" "	53	52	51	50	51.50				
5	45	65	55.0	P.C.	51	50	52	53	51.50				
6	49	63	56.0	P.C.	52	53	53	54	53.0				
7	40	64	52.0	Cldy	51	50	52	52	51.25				.15 rain
8	41	67	54.0	clear	50	50	51	55	51.5				
9	40	60	50.0	Clear	50	49	51	53	50.75				
10	33	66	49.5	clear	51	50	52	54	51.75				
11	42	76	59.0	PTLYCLD	52	51	53	55	52.75				
12	53	76	64.5	P.C.	53	52	54	55	53.5				
13	55	82	68.5	P.C.	53	53	55	56	54.25				.33 RAIN
14	54	69	61.5	Cldy	54	53	54	55	54.0				
15	55	70	62.5	Cldy	53	53	53	54	53.25				.50 RAIN
16	60	67	63.5	cldy-PC	53	54	54	56	54.5				.07 RAIN
17	50	65	57.5	Ptlycldy	54	53	53	55	53.75				.22 Rain
18	40	68	54.0	Clear	53	51	53	56	53.25				
19	39	76	57.5	Clear	53	51	53	56	53.25				
20	50	77	63.5	Clear	54	52	54	54	53.50				.03 RAIN
21	53	76	64.5	Clear	52	51	52	54	52.25				
22	51	77	64.0	Clear	52	51	53	54	52.5				
23	53	80	66.5	Clear	54	53	53	55	53.75				
24	56	72	64.00	FAIR	54	52	53	54	53.0	~~Crew [illegible]~~			
25	46	61	53.5	Cldy	53	52	52	55	53	PC [illegible]			.19 [illegible] RAIN
26	43	61	52.0	Cldy	54	52	53	53	53.0				.08 NITE RAIN .14 RAIN
27	47	60	53.5	CLDY	52	51	52	52	51.75				
28	42	50	46.0	cldy	51	50	50	51	50.5				.60 NITE .13 RAIN
29	40	72	56.0	P.C.	50	49	50	51	50.0				
30	32	60	46.0	PC	50	49	48	52	49.75				
31													
	TOTAL	1698.00			TOTAL	1568.25				TOTAL			
	MEAN	56.60			MEAN	52.78				MEAN			

RECORD OF AIR AND WATER TEMPERATURES

STATION PENDILLS CREEK MONTH Oct. 94

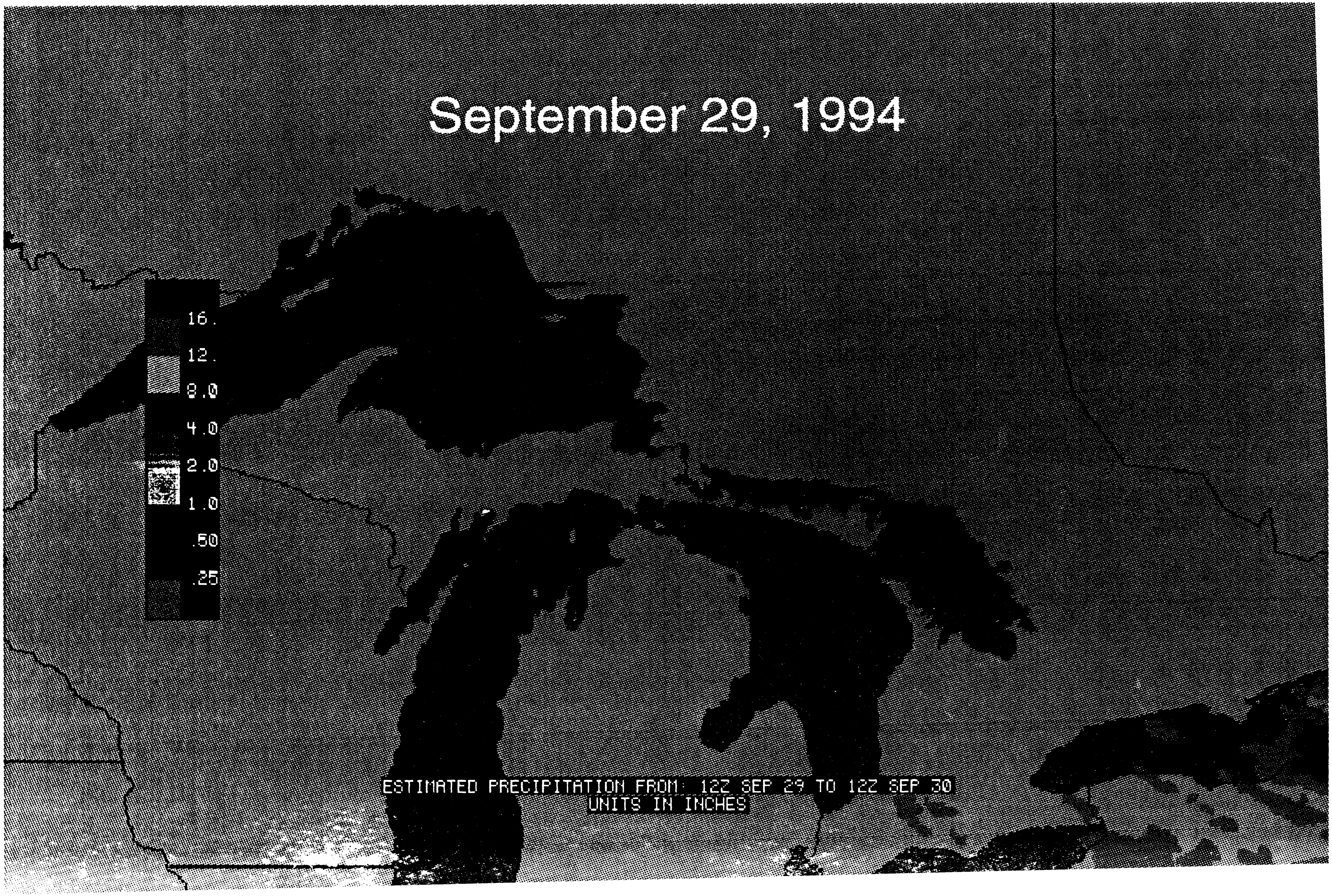
	AIR			WEATHER	POND WATER					WATER			REMARKS
DAY	LOW	HIGH	MEAN		12:00	LOW	NOON	HIGH	MEAN	LOW	HIGH	MEAN	
1	38	55	46.5	SUNNY	51	50	50	52	50.75				
2	32	55	43.5	SUNNY	50	48	50	51	49.75				
3	26	51	38.5	Fair	50	48	48	50	49.0				
4	36	48	42	Cldy	50	49	45	45	47.25				
5	32	58	45	FAIR	49	50	50	51	50.0				
6	40	70	55	CLEAR	50	50	50	[illegible]	50.25				
7	48	71	59.5	PTCLDY	53	51	52	54	52.5				
8	51	63	57.0	CLDY	53	52	52	53	52.5				0.11 NITE / 0.14
9	36	45	40.5	PTLY CLDY	52	49	50	51	50.5				0.33 NITE / .08
10	31	51	41.0	PTLY CLDY	49	47	48	50	48.5				0.08 NITE
11	28	61	44.5	FAIR	50	47	48	50	48.75				
12	38	67	52.5	FAER	50	49	50	51	50.0				
13	33	61	47	FAIR	50	48	50	51	[illegible]				
14	33	56	44.5	FAIR	51	48	49	50	49.5				
15	31	64	47.5	PTL CLD	50	48	48	50	49.0				
16	32	65	48.5	FAIR	50	48	48	51	49.25				
17	43	53	48.0	CLDY	50	49	50	50	49.75				0.09 NITE / 0.17
18	46	61	53.5	cldy	50	50	51	52	50.75				.50 RAIN .03 DRY
19	52	68	60.0	CLDY	52	51	52	54	52.25	Windy			leaves Blowing
20	51	53	52.0	CLDY	52	52	51	52	51.5				
31	45	60	52.5	PC	51	50	51	52	51.0				
22	43	66	54.5	PC	50	51	51	52	[illegible]				.04 Night
23	41	55	48.0	Cldy	52	50	51	51	50.75				.30 Night rain .03 dry
24	40	48	44.0	Cldy	50	47	48	48	48.25				
25	41	49	45.0	M.C.	48	47	48	47	47.5				.10 RAIN .10 Rain
26	35	46	40.5	Cldy	48	47	48	47	47.5				0.04 NITE
27	32	59	45.5	Clear	48	47	48	47	47.5				
28	40	61	50.5	CLDY	48	48	48	50	48.5				
29	49	58	53.5	P.C.	50	50	50	51	50.25				.10 RAIN
30	40	60	50.0	clear	50	48	48	49	48.75				
31	34	48	41.0	P.C.	49	47	47	48	47.75				
	TOTAL	1491.5			TOTAL			1540.25		TOTAL			
	MEAN	48.1			MEAN			49.69		MEAN			

APPENDIX H:
MICHIGAN DAILY PRECIPITATION MAPS



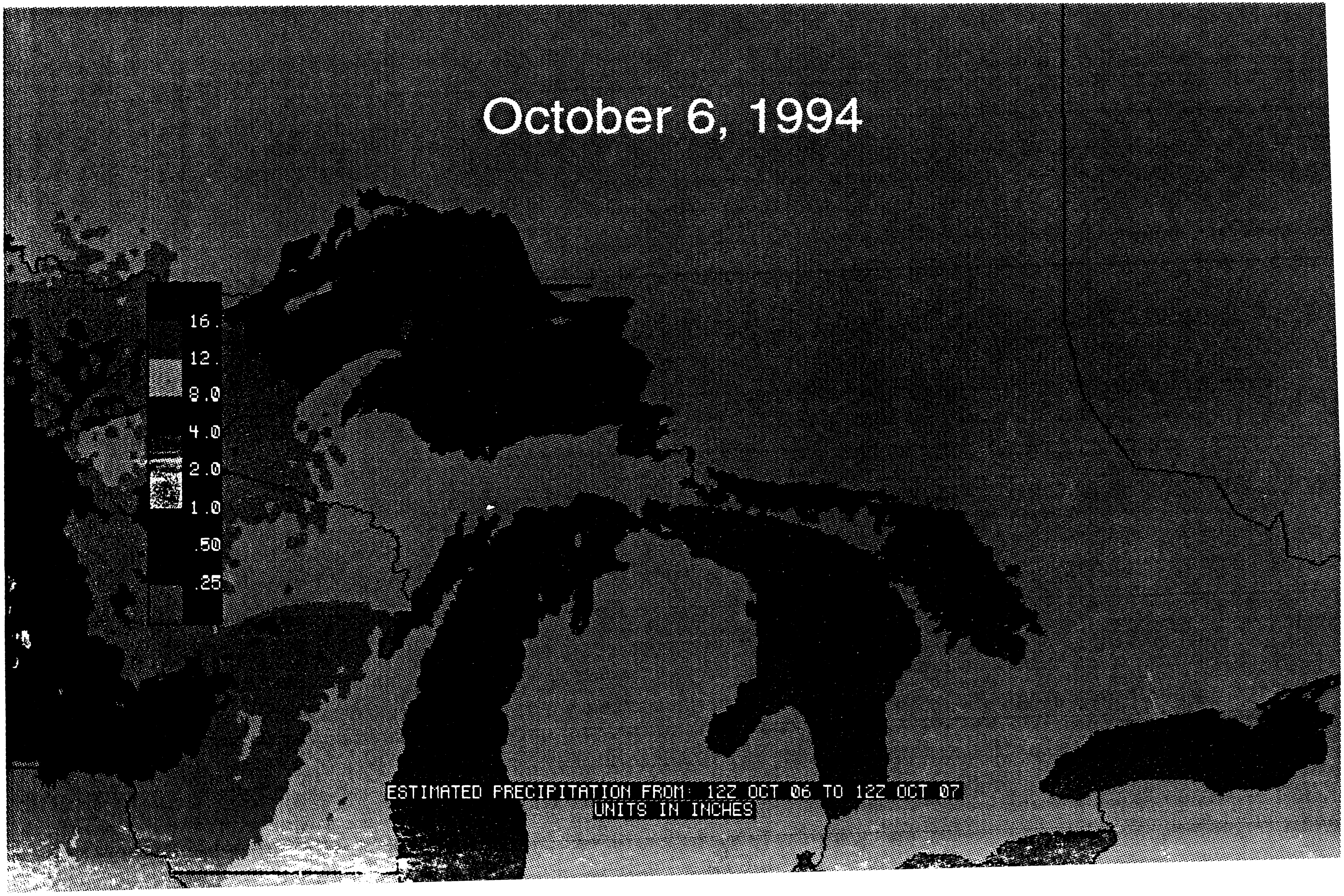
September 27, 1994

ESTIMATED PRECIPITATION FROM: 12Z SEP 27 TO 12Z SEP 28
UNITS IN INCHES



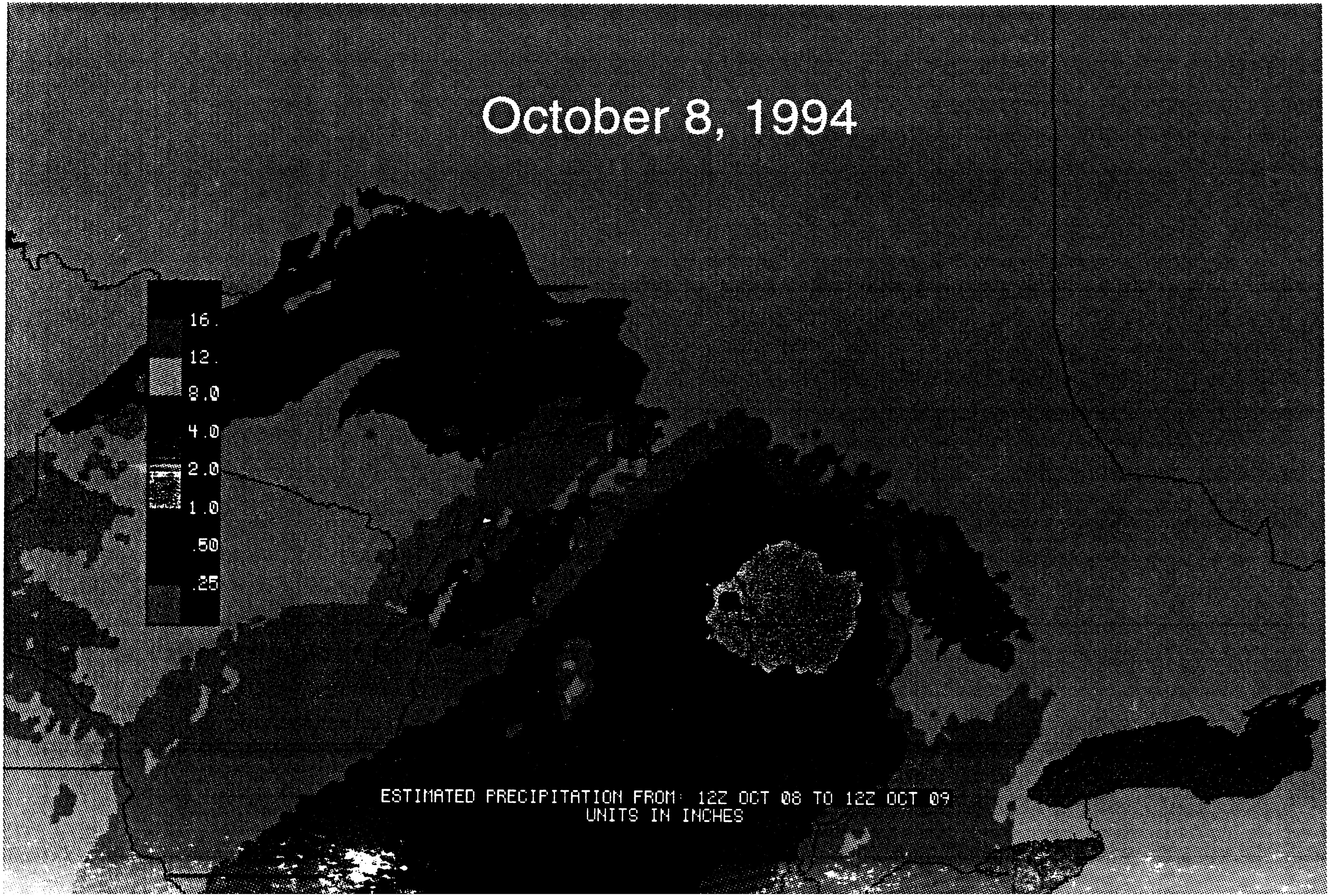
September 29, 1994

ESTIMATED PRECIPITATION FROM: 12Z SEP 29 TO 12Z SEP 30
UNITS IN INCHES



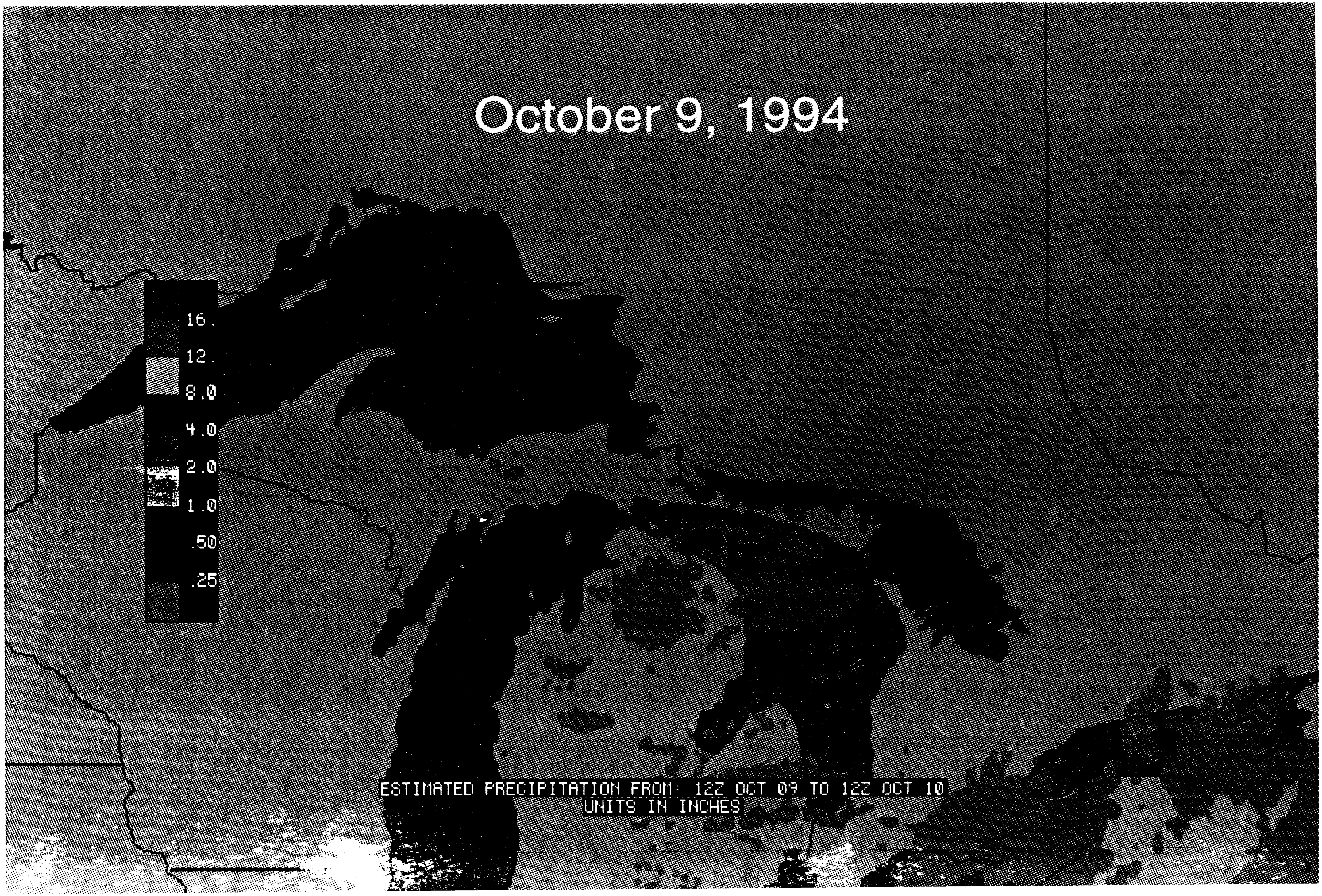
October 6, 1994

October 7, 1994

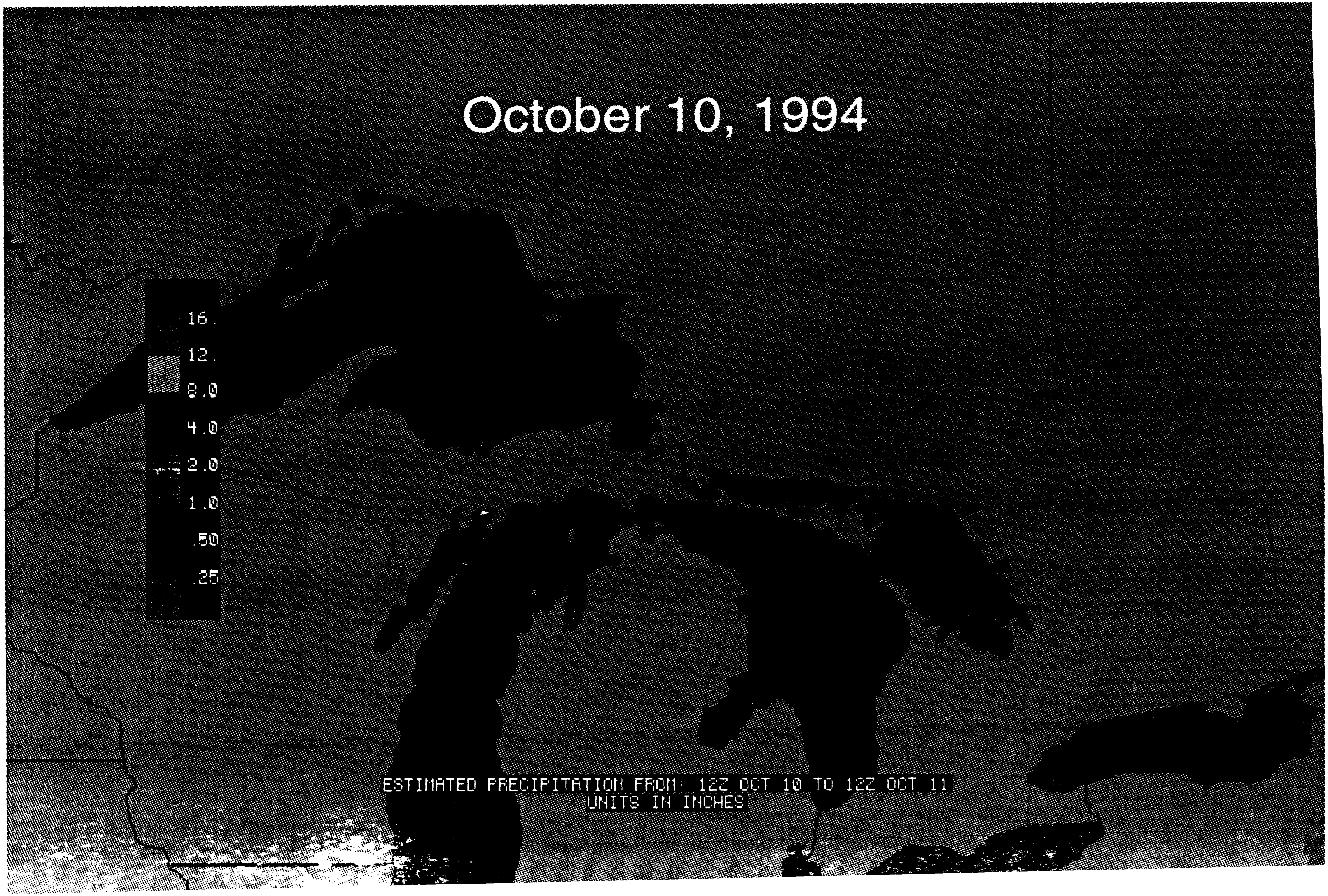


October 8, 1994

ESTIMATED PRECIPITATION FROM: 12Z OCT 08 TO 12Z OCT 09
UNITS IN INCHES



October 9, 1994



October 10, 1994

ESTIMATED PRECIPITATION FROM: 12Z OCT 10 TO 12Z OCT 11
UNITS IN INCHES