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TB153: A Long-Term Study of an Oak Pine Forest Ecosystem: Techniques Manual for the Holt Research Forest

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A Long-Term Study of an Oak Pine Forest Ecosystem: Techniques Manual for the Holt Research Forest

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INTRODUCTION

The manual is a compilation of the study techniques used for the long-term forest ecosystem research project at the Holt Research Forest in Arrowsic, Maine, plus brief evaluations of each method's advantages and drawbacks. It is based on 12 years of work by a team of three university professors, an associate scientist who has lived on the forest since 1983, a research assistant, several graduate students, and numerous undergraduate field assistants. We hope this manual will be useful to other researchers planning, or already involved in, other forest ecosystem studies. Of course, this techniques manual can, at best, only serve as a beginning point for other researchers. They will need to develop their own specific procedures and, it is hoped, detail them in their own manuals. If all long-term forest ecosystem projects have such a manual, it will greatly facilitate comparing and sharing data.

In 1981, the Holt family approached the University of Maine's College of Forest Resources with the idea of setting up a foundation to support a long-term research and management program on the family's 300-acre forest. The forest, across the Kennebec River from Bath in the island town of Arrowsic, is an oak-pine forest typical of the mid-coast peninsulas and dry ridges of southern Maine. As an undeveloped tract in a region beset by development pressure, the forest offered the perfect opportunity for the College of Forest Resources to study forest management and ecology with its implications for small woodlot owners. At the same time it allowed the Holts to divest of their family land without developing it. Thus the Holt Research Forest and Holt Woodlands Research Foundation were born.

A two-part plan was developed. The research plan emphasized two objectives: monitoring long-term changes in the forest's plant and animal populations, and documenting the effect of forest management on these populations. The management plan featured three goals, reflecting those of other small woodlot owners in southern Maine: maximizing the production of high-quality timber, enhancing wildlife diversity and abundance, and maintaining the forest's aesthetic qualities.

Full-time work began in 1983 when a grid system was established and base-line studies were initiated. In 1986–87, a group-selection timber harvest was conducted on selected blocks in half of the study area. Studies continue to document the impact of the harvest on the forest ecosystem. The long-term nature of the study also allows us to document ecosystem dynamics in relation to other influences such as climate change, air pollution, insect outbreaks, and even forest fragmentation and habitat loss in other regions as it affects migratory species that pass through the Holt Forest.

Please note: the mention of trade names or commercial products does not constitute an endorsement of these products by the university or any members of the Holt Research Team. Names of products mentioned herein are used for identification purposes only and maybe trademarks or registered trademarks of their respective companies.

We welcome comments on this manual, copies of similar manuals, and site visists from other ecologists. Please direct communication to either

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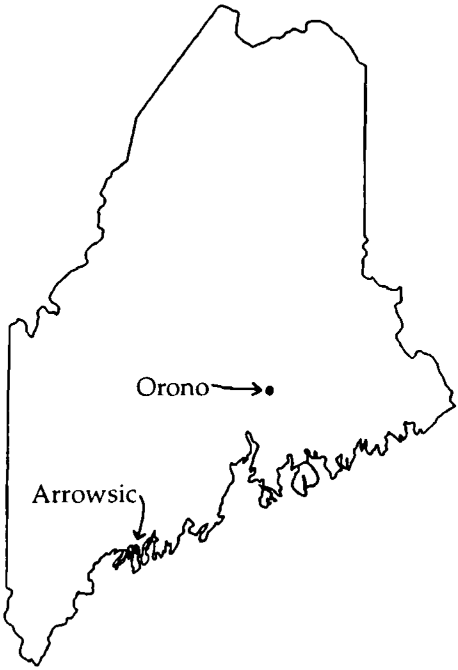


CHAPTER 1

GENERAL INFORMATION ABOUT THE HOLT RESEARCH FOREST

Using the Grid System
General Instructions

USING THE GRID SYSTEM

The Holt Forest (Figures 1–1 and 1–2) is located in Arrowsic, Sagadahoc Country, Maine (Lat. 44°N Long. 70°W), is bounded on the east by the Back River and on the west by Sewall Pond, and is divided by the Old Stage Road. The study area is located on the east side of the property and is divided into 40 one-hectare (ha) blocks. The western half of the study area comprises a 20ha managed area where forest management is practiced, and the eastern half is a 20ha control area where no manipulations are allowed. The study area is also split north-south by an old barbed wire fence; the change in vegetation is noticeable.

Grid Layout

The blocks in the study area are laid out in a grid, each block measuring 100x100m (1ha). The block corners are marked by a yellow PVC marker over a rebar stake; both the stake and pink flagging on a nearby tree are labeled with the location. The blocks are divided into four 50x50m quadrats (0.25ha) by an oranged-topped iron pin in the block center. The quadrat corners at the midpoint of the block lines are marked with an orange iron pin labeled with a metal tag and pink flagging.

The quadrats are subdivided into four 25x25m (0.0625ha) subquadrats by an orange iron pin in the quadrat center. The pin is labeled with a metal tag and red flagging. The grid layout is illustrated in Figures 1–1 and 1–2.

Markings

Most of the lines have been brushed and marked by paint on the trees. Trees along the boundary of the study area and along the 5/6 line between the control and managed area are painted red. Block lines are painted white. Quadrat lines passing through block centers are marked by double blue lines. Subquad lines will be marked by double yellow lines.

Outside of the study area, the block lines have been extended north, east, and south to the property boundaries, and west to the Old Stage Road. They are marked with white paint, iron pins at 50m intervals, and nails in the middle of the Old Stage Road. The boundaries of the property are painted blue.

Table 1–1 is a list of these and other markings used at the Holt Forest and describes their locations and uses.

Coding

Each block has a unique letter-number code. Blocks are numbered 3 through 8 from west to east, and C through J from north to south (see Figures 1–1 and 1–2). Quadrats and subquadrats are numbered 1–4. Hence, a seedtrap located in 3E42 would be found in block 3E, quadrat 4, subquadrat 2.

A block line is named by the letters or numbers of the blocks on either side of the line. Hence, the 5/6 line is a north-south line, and the F/G line is an east-west line.

The north-south quadrat lines that run through the center of the blocks (named the 3, 4, 5, 6, 7, and 8 lines) are often called transect or census lines because they are used in transect surveys of birds and mammals.

Two other sets of lines run through the study area. They are small mammal trap lines, and S-1 and S-10 lines (see "Small Mammal Trapping" and "S-1 Instructions").

Access

There are five points of access to the study area from the Old Stage Road. From south to north they are

1. A woods road that starts behind the log house office and enters the study area in quadrat 3I3.
2. A woods road that begins across from the Arrowsic Conservation Area parking spot and enters quadrat 3G3. This road and the one above intersect near the center of block 6H.
3. Line F/G, the north vs. south dividing line. It begins near a large yellow birch on the edge of the Old Stage Road.
4. Line D/E; it begins near the northern logging road and landing.
5. A woods road that begins across from the residence just north of the property line on the west side of Old Stage Road and ends in block 5C near the salt marsh.

It is important to use these access routes and the grid system lines at all times. Walking off the lines results in trampled vegetation and can harm ground-nesting birds.

Date: 9 OCT 92 File name: GRID.INS

Table 1–1. Markings in the Holt Research Forest.

Marker	Locations and Use
yellow PVC markers	block corners (over rebar stakes)
iron pins	block line midpoints, block centers, quadrat centers (rebar with tops painted orange)
red and orange flags (metal stakes)	north and south edges of S-10 plots at 5m intervals and N, S, E, W of quadrat centers representing the $4m^2$ regeneration plots
orange flags (plastic stakes)	in 6H4 marking plants used in a discontinued phenology study
pink flags	location of individual plants for reproductive effort study, south of S-1s and along 3 and 8 lines
pink flagging	block corners and midpoints, quadrat centers, census lines, lines outside study area between blocks, leads of moisture blocks along S-1 lines.
orange flagging	with wood stakes for frass card stations, mark trail on S-1 lines
orange-and-black-striped flagging	small mammal trap stations
red plastic stakes with metal tags	small mammal trap stations
red-brushed lines	edge of the study area and dividing line between managed and control (line 5/6)
white-brushed lines	block lines exclusive of red lines
blue-brushed lines	property lines
painted double blue stripes	quadrat lines other than block lines includes brushed N/S census lines and not brushed E/W lines
painted double yellow stripes	subquadrat line
killer tree flagging	hazardous trees, hanging branches, etc.
pink-and-black-striped flagging	hazards, such as stinging insect nests
blue flags	centers of mapped harvest gaps
blue flagging	south end of mapped ledge and tree gaps
green flags	nest predation study, nest location
yellow flags	nest predation study, indicates nest nearby
yellow flagging	nest predation study, marks yellow flag
green flagging	extension of nest predation transect outside study area
tall pink flags	fruit production line endpoints

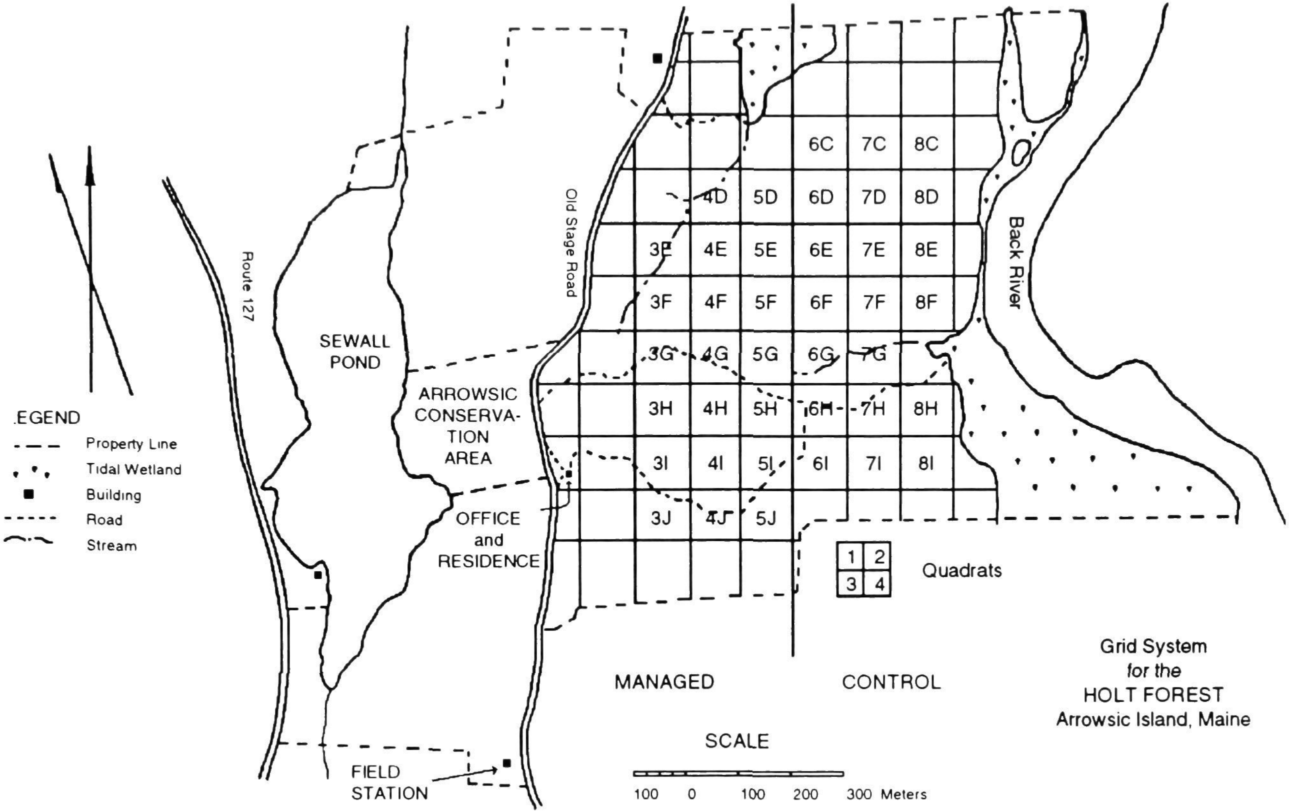


Figure 1–1. Grid system of the Holt Forest map.

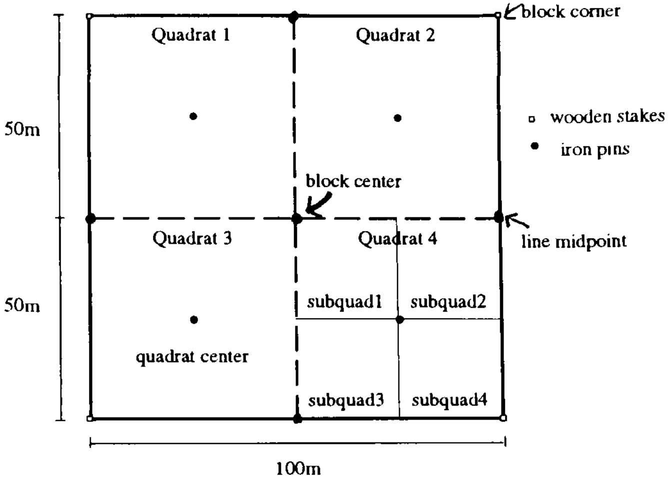


Figure 1–2a. Layout of a study block

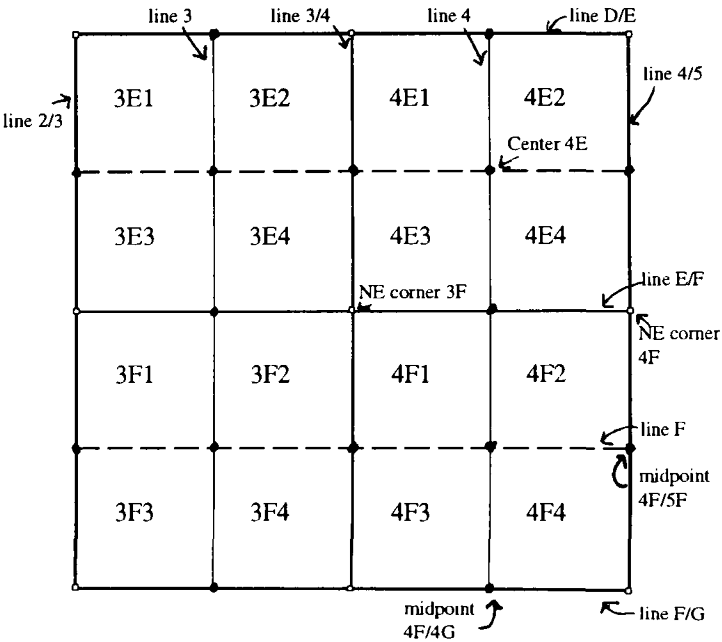


Figure 1–2b. Layout of 4 adjacent study blocks (3E, 4E, 3F, 4F).

GENERAL INSTRUCTIONS

1. All measurements are in metric units.
2. To facilitate locating people in the forest, everyone must sign in and out on the chalkboard on the ground floor of the lab. The following information will be recorded: Name (initials), Location, Time out (when you went into the field), Time in (when you expect to return), and Work (what you will be doing). Upon return, erase your chalkboard information and record your activities in the log book.
3. When walking through the study area, walk only on roads and grid lines. To help maintain the integrity of the vegetation, avoid going into a study block except when working in it, and when working in the blocks, use extreme care to minimize vegetation trampling. Fruit within the study area should not be picked.
4. Keep the forest tidy by picking up litter (even if it is not your own) and being judicious in the use of flagging. Make sure that all markings no longer needed are removed.
5. Any hazards such as stinging insect nests should be marked with pink-and-black-striped flagging. Hazardous trees should be marked with "Killer tree" flagging. All hazards should be written on chalkboard to inform others.

Equipment

1. Most equipment will be stored on the bottom floor of the lab, and all equipment should be returned to its place at the end of each day.
2. All equipment should be cleaned or oiled as necessary; for DBH tapes this means oiling after every day of use.
3. Any missing or broken equipment must be reported to a supervisor.

Data Sheets

1. Record data carefully; it must be accurate and legible.
2. Fill out each data sheet completely; date, observer, and location are recorded on every sheet.
3. All dates are recorded by day-month-year, e.g., 20 JUN 83. Always use the first three letters as abbreviations for the month: January — JAN; February — FEB; March — MAR; April — APR; May — MAY; June — JUN; July — JUL; August — AUG; September — SEP; October — OCT; November — NOV; December — DEC.

4. All times are recorded by 24-hour time clock, e.g., 6:00 AM = 0600 hrs; 6:00 PM = 1800 hrs; noon = 1200 hrs; midnight = 2400 hrs.
5. Record the names of observers and recorders with three initials, e.g., MLH, AJK, JWW.
6. Weather should be recorded as general information, two to five words are usually enough, (e.g., rain, cool, breezy; partly cloudy, warm, no wind; clear, hot, still).
7. If more than one data sheet is used for any single quadrat, block, or observation period, the pages should be numbered to include the total number of pages (e.g., page 2 of 3 or page 2/3). They should be stapled together.
8. A dot and dash tally system will be used for counts: 1–4 are recorded by dots and 5–10 by dashes, e.g., 1,· 2,·· 3,∴ 4,∷ 5,⁖ 6,⌐ 7,⊏ 8,□ 9,⊠ 10,⊠.
9. Errors made while recording data should be crossed out and rewritten, not erased or written over.

Safety

Everyone is expected to adhere to "Safety Guidelines and Regulations for All Personnel" established by the College of Forest Resources. The following rules should also be observed:

1. Hardhats and rugged work boots (preferably steel-toed) will be worn when doing any axe or hand saw work.
2. No smoking in the woods.

Date: 7 MAY 90 File name: GENERAL.INS

CHAPTER 2

PHYSICAL PARAMETERS MONITORING AT THE HOLT RESEARCH FOREST

Soils Mapping
Soil Moisture Block Readings
Meteorological Station
Light Measurements with a Ceptometer

SOILS MAPPING

An initial soil survey was conducted in 1981 to determine the major soil types present across the entire Holt property. This was a medium-intensity survey (order 2) with 2 acres (0.8ha) as the minimum delineation.

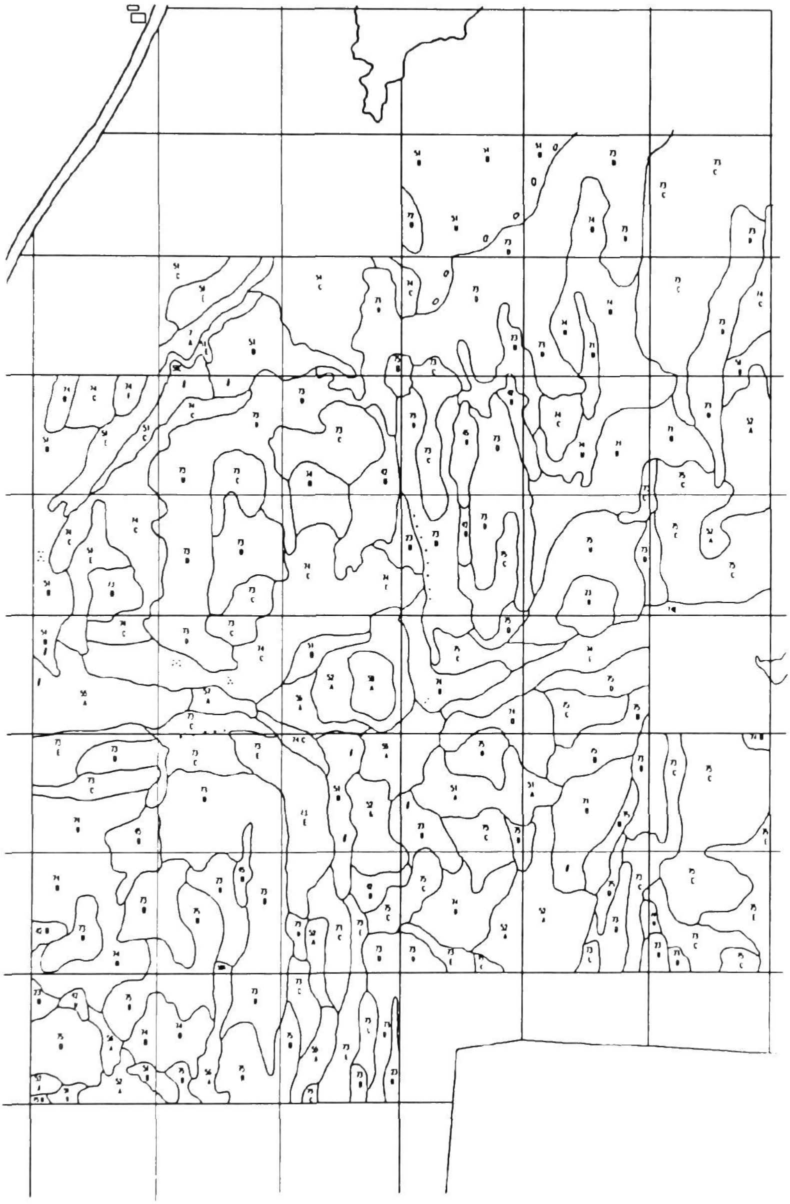
A high-intensity soil survey (order 1) was conducted in the study area in 1986 and 1987 by a soil scientist from the USDA Soil Conservation Service. The survey had a 1/8-acre ($500m^2$) minimum delineation. The S-1 line was also mapped, with the soil type of each $1m^2$ plot being determined. The soil types of the study area are listed and described in Table 2–1. See Figure 2–1 for the soils map.

Date: 5 JAN 93 File name: SOILSMAP.DES

Table 2–1. Holt Research Forest soils.

Soil Type	Slope	Soil #	Drainage class
Biddeford mucky peat	0–3%	58A	very poorly
Boothbay silt loam	3–8%	51B	moderately well & somewhat poorly
Boothbay silt loam	8–15%	51C	
Boothbay silt loam	25–35%	51E	
Brayton fine sandy loam	0–5%	45B	poorly
Charles silt loam	0–3%	7A	
Croghan loamy fine sand	0–3%	57A	moderately well
Moosilauke fine sandy loam	0–3%	55A	somewhat poorly and poorly
Naskeag-Lyman complex	0–5%	71B	somewhat poorly and poorly to somewhat excessively
Ricker-Lyman complex	0–8%	73B	well to excessively & somewhat excessively
Ricker-Lyman complex	8–15%	73C	"
Ricker-Lyman complex	15–25%	73D	
Ricker-Lyman complex	25–45%	73E	
Scantic Silt Loam	0–3%	52A	poorly
Skerry fine sandy loam	0–8%	23B	moderately well
Swanton fine sandy loam	0–3%	56A	somewhat poorly and poorly
Tunbridge fine sandy loam	0–8%	74B	well
Tunbridge fine sandy loam	8–15%	74C	
Tunbridge fine sandy loam	25–35%	74E	
Tunbridge-Lyman complex	0–8%	75B	well to somewhat excessively
Tunbridge-Lyman complex	8–15%	75C	
Tunbridge-Lyman complex	15–30%	75D	
Tunbridge-Lyman complex	30–45%	75E	
Westbury fine sandy loam	0–5%	42B	somewhat poorly

Figure 2–1. Holt Forest soils map.



SOIL MOISTURE BLOCK READINGS

Introduction

Holt Forest soils range from xeric ledges to permanently saturated swamps. Soil moisture blocks are used to measure soil moisture in four dominant soil types at various depths and under various cover types throughout the growing season.

Soil moisture blocks are small (3x4x1.5cm) blocks of gypsum and nylon. Imbedded in the block are two stainless steel screens each attached to a wire; the screens are separated by a piece of plastic rod. The blocks are used to estimate the percentage of available soil moisture based on the resistance to an electrical current within the block. A total of 21 soil moisture blocks are located along the north side of the north S-1 line and are distributed among various soil types. They are marked by pink flagging tied to the wires that come out of the ground. The flagging has the location and depth of each block written on it. Where soil depth allows, two blocks are buried at each location, one each at 15cm and 30cm. All locations and depths are listed on the data sheet.

Procedure

1. Readings are taken with a Bouyoucos moisture meter.
2. Readings should be taken on Wednesday afternoons throughout the growing season and can be incorporated with other activities such as salamander shingle counts.
3. Take readings by attaching the end of each wire from the moisture block to an alligator clip on the leads from the moisture meter. Either wire can be connected to either lead; it is important that the leads don't touch while a reading is being made.
4. After connecting the leads, the meter must be calibrated. Press the button on the right marked "PRESS TO CAL." The needle will swing towards 100. Adjust it with the knob on the left marked "CAL." until it reads precisely 100.
5. Once the calibration is correct, press both buttons simultaneously to get a reading from the block.
6. Data are recorded on a soil moisture block data sheet by location (see Figure 2–2). Any readings above 103 should be recorded as 100+. All other readings should be approximated to the nearest 1 percent.
7. The soil moisture blocks dissolve in the soil. The rate of dissolving varies greatly between locations. The readings should be monitored carefully to notice any discrepancies

between blocks in similar soils and moisture conditions. Blocks may have to be replaced.

Equipment

Moisture meter	Clipboard
Data sheet	Pencils

Evaluation

Use of soil moisture blocks began in 1985, with 72 sample locations (one block per location @ 15cm deep) scattered along the S-1 lines in a variety of soil types. This pattern of sampling was maintained until 1991 when the current sampling design was established.

The primary reason for changing the sample design was the cost of blocks, which needed to be replaced more frequently than we had anticipated. Soil moisture blocks deteriorate at variable rates from site to site, which made the reliability of readings suspect unless the blocks were pulled and examined at regular intervals. Blocks located in wet and/or acidic soils seemed to be the most vulnerable to dissolution, and at some sites they lasted less than one year. In addition, the tremendous microsite variation necessitated the use of at least two blocks in close proximity, and ideally there should be two depths sampled per location. This system for measuring soil moisture is primarily designed for agricultural systems and the conversion to forest uses is not easy.

On the plus side, the blocks do provide a fixed site reading over the life of the block and provide reliable data that are indicative of soil moisture conditions of the entire study area.

Date: 15 DEC 87 File name: SOILMB.INS

Figure 2–2. Soil moisture block data sheet.

HOLT FOREST
MOISTURE BLOCK READINGS

Date 25SEP Weather Sunny Cool Observer EHM

STATION	SOILTYPE	DEPTH	% MOISTURE
N5	BBY	15	0
N5	BBY	30	0
N20	BBY	15	53
N20	BBY	30	57
N35	BBY	15	67
N35	BBY	30	57
N105	TUN	15	85
N105	TUN	30	90
N110	TUN	15	82
N110	TUN	30	88
N120	TUN	15	64
N120	TUN	30	0
N135	RIK	15	40
N140	RIK	15	84
N150	LYM	15	44
N150	LYM	30	42
N165	LYM	15	28
N165	LYM	30	76
N175	RIK	15	40
N180	LYM	15	71
N180	LYM	30	60

METEOROLOGICAL STATION INSTRUCTIONS

Introduction

Meteorological data are collected on site to establish a database that is specific to the Holt Research Forest. The information allows us to examine the effects of weather on a variety of plant and animal processes and also provides the basis for looking at both cyclic and long-term changes in weather patterns.

Setup of Station

The meteorological station is located outside the study area in the center of a 25m-radius clearing just west of the northwest corner of 3I. The station consists of a 12m tower with a solar pyranometer (Li-Cor LI-200SB and Calconnector), a wind anemometer (R.M. Young Model 12102 Gill 3 cup), and a microvane (R.M. Young Model 12302 Gill microvane) attached to the top. A lightning rod and two grounding cables are attached to the tower to minimize chances of a direct lightning strike. In a small instrument shelter is an air temperature and relative humidity probe (Campbell Scientific Model 207). On a stand near the tower is a precipitation gauge (Weathertronics electrically heated rain and snow gauge Model 6021). In a small shed is a datalogger (*Campbell Scientific CR21XL) that samples, calculates and stores all measurements from the instruments, a thermocouple probe on the micrologger panel, and an answering modem for communication. A 220-volt AC power cable and a data communications cable run from the shed to the residence/office. The setup of instruments is discussed in greater detail in the 21X Micrologger Operator Manual.

The datalogger takes measurements at 60-second intervals and is programmed to store the following information on a daily basis:

SOLAR
- Solar radiation from whole hemisphere, global sun plus sky radiation (total kW/m^2 [joules] per day)

PRECIPITATION
- Total Precipitation (mm/day)

WIND
- Wind Rose in 45° quadrants
- Mean Wind Speed (m/sec)
- Mean Vector Magnitude
- Mean Vector Direction (0–359°)
- Standard Deviation of Direction
- Maximum Wind Speed (m/sec)

TEMPERATURE AND RELATIVE HUMIDITY

- Mean Temperature (°C)
- Standard Deviation of Temperature
- Maximum and Minimum Temperature
- Time of Maximum and Minimum Temperature
- Relative Humidity at Maximum and Minimum Temperature
- Maximum and Minimum Relative Humidity
- Time of Maximum and Minimum Relative Humidity

The datalogger can be programmed either manually using the micrologger keyboard or remotely by linking it with the computer (see Downloading Data) and using the telecommunications software (PC208) program TERM. See the software manual for specifics.

Downloading Data

Communication with the datalogger is established using telecommunications software (Campbell Scientific PC208) with short haul answer and call modems (Campbell Scientific Model SC95A and SC95C) connected by a shielded twisted pair cable (Belden 8451). The datalogger is downloaded on a weekly basis onto a computer.

To download data, first turn on the computer and the calling modem. Go to the PC208 directory on the C drive and type TELCOM to begin the software. A prompt asking for the station file name will appear; HOLT will always be the station. Most often the /E (edit parameters) option is used, though occasionally the /C (call datalogger now) and the /G (get all data) options are needed. You will be prompted for the station parameters. The parameters to use are as follows:

Datalogger or Command Type	: 21X
Data Collection Method	: Most Recent Arrays; Create;
Number of Arrays to Collect	: 24
Data File Format	: Printable ASCII
Fix Datalogger Clock Using PC Clock	: When 30 sec off
Primary Call Interval (minutes)	: 60
Recovery Call Interval #1 (minutes)	: 15
Repetitions of Recovery Interval #1	: 4
Recovery Call Interval #2 (minutes)	: 60
Maximum Time Call Will Take (minutes)	: 10
Next Time To Call	: 21-12-92 9:15:00

Interface devices:
COM2 Baud Rate: 9600
Short Haul

Most of these parameters are fixed; the only ones to change on a regular basis are "number of arrays to collect" and "next time to call." Three arrays are created per day; therefore, calculate the number of arrays to collect as three times the number of days since the last download, plus three (to allow a one day overlap between data sets): [3 x #days]+3. The "next time to call" may need to be changed to allow a call to go through after an unsuccessful attempt at establishing communication has occurred.

The file created by the download is HOLT.DAT. This should be copied to the C:\HOLT\DATA\METSTA directory, and the name changed to MET(day month) .(year)D reflecting the date of download, e.g., MET21DEC.92D. Using WordPerfect, these data are then copied to the end of either file MET01-06.(year)D or MET07-12.(year)D. MET01-06 contains January through June data and MET07-12 contains July through December data, e.g., MET21DEC.92D should be copied to the end of MET07-12.92D. When duplicate days of data in these files occur, one set should be eliminated using two WordPerfect macros: D1 removes one day (3 arrays) or D2 erases two days (6 arrays). The file should be saved, replacing the old copy.

Data are then summarized on a monthly basis using the SPLIT program in the PC208 software package. Four parameter files were created that direct SPLIT to analyze and organize various elements of the downloaded data into four summaries: Temperature, Pyranometer and Precipitation, Wind Means (i.e., wind speed, vector magnitude and vector direction), and Wind Rose. To run SPLIT, the data must be saved in an ASCII format.

Equipment Maintenance

Wind instruments. The instruments should be checked a minimum of once a year to ensure that they are functioning. Make sure all connections are good; the instruments need to swing freely with minimal resistance and the microvane must be checked for correct direction (north is 0 degrees). Additionally, the data from the datalogger should be checked frequently for irregularities that may indicate a problem.

Solar pyranometer. This sensor should be recalibrated every two years whether or not it is in use. There are two sensors, one that is in use and a second that serves as a backup. To minimize costs, the backup should not be sent for recalibration until replacement is anticipated. Daily readings of 0, -99999, or -6999 from the datalogger indicate the instrument has failed and needs to be replaced.

Relative humidity, temperature probe. The relative humidity sensor (PCRC-11) needs to be checked regularly for signs of corrosion or flaking and should be replaced if either is present. The temperature sensor does not require any maintenance. Additionally, the data from the datalogger should be checked frequently for irregularities that may indicate a problem.

Precipitation gauge. The screens on the gauge should be cleaned each spring and fall and the calibration of the tipping bucket mechanism should be checked yearly. The calibration is tested by putting 7.85 milliliters of water (equivalent to 0.25mm of precipitation) in the higher bucket; this should cause the bucket to tip. If the calibration is off, it may need to be returned to the factory for recalibration. The gauge needs to be plugged in (in the shed) to melt snow; checking it after a snowstorm or touching the gauge when temperatures are below freezing will indicate whether or not the heaters are working.

Evaluation

All components of the meteorological station currently function well. Originally, the datalogger was located in the office and was connected to the field instruments with long (100m) leads running in a PVC pipe along the ground. During thunderstorms, these long leads acted like antennae which sometimes resulted in an induced charge of high voltage causing considerable damage to the datalogger. This occurred in spite of our best efforts to isolate the datalogger by installing spark gaps and a lightning rod. We solved the problem by moving the datalogger to a shed at the base of the tower, thereby eliminating the long wire leads.

Date: 04 JAN 92 File name: METSTA.INS

LIGHT MEASUREMENTS WITH A CEPTOMETER

Introduction

The Decagon Sunfleck Ceptometer is an instrument that measures the amount of light in the photosynthetically active radiation (PAR) waveband, 400–700 nanometers (nm). The ceptometer has 80 sensors distributed along a probe. A microprocessor scans them to produce a reading that is the average light of all the sensors. The measurement is in $\mu mol/m^2 s^2$. In addition, the ceptometer outputs a sunfleck reading which is related to the fraction of the probes that are being hit by sunflecks (a direct beam of solar radiation). Both of these measurements are useful in determining the light penetration into the forest understory as influenced by the canopy structure. Ceptometer measurements are used in methods for S-1s, fruit production, and regeneration studies, and for evaluating defoliation. In general, the ceptometer has replaced the use of the spherical densiometer.

Procedure

The ceptometer

The ceptometer is a 1m-long wand with a small box at one end. The box has the function keys to control the ceptometer, a display window, and a bubble level. There are two control keys (A & B) and a function key. The function key is pressed until the desired function is reached. A small arrow at the top of the display points to the function number. There are eight functions that can be selected (see ceptometer manual for details). Functions 1:(PAR measurement), 6:(setting the time), and 8:(send/erase memory) are used most often and are reviewed here.

Function 1. This function is used for taking most field measurements. It records time, PAR, and sunfleck fraction. Press button A to sample the PAR. The sample number and the PAR measurement will be displayed. After an adequate number of samples are recorded (this varies according to study), press button B to average the samples. The average will be displayed; A can be pushed to erase the average or B can be pushed to store the reading. If B is pushed the memory indicator will display the number of averaged readings that have been stored. Pushing A will clear the readings and reset the sample counter. The normal sequence of pushing buttons is

A (pushed as many times as the number of required samples, e.g., push A three times for S-1 sample),
B to average,
B to store,
A to clear and begin again.

To take field measurements, it is necessary to follow the specific directions given in each set of instructions. When taking readings, it is absolutely essential for the ceptometer to be level; use the bubble indicator on the keyboard for this purpose.

While taking field measurements, it is essential to keep detailed records of where each stored data point was taken. The ceptometer only records time and the readings. The line number in the data set corresponds to the number indicated by the memory indicator. This number should be recorded along with the location where the readings were taken.

Function 6. This function is used to set the time. Button A controls the hour value and button B controls the minute value. The clock can be set by moving one hour or minute at a time by single presses or moving rapidly by holding the button down.

Function 8. This function is used to download data and erase the memory. The RS-232 cable labeled DECAGON is connected to the ceptometer (9-pin) and serial port #2 (25-pin) on the computer. Pushing B sends the data, while pushing A will interrupt the sending function. Once the data are successfully downloaded and the data set checked, the memory can be cleared by holding down A and pressing B.

Data downloading has been most successful with the Telecommunications program on Desktop (PCTOOLS).

Type "desktop" and press RETURN to begin the program.

From the desktop menu, select Telecommunications, then Modem.

A menu will be displayed; highlight the line labeled ceptometer 1200 E 7 1.

Press F8 for manual connection.

Press F6 to receive an ASCII file.

Type in the file name, and press RETURN and RETURN with the Save box highlighted. The computer is now ready to accept data. Press B on the ceptometer to send the data. The data will be displayed on the screen as it is received. When data transfer is completed press ESC to save data. Pressing F3 or typing "exit" will return the desktop menu, and selecting exit will close the program. Check the file for completeness and integrity of the data before erasing the ceptometer memory.

The quantum sensor

A quantum sensor needs to be set up at the meteorological station to record PAR in full sun to provide a baseline data set for comparison to the ceptometer readings. A quantum sensor should be mounted on a tripod and set in a location close to the tower and shed, in full sun where no shadows will pass across it. The wires are mounted to a CR21X micrologger, and it is programmed to take readings at one-minute intervals for the duration of the ceptometer work. The time on the CR21X must be set (*5) and synchronized with the ceptometer. Hook-up of the quantum sensor wires are red to high (H) and black to ground on any of the input channels (1–8). Usually the spare CR21X is used, and the data are downloaded in the same way as described in the meteorological station instructions.

Date: 15 JAN 93 File name: CEPTOMTR.INS

CHAPTER 3

PLANT ECOLOGY RESEARCH AT THE HOLT RESEARCH FOREST

Trees
- Instructions for Tree Numbering and DBH Marking
- Timber Inventory
- Tree Mapping
- S-10 Mapping
- Tree Regeneration Inventory
- Tree Height and Crown Measurements
- Cover Type Mapping
- Gap Mapping
- Small Mammal Trap Station Timber Inventory
- Tree Vigor
- Litter and Seed Production Studies
  - Instructions for Building Seed Traps
  - Seed Collection
  - Instructions for Litter Trap Construction
  - Litter and Seed Production

Herbs and Shrubs
- Relevé
- How to Teach Relevé Technique
- S-1
- Plant Reproductive Effort
- Fruit Production

INSTRUCTIONS FOR TREE NUMBERING AND DBH MARKING

Introduction

To facilitate collecting tree growth data over several years, all trees are individually numbered and marked with a DBH (Diameter at Breast Height) line. This promotes faster and more accurate data collection and consistent measurement of diameters from year to year. These instructions detail the initial procedure of numbering and marking trees. Once the initial numbering and marking is completed, only recruitment trees are added in subsequent years.

The following two classifications summarize the numbering and marking pattern on the Holt Forest.

- Timber inventory (TI) trees, those ≥9.5cm DBH, are numbered and marked in all quadrats.
- Regeneration (REG) trees, those ≥1.5cm and <9.5cm DBH, are marked and numbered only within the S-10 strips.

Procedures

1. *Tree numbering.* It is most important that each tree has a unique number in its quadrat and that a tally is kept of the numbers used within each quadrat.
   a. *TI trees.* Timber inventory or TI trees are those ≥9.5cm DBH. Each TI tree in a quadrat receives a number that is unique within that quadrat. TI trees are tagged with a pre-numbered (1–1000) rectangular aluminum tag. The tag is nailed to the base of the tree, on the south side, in the least exposed location (e.g., within the fold of a root). The tag should be placed below where a tree would be cut to be harvested. The aluminum nail should be driven only halfway in to allow for growth of the tree. Crotched or multiple stem trees receive only one number. Keep a tally of the tag numbers used in each quadrat.
   b. *REG trees.* Regeneration or REG trees are those ≥1.5cm and <9.5cm DBH. REG trees are numbered only in the S-10 strips. (Two S-10 strips, each 10m wide by 600m long, run east/west across the study area in the "E" and "I" blocks. Their north and south boundaries are marked by red flags at 5m intervals. See Figure 3–1.) Each REG tree receives a number that is unique to the S-10 in that quadrat, beginning at 1900. The numbers are hand written on aluminum tags attached to green plastic

tape. The tape is tied around the tree in a large loop that will not constrict the tree in any manner. The tag and loop should be placed above the ground. Keep a tally of the REG numbers used in each quadrat. When working in S-10 strips, use the red flags as boundary lines, not the painted lines. A tree is considered to be "in" the S-10 if it is rooted within the S-10 or if more than half its base is in the S-10. If a multiple-stem or crotched tree occurs on a boundary line, then it is counted in the quadrat where the most stems occur.

c. *Multiple stem trees.* Multiple stem trees are trees that apparently share a common root system but have more than one stem emerging. Trees with multiple stems receive one number, either a TI or REG number. Most multiple stem trees will fall into one or the other category. When a tree does have both TI and REG size stems, the tree receives a TI number written on a REG tag. Be sure that what appears to be one multiple stem tree is not two separate trees grown together; check the species of each stem. Additionally, each stem receives a sequential letter designation (A, B, C...) from west to east. On TI trees, these letters should be painted on the stem below the DBH line with a paint tube marker. On REG trees, the letter is written with the tree number on the tied-on tag.

d. Dead trees. All free-standing dead trees ≥9.5cm DBH are treated like TI trees; leaning dead trees are not included.

2. *Marking DBH lines.* The same procedure is used to mark DBH for all trees regardless of size. DBH lines are made using a paint tube marker to make a single horizontal line approximately 8cm long (less on small trees). All marks should be located on the south side of the bole. Scrape off all lichens occurring where the mark will be placed to increase the longevity of these marks. Make the line so that its top edge is at breast height. Breast height is defined by the top of the height stick (130cm) when it is placed on the highest ground around the base of the tree (see Figure 3–2a). This means that the tree's DBH should be measured by placing the DBH tape or fork just above the paint line. If a deformity or branch occurs at breast height, move the DBH mark just above or below it, wherever the diameter most accurately reflects the size of the tree. If a tree has a crotch between

30cm and 130cm, then breast height is marked 1m above the crotch on each stem. The height stick illustrated in Figure 3–2b is used in many of the methods. The inscribed orange lines are used primarily in regeneration measurements, and the inscribed white lines are used primarily in relevé measurements. The highest white line on the height stick is 1m.

3. *Covering the forest.*
   a. *TI trees.* The most efficient means for covering a quadrat is to make parallel east/west sweeps across it, beginning in the NW corner. Up to 6 sweeps across the quadrat may be necessary to completely cover it. The marker determines which trees are ≥9.5cm DBH and marks them. Then the marked trees are numbered; check to make sure all the TI trees in the S-10s are included.
   b. *REG trees.* Numbering and marking DBH on REG trees in the S-10s should proceed by weaving north/south across the S-10s starting from the west and moving east. In this manner, number the trees more or less sequentially from west to east. Avoid trampling the S-1 plots which are located at the southern edge of the S-10. Remember that in each new quadrat the numbering sequence for REG trees begins with 1900 again. The marker should first measure trees with a tree fork to determine in which DBH category a tree falls. If a tree is close to 9.5cm, it may be necessary to use a DBH tape to accurately determine its DBH. Next the breast height line should be put on those trees with DBH ≥1.5 and <9.5. Use care when moving the breast height line from an opposite side of the tree to the south side to ensure that the height stays the same.

Equipment

Paint tubes	Rags
Height stick	Tree fork
DBH tape	Aluminum tags
Green tie tape	Nails
Nail apron	Hammer
Hammer holster	Tally sheet
Pencils	

Evaluation

This procedure was done in 1986. Marking and numbering was originally conducted by two-person crews, but we found that one person working alone was more efficient.

The DBH lines greatly improve the accuracy and speed of measuring tree diameters by ensuring that a tree will be measured at the same location each time. As with any marking system, the lines do age and need to be maintained. All trees initially were marked in 1986 and 1987, and five years later most marks are still readily visible although some need to be revitalized.

The tree numbers work well. Any difficulties will come when tags are lost (e.g., in a timber harvest) or in keeping track of numbers to avoid duplication within a quadrat. Putting the tags at the base of the tree causes two problems: the tallier must bend over to read the number, and the tags can get buried as litter accumulates around the base of the tree. An alternative may be to put the tags at DBH height, and the nail could serve a dual purpose of holding the tag and being a DBH mark. This should be done only where no tree harvesting will take place.

For both DBH lines and tree numbers, it is particularly important to be consistent in which side of the tree is marked; field time can be greatly increased if a tallier has to spend a lot of time searching for a tag or a DBH line.

Date: 29 OCT 87 File name: TREENO.INS

Figure 3–1. Holt Forest study area, vegetation mapping units.

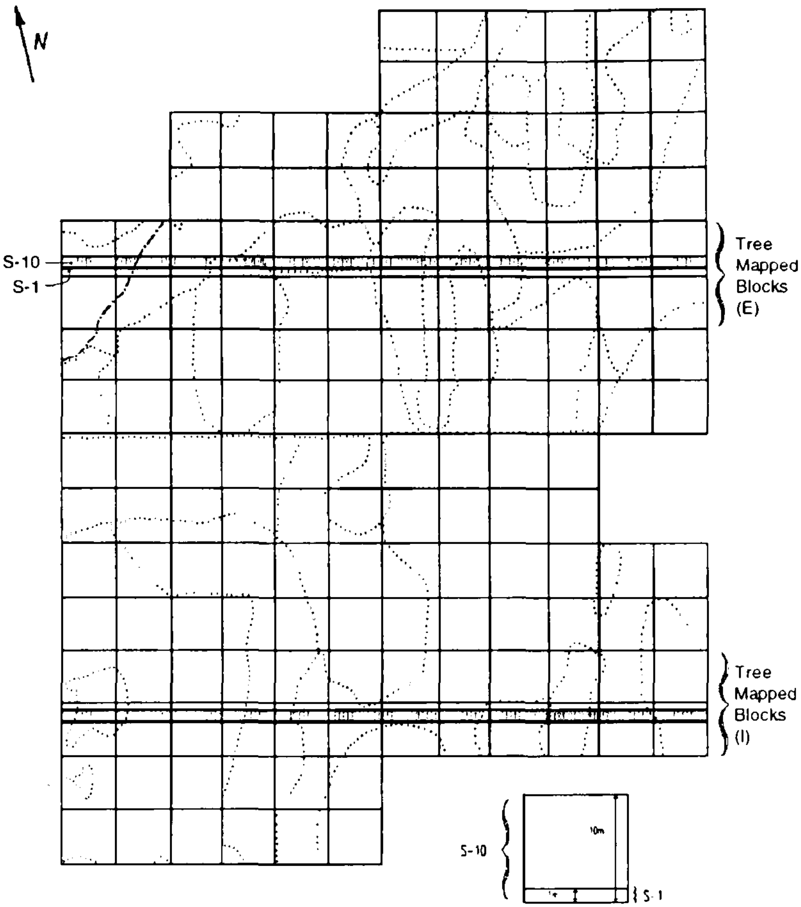
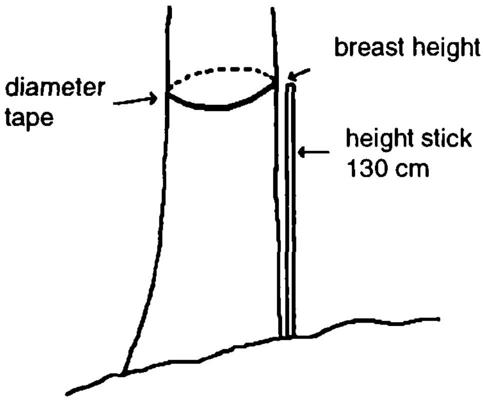
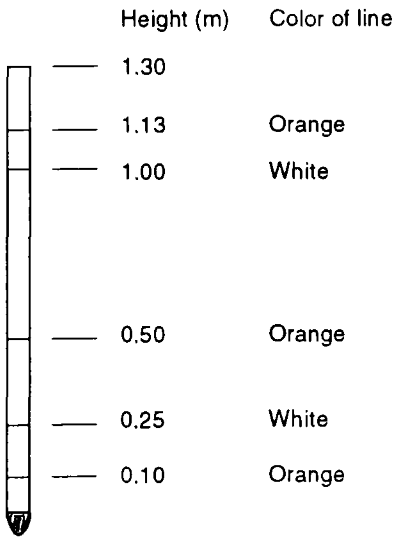


Figure 3–2. Breast height measurement and illustration of a height stick.



a. Breast height



b. Height stick

TIMBER INVENTORY INSTRUCTIONS

Introduction

A complete timber inventory is conducted in every block during selected years. The purpose is to collect new diameter and condition data for numbered trees, to number ingrowth trees, and to record any fallen trees. It is undertaken primarily by student crews beginning in mid-May and continues until completion.

Set-up

Covering the area

All blocks in the study area are measured. The block progression should begin with 6C and proceed east on C, west on D, east on E, west on F, east on G, west on H, east on I, west on J. Within a block each quadrat is tallied separately, moving in the "U" shaped order 1, 3, 4, 2, when going east, and 2, 4, 3, 1 when going west (see "Tree Mapping Instructions").

Crews

Crews consist of three people, one recorder and two observers. The recorder is responsible for recording data on the polycorder, making sure all numbered trees are found, and defining the southern line of the measuring area. The observers measure trees.

Procedure

1. When a crew first arrives at a quadrat, the observers lay out the 50m ropes along the two quadrat lines to help define the quadrat boundaries. Quadrat lines are marked by two horizontal blue lines painted on bordering trees.
2. The recorder records the date, observers, recorder, weather, and comments on a tally sheet to keep a record of observation dates and any problems encountered.
3. The most efficient means for covering the area of a quadrat is to make three parallel sweeps (east-west) beginning in the NW corner (see illustration on page 33). This can be varied according to stand density. While the observers make the sweeps, the recorder defines the southern edge of the quadrat, keeps the observers in line, and makes sure all trees are measured.
4. The observers call out the tree number, species, diameter, and condition (if it is in a category other than "live"). The recorder repeats the information back to each observer to corroborate it, and then records it on the polycorder with the timber inventory program.

a. *Diameter measurements*. Measure tree diameter with a diameter tape at breast height as defined by the top edge of a DBH paint line, 130cm up from the base of the bole (see Figure 3–2a). All trees with a DBH greater than 9.49cm will be recorded by one-centimeter classes. A DBH class (x) is delineated by the following rule: [(x-1)+.5] to [x+.49], e.g., [(10-1)+.5] to [10+.49] = 9.5 to 10.49.

b. *Tree number, species, and condition*. Tree number is found on an aluminum tag at the base of the tree. Tree species and condition codes are found in Table 3–1. The conditions are defined as (0) live—a healthy tree; (1) dead--no living cambium layer; (2) cull—a deformed or damaged tree of no commercial value; (3) dead top—a tree with the top 1m or more dead; (4) almost dead—a tree that will probably die within 5 years; (5) still standing—a tree that was dead during a previous inventory and is still standing; and (6) dead and down—a dead tree that has fallen.

5. Mark the tree on its south side with a chalk stick so the recorder can check the tally. Mark dead trees permanently by hacking them twice on the south side so they are not recorded again in future inventories.
6. In all subsequent timber inventories, crews must look for "recruitment" trees, trees that have grown into the TI class by reaching a DBH ≥9.5 (measure, don't estimate). Recruitment trees are given a unique number (bring appropriate tags for this purpose), and the DBH line is marked (see "Instructions for Tree Numbering and DBH Marking"). Then measure the tree for timber inventory and record the data.
7. Any TI trees that have faded DBH marks or multi-stem letters should be remarked with paint tubes.

Equipment

Diameter tapes (3)
Marking chalk (2–3 per quadrat)
50m ropes (2)
Instructions
Polycorder
Paint tubes for DBH lines
Height stick (1) 130cm
Chalk holders
Hatchet (2) for marking dead trees
Numbered aluminum tags, nails, hammer for recruitment trees

Evaluation

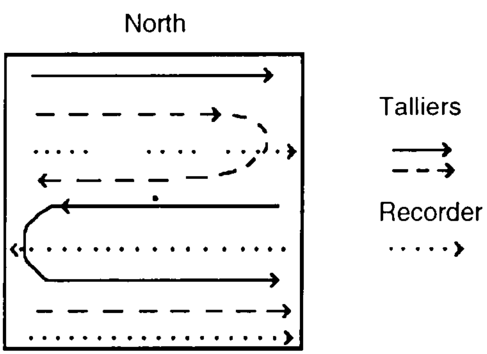
The timber inventory (a 100% tally of the trees in the study area) is a very effective means of closely monitoring the growth, condition and death of individual trees in the forest, but it is labor intensive. It takes a 3-person crew most of a 12-week field season to complete an inventory. The set-up (see "Instructions for Tree Numbering and DBH Marking") is also labor intensive. Approximately 30,000 trees are measured in a complete timber inventory.

It is very important to make sure that all trees are tallied and that ingrowth trees are found. The role of the recorder is particularly important; he/she must be vigilant in watching the talliers to catch missed trees and incorrect species or condition. An improved polycorder program for tree checking would improve the speed and quality of field checks for "missing" trees.

We have also found that the quadrat ($2500m^2$) level sample area seems to contain too many trees to handle efficiently when checking data or locating missing trees. Furthermore many other study components are measured at the subquad ($625m^2$) level, so comparisons are difficult. In the future, the timber inventory will be conducted at the subquad level.

The original timber inventory methods included both measuring and estimating tree heights. This was dropped because of time constraints. Additionally, the reliability of the height estimates was poor, and the sample size (estimating every tenth tree and measuring every fortieth) was not adequate.

Date: 1 DEC 87 File name: TIMBERIN.INS



Routes to cover a quadrat.

Table 3–1. Tree species and condition codes.

Species Name	Tree Species Codes Common Name	Number
Pinus strobus	White Pine	1
Picea rubens	Red Spruce	2
Abies balsamea	Balsam Fir	3
Tsuga canadensis	Hemlock	4
Quercus rubra	Red Oak	5
Quercus alba	White Oak	6
Acer rubrum	Red Maple	7
Betula alleghaniensis	Yellow Birch	8
Betula papyrifera	Paper Birch	9
Betula populifolia	Gray Birch	10
Fagus grandifolia	Beech	11
Fraxinus americana	White Ash	12
Acer pensylvanicum	Striped Maple	13
Populus grandidentata	Bigtooth Aspen	14
Populus tremuloides	Quaking Aspen	15
Prunus serotina	Black Cherry	16
Pyrus malus	Apple	17
Ostrya virginiana	Hop Hornbeam	18
Pinus resinosa	Red Pine	19
Pinus rigida	Pitch Pine	20
Hamamelis virginiana	Witch Hazel	25
Alnus sp.	Alder Sp.	26

Tree Condition Codes

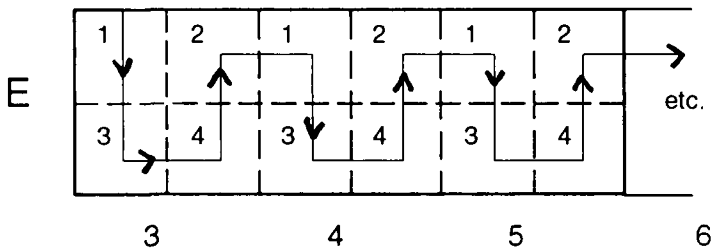
Tree Condition Class	Code
Live	0
Dead	1
Cull	2
Dead-Top	3
Almost Dead	4
Still Standing	5
Dead and Down	6

TREE MAPPING INSTRUCTIONS

Introduction

Mapping trees within a portion of the study area where other environmental factors are monitored allows us to better understand the dynamics of the forest (e.g., how trees react to soil and moisture conditions). These instructions detail the initial mapping of all timber inventory (TI) trees (DBH ≥9.5cm). In subsequent years, "recruitment" trees (those that have grown into the TI size class) will be mapped and numbered.

Trees are mapped on a quadrat basis within the "E" and "I" blocks, a total of 48 quadrats. Mapping begins in the 3E block and moves east; this sequence is repeated in the I blocks beginning with 3I. Within a block, quadrats are covered in the "U"-shaped sequence of 1,3,4,2 (see below).



Tree mapping is done by measuring distance and direction from fixed points. Mapping crews consist of two people, a mapper and a locator. The mapper is responsible for recording data, reading angles, reading distances, holding the 50m tape, and checking to see that all numbered trees are mapped. The locator is responsible for reading the tree number and distance, measuring DBH, determining species and condition, holding the target, and giving the information to the mapper. Read "Timber Inventory Instructions" first.

Procedure

1. Record date, mapper, locator, weather, quadrat, mapping station, and page number on the data sheet (see Figure 3–3). A separate data sheet should be used for each quadrat. Record multiple stem or crotched trees so that the first stem (usually A) is recorded in the left column and the other lettered stems are recorded in the right column. All single stem trees should be recorded in the left column only.

2. The mapper stands at the mapping station. Stations should be located at the corner pins of each quadrat. For example, the station pins for quadrat 3E1 would be: NW corner of 3E (NW), 2E/3E (NE), center of 3E (SE), and 3D/3E (SW). In most quadrats it will not be possible to see all the trees from the corners. In such cases, stations will have to be set up within the quadrat; these stations will be called intermediate points (IP) and will be marked by a flag while in use. (See Procedure number 6 for setting up IPs.)
3. The locator moves from tree to tree within the quadrat and gives the tree number, species, and condition to the mapper, who records the data and repeats them back to the locator to corroborate it. Species and condition number codes are listed in Table 3–1. The locator should set up the target and/or hold a flashlight to enable the mapper to accurately sight a tree.
4. The mapper reads the direction and the distance to the tree using a compass and rangefinder. Both instruments should be held directly over the station pin or flag and aimed at the center of the tree. When using a compass, angles should be recorded to the nearest half degree. The distance is measured with a 123X Rangefinder to the nearest tenth of a meter when possible. Distances less than 2m should be measured using a tape. Both distance and direction measurements should be to the center of the base of the tree.
5. Meanwhile, the locator measures the DBH. DBH should be measured at the top edge of the breast height line and recorded to the nearest DBH class (defined in Data Sheet Components below).
6. When using an intermediate point, its location must be recorded before being set up. Do this the same way a tree is recorded: measure the direction and distance from a corner to an IP and not vice versa. Record the IP location at the bottom of the data sheet.
7. To integrate tree mapping and S-10 mapping, locate at least three flags along the S-10 boundary while mapping a quadrat. The quadrat center should also be located. The S-10 flag number, quadrat center, and their locations are recorded at the bottom of the data sheet.

Data Sheet Components

Quadrat—Only one quadrat per data sheet.
Page—Page number out of total pages for the quadrat.
Sta—Station number where the mapper is located.

Tree#—Number on the tag attached to the tree. Also record A, B, etc., from multiple stem or crotched trees.
Spec—Number code for tree species, see Table 3–1.
DBH—Diameter at breast height. Record by DBH class (x) as calculated by
[(x-1)+0.5] to [x+0.49]; e.g., 5cm is 4.5 to 5.49.
Cond—Number code for tree condition, see Table 3–1.
Direct—Compass direction from station to tree (nearest half degree in 0–360° scale).
Dist—Distance from station to tree (nearest tenth of a meter).

At the bottom, IP numbers, S-10 flag numbers and quadrat centers are recorded with their locations when appropriate.

Equipment

Rangefinder
Compass
Flashlight
Target
Clipboard
Pencils
Tape (50 m)
DBH tape
Extra batteries
Flags
Data sheets

Evaluation

Errors in recording data were the most common problems and required some additional field checks. A higher quality range finder would improve accuracy and save time by requiring less calibration. Although a hand-held electronic distance measurer would work in an open forest in the right weather conditions (calm and dry), the advantage of a range finder is that it can work in dense vegetation with the use of a flashlight. In hind-sight we might have selected the areas to be mapped based on how well they represent the major forest cover and soil types across the forest.

Date: 4 NOV 87 File name: TREEMAP.INS

Figure 3–3. Tree mapping data sheet.

HOLT RESEARCH FOREST TREE MAPPING DATA SHEET

Date 15JUL86 Observers MKM-M UWL-L Weather sunny, breezy

Quadrat 6I2 Page 4 of 11

Sta	Tree#	Spec	DBH	Cond	Direct	Dist	Tree#	Spec	DBH	Cond	Direct	Dist
SE	987A	7	10	0	294	25.9	987B	7	24	0	294	25.7
SE	988	7	13	0	295	26.4						
SW	989	1	34	0	107	21.4						
IP1	990A	5	17	5	210	16.7	990B	5	18	5	209	16.7
IP1	991	5	31	0	214	16.5						
SW	992A	5	16	0	236	10.2	992B	5	14	0	236	10.0
SW	993	1	23	0	64.0	23.7						
SW	994	1	34	0	60.0	26.0						
IP1	995	3	10	0	289	13.5						
NW	996	1	33	0	177.0	27.0						
SW	997	1	31	0	57.0	23.5						
SW	998	1	13	5	57.0	21.7						
SW	999	1	26	0	61.5	21.7						
SW	1000	5	16	0	78.0	18.0						
SW	1	5	12	0	85.5	19.1						
SW	2	1	20	0	101	17.9						
SW	3	2	17	0	101.5	11.7						
SW	4	6	10	5	95.5	10.7						
SW	5	5	11	5	92.0	10.2						
SW	6	5	17	1	89.0	11.7						
SW	7	6	10	3	89.0	11.2						
SW	8	5	23	0	72.0	10.4						

S-10 MAPPING INSTRUCTIONS

Introduction

S-10s are 10m-wide strips which run the length of the "E" and "I" blocks (see Figure 3–1). Both the north and south boundaries of the S-10s are marked at 5m intervals by numbered red or orange flags. The numbering begins at 0 on the west side of the study area (3El & 3I3) and ends at 600 on the east side of the study area (8E2 & 8I4). Mapping is conducted from west to east.

Mapping S-10s allows us to better understand the dynamics of the forest, particularly the role of regeneration trees within the system. All regeneration (REG) trees (DBH ≥1.5cm and <9.5cm) within the S-10 strips are mapped during selected years. Initially, all REG trees are mapped using direction and distance data from fixed points. In subsequent years "recruitment" trees (those that have grown into the REG size class) will be mapped and numbered, and all trees will be measured.

Crews consist of two people: a mapper and a locator. The mapper is responsible for recording data, reading angles, holding the 50m tape, and checking to see that all numbered trees are mapped. The locator is responsible for reading the tree number and distance, measuring DBH, determining species and condition, and giving the information to the mapper. Read "Timber Inventory Instructions" first.

Procedure

1. Record date, mapper, locator, weather, quadrat, mapping station, and page number on the data sheet (see Figure 3–4). A separate data sheet should be used for each quadrat. Record multiple stem or crotched trees so that the first stem (usually A) is recorded in the left column and the other lettered stems are in the right column. All single stem trees should be recorded in the left column only.
2. The mapper stands just south of the station flag. For most locations, setting up mapping stations at 10m intervals should allow the mapper to see all trees within the strip (e.g., from station 5 all trees between 0 to 10 should be located). It is preferable to establish stations on the south edge only. Care should be taken to avoid trampling the S-1 plot, which is located in the southernmost meter of the S-10. If a northern station must be used, be sure to record an N with the station number on the data sheet.

3. The locator moves from tree to tree within the strip, and first gives the tree number, species, and condition (live or dead) to the mapper who records the data and repeats them back to the locator to corroborate it. Species and condition number codes are listed in Table 3–1.
4. The locator then measures the DBH. DBH should be measured at the top edge of the breast height line and recorded to the nearest DBH class.
5. While the locator measures the DBH, the mapper reads the direction to the tree using a compass. The compass should be held directly over the flag and aimed at the base of the tree. The angle is recorded to the nearest half degree.
6. The distance from the station to the tree is measured with the mapper holding the zero end of the 50m tape and the locator holding the distance end at the tree. The distance is measured to the center of the tree and to the nearest tenth of a meter.
7. In subsequent years, only recruitment trees are mapped. For trees being remeasured, record all the data except direction and distance. An effort should also be made to locate dead and down trees.

Data Sheet Components

Sta—Station number where the mapper is located; if the north station must be used, be sure to record N next to the plot number.

Tree#—Number on the tag attached to the tree; record A, B, etc., for multiple-stem or crotched trees.

Spec—Number code for tree species, see TI Table 3–1.

DBH—Diameter at breast height. Record by DBH class (x) as calculated by [(x-l) + 0.5 to (x+0.49)]; e.g., 5cm is 4.5 to 5.49.

Cond—Number code for tree condition. For REG trees, use live = 0 and dead = 1.

Direct—Compass direction from station to tree (nearest half degree).

Dist—Distance from station to tree (nearest tenth of a meter).

Equipment

Tape (50 m)
DBH tape or Tree fork
Clipboard
Pencils
Compass
Flashlight
Data sheets

Evaluation

This method is similar to the method used for tree mapping and was similarly successful. The mortality rate among these trees, however, is much higher, so the turnover and ingrowth rate are more rapid and subsequently more care must be used to ensure that all trees are mapped.

To make overlaying quadrat maps of TI trees and S-10 maps of REGEN trees more accurate, it might be useful to include 4–5 TI trees per quadrat in the S-10 inventory. This essentially would allow these trees to be used as reference points when overlaying the two maps.

Date: 4 NOV 87 File name: S10MAP.INS

Figure 3–4. S-10 mapping data sheet.

HOLT RESEARCH FOREST S-10 MAPPING DATA SHEET

Date 17JUN86 Observers M-RFL L-MLW Weather Windy, cool, clear

Quadrat SI4 Page 5 of 6

Sta	Tree#	Spec	DBH	Cond	Direct	Dist	Sta	Tree#	Spec	DBH	Cond	Direct	Dist
295	1956	BF	3		339.5	4.4							
295	1957	RS	7		352.5	3.3							
295	1980	BF	3	1	349.5	5.0							
295	1958	BF	5		357	6.3							
295	1960A	WH	3		21	5.3	295	1960B	WH	3		21	5.4
							295	1960C	WH	3		21	5.3
							295	1960D	WH	2		21	5.4
295	1961	BF	2		43	3.2							
295	1962	RS	8	1	56	3.3							
295	1963	RS	4	1	86	3.7							
295	1964	BF	3	1	29	7.3							
295	1965	BF	3	1	26	6.9							
295	1966	RS	2		36	8.0							
295	1959	BF	2	1	354	6.0							
295	1967	WH	3		41	6.7							

TREE REGENERATION INVENTORY INSTRUCTIONS

Introduction

Five permanent circular regeneration plots, one 200m² (radius = 7.98m) and four 4m² (radius = 1.13m), are located in each quadrat. They are inventoried periodically to evaluate the status of regeneration from seedling to sapling size over a large portion of the study area. The 4m² plots measure seedlings and saplings <1.5cm DBH, and the 200m² plot measures saplings between 1.5 and 9.49cm DBH.

Set-up

To lay out the plots, first locate the center pin of the quadrat. This point will be the center of the 200m² plot and the 4m² plots are spaced around it (Figure 3–5).

The boundaries of the 200m² plot are not permanently marked. Trees are determined to be in or out of the plot by measuring to the base of the tree.

The 4m² plot centers are permanently marked with a small red or orange flag. They are located 4m from the quadrat center in each of the cardinal directions (N, S, E, and W). If the old flag cannot be found, the plot center must be relocated. The flags may be missing; a metal detector can help locate the wire and the flag should be replaced.

4m² Plot Procedure

The 4m² plots should be measured first to avoid trampling. Proceed in the order, north, east, south, west. The boundary of a plot is determined by rotating a height stick (1.13m is the highest orange mark) around the plot center.

1. Record date, observers, recorder, weather, and quadrat number (see Figure 3–6). Plot number (quadrat and direction, e.g., 3E1N) is recorded in the left margin under P#.
2. *Tree regeneration.* Count and record all young trees by species and height class. See Tables 3–1 and 3–2 for species and height class codes. Designated on the height stick with orange lines, the height classes are
    1. <0.1m tall;
    2. 0.1–0.49m tall;
    3. 0.5–2m tall;
    4. >2m tall and <1.5cm DBH.

   The plot should be divided between the observers, with each systematically searching half. It is best to start together at a known point and rotate the height stick around the center flag slowly scanning the ground as the stick passes over it.

Tiny seedlings are very difficult to spot, so look carefully. As seedlings are found, their species and size class are called out to the recorder, who repeats the information back to corroborate it. They are recorded by species and class with a dot and dash tally. The number is then tallied as (number of trees, decimal point, height class). For example, 12 trees in the first size class would be recorded "12.1" (See Figure 3–6.)

3. *Ground layer coverage*. This is an estimate of what portion of the ground different components cover. Ground layer cover codes are listed here and in Table 3–2.
   - 0 = dry litter
   - 1 = wet litter (litter that has been in standing water for extended periods, usually dark and compact)
   - 2 = log (>10cm diameter)
   - 3 = tree bole
   - 4 = tree root
   - 5 = moss
   - 6 = lichens
   - 7 = soil
   - 8 = bare rock
   - 9 = water
   - 10 = slash

   Make estimates to the nearest 10% for all components constituting >5% (i.e., 10%, 20%, 30%, etc.). Note that if a component = 6% it would be recorded as 10%. All three crew members should make independent estimates and then reach a consensus.
4. *Low stratum coverage*. This refers to vegetation <0.5m tall. It is estimated (see "Relevé Instructions") and recorded to the nearest 10%. First estimate the total coverage; if coverage is less than 5%, put a dash "–" in the % column next to "Total." All individual species covering >5% of the plot are then listed (use abbreviated scientific names) in the species column and their coverage estimated to the nearest 10%. If no single species has >5% coverage, list the most common species with a "–" in the % column. If no single species predominates, write "mixed" in the species column.
5. *Mid-stratum coverage*. This refers to the vegetation between 0.5 and 2m tall. Data for coverage by species are recorded per the instructions for the low stratum. All vegetation in this cylindrical volume is taken into account even if it belongs to a plant rooted outside the plot or to a tree higher than 2m.

6. *Ceptometer readings.* These are taken by the recorder while the others set up the next plot. A reading is taken in each of the four cardinal directions at a height of 1m. These four readings are averaged to a single reading for each station. See "Light Measurements with a Ceptometer" for more detail on the use of the ceptometer.

200m² Plot Procedure

The 200m² plot is inventoried after the 4m² plots are completed. All trees within a 7.98m radius of the plot center, and between 1.5 and 9.49cm DBH, are measured with a tree fork and recorded by species, condition, and DBH class. The DBH class for DBH x = [(x-1)+.5] to [x+.49].

1. Record date, observers, recorder, weather, and quadrat number (see Figure 3–7).
2. To have a consistent starting place, the observers start by the north 4m² flag and move clockwise, calling out the species, DBH class, and condition (live or dead) of each tree 1.5–9.49cm DBH. After a tree is counted, it is marked with chalk on the side toward the plot center. Dead trees are scarred twice on the side toward plot center. If a tree is near the plot boundary, a 7.98m tape or an electronic distance measuring device is used to determine if it is in or out. To be in, more than half of the base of the tree should be in the plot.
3. The recorder calls back the information to corroborate it. Species are recorded with number codes (see Table 3–1). Note condition as dead (1) or live (0); keep separate rows for each species and condition on the data sheets. The number of trees in each size class is recorded with a dot and dash tally. The number is then tallied as: # of trees, decimal point, size class, e.g., "3.2" means three trees in the second size class.
4. When the five plots (four 4m² and one 200m²) in a quadrat are finished, the data sheets are checked for completeness and stapled together.

Equipment

Tree marking chalk	Chalk holders
Tree forks (2)	Clipboard
Data sheets (200m², 4m²)	Instructions
Pencils	Fixed radius plot tape (7.98m)
Hatchets (2)	Height sticks (2)
Compass	Stapler
Ruler	Ceptometer

Evaluation

The regeneration plots, both 200m^2 and 4m^2, provide insight into the dynamics of the forest. The location of one sample site per quadrat provides a good indicator for the forest as a whole, but its limits become apparent when utilizing more detailed forest cover and soil type information. For many of the dominant types there are inadequate sample sizes to do an analysis on the differences among types. In general the variability between plots is quite high, resulting in large standard deviations and weakening any statistical analysis.

In 1992, a remeasurement of a limited set of the original 160 sites was undertaken; only sites in five major forest/drainage class types were sampled because the other types had an inadequate sample size from the 1984 inventory. In addition, sample sites were added in the larger harvest gaps.

Date: 4 NOV 87 File name: REGEN.INS

Figure 3–5. Layout of regeneration plots within a quadrat.

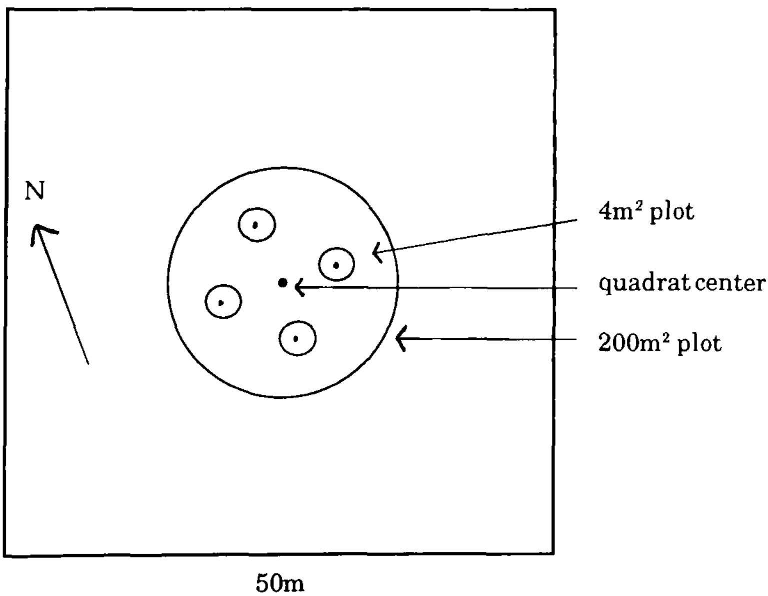


Table 3–2. Ground layer components and height class codes for $4m^2$ regeneration plots.

Ground Layer Components Codes

Ground Layer Components	Number Code
Dry Litter	0
Wet Litter	1
Log	2
Tree Bole	3
Tree Root	4
Moss	5
Lichens	6
Soil	7
Bare Rock	8
Water	9
Slash	10

Height Classes for $4m^2$ Regeneration Plot

1	<0.1m tall
2	0.1–0.499m tall
3	0.5–2m tall
4	>2m tall and <1.5cm DBH

Low Stratum—<0.5m tall
Mid-Stratum—0.5–2m tall

Figure 3–6. 4m² regeneration plots data sheet.

HOLT FOREST 4m² REGENERATION PLOTS

Date 15 JUN 84 Observers JJS DCK Recorder SMC

Quadrat 4D1 Weather clear, cool

P#	Spec	Class A	Class B	Class C	Class D	Ground Layer %	Ground Layer Components	low stratum <1m %	low stratum <1m Species	mid stratum 1–5m %	mid stratum 1–5m Species	Density >5m
N	12	3.1	5.2			100	dry litter	40	Total	10	Total	#1
	16		1.2	4.3				20	Aster macro.	10	B.cherry	97
												#2
												100
E	3		2.2	4.3				30	Total	–	Total	#1
	1	2.1						20	B.fir	–	B.fir	94
	7		3.2									
												#2
												86
S	12	7.1			1.4			–	Total	–	Total	#1
	16		1.2					–	wh.ash	–	wh.ash	95
												#2
												99
W	1			3.3		100	dry litter	–	Total	0	Total	#1
								–	Maian.	0		93
												#2
												94

Figure 3–7. 200m² regeneration plots data sheet.

HOLT FOREST 200m² REGENERATION PLOTS

Date 28JUN83 Observers CAM JKF Recorder HRA

Quadrats 7P4 Weather clear, warm

DBH Class

Spec	Cond	2	3	4	5	6	7	8	9
8	0	• 1.2	• 1.3	• 1.4					
5	0	☒• 11.2							
1	0		∴ 3.3		• 1.5			• 1.8	
13	0		• 1.3						
6	1			•• 2.4	∴ 3.5				
7	0	□ 8.2				• 1.6	•• 2.7		
6	0		∴ 3.3					• 1.8	
7	1	6.2	∷ 4.3						

TREE HEIGHT AND CROWN MEASUREMENTS INSTRUCTIONS

Introduction

Crown measurements are taken on all timber inventory or TI trees (DBH ≥9.5cm) within the S-10 strip. Measurements consist of crown radius distance in four directions, crown height, and live crown ratio. This information will be correlated with shigometer readings taken from the same trees to assess tree vigor.

Procedure

Data are recorded on polycorders. Each quadrat's data are recorded in a separate file and named "CMquadrat," e.g., CM3E1. The polycorder format file is named CROWN-FMT.

1. Take a checklist of either shigometer data or TI trees within the S-10. As each tree is measured, make a chalk mark on the tree and check off the tree number on the list. This makes it easy to identify overlooked trees.
2. *Crown radius*. The crown radius is measured in four directions. They should approximate the cardinal directions but be parallel and perpendicular to the S-10 lines. Directions can be estimated in the field.

   Stick the tack of the logger's tape into the bole on the side of the tree approximately even with the tree's center so that the crown radius measurement starts at the tree's center. Walk away from the bole in the selected direction. Measure the radius where the tape crosses under the live crown. Be sure that the tape is parallel to the ground and that the point where the crown radius is measured is directly under the edge of the crown. Repeat the same in the three other directions.

   After recording the tree number, record the radius measurements on the polycorder under the prompts NORTH RAD, EAST RAD, SOUTH RAD, and WEST RAD. Distances should be recorded to the nearest 0.1 m.
3. *Height and live crown ratio*. The live crown ratio is an estimate (expressed as a percentage) of the portion of the tree height that has live branches (see Figure 3–8a). The height and live crown ratio (LCR) are measured with a clinometer (percentage scale) and a tape measure. To take the measurements, the recorder positions him/herself at a sighting location where (1) the distance from the tree equals

or exceeds the height of the tree and (2) the tree's top, base, and live crown bottom can be seen.

a. Measure the distance from the tree to the sighting location and input on the polycorder under the prompt HT DIST.
b. Use a clinometer to measure the angle of sight to the top of the tree (TOP %), the base of the tree (BOT %), and the bottom of the live crown (LCR %). The clinometer is read on the right side of the scale (the + and percentage scale) to the nearest percentage (see Figure 3–8b). When gaps within the crown are greater than one-half the height of the main crown, they are excluded from the estimate; the heights of upper and lower portions of the crown are added together for the total figure. Any living branches are considered part of the live crown (see Figure 3–8a). A note should be made on the check list to indicate trees where epicormic branches make up a portion of the live crown.

Equipment

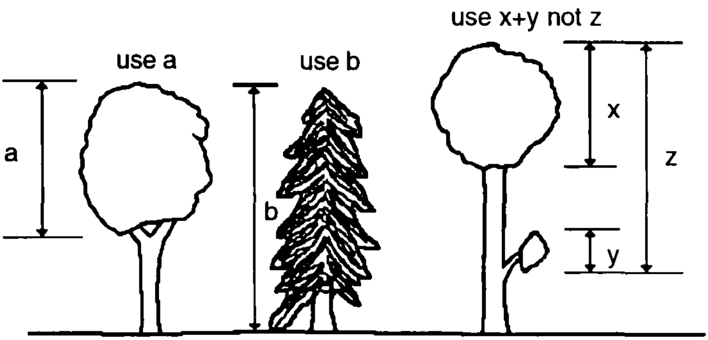
Polycorder
Pencil
Compass
Chalk holders
Clinometer
List of TI or shigometer trees in S-10 strip
Tree marking chalk
50m loggers tape

Evaluation

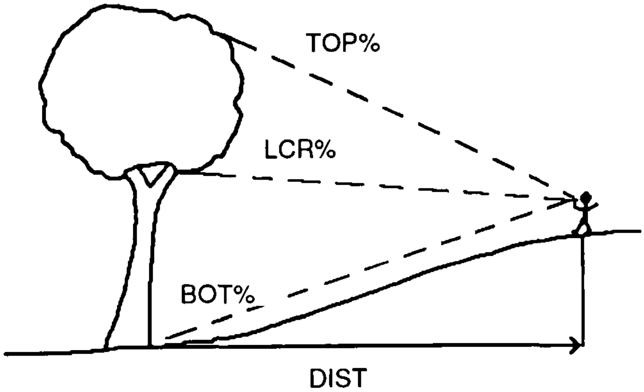
These methods adequately document the general size and shape of the tree crown. Although primarily designed for comparison with tree vigor measurements, when repeated they may also provide a look at temporal and spatial changes in tree crowns particularly in harvested areas where a response to harvesting by the remaining trees would be expected. More detailed mapping of the crowns would require that more crown radii be measured and probably at multiple heights.

Date: 18 JUL 89 File name: CROWNMAP.INS

Figure 3–8. Live crown ratio and height and live crown measurement.



a. Live crown ratio



b. Height and live crown measurement
Tree height = [(TOP%–BOT%)×DIST]÷100
Live crown ratio = [(TOP%–LCR%)×DIST]÷Tree height

COVER TYPE MAPPING DESCRIPTION

Cover type mapping was conducted in 1983 by M. L. Hunter, A. J. Kimball, and J. W. Witham. A total of 38 stands were mapped. These stands were grouped into 10 cover types based primarily on the dominant tree species in the stand and secondarily on moisture conditions. Following are the cover types and a description of the type characteristics.

Coniferous. Dominated by white pine with a strong component of red spruce with few other coniferous species.

Deciduous. Lightly stocked and dominated by red maple and red oak with a component of white pine and miscellaneous deciduous species.

Mixed Mesic. No species dominate but the primary species are white pine, red maple, red oak and red spruce. These stands are the most variable in species composition.

Mixed Xeric. On drier ledge-dominated sites; primary species are white pine and red oak. Ericaceous species and juniper (*Juniperus communis*) dominate the understory in small ledge openings.

Open Xeric. Small diameter, short stature, and widely spaced white pine and red oak with ericaceous shrubs dominating the understory.

Pine Juniper. Small diameter white pine with a strong ground component of juniper on dry ledge sites.

Hemlock. Dominated by dense stands of hemlock with little understory growth. White pine and red oak are the most important secondary species; paper birch is most common in hemlock stands.

Red Maple. A very wet site dominated by red maple. Understory species are dominated by obligatory wetland species.

Young Pine. Dense white pine stands planted 30–40 years ago with little understory but remnants of old field species.

Pine. White pine dominate with red maple as a secondary species. They tend to be tall, densely stocks stands. Many of the stands have a dense balsam fir understory.

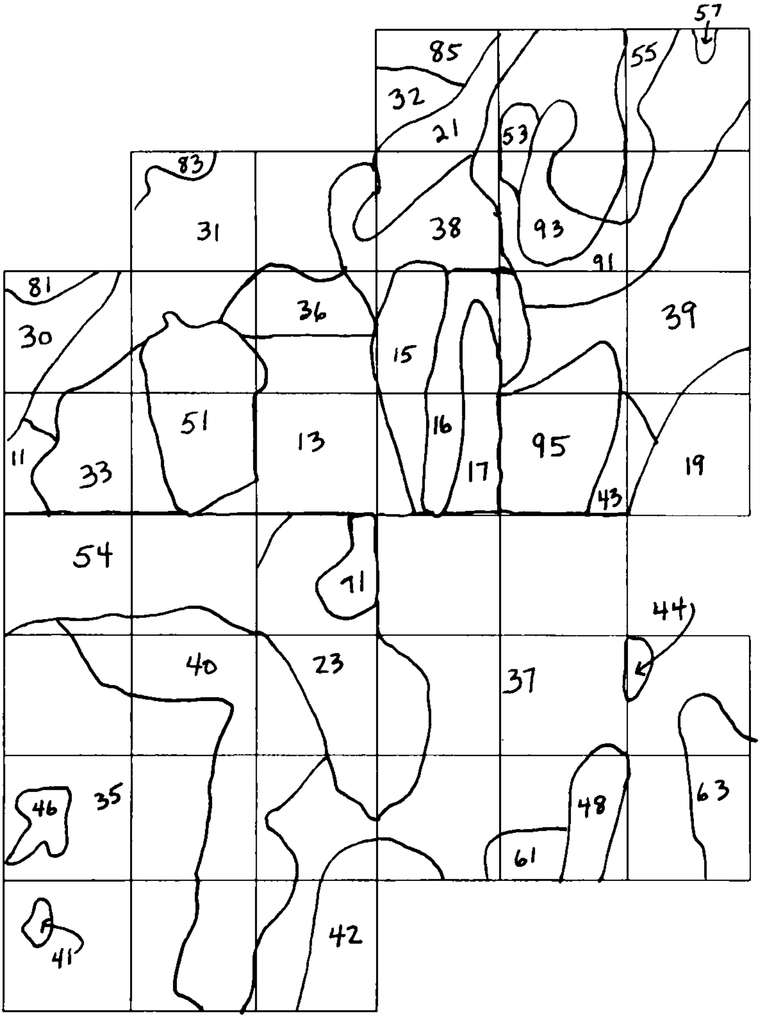
The stands as mapped are listed in Table 3–3 with stand number, cover type and a brief description. For location of stands by number refer to Figure 3–9.

Date: 13 JAN 93 File name: COVTYPE.DES

Table 3–3. Holt Research Forest cover types and stands

Cover Type	Stand #	Description as mapped
Coniferous	11	Conifer (sp. pine)
	13	Coniferous
	15	Dry coniferous
	16	Moist pine-spruce
	17	Dry pine-spruce
	19	Mesic coniferous
Deciduous	21	Deciduous
	23	Deciduous
Mixed Mesic	30	Mixed old field w/ pine
	31	MM (mesic mixed) moist
	32	Mixed
	33	MM-OF (wolf pine ledges)
	34	Mesic mixed (moist)
	35	Mesic mixed
	36	Mixed dry
	37	Mixed mesic
	38	Mixed (drier)
	39	Mixed
Mixed Xeric	40	Xeric
	41	Xeric
	42	Xeric (oak-pine)
	43	Xeric
	44	Xeric
Open	46	Open (xeric)
	48	Open (xeric)
Pine-juniper	51	Pine-juniper
	53	Pine-juniper
	55	Pine-juniper
	57	Juniper
Hemlock	61	Hemlock (mesic)
	63	Hemlock
Red maple	71	Red maple swamp
Young pine	81	Young pine
	83	Young pine
	85	Young pine
Pine	91	Dry pine
	93	Pole pine
	95	Pole pine

Figure 3–9. Cover type map.



GAP MAPPING INSTRUCTIONS

Introduction

All gaps within the study area are mapped to provide a basis for observing forest dynamics. Gaps are defined as any opening in the forest canopy $\geq 10m^2$ and with vegetation in the opening <2m in height. The major types are harvest, ledge, and tree gaps (ledge and tree gaps are together referred to as natural gaps). Harvest gaps are the result of a timber harvesting operation in 1987 and 1988. Ledge gaps are openings where shallow or nonexistent soils severely limit the development of forest. Tree gaps are openings resulting from the loss of a tree (or trees) in the canopy. Some causes of loss include windthrow or mortality from disease or insects. Harvest gaps were originally mapped in the summer of 1989, and the ledge and tree gaps were mapped in the summer of 1990.

Procedure

Mapping harvest gaps

Harvesting occurred in ten blocks in the managed area: 3E, 3G, 3J, 4D, 4F. 4G, 4I, 5E, 5G, and 5J (see "Using the Grid System"). Only harvested gaps were mapped in these blocks. This mapping was done previous to the natural gaps, and the techniques and criteria used were somewhat different. The harvest gaps were mapped with hand-held compass and tape from known points along the grid system. In all future mapping, the methods described for ledge and tree gaps will be used.

Mapping ledge and tree gaps

Natural gaps are mapped in the ten blocks in the managed area that were not harvested and the 20 blocks in the control area. A two-person crew is required, but in larger, more complex gaps, three people may speed up the process.

Each quadrat is systematically searched for gaps $>10m^2$ in area where the vegetation in the opening is <2m tall. Area is determined initially by measuring the long and short axis of the gap using the dripline of vegetation >2m tall to define the gap edge (see Figure 3–10). The following formula is used to determine the area. It assumes that gaps are elliptical in shape.

$$AREA = \pi(\tfrac{1}{2}W \times \tfrac{1}{2}L),$$

where W = width or short axis and L = length or long axis.

This initial area calculation provides the basis for determining into which size category a gap belongs. Gaps $<10m^2$ are not mapped, and as described below, gaps 10–50m^2 are mapped differently from gaps >50m^2 Table 3–4 gives examples of axis measurements and their areas to assist with this initial determination of gap size category.

Once gap size category is determined, gaps are mapped by recording azimuth and distance from a known point on the grid system to various points on the gap. Measurements are made with a hand compass and either a tape or a hand-held electronic distance measurer (EDM). Gaps 10–50m^2 in area are located to the approximate center of the gap but the edges are not mapped. Gaps >50m^2 in area are located to a control point and the edges are mapped.

Gaps 10–50m^2

Since the edges are not mapped, the area of gaps 10–50m^2 is based on the assumption that the gaps are elliptical in shape. The only measurements taken are near the gap center, the long axis and its longest perpendicular axis.

Data sheet components (see Figure 3–11)

Quad—where the majority of the gap is located.
Gap #—unique number assigned to each gap within a quadrat.
Known Pt— location on the grid system used to locate gap.
Dist—from known point to gap center.
Dir—azimuth (0–360°) from known point to gap center.
Long—distance along the longest axis.
Short—distance along the shortest axis perpendicular to the long axis.
Orient—azimuth of the longest axis.
Gap Type—origin of the gap (see Table 3–6).
Veg Ht—approximate mean height of the vegetation in the gap.
Veg Type—ocular estimation of dominant vegetation in the gap (see Table 3–5).

Gaps >50m^2

The mapping of gaps > 50m^2 is more complex. A "control point" is established inside the gap from which the other points are measured. The recorder stands at the control point while the mapper moves around the edge of the gap. The recorder measures azimuths, holds an end of the tape or the EDM target, assists with perimeter height measurements, records data, and draws a sketch map of the gap. The mapper measures distances and gives the information to the recorder.

Data sheet components (see Figure 3–12)

Quadrat, Gap#, Gap Type, Veg Ht, and Veg Type—These are all described in the data sheet components for 10–50m² gaps.

CONTROL POINTS—CP-A "control point" (A) should be established in a location inside the gap where as much as possible of the gap edge is visible. The point should be marked temporarily with a large flagged spike. In larger, more complex gaps, it may be necessary to establish more than one control point (B, C).

Known Point—Usually a junction or mid-point on a grid line.

Direction, Distance—The direction (azimuth) and distance are measured from the known point to the control point.

ORIENTATION

Degrees—The azimuth of the longest axis. Though it may be difficult to determine, the best reading should be taken, except in nearly circular gaps.

Trap stations—Any seed or small mammal trap stations within the gap should be noted.

GAP EDGE

CP Used—Control point used for measuring that gap edge point.

Direction—Azimuth from control point to gap edge point.

Distance—Distance from control point to gap edge point.

Measurements to the gap edge should be made in approximately 60° segments, for a minimum of six points. It is important to measure to locations that best define the shape of the gap (see Figure 3–10). In some small circular gaps four points may be adequate. In larger, more irregularly shaped gaps, more points will be necessary.

PERIMETER HEIGHT—The mean height of the trees that form the perimeter of the gap is determined by taking two height measurements in each of the north and south sectors.

North/South Sector—The gap is divided into two 180° north and south sectors.

Mean Min/Mean Max—In each sector, the observer uses his/her judgment to identify a mean tall tree and a mean small tree. The heights of both trees are measured using a hand clinometer and a tape or EDM.

Dist—The distance from the observer to the tree being measured.

Top%/Bot%—The clinometer %slope readings for both the top (TOP%) and bottom (BOT%) of the tree (see "Tree Height and Crown Measurement Instructions" for more details).

Height is calculated with the following formula:

Height = [Distance x (TOP% - BOT%)] ÷ 100.

Sketch Map—The sketch map should be as accurate as possible in representing the shape of the gap. A north arrow and the control and known points should be included.

Equipment

Compass (Suunto)
Tape (50m)
Spikes
Flagging
Study area map
Clipboards
Clinometer (Suunto)
Electronic distance measurer (Sonin 250, sending and target units)
Data sheets

Evaluation

This method has worked well to allow us to document the location, size, and shape of the gaps within the study area. It is a time-consuming process, however, with the initial task requiring a complete search of the entire 40ha. Then a crew must return and accurately locate and map each gap. The initial search is best done by someone very familiar with the study area.

In the field, an emphasis should be placed on making accurate sketch maps and taking enough points to map an entire gap completely. The electronic distance measurer works well in open locations, but more traditional methods are needed in heavily vegetated areas. It is important to define a gap clearly or questions, such as where is the edge of the gap, or at what distance does a canopy become closed, will arise continually.

Perimeter height is an important variable particularly on the southern edge of the gap; our method provides information that can be used for an approximate estimate of light availability. More detailed methods would be required for any in-depth look at light availability. Similarly, although our vegetation estimates give a rough picture of the vegetative response in the gaps, more detailed methods should be used to determine the response of vegetation to these forest openings.

One limitation is that these measurements represent a snapshot in time of a rapidly changing, dynamic ecosystem. Consequently, the mapping would need to be redone at regular intervals to maintain a current picture of the gaps. The assumption that small gaps have an elliptical shape limits attempts to compare gap shapes of small gaps to large gaps, but is reasonable for area estimates.

Date: 6 JAN 93 File name: GAPS.INS

Table 3–4. Gap area calculations.

Gaps 10m²			Gaps 50m²		
Axis		Area	Axis		Area
Long	Short	(m^2)	Long	Short	(m^2)
4	3	9.42	10	6	47.1
6	2	9.42	12	5	47.1
7	2	11.0	9	7	49.5
5	3	11.8	8	8	50.3
4	4	12.6	11	6	51.8

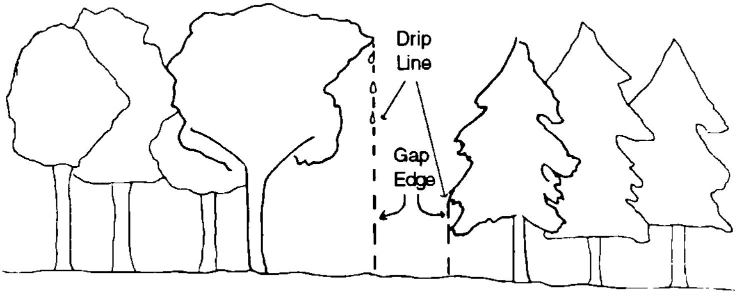
Table 3–5. Listing of gap vegetation types.

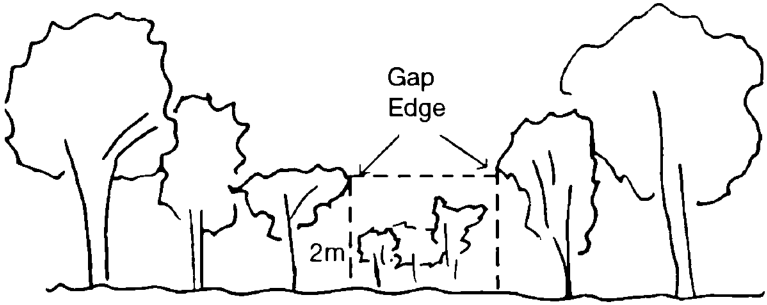
Code	Vegetation type
1	Herbaceous
2	Lichen
3	Ericaceous
4	Juniper
5	Ferns
6	Tree regeneration
7	Litter
8	Slash
9	Forbes (sedge, grass, rush)
10	Shrub
11	Moss
12	*Rubus* sp.

Table 3–6. Listing of gap types (origin).

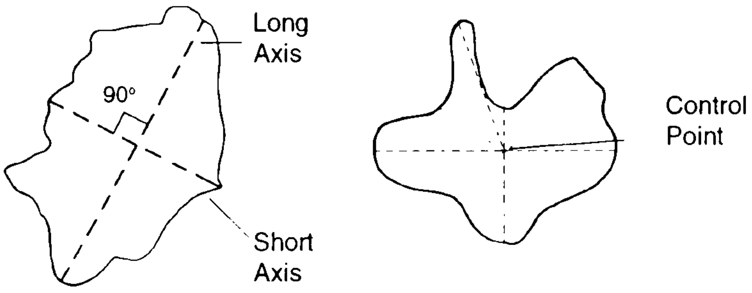
Code	Origin of gap
1	Mortality of tree (cause if known, e.g., gypsy moth defoliation)
2	Ledge
3	Wet area
4	Windthrow
5	Old down tree
6	Remnant agriculture
7	Harvest
8	Borrow pit
9	Old road

Figure 3–10. Diagram of gaps.





Defining gap edge using the dripline of adjacent vegetation ≥2m tall.



Gaps 10–50m^2 Gaps >50m^2

Measuring gaps. Gaps 10–50m^2 are measured on the long axis and then on the perpendicular short axis. Gaps >50m^2 have a control point established from where measurements are made to all gap edges to define a change in shape.

Figure 3–11. Forest gap assessment <50m² data sheet.

HOLT RESEARCH FOREST

FOREST GAP ASSESSMENT <50m²

Date 19 JUN 90 Observers SKC ALM SWG Weather Cloudy, 80°F

Quad	Gap#	Known Pt	Dist	Dir	Long	Short	Orient	Gap Type	Veg Ht	Veg Type
6E1	4	Cntr 6E1	15	2	11	2	14	2	1	4
	~~5~~									
6E2	1	6D/6E	19	138	4	3	178	1	1	1
	2	Cntr 6E	27	34	5	3	328	1	1	6
	3	Cntr 6E2	6	191	9	4	257	2	1	6
6E3	3	Cntr 6E3	14	15	9	2	213	2	1	5
6E4	4	Cntr 6E4	19	191	4	3	30	2	1	5
	9	Ctr 6E4	20	31	6	3	215	2	2	3
	7	Ctr 6E4	16	102	6	4	294	2	1	5

Figure 3–12. Forest gap assessment >50m² data sheet.

HOLT RESEARCH FOREST
FOREST GAP ASSESSMENT >50m²

Date 19 JUN 90 Observers SKC, ALM, SWG Weather cloudy, 80°F

Quadrat 6E1 Gap # 3 Gap Type 2 Veg Ht 1 Veg Type 5

CONTROL POINTS

CP	Known Point	Direction	Distance
To A from	NE 5E	177	24
To B from			
To C from			

ORIENTATION

207 Degrees

Trap Stations

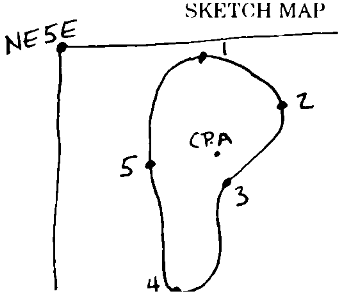
GAP EDGE

	1	2	3	4	5	6	7	8	9	10	11	12
CP Used	A	A	A	A	A							
Direction	1	63	211	212	302							
Distance	7	3	3	8	4							

PERIMETER HEIGHT

North Sector						South Sector					
Mean Min			Mean Max			Mean Min			Mean Max		
Dist	Top%	Bot%	Dist	Top%	Bot%	Dist	Top%	Bot%	Dist	Top%	Bot%
11	132	-34							16	143	7

SKETCH MAP



SMALL MAMMAL TRAP STATION TIMBER INVENTORY INSTRUCTIONS

Introduction

To relate tree-level habitat information to small mammal data, a timber inventory is done at all transect line small mammal trap stations. Since there are 24 stations on each of six lines, a total of 144 stations are measured (see "Small Mammal Trapping Instructions" Figure 4–6). The area of the plot at each station is 200m², defined by a 7.98m radius around the red plastic stake. A two-person crew completes the measurements on each plot.

The following measurements are taken:

- All TI trees (≥9.5cm DBH) are measured and recorded by species, DBH class, and condition (see Data Sheet Components below for definitions).
- All REG trees (≥1.5cm and <9.5cm) are counted by species.
- All logs ≥10cm diameter are tallied by species and decomposition class, and measured for length and average diameter.
- All stumps are measured for basal diameter.
- Vegetation coverage estimates are made.
- Light is measured using a ceptometer.

Procedure: Trees, Logs, and Stumps

1. Record date, observers, weather, and trap station number on the data sheet (Figure 3–13). Trap station number is recorded in the left margin where the new data begin.
2. Use the first row of each trap station on the data sheet to record the data for the nearest TI tree, log and stump (do not include a REG tree here). Use the second row to record the distance to that nearest tree, log, and stump. "Nearest" and "Distance" should be written on the left most column of the data sheet. If no trees, logs or stumps are present within the plot, then record "NONE"
3. Measure the other trees in the plot. The recorder holds the 7.98m-radius rope at the red stake while the observer at the other end of the rope determines the edge of the plot. All trees near the edge of the plot should be carefully checked to determine if they are in or out of the plot. To be counted in, more than half of the base of the tree should be in the plot. Starting at the outside edge, the observer proceeds around the plot in a clockwise direction. Each tree is measured at DBH, and its DBH class determined. Trees ≥9.5cm have more data collected (see Introduction and Data Sheet Com-

ponents). The information is called out to the recorder. The tree is then marked with chalk on the side towards the trap station to avoid counting it more than once.

4. The recorder calls back the information to the observer to corroborate it.
5. After all trees are measured, the observer measures all logs and stumps. (Note that the log "class" column contains both species and decomposition class data.) Those logs and stumps already recorded in the first line as "nearest" are not remeasured.

Data Sheet Components: Trees, Logs, and Stumps

STA#: Station number. To be taken from the aluminum tag attached to the red stake, e.g., 3G31.

Trees ≥9.5cm DBH: Refers to TI trees.

Spec: Tree species by code number (see Table 3–1).

DBH: Diameter at Breast Height (1.3 m), here refers to DBH class defined by rounding actual DBH to the nearest centimeter: 10cm class = DBH 9.5 to 10.49cm.

CND: Condition of the tree: live=0 dead=1.

Trees <9.5: Refers to REG trees.

Spec: Tree species code number (see Table 3–1).

: Number of individuals of that species. Use dot and dash tally and then record total number.

Logs: A log must be down and supported only by its branches or another log to be counted; no leaners or dead trees supported by other trees are counted. Evaluate only the portion of the log within the plot and >10cm diameter.

Dia: Average diameter of the log (usually at the midpoint) by centimeter class. When the midpoint does not appear average, estimate the diameter by taking measurements in several places.

Length: Total length of the log within the plot and >10cm diameter. For a forked log, add the length of both branches.

Class: Species and decomposition class separated by a decimal. Species number is the first listed, followed by the decimal point and then the class. Use the species codes from Table 3–1; when a log cannot be identified, the code = 0. Decomposition classes are based on those listed in Table 3–7.

Stumps: Dead trees <1.3m tall and with a basal diameter ≥9.5cm diameter at .25m above the ground will be considered stumps.

Basal Dia: Measure the diameter of the stump at .25m above the ground and record by centimeter class.

Equipment

Diameter tape
50m tape
Height stick
Clipboard
Pencils
Tree species codes from Table 3–1
Tree fork
7.98m rope
Chalk
Data sheets

Procedure: Vegetation Coverage Estimates

To create a more complete picture of the vegetation at each trap station, vegetation coverage estimates are made at each station where the timber inventory work was conducted. This should be completed as close to the time of the inventory as possible. Estimates are made for the entire $200m^2$ area.

On the data sheets (Figures 3–14 and 3–15), there are three coverage categories: ground coverage, (total) coverage, and evergreen coverage. A fourth category, the dominant species category, is for recording the number code of the dominant species, if there is one, in each height class. The four height classes are <0.25m, 0.25–1m, 1–5m, and >5m.

Record the trap station number in the STA# column. Percentage coverages for total coverage and evergreen categories are estimated to the nearest 10%. The coverage codes are as follows:

0 = no coverage in strata

1 = < 5% coverage

10 = 5–15% coverage

20 = 15–25% coverage and etc. by 10% classes to >95% which is 100.

See "Relevé Instructions" for estimating percentage coverage. Total coverage estimates should include all species coverage while evergreen coverage estimates are for evergreen species only. Evergreen species are any that maintain live needles or leaves throughout the year. The evergreen estimate should be a percentage of the $200m^2$ plot (*not* percentage of the total coverage percentage).

The ground coverage category should include the code for all ground components which are >5% of the area and their percentage codes. The ground components are dry or wet litter, log, tree root or bole, moss, lichens, soil, bare rock, slash, or water. See Table 3–2 for descriptions and number codes of the components.

Procedure: Light Measurements

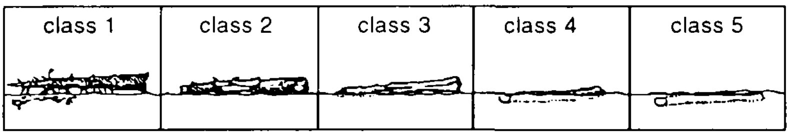
Ceptometer readings are taken at each transect trap station as close to the time of the inventory as possible. A reading should be taken in each of the four cardinal directions at a height of 1m. These four readings are averaged to a single reading for each station. Take a checklist of trap stations and record the memory number of the stored data point at each station. See "Light Measurements with a Ceptometer" for more detail on the use of the ceptometer.

Evaluation

These methods seem to work well, but we have not done enough analyses to be able to evaluate them thoroughly. The selection of these variables was based on other small mammal habitat studies. These measurements should allow us to document both temporal changes and differences between sites. Most of the physical parameters are quantitative, and changes are easily detected, but the vegetative and ground cover estimates are ocular, and subtle changes are not as detectable.

Date: 13 JAN 1988 File name: SMTI. INS

Table 3–7. Decomposition classes for logs. From: Thomas, J.W. et al. 1979. Snags. In *Wildlife habitats in managed forests: The Blue Mountains of Oregon and Washington*, ed. J.W. Thomas, pp. 60–77. USDA Forest Service Agricultural Handbook No. 553. Washington, DC.



Log Decomposition

Figure 3–13. Small mammal trap station tree inventory data sheet

HOLT RESEARCH FOREST
SMALL MAMMAL TRAP STATION TREE INVENTORY

Date 10SEP86 Observers JWW JJJ Weather Clear Cool

STA	Trees ≥9.5cm DBH						Trees<9.5		Logs			Stumps
#	Spec	DBH	CND	Spec	DBH	CND	Spec	#	Dia	Length	Class	Basal Dia
4K33	Nearest			3	12	0		—	14	4	3.3	12
	Distance			.5m				—		1.8m		6.4m
	6	11	0	6	16	1	7	9	11	3	4.4	14
	7	12	1	7	14	0	6	2				16
	7	10	0	7	11	0						
4K32	Nearest			9	32	0		—		None		None
	Distance				1.4m			—				
	7	22	0	7	21	1	1	5				
	7	29	0	5	12	0	7	3				
	1	15	0	1	14	0	5	1				
	1	26	0									
4K31	Nearest			5	22	1		—	13	7	2.2	None
	Distance				1.1m			—		2.1m		
	5	11	0	2	11	0	1	3	20	3	1.4	
	5	19	0	2	14	1	3	7				
	1	12	0	3	11	0	4	2				
	6	15	0									
4K13	Nearest			3	11	0	—			None		None
	Distance				4m							
	7	11	0	7	12	1	1	2				
	7	14	0	8	24	0	7	4				

Figure 3–14. Small mammal trap station coverage estimates data sheet.

HOLT RESEARCH FOREST
SMALL MAMMAL TRAP STATION COVERAGE ESTIMATES

Date 11 SEP 90 Observers JWW Weather fog, cool
Page 1 of 6 Line 3

STA #	GRND COV	% Coverage Height class[a] 1	2	3	4	% Evergreen Height class 1	2	3	4	Dominant Species Height class 1	2	3	4
I13	100dl	20	40	20	20	10	1	10	10	746	747	—	—
I12	80dl 20moss	20	20	20	10	10	1	10	1	756	747	—	—
I11	100dl	10	30	1	20	1	1	1	10	—	—	—	—
H33	100dl	10	10	10	30	10	1	10	20	746	95	—	—
H32	100dl	20	20	20	30	10	1	10	10	746	95	—	5
H31	100dl	10	20	10	30	1	1	1	1	—	—	—	5
H13	90dl 10moss	10	1	20	30	10	1	20	20	—	—	—	2
H12	80dl 20moss	10	1	20	30	10	1	20	20	746	—	4	—
H11	80dl 20moss	1	1	30	20	1	1	30	10	—	—	4	—
G33	90dl 10rock	1	1	10	10	1	1	10	1	—	—	4	—
G32	90dl 10slash	40	40	10	10	1	1	1	1	—	185	7	—
G31	90dl 10slash	20	20	20	30	1	1	20	10	—	—	4	—
G13	90dl 10slash	30	20	10	20	1	1	1	—	—	—	—	5
G12	90dl 10slash	10	10	10	20	1	10	10	1	—	—	4	—
G11	90dl 10slash	20	10	30	10	1	1	10	1	—	—	7	—
F33	100dl	10	10	1	30	1	10	1	30	—	3	—	2
F32	100dl	10	1	1	20	1	1	1	20	—	—	—	—
F31	100dl	10	1	10	20	1	1	1	10	—	—	—	—
F13	80dl 20moss	1	10	10	10	1	10	10	10	—	3	3	2
F12	90dl 10moss	20	10	10	20	10	10	10	20	—	3	3	—
F11	90dl 10slash	20	60	10	1	1	1	1	—	245	75	—	—
E33	80dl 20slash	10	30	20	30	1	10	10	10	—	—	—	—
E32	100dl	20	40	10	20	1	1	1	1	245	—	—	9
E31	90dl 10slash	10	30	20	10	1	1	1	1	—	12	—	14

[a] where 1 = low herbaceous (<0.25m), 2 = high herbaceous (0.25–1m), 3 = shrub (1–5m), 4 = tree (>5m).

Figure 3–15. Small mammal trap station coverage estimates data sheet, p. 2.

HOLT RESEARCH FOREST
SMALL MAMMAL TRAP STATION COVERAGE ESTIMATES

Date 11SEP90 Observers JWW Weather fog, cool
Page 2 of 6 Line 4

STA #	GRND COV	% Coverage Height class[a]				% Evergreen Height class				Dominant Species Height class			
		1	2	3	4	1	2	3	4	1	2	3	4
E31	100dl	20	40	10	10	1	1	1	10	245	–	–	–
E32	90dl 10slash	20	40	10	1	1	1	20	1	–	12	–	–
E33	90dl 10slash	10	20	10	20	1	1	1	1	–	–	–	–
F11	80dl 20moss	10	1	20	30	10	1	20	20	–	–	–	2
F12	90dl 10moss	20	10	1	1	10	1	1	1	–	3	–	–
F13	100dl	10	1	10	20	1	1	1	10	–	–	–	2
F31	100dl	10	10	1	1	10	20	10	10	–	3	3	2
F32	90dl 10slash	20	10	20	10	1	1	10	1	–	–	7	–
F33	100dl	10	10	1	30	1	10	1	30	–	3	–	–
G11	90dl 10slash	20	10	10	20	1	1	20	10	–	185	–	–
G12	100dl	10	1	10	10	1	1	1	10	–	–	4	–
G13	90dl 10slash	10	10	10	10	1	1	20	10	–	–	7	–
G31	90dl 10slash	20	20	10	30	1	1	1	–	–	–	4	–
G32	90dl 10slash	40	20	10	10	1	1	10	10	–	–	4	5
G33	90dl 10moss	1	1	10	20	1	1	10	1	–	–	–	2
H11	80dl 20moss	1	1	10	10	1	1	30	10	–	–	4	–
H12	80dl 20moss	10	1	10	10	1	10	1	10	746	–	–	–
H13	90dl 10moss	10	1	20	10	10	1	20	10	–	–	5	–
H31	100dl	10	20	10	30	1	1	10	10	746	–	–	5
H32	100dl	20	10	20	30	1	10	20	20	–	747	–	–
H33	100dl	20	10	10	20	10	1	20	20	746	95	–	–
I11	90dl 10moss	10	10	20	20	1	10	10	20	756	747	–	–
I12	100dl	10	30	10	20	10	1	10	1	–	95	–	–
I13	100dl	10	40	20	10	10	1	10	20	746	–	–	–

TREE VIGOR INSTRUCTIONS

Introduction

The shigometer is an instrument that measures cambial electrical resistance; these measurements can be equated to tree vigor. The output reading is the resistance of the electrolyte concentration in the cambium layer of the tree to a pulsed direct current given in Kohms. Readings are relative to species and time of year. The more vigorous a tree, the lower the reading will be.

All TI trees in the 10cm DBH class (9.5 to 10.49cm) and larger, and rooted within the S-10s, should be measured annually or semi-annually. Since the data are recorded on an individual tree basis, tree vigor can be related to tree crown size and location from the crown measurement data.

Using the Shigometer

The shigometer consists of a double-needled probe mounted in a plexiglass handle which is wired to the instrument. The instrument is powered by a regular 9-volt transistor radio battery and a battery check must be done regularly. Set the on/off setting switch to battery, and replace the battery before the voltage drops below 6 volts. The shigometer is fairly weatherproof and can be used in rainy weather if the device itself is shielded by the user's rain coat. A tool kit with wrench, replacement needles (minimum 10), extra batteries (9-volt), Phillips screwdriver, and a spare probe should be carried.

Calibration

Instrument calibration must be checked before each period of use and frequently during use. Both the zero and the resistance scale must be checked with the needle probe connected but *not* inserted in wood. Set the on/off setting switch to zero, and use the zero calibration dial to adjust the display until it reads exactly 000. To calibrate the resistance scale, set the on/off setting switch to calibrate, and use the calibration dial to adjust the display until it reads exactly 200. Set the switch to "high" for operation. (Older models lack the high/low option.) The display should read something in excess of 650 when the probes are out of the tree.

Measuring

The needle probe is very sharp and can result in a nasty slash or puncture wound; be careful when using and transporting this device. Insert the needles of the probe into the tree at or near breast height. Hold the probe so that one needle is inserted *above* the other and thrust in with one smooth push until the base of the needle is against the bark. On large trees it will be necessary to use bark fissures or to shave off some of the outer bark in order to reach the cambium. After the needles are inserted, watch the display and give it time to stabilize, usually about 10 seconds, before taking a reading.

Procedure

1. In order to prevent omissions, use a checklist with quadrat, tree number, DBH, species, and most recent shigometer reading. It takes two full field days for two people to complete the measurements of the permanent sample within the S-10s. Ideally these should be two consecutive days to minimize any drought/rainfall variations. All readings should be completed before 15 August.
2. Data are recorded on a hand-held electronic data recorder. The recorder should be programmed for this year's data before the data are taken. The polycorder will prompt you for the current data needs. At minimum, record the quadrat, tree number, and shigometer reading.
   a. *Tree number*. Record the tree number as it appears on the aluminum tag nailed to the base of the tree. To be included in this study, the tree must be rooted within the S-10 or have been used in a previous session. To avoid omissions, use a checklist of permanent sample trees. To avoid duplication, mark each tree prominently on the west side with railroad chalk. Be alert for multiple stem situations. Multiple stem trees are labelled in the field at or near DBH with letters A-H in white paint. Tree 237A is entered in the polycorder as 237.1, and tree 237D is recorded as tree 237.4.
   b. *Shigometer reading*. Take the shigometer reading as described above; remember to pause long enough for the display to stabilize before recording the reading. Mark the tree with chalk in the direction you're working. Use one smooth pull to remove the probes. Probes will snap probably several times a day. Try to be careful, and bring replacement probes. Avoid taking readings near wounds in the cambium. Wounds from previous shigometer readings are especially likely to be encountered in red maple.

Dry dead wood will give a reading around 600. Wet dead wood will give a reading similar to live cambium so caution must be used in determining whether the tree or cambium is dead or alive. Dying trees often have vertical streaks of both dead and live wood. Try to take readings only from live wood. Standing dead trees are recorded as 600. Dead and down trees are recorded as 999. Live down trees are measured at breast height *along* the stem. Make a note of live down trees, or if the polycorder offers an opensides category for the crown, enter 999 there.

Equipment

Shigometer
Needles
Spare 9 volt battery
Hatchet or stout knife to flake off some plates of outer bark
Checklist of permanent sample trees
Chalk and holder
Extra probe
Small wrench
Small Phillips screwdriver
Polycorder with appropriate format *or* data sheets and clipboard
Pencils for checklist and data comments

Evaluation

The shigometer has provided us with tree vigor data reflecting both the differences between trees and the year-to-year variation of individual trees. The readings are efficient to take; 750± trees can be measured in fewer than 2 days by a two-person crew. If DBH measurements are taken also, a three-person crew would be needed to measure all trees in 2 days.

Date: 8 AUG 90 File name: SHIGO.INS

LITTER AND SEED PRODUCTION STUDIES

The techniques used at the Holt Research Forest to study forest productivity have changed over time. Initially we collected litter in 40 large seed traps throughout the forest in order to make estimates of forest biomass and seed production. For reasons discussed in the Evaluation, we have focused on seed production and eliminated biomass collection and have changed our techniques for seed collection to using smaller but more numerous traps throughout the forest.

Because the techniques that we no longer use may be useful in understanding why we changed methods and also may be of value at other research stations, we have included them here.

Following the Evaluation are four sets of instructions. Our current methods are detailed in "Instructions for Building Seed Traps" and "Seed Collection," while "Instructions for Litter Trap Construction" and "Litter and Seed Production" describe the methods we no longer use.

Evaluation

These methods have undergone considerable change; litter collection and weight measurement has been dropped; the number of traps has increased and the location of the traps has changed. The original 40 litter traps (sample area=0.5m^2 each) have been replaced by 264 seed traps (sample area=0.042m^2). Although the total area sampled is less, sampling occurs at a greater number of locations and provides data that are more directly tied to both small mammals and S-1s. Overall, this method of collection works best for those species that are wind dispersed. For species with heavy seeds (e.g., *Quercus* spp.), the number of seeds found is too dependent on the proximity of a tree to the trap.

Litter sorting was dropped because measurement of litter fall alone does not provide an accurate biomass production estimate. Secondly, the process of sorting litter into its many components was a formidable task and it was difficult to find the labor to do the work. The current methods work better because samples only need to be collected once per year, collecting the entire bag speeds up the collection process, and smaller samples are easier to sort. Maintenance of the traps and stations is also easier; bags seem to last longer because their exposure time is reduced and there are no wooden posts to deteriorate.

INSTRUCTIONS FOR BUILDING SEED TRAPS

Each seed trap is constructed from the materials listed at the end of these instructions. The basic components of the finished trap are the seed bags and the wire frame. Construction involves three activities: making the seed bags, making the wire frame, and setting up the components in the field.

The Seed Bags

The easiest method for cutting the netting is to hang the roll from a support, or the ceiling, and position a cutting board close by. Pull the netting across the board, and with the razor knife, cut off a 70cm length. Because the rolls come in a fixed width of 139cm, this width should be cut in half to yield two pieces approximately 70x70cm in size. Take each piece, fold in half and sew the edges up on one end and along the side, creating an L-shaped seam. This will form a rectangular bag. To increase the strength of the bag, sew the ends twice.

The Wire Frame

Each trap is made from a strip of the tomato cage wire five feet tall. Unwind the roll to a length of 10 mesh boxes (5 ft). On the tenth box, use the wire cutters to cut the wire from the top of the roll to the bottom. Make the cuts on the inside of the last vertical wire. This cut will yield a strip of wire where one end will have a column of complete boxes and the other end will be open wires. Roll this strip up twice, starting with the boxed end. This will form a double thickness wire tube with the boxed end in the center and the open wires on the outside. Bend the wire strips around the leading edge of the inner, boxed end. Some wire cutters can be used to bend the wire strips; otherwise use pliers. Shape the opening of one end of the roll with the cardboard circle (23cm diameter) and tie a piece of plastic flagging on it.

The final piece of indoor work is to cut the gasline hose. First split the hose, or segments of hose, down one side with a small knife. Next cut the hose into 1/2" segments. This can be done easily with some wire cutters.

Set-up

It is best to complete the traps in the field because it is easier to carry the wire rolls than the actual traps. Materials needed are the wire rolls, seed bags, gasline hose segments, binder clips, aluminum tree tags, nails, nylon string, and wire cutters (maybe pliers).

To form the base of the trap, hold the end of the roll that does not have the plastic flagging and make a cut in the middle of each mesh box. Make similar cuts on the next two layers up. These cuts will form trap supports. Fold these supports up from the uncut layer and splay them out at a 90 degree angle from the trap frame. (For steeply sloping areas, cut up three layers on one half of the roll and only one or two layers on the other half. Then when in place, put the side with the three cut layers on the uphill side of the trap.) Stand the trap, with the flagged end up and the base end on the ground. Bend the supports so that (a) they lie flat on the ground, (b) the uncut layer is as close to the ground as possible, and (c) the top of the trap is level.

Remove the flagging from the roll. Put the seed bag in the trap so the bottom of the bag is about one to two feet from the ground. Fold the opening of the bag over the sides of the frame. Attach five of the 1/2" gasline hose segments over the bag onto the opening of the frame. Try to place these segments over the upright supports of the frame. Place a binder clip over each hose segment. If the trap has a label, write it on the aluminum tree tag and attach the tag to the frame. To anchor the trap, place some rocks or branches across the supports. If there is nothing usable nearby, use the nails. Because the wire was rolled up twice, put a nail between the two wires in the bottom layer and push it into the ground. In areas with shallow soils it will be necessary to push the nail in at an angle. Use as many nails as needed to secure the trap. In sloping areas it may be necessary to tie the trap to a stationary object with the nylon string, or put a couple of nails in the ground and tie the trap to them. When the trap is secure, check to see if the ends of the wire strips, which were used to form the roll, are pointing in towards the net. If they are, bend them away; otherwise the ends may poke a hole in the bag. Also, make sure the top of the trap is level.

Materials

1. Wire rolls used to make tomato cages. The wire mesh is six inches long by four inches high.
2. Automobile gasline hose, 1/4" dia. Five, 1/2"-long sections of hose are used per trap.
3. Binder clips, 5/8" size. Five clips are used per trap.
4. UV-resistant "no-see-um" nylon netting. A piece of netting, about 70x70cm in size is used per trap.
5. 50D common nails. The nails are used to anchor the traps in the field. Two to five nails are needed per trap.

6. Synthetic sewing thread. Cotton thread is unacceptable as it will degrade in the field.
7. Miscellaneous supplies and tools. These include plastic flagging, a cardboard circle 23cm in diameter, nylon string, aluminum tree tags (the kind that can be embossed with a pen or pencil), a razor knife, a cutting board, a small sharp pocket knife, a sewing machine, wire cutters and pliers.

Date: 12 OCT 88 File name: SEED.INS

SEED COLLECTION

Introduction

Seed traps are located along the S-1s at 10m intervals just south of the red-flagged stations, and along the small mammal trapping transect lines 2m from the trap stations in a randomly selected direction (north, south, east or west). The information obtained by collecting, sorting and counting seeds at these locations is used to assess the effect of annual seedfall on small mammal populations and to correlate with seedling numbers on S-1 plots.

Procedure

Seed collection

1. Set up the seed traps as described in "Instructions for Building Seed Traps." Set bags into the traps in late May, before the red maple seedfall.
2. Bags are left for a year and are collected at the same time the following spring.
3. Before collecting bags, print out a set of labels with the station location and date on them. Print one set for S-1 stations specifying north or south line, and one set for the small mammal transect lines.
4. Take the labels, a set of empty net bags, and a half dozen plastic grocery or similar bags into the field. Also, bring some small paper bags, a marker, and a stapler in case there are not enough replacement net bags as a result of rips.
5. At each station, put the correct label in the sample net bag, remove the bag and knot it. If there are any sticks that might puncture the bag, remove them, making sure there are no seeds attached. If a bag is ripped, put the contents into a small paper bag, label it, and staple it closed. Bring in the ripped bag for repair.
6. Put an empty replacement bag into the trap. Check to make sure it has no holes. Secure it with the binder clips. Gloves may help protect your hand from abrasion that can come from squeezing these clips repeatedly.
7. When the pack basket is full of knotted sample bags, put them in a plastic grocery bag and drop it off along a path to pick up later. Be careful throughout that no net bags fall out of the pack basket.
8. When all the net bags have been collected, put them into brown paper grocery bags, label with "S-1" or "SM," the date, collector's initials, and number the bags "Bag 1 of 5" to account for all bags. Staple the grocery bags shut.

Sample sorting

1. Record the sample collection date, the sorting date, and the initials of the sorter on the data sheet (see Figure 3–16).
2. Empty the net bag sample into a white enamel pan and remove the larger material. Deciduous leaves, pine needles, twigs and branches are most easily sorted out. Be sure that no seeds are stuck between or to any of the material removed. This material may be discarded.
3. Once the larger material is removed, the seeds will become more visible. The remaining material is usually a mixture of spruce or hemlock needles, bracts, lichens, insects, seeds, and other miscellaneous items.
4. Smooth out this heterogeneous mixture and search it systematically, rapidly, and accurately. Use forceps or another instrument to help move material or remove seeds. The objective is to count *all* tree seeds in the sample.
5. Identify seeds by species (seed books are available to help with identification) and then either remove them for counting or count them within the sample. If seeds are removed, they should be placed in a petri dish. When there are seeds of many species, they should be placed in separate petri dishes to facilitate counting. If the seeds are not removed, maintain a clear line between counted and uncounted seeds. Generally, seeds should be counted in the pan only when large numbers of one species are present. If a fruit has multiple seeds (e.g., a pine cone) tear it apart and count the individual seeds.
6. After seeds are counted, record the final tally on the data sheet under the correct seed trap location (STA). There are two columns for these data, one for the species (SP) and one for the total number of seeds (#SDS). If no seeds are found, then record "NO SEEDS" next to the station name.
7. Subsamples. It is appropriate to take a subsample if, after the larger material is removed, the remaining mix of coniferous needles, seeds, and miscellaneous materials would require significantly more than one half hour to sort and count.
   a. Remove as much non-seed material as can be done efficiently. Use a balance to divide the remaining sample in half. This is then a subsample factor of 1/2. Divide one of the halves equally (a 1/4 subsample factor) and continue this process until the sample is small enough to count the seeds efficiently. Usually a subsample factor of 1/4 or 1/8 is adequate.

b. Then count the number of seeds in the subsample. On the data sheet, write "yes" in the subsample column (SUB). The number of seeds counted before a subsample was taken should be recorded in the upper part of the data sheet. Those counted as part of the subsample should be recorded below in the section marked "SUBSAMPLE DATA"
c. Record the sample station (STA), the subsample factor, and, in the appropriate columns, the species and number of seeds.
d. To determine the number of seeds estimated to be in the entire sample, multiply the denominator of the subsample factor (e.g., 4 or 8) by the number of seeds in the subsample. Record this in the "EST#" column.

8. Discard the seeds when sorting and counting is completed.

Equipment

Collecting
- Set of empty net bags
- Labels
- Plastic grocery bags
- Small paper bags
- Marker
- Stapler
- Pack basket
- Gloves

Sorting
- Data sheets
- White enamel pan
- Petri dishes
- Forceps
- Balance

Date: 12 OCT 88 File name: SEEDCOLL.INS

Figure 3–16. Seed sorting data sheets.

HOLT RESEARCH FOREST
S-1 STATION SEED COLLECTION DATA SHEET

Date of Collection MAY 91 Page 1 of 3

STA	Sp	#Sds	Sp	#Sds	Sp	#Sds	Sp	#Sds	Sp	#Sds	Sp	#Sds	Sp	#Sds	Sub	Sortr
N1	7	3	8	1												RAL
N11	9	1	7	9												RAL
N21	7	2	9	1												RAL
N31	8	2	9	7												RRM
N41	9	5	7	2												RRM
N51	7	3														RAL
N61	9	10	7	1												RAL
N71	1	1	7	7	5	3										RMM
N81	5	3	8	1												RMM
N91	5	4	8	1												RRM
N101	1	1	8	1												RAL
N111	1	1	7	1												RAL
N121	7	1	8	2												RRM
N131	NO	SEE	DS													RRM
N141	NO	SEE	DS													RAL
N151	1	2	8	2	9	1										RMM
N161	NO	SEE	DS													RAL
N171	1	22														RAL
N181	2	1														RMM
N191	1	1														RRM
N201	1	54	9	19												RRM
N211																RAL
N221	9	1														RAL
N231	7	1	20	1												RMM
N241	10	1														RRM
N251	7	2														RAL
N261	7	4	9	1	10	2										RAL
N271	7	2														RMM
N281	NO	SEE	DS													RMM
N291	1	1														RRM
N301	1	1	8	1	10	1										RAL
N311																RAL
N321	1	81														RRM
N331	NO	SEE	DS													RMM
N341	9	1														RAL
N351	NO	SEE	DS													RAL
N361	9	2	8	1												RAL
N371	1	1	9	1												RRM
N381	3	1														RRM
N391	9	9	7	3												RMM
N401	7	2	10	2												RMM
N411	1	1	9	3												RAL
N421	1	1	9	2												RMM
N431	1	3	7	1												RMM
N441	1	1														RAL
N451	7	1														RAL

SUBSAMPLE DATA

Sta	Subsample Factor	Sp	#Sds	Est#	Sp	#Sds	Est#	Sp	#Sds	Est#	Sp	#Sds	Est#
N211	1/4	1	8	32	9	16	64	10	2	8			
N311	1/4	1	4	16	9	23	92	7	2	8			

INSTRUCTIONS FOR LITTER TRAP CONSTRUCTION

Each litter trap is constructed from the materials listed in Table 3–8. In addition, a sewing machine, iron, scissors, and straight pins are needed. The basic components of the finished trap are the net cone, a border, a support rod, and posts.

Net

The net section is cut from a large roll of netting. A pattern, which is a 126° section of a 114cm-radius circle made from 0.32 hardboard, is used to define the edge of cutting. Alignment of the pattern on the netting should minimize waste. Figure 3–17 shows the pattern with corners labeled.

The piece of netting, once cut, is folded in half by bringing corners A and C together. Edges AB and BC are together and are sewn parallel to, and 1.5cm from, the edge. This will form a cone-shaped piece of netting, the basic shape of the trap.

Border

The border is a 13x260cm piece of ripstop nylon. The edges of this piece are hemmed by folding under 1.5cm on each side (Figure 3–18). Using an iron makes this fold stay in place for sewing. The folds are sewn to make the border 10cm wide. This border piece is then folded and ironed lengthwise down the middle.

Sewing Net to Border

The border is fitted over the top edge (length AC) of the net and pinned in place. The net should be within the fold of the border and in the fold as far as possible (Figure 3–18). One end of the border should be turned under 4–5cm, to create an overlap (Figure 3–18). This end will then be pinned to the netting, and the border can then be pinned all the way around. The extra length at the other end will also be turned under, leaving a small gap where the two ends of the border met along the net. This is where the support rod will be slipped into the net. The border is then sewn to the netting by stitching all the way around 1.4cm above the bottom of the border (Figure 3–18). The assembled net should now resemble Figure 3–19.

Support Rods

The support rods are cut from a 3.66m (12-foot) length of 0.635cm-diameter (0.25-inch) aluminum rod. The pieces are cut 254cm long and curved using a metal rolling machine until the ends meet to form a circle. The curved rod is then slipped into the border section of the net. The ends of the rod must meet at the gap formed at the ends of the border. A 3.8cm piece of gas line hose (0.25 inch inside diameter) is slipped over the rod ends; a hose clamp is put on each side of the hose and tightened to secure the support rod in place (see Figure 3–20).

Wooden Posts

The posts used for the initial setup were 3.8x3.8x165–175cm (1.5x1.5x65–70 inch) and made from ash. They were pointed on the bottom using a circular saw, and then the bottoms were coated with creosote.

Set-up

The litter trap assembly is supported by three posts and placed 1.5m above the ground. The top of the trap should be level to ensure that the full diameter of the trap is collecting litter. The posts are pounded into the ground using a sledge hammer. They should be equally distributed around the circumference of the litter trap. Laying the trap on the ground assists with the layout of the posts. The posts should be plumb or leaning into the trap slightly. Some sites will have such shallow soil that it won't be possible to pound the posts in. At these sites, posts may need to be cut and should be supported by rocks around the base and with strapping screwed from post to post. When all three posts are in place, the litter trap is placed on top of the posts and attached by hammering a staple around the support rod through the border material (Figure 3–21). Two staples are used per post.

Date: 4 JAN 1988 File name: LTRAPCON.INS

Table 3–8. Litter trap materials list.

Netting—126° section of a 114cm radius circle; the "no-see-um" netting should be UV resistant
Ripstop Nylon—13x260cm
Aluminum rod—0.635cm diameter, 254cm long
Wooden posts
Staples
Gas line hose
Hose clamps
Thread for sewing

Figure 3–17. Layout of netting for litter trap.

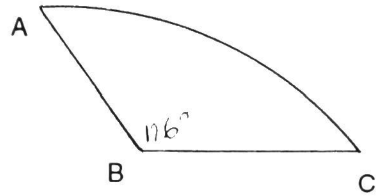


Figure 3–18. Border of litter trap assembly.

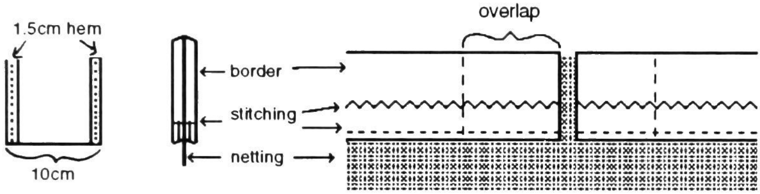


Figure 3–19. Assembled net.

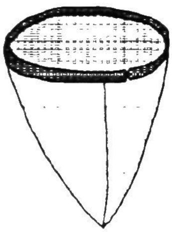


Figure 3–20. Support rod coupling device.

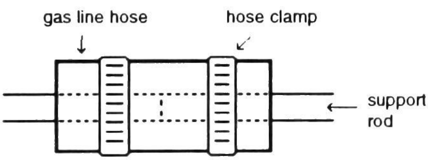
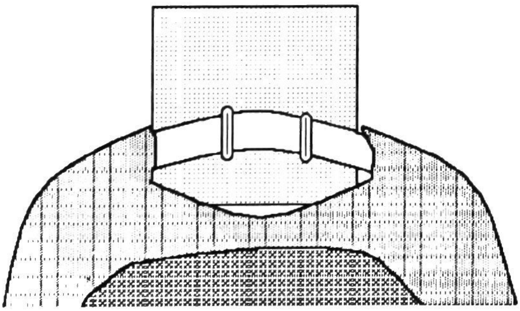


Figure 3–21. Attachment of support rod to wooden post (from above).



LITTER AND SEED PRODUCTION

Introduction

Forty litter traps (one per block) are located within the study area to collect litter fall. Each litter trap was randomly located (see Table 3–9 for locations). Collections from the traps are made at two-week intervals during the heaviest leaf-fall period (September-November), at one month intervals during the rest of the year, and as snow will allow in winter. One person can easily empty all the traps within a four-hour period. The samples are then sorted, dried, and weighed; the results are used in estimates of forest productivity.

Procedure

Sample collection

Collections should be made only on days when the samples are fairly dry; wet samples could begin to rot before they are sorted and dried.

1. Before beginning, label 40 lunch-size paper bags with block and date using a felt-tip marker.
2. Start collecting at 3J, proceed north to 3E, then to 4D, and south to 4J. This north-south progression continues to 8I. In this manner, if the pack basket becomes full, samples can be put in a large bag and left along the south road to be picked up on the way out.
3. Large accumulations of leaves need to be placed into the bag before inverting the bottom of the litter trap. Large twigs or branches may need to be broken to fit into the sample bag. All of these operations take place within the confines of the trap to prevent any loss of material.
4. Transfer the contents of the trap into the bag by stuffing the lower end of the litter trap into the sample bags and then turning the litter trap inside out within the bag as the litter trap is pulled out. The rock that is used to weigh down the litter trap is then returned to the litter trap.
5. Once the trap is emptied, fold and staple shut the top of the bag. Make sure there are no tears in the bags. A torn or leaking bag should be replaced immediately and properly labeled.

Sample sorting

Samples should be sorted as soon as possible after collecting to prevent them from becoming too dry and brittle. The following procedure should be followed.

1. Empty the sample into a white enamel pan and sort out all leaves and twigs from deciduous trees and shrubs, placing them in a second pan. Tweezers work well for small items.
2. Sort through the remaining mostly coniferous material and remove (a) all seeds and fruits and (b) miscellaneous material, e.g., lichens, fungi, and insects to another pan.
3. Record the one or two dominant coniferous or deciduous tree species on the data sheet (see Figure 3–22) in the Dom. Spec. column with the appropriate species code (see Table 3–1). Write "mixed" if there is no clear dominant species. If no deciduous or coniferous materials are found, draw a line through the appropriate columns under Total and Bag. If a trace amount of deciduous or coniferous material is found, write the species abbreviation and "trace" in the Dom. Spec. column.
4. (a) Return the deciduous leaves and twigs to the original bag and place coniferous leaves and twigs in a new bag; (b) fold and staple the tops of the bags; and (c) label the bags with the block number, collection date, and "C" or "D" for coniferous or deciduous. Note anything unusual in the collection such as a branch.
5. If there are seeds or miscellaneous materials in the sample, or if it is so large that a subsample has to be taken, put a check mark in the appropriate column on page 1 of the data sheet.
6. It is appropriate to take a subsample if, after the deciduous leaves are removed, the remaining mix of coniferous needles, seeds, and miscellaneous materials would require significantly more than half an hour to sort. Stir the material into a homogeneous mixture in the tray, then remove an appropriate portion, usually 1/4 to 1/8. This is determined using a balance, by equally dividing the sample the appropriate number of times. Bag the remaining material and label it with the block number, date, and the words RESIDUAL SUBSAMPLE. After you have sorted the subsample, bag each component and label it with the date, block number, and word SUBSAMPLE.
7. Seeds should be sorted by species, counted, and the number (N) and species identification code (SP) should be recorded on page 2 of the data sheet (Figure 3–23). If a fruit has multiple seeds, e.g., a pine cone, tear it apart and count the individual seeds. Place the extra material in the deciduous

or coniferous bag as appropriate. Be sure to enclose a label with block number, collection date, and contents.

8. If there is enough miscellaneous material to weigh, put it into a whirlpack or plastic bag and enclose a label with block number and collection date; otherwise write "trace." Record the identity of the material (e.g., lichens) in the ID column.

Sample weighing

After sorting, the samples are dried to constant weight (approximately 48 hours) using a drying oven, then weighed on a balance to the nearest 0.01 g.

To begin the procedure, mark two plastic tare bags "C" and "D" for coniferous and deciduous. Record the weights of these bags on the data form in the bag column. The contents of the paper bags are placed in the appropriate tare bag, and the weights are recorded in the total column by block number. After weighing, the contents are discarded. Miscellaneous items are weighed in their whirlpack bag, the contents are discarded, and the bag weighed. Seeds that need to be weighed are handled in the same manner, but they must be sorted by species.

All components of a subsample must be weighed including the residual. The weights then can be summed by component.

Equipment

Collecting
- Pack basket
- Plastic garbage bag
- Paper (grocery size) bags
- Labeled bags (lunch size) plus extras
- Stapler with extra staples

Weighing
- Plastic bags
- Data form

Sorting
- Two large enamel pans
- Four small dishes for seed and miscellaneous
- Whirlpack bags
- Data form

Date: 1 DEC 87

File name: LITTER.INS

Table 3–9. Litter trap locations.

Block #	Direction*	Distance*	Block#	Direction*	Distance*
3E	138	3	6C	63	8
3F	161	10	6D	325	14
3G	229	14	6E	11	18
3H	275	11	6F	27	20
3I	153	3	6G	283	7
3J	320	6	6H	177	1
4D	205	18	6I	84	20
4E	16	2	7C	314	5
4F	167	7	7D	75	14
4G	94	20	7E	250	17
4H	52	17	7F	346	14
4I	162	14	7G	20	16
4J	266	7	7H	108	6
5D	39	6	7I	298	18
5E	153	11	8C	81	15
5F	251	15	8D	20	15
5G	2	9	8E	52	19
5H	286	5	8F	179	19
5I	177	9	8H	309	19
5J	160	15	8I	280	7

*Direction (degrees) and distance (m) from block center.

Figure 3–22. Litter samples data sheet, p.1 weights.

HOLT FOREST LITTER SAMPLES

Page 1

Sample date 3 JUN 85 Weigher Selena Tardiff Weighing date 1 FEB88 12 JAN88

Block	Coniferous			Deciduous			Samples		
	Total wt	Bag wt	Dom. Spec	Total wt	Bag wt	Dom. Spec	Seed	Misc	Sub
3E	4.06	3.54	WP	6.88	3.59	MIXED		✓	
3F	4.21	3.59	WP	6.93	3.59	WH			
3G	4.50	3.54	HEM	9.29	3.53	MIXED			
3H	4.04	3.58	WP	4.42	3.59	RO			✓
3I	5.28	3.53	WP	4.44	3.53	RM			
3J	4.42	3.53	WP	6.23	3.52	RM			
4D	8.07	3.53	HEM	4.47	3.53	RB	✓		
4E	4.54	3.54	WP	5.42	3.51	RO			
4F	5.52	3.59	WP	—	—	TRACE			
4G	4.10	3.59	WP	7.90	3.59	MIXED			
4H	4.30	3.53	WP	5.82	3.51	MIXED			
4I	3.71	3.53	WP	6.97	3.53	RO			
4J	11.09	3.53	WP	5.41	3.53	MIXED			
5D	4.48	3.59	WP	6.99	3.59	MIXED			
5E	4.15	3.59	WP	7.19	3.59	MIXED			
5F	4.80	3.59	WP	5.44	3.59	RM		✓	
5G	3.83	3.59	MIXED	8.43	3.59	RM			
5H	—	—	TRACE	6.70	3.53	RM			
5I	3.75	3.53	WP	8.70	3.59	RM		✓	✓
5J	4.15	3.59	WP	3.71	3.53	WB			
6C	5.42	3.53	WP	5.16	3.59	MIXED			
6D	—	—	TRACE	7.23	3.53	MIXED			
6E	7.63	3.53	MIXED	5.57	3.53	MIXED	✓	✓	
6F	18.16	3.59	MIXED	3.92	3.59	MIXED	✓	✓	
6G	3.69	3.59	WP	7.43	3.59	MIXED		✓	
6H	3.83	3.59	WP	9.76	3.59	RM			
6I	3.95	3.59	WP	7.09	3.59	MIXED			
7C	3.89	3.53	WP	6.35	3.53	WH			
7D	5.58	3.53	WP	6.81	3.53	RM			
7E	5.75	3.53	WP	6.39	3.53	MIXED			
7F	7.30	3.53	WP	5.93	3.53	RM			
7G	3.99	3.59	MIXED	14.60	3.53	MIXED		✓	
7H	5.27	3.53	MIXED	5.27	3.53	RM			✓
7I	3.82	3.53	WP	8.13	3.53	RM	✓		

SUBSAMPLES

Block	Residuals		Coniferous		Deciduous		Subsample Factor
	Tot. wt.	Bag wt.	Tot. wt.	Bag wt.	Tot. wt.	Bag wt.	
3H	5.40	2.89	3.15	2.90	3.26	2.88	1/4
5H	5.90	2.87	3.08	2.90	3.62	2.86	1/4
7H	10.55	2.84	3.56	2.85	3.20	2.84	1/8
4F					3.74	2.90	

Figure 3–23. Litter samples data sheet, p.2. seed and misc. counts.

HOLT FOREST LITTER SAMPLES

Page 2

Sample date 4SEP88 Sorter ______________ Sorting date ________________

Block	Seeds SP	N	SP	N	SP	N	SP	N	SP	N	SP	N	Miscellaneous Total	Bag	ID	
3E	WB	22	GB	3											insects lichen	frass
3F	RO	4	WB	1											insects	lichen frass
3G	WB	1	HM	1											insects	
3H															lichen	
3I															insects & frass	lichen
3J	RO	1													insects frass	
4D															insects lichen	
4E															galls lichen insect	
4F	WB	101	GB	5											lichen insect	
4G	RO	1	WB	2											lichen insects	frass
4H															lichen	
4I	RO	1	WB	1											lichen insects	frass
4J															insects frass	
5D	WB	1													lichen	frass
5E	WB	1													lichen insects	frass
5F	WB	4													"	
5G	RM	1	WB	15											lichen insect	
5H															lichen frass	
5I															insects lichen	
5J	GB	1													lichen	
6C	WB	1													insects	lichen frass
6D															lichen	
6E	WB	3													lichen	
6F															insects	
6G	WB	5													insects	frass
6H	RO	6													lichen insects	frass
6I	WB	2													insects	
7C															insects	frass
7D	WB	1													lichen insects	frass
7E															frass insects	
7F															lichen insects	frass
7G	WB	152	GB	1											lichen	
7H															lichen insects	frass
7I	SUBSAMPLE				WB	86	1	multiplied		by factor			= 344		lichen insects	

SUBSAMPLE DATA

Sta	Subsample Factor	Sp	#Sds	Est#	Sp	#Sds	Est#	Sp	#Sds	Est#	Sp	#Sds	Est#

RELEVÉ INSTRUCTIONS

Introduction

The vegetation of each quadrat is measured using the relevé method during July and August of selected years. The purpose is to detect changes in species and abundance, and give a complete picture of the study area vegetation in each strata.

The pattern of measurement follows the one established for the timber inventory. To incorporate seasonal changes in the flora, the four quadrats of a block are measured at different times throughout the period. Quadrat 1 is measured on the first round, quadrat 2 on the second, quadrat 3 on the third, and quadrat 4 on the fourth. The crew consists of four people, one observer for each 25x25m subquadrat.

Procedures

1. Locate the quadrat center to define the subquadrats. Record location (quadrat and subquadrat, e.g., 3E1-2), date, observer, subquad physiography, and weather. Each observer should do the same subquadrat number throughout the season.
2. Each observer walks the boundary between subquadrats with the adjacent observer and decides which plants belong in which subquadrats. North-south lines are walked first, then east-west.
3. First, list the plant species using the following method. Search the lowest three strata of plants using the white lines on a height stick to delineate height classes (<25cm tall, .25–1m, and 1–5m). Make a small tick mark in the appropriate cell of the data sheet to indicate a species has been found. Count and record the number of any "rare" plants, i.e., fewer than 5 specimens. Walk back and forth across the subquadrat in parallel lines, searching systematically for at least 50 minutes. Use a timer to assure this. In wet areas and disturbed sites, many species occur that are not on the data form; supplemental forms listing species for these types of sites are available. Collect small sections of hard to identify or uncommon plants to confirm identification. A Holt plant list with identification characteristics is available under filename: PLANT-ID.LST.
4. Once the species list is complete, assess the abundance of each species in the three lowest strata using the following coverage codes.

0—None present.
1 (Rare)—Less than or equal to 5 individuals; record number.
3 (Occasional)—Numerous individuals but not common. You have to look around to find it.
4 (Common)—Occurs more or less everywhere you look, but has a coverage of less than 5%.

Very abundant species (>5%) are rated by their coverage:

5—5–25%
6—25–30%
7—50–75%
8—75–100%

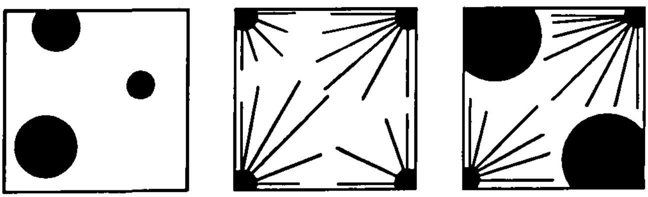
Record by code numbers, not descriptors.

5. Search and record species for the 5–10m and >10m strata using steps 3 and 4. For tree species in the 5–10m and >10m strata, assess abundance by the total coverage of each species rather than by the number of individuals. The coverage classes and their codes for the upper two strata are

   3—<1%
   4—1–5%
   5—5–25%
   6—25–50%
   7—50–75%
   8—75–100%

   Note that the computer code skips classes 1 and 2; this is to make this scale comparable to the species scale used for the lowest three strata. Coverage refers to that portion of the ground that a species would cover if projected into a horizontal plane. The spaces among the leaves of a plant are not considered covered (Figure 3–24).

Figure 3–24. An example of coverage estimates.



20% 20% 50%

The observer makes these assessments assuming the subquadrat to be 100%. The recorder uses an approximate mean of the four subquadrats to assign the species to an abundance class for the whole quadrat. Table 3–10 is useful because it relates percentage coverage with actual area at both the quadrat and subquadrat level. It is also helpful to know whether ratings for the individual subquadrats were relatively high or low in each abundance class.

Table 3–10. Percentage coverage-area relationships.

% Coverage	Area 50x50m quadrat	25x25m subquadrat
1%	5x5m	2.5x2.5m
5%	11x11m	5.5x5.5m
25%	25x25m	12.5x12.5m
50%	35x35m	17.5x17.5m
75%	43x43m	21.5x21.5m

6. Once the species assessment is complete, the predominant vegetation type in each height strata for the subquadrat is recorded on the polycorder in a file SQTD(YR) (see below for format) using these codes:
   C=Coniferous
   S=Shrub
   D=Deciduous
   H=Herbaceous
   M=Mixed—Trees only, but not more than 75% either coniferous or deciduous
   B=Bryophytes
   L=Slash
7. Next, estimate the subquadrat density for each stratum using the following coverage codes:
   A=<5%
   B=5–25%
   C=25–50%
   D=50–75%
   E=>75%
8. Finally, record the mean and maximum height of the canopy in meters.
9. As each person finishes his/her subquadrat, she/he enters the data on the polycorder. If there are more persons

finished than there are polycorders, then one person should record while the other reads the data.

10. After all the individual subquadrat data are entered into the polycorder, the group collectively enters data for the quadrat in a file QUADTD(YR) (see below for format). These will consist of the following parameters:
    1. Quadrat location
    2. Date
    3. Mean canopy height
    4. Maximum canopy height (Maximum of whole quadrat; not mean of subquadrat maxima)
    5. Overall quadrat strata type and density
    6. Average percentage coverage for trees by species in the 5–10 and >10m strata throughout the quadrat

    Quadrat abundance figures for other species and strata will be generated by computer.
11. To facilitate group communication about uncommon and hard-to-identify species, team members should read their lists of species that do not appear on the data form and show any specimens they collected. This is an important exercise to keep everyone familiar with plants that are seldom seen.

Polycorder Formatting

The format for the SQTD file is SUBQUAD, OBSERVER, TYPESTR1, DENSSTR1, TYPESTR2, DENSSTR2, TYPESTR3, DENSSTR3, TYPESTR4, DENSSTR4, TYPESTR5, DENSSTR5, MAXCANHT, MNCANHT, where TYPE is vegetation type, DENS is density, STR# is the height strata number, MAX is maximum, MN is mean, and CANHT is canopy height.

The format for the QUADTD file is QUADRAT, DATE, TYPESTR1, DENSSTR1, TYPESTR2, DENSSTR2, TYPESTR3, DENSSTR3, TYPESTR4, DENSSTR4, TYPESTR5, DENSSTR5, MAXCANHT, MNCANHT, TREENUM, HTCL4, HTCL5, etc., up to 12 total species.

Additional Notes

1. Certain species (e.g., *Clintonia*, *Cypripedium*, *Oryzopsis*, and *Deschampsia*) have small fruiting stalks that are much higher than the rest of the plant. These are ignored when assigning a plant to a strata.
2. In certain species, individual stems are tightly aggregated into clumps (e.g., *Monotropa*, *Deschampsia*, many ferns, many shrubs), or mats (e.g., *Mitchella* and *Epigaea*). These

aggregations are considered individuals for the purposes of deciding if a species is rare or uncommon. If the aggregations are unusually large, they are given more weight accordingly.

3. If a species cannot be identified, a specimen should be collected and labeled with the quadrat number and an identification number. On the relevé form, record these species with improvised names, (e.g., *Carex "paucifolia,"* 5 seeded grass, etc.) until they can be identified that evening with the herbarium. Cut the specimen (i.e., do not pull it out with the roots) to facilitate its regeneration. The exception to this rule is *Potentilla* for which the roots are diagnostic.
4. Plants that have a distinct crown supported by a stem are counted in the strata where the crown is located, and the stem is effectively ignored (e.g., most *Quercus*, *Pteridium*, and *Aralia*).
5. Suckers arising from trees are considered separate individuals. Suckers in a clump of shrubs are not considered separately.
6. Lichens and mosses growing on boles of erect or recently fallen trees are not considered; only those that are established on the ground are included.
7. If a low tree branch has rooted (e.g., *Abies*), it is considered a separate individual.
8. "Mixed" refers only to coniferous plus deciduous, not shrub plus herbs, or shrub plus conifer.
9. Tree boles are not included in coverage estimates; photosynthetic surfaces are the key element.
10. Only living plants are recorded; e.g., last year's *Monotropa* stalks are ignored.
11. Plants tall enough to extend through more than one strata are recorded in each stratum if they have leaves present in each stratum. Their abundance score in each stratum should reflect their abundance in that stratum, not their overall abundance.

Equipment

Data sheets
Clipboard
Plastic bags & labels for specimens
Species lists
Timer
Instruction sheet
Extra pencils
Height sticks (4)
Polycorders

Evaluation

As with most ocular estimation methods, there is a problem of observer bias and repeatability. This problem may be somewhat accentuated by the large sample plot size (625 m^2). Using this method to identify subtle changes in plant communities is not always reliable, especially since rarer species may be missed by some observers. The broad abundance categories add to the problem of seeing change because in such large plots, the percentage cover classes (>5%) are seldom used, except for trees and shrubs.

On the positive side, the resulting data provide a relative abundance and complete species list for each subquadrat and for the entire 40ha study area. The data are balanced for seasonal changes in abundance. Relevé training, learning species identification, and conducting the sampling takes a four-person crew approximately 55 field days. Depending on the species complexity, the skill of the crew, and weather, from 3–6 quadrats can be sampled in a day.

Date: 20 JUN 88 File name: RELEVÉ.INS

HOW TO TEACH THE RELEVÉ TECHNIQUE

Day 1

Morning

Teach the grid system. (See "Using the Grid System.")

Afternoon

1. Start with basic plant identification by spending 2 hours in an area of the forest where common species are common and rare ones are generally absent. Point out identification tricks, e.g., if you find a very small or aberrant individual, look for nearby large or normal individuals for comparison.
2. Teach coverage estimation by working in a tight group. Estimate coverage by species and strata in a circle formed by the group. Repeat in several places and continue until concordance is tight. Expand the size of the circle until it has a 15–20m radius. At this size also try estimating coverage for individual tree species.
3. Teach metric tree height estimation. Use marked height trees.
4. Layout 25x25m plot.
5. Encourage review with books and herbarium in evening.

Day 2

1. Spend two more hours reviewing plant i.d.s and learning new ones. Use the second hour to have assistants search for new species and aberrant specimens.
2. Continue teaching coverage estimation technique, but quickly expand to large (ca. 20m radius) plots. At this size, introduce estimating coverage for individual tree species.
3. Once concordance is reasonable, set up a 25x25m plot and have each person do a relevé on it independently; then compare results.

Remainder of Training

Repeat Day 2, step 3, for 4 to 6 days, moving to new environments. Repeat plant quizzes while moving between quadrats. The instructor should be available to assist with plant identification and should complete a relevé form to corroborate assistants' work. Later they can be left on their own and accompanied only when they enter new forest types. A Holt plant list with identification characteristics is available, though it is more useful to an intermediate than a beginner.

Date: 4 JAN 1988 File name: RELTEACH.INS

S-1 INSTRUCTIONS

Introduction

The S-1s are two 600m-long strips across the study area which are the southernmost one-meter wide strips of the S-10s. They cover a total of $1200m^2$ (Figure 3–1). The S-1s are divided into 600 1x1m plots and are marked at every fifth meter with a red or orange flag. The flags are labeled with their distance from the west end of the S-1 line.

Seedlings and Coverage

Two analyses, a seedling count (similar to that used on the $4m^2$ regeneration plots) and a mini-relevé, are conducted on each $1m^2$ plot. These analyses provide information on the regeneration of the forest and on the herbaceous vegetation. In selected years, all S-1 plots are measured. Each year every fifth plot (1, 6, 11, etc.) is measured. S-1 analyses are conducted by two-person crews, one of whom must be very familiar with the forest's vascular flora. This person is called the botanist and the other is called the forester. Monitoring of S-1s begins on the west side and proceeds east across the study area. Plots are numbered from 1 to 600 with an "N" (north) or "S" (south) prefix.

Procedure

1. Lay a 50m tape along the flags that mark the southern boundary of the S-10. When every fifth plot is being sampled, a tape is not necessary.
2. Place the $1m^2$ quadrat frame over the plot. The orange flag numbers reflect the distance along the S-1 line; the plot number corresponds to the distance at the southeast corner of the plot. When every plot is being done, lay the frame along the tape and mark the two east corners with wire stakes. When every fifth plot is being done, the southwest corner goes over the orange flag and one other corner (usually the northeast corner, opposite the orange flag) is marked with a permanent white plastic stick or an orange-painted popsicle stick. This facilitates locating the quadrat in the same place each year.

   Place the frame as close as possible to the ground. Return vegetation bent by the frame to its natural position. On uneven ground, hold the frame level and drop surveying pins to mark the corners of the plot.

3. Record date, observer, recorder, weather, and plot number on both data sheets. For plot number, be sure to indicate north or south.
4. *Seedlings.* (See Figure 3–25.) With one person north of and the other south of the plot, lay a height stick to divide the $1m^2$ quadrat approximately in half. Count tree seedlings by species and size class. The botanist records the data as described under Data Sheet Components. Count only those seedlings that are rooted within the plot. Seedlings should be distinguished from root or stump suckers.
5. *Ground components.* (See Figure 3–25.) The botanist estimates percentage ground coverage by the following components: dry or wet litter, log, tree root or bole, moss, lichens, soil, bare rock, or water. See Table 3–2 for descriptions and number codes of the components.
6. *Species coverage.* (See Figure 3–26.)
   a. The botanist identifies all species of plants within the plot, while the forester records abbreviated names. These should be recorded on page 2 of the S-1 coverage data sheet. The forester should say the names back to the botanist for confirmation and to set the recording pace. Start with the tallest plants (maximum of 5m) and work down. If a plant overhangs the plot but it is rooted outside the plot, it is still counted. After the obvious species are recorded, the botanist searches the plot thoroughly while the forester records the species numbers.
   b. The botanist then records the relative abundance for each species in each of the three height strata on the following scale:
      R = 1 individual,
      1 = >1 individual and/or <5% coverage,
      10 = 5–15% coverage,
      20 = 15–25% coverage, etc., by 10% classes to
      100 = >95%.
7. *Total vegetation coverage.* (See Figure 3–25.) The botanist estimates the total herbaceous coverage by height strata and records the estimate on page 1. The categories are as follows:
   0 = no plants in strata,
   1 = <5% coverage,
   10 = 5–15% coverage,
   20 = 15–25% coverage, etc., by 10% classes to
   100 = >95%.

See "Relevé Instructions" for estimating percentage coverage.

8. Whoever finishes first should move the quadrat frame to the next location.

Data sheet components

There are two data sheets for every plot. The first data sheet is for seedling counts, ground components, and total vegetation coverage; the second sheet is for species lists and relative abundances.

Page 1: Seedlings, ground components, and total vegetation coverage (Figure 3–25)

Plot #: (Plot number) Be sure to record N or S. The number on each flag is the number for the plot to the west of the flag. So a flag numbered 10 means that the plot to the west is N or S 10 and the plot to the east is N or S 11.

SEEDLINGS

Spec: (Tree species) Record by species number (see Table 3–1). When all seedlings have been counted, the tallies can be summarized by recording the number of seedlings, a decimal point, and the size class (e.g., 12 seedlings in the number two size class would be recorded 12.2). The size classes are defined as follows:

1=<0.1m tall (first white line on the height stick)

2=0.1 to 0.499m tall (second white line on height stick)

3=0.5 to 2m tall (2x height stick)

4=>2m tall and <1.5cm DBH

When suckers are present, use a slash to diagonally divide the appropriate column and record the number of suckers in the lower portion.

GROUND

%: (Percentage coverage) Estimate coverage for the ground components listed in the Comp. column. They should add up to 100%.

Comp: (Ground component) List ground components as outlined in Procedure 5.

VEGETATION COVERAGE

% Cov: (Percentage coverage) These were the readings from the canopy prism and spherical densiometer; we now use a ceptometer which records data electronically.

<0.25, 0.25–1, 1–5: (Height strata) Record total vegetation coverage for the plot within each height strata.

It is preferable to record page one data on the polycorder. Seedling data and coverage data are recorded on different polycorders. Formats are as follows: S-1 coverage variables are PLOTNUM, COV<.25, COV.25–1, COV1–5, GCOMP1, %COV1, GCOMP2, %COV2, GCOMP3, %COV3, GCOMP4, and %COV4. S-1 seedling variables are PLOTNUM, SPECIES, SEEDLNG1, SEEDLNG2, SEEDLNG3, and SEEDLNG4.

Page 2: Species coverage (Figure 3–26)

Plot #: (Plot number) Record as described previously. Use both columns for species within one plot.

Species: (Plant species name) Abbreviate in an easily recognized form.

Num: (Plant species number) See separate species list for numbers.

<0.25, .25–1, or 1–5: (Height strata) Record abundance as described in Procedure 7 for each species within a height strata.

Equipment

Quadrat frame	50m tape
Wire stakes	Height stick
1.5cm-diameter caliper	Plant species list with numbers
Data sheets	Pencils
Clipboard	Polycorders (2)

Light Measurements

Light measurements are made using a ceptometer. Refer to "Light Measurements with a Ceptometer" instructions for operation of the ceptometer.

Ceptometer readings should be taken at each S-1 plot that was sampled as close to the time of the sampling as possible. To take ceptometer readings, stand on the north side of the plot. Hold the ceptometer perpendicular to the S-1 line with the tip of the ceptometer near the S-1 line with the light sensors equi-distant from the north and south edges. Take readings at a height of 0.25m and at distances of 0.25, 0.5, and 0.75m across the plot; the three readings are averaged to give one reading per plot.

In order to keep track of the readings, take a list of the S-1 stations into the field and record next to each the memory number for the reading from that station.

Equipment

Sunfleck ceptometer
Pencil
List of S-1 stations
Clipboard

Photography of S-1 Plots

To produce a permanent visual record, selected S-1 plots are photographed before the forest manipulation, and again as needed in the future. Initially we will photograph every tenth plot on the managed area (1, 11, 21, etc.) and every twentieth plot on the control area (301, 321, 341, etc.)

Procedure

1. Photographs should be taken in late July–early August, as close to the time of S1 measurements as possible. By taking them near noon, long shadows will be avoided.
2. Use a 35mm camera with a 55mm focal length lens. High-speed ektachrome (ASA 400) allows you to use a high F-stop, thereby assuring reasonable depth of field. A slow shutter speed (1/8 to 1/30 seconds) will be necessary.
3. Photographs should be taken at an oblique angle, about 1m south of the plot and 1.5m above it. A tripod is necessary to keep the height standard and because of the low shutter speeds required. The small tripod with the legs fully extended and the center post half extended will give the desired height.
4. Place the plot frame around the plot and adjust the camera so that the sides of the frame coincide with the edges of the view-finder reasonably well.
5. Focus on vegetation near the ground, near the center of the plot. If the illumination at this spot is not representative pan around the plot to get an average value. If vegetation *outside* the plot is obscuring the view it should be pulled out of the way.
6. On the bottom of a small clipboard, tape a 3x5 card with the date and transect location (north or south) written in bold letters. On the top, use the clip to hold 2 or 3 cards to give the plot number. The clipboard should be positioned near the back of the plot or in a bare spot so that it can be read on the photo, but will not obscure the vegetation. Often it will be necessary to use the camera's timed shutter release to take the photo while holding the clipboard above the plot.

Equipment

35mm camera with 55mm lens
Tripod
Quadrat frame
Kodak high-speed ektachrome film (400 ASA)
Clipboard and number cards

Evaluation

The relevé portion of this study shares the subquadrat relevés' problems, but they are minimized by using a smaller sample size ($1m^2$), repeating the same 240 plots every year, and using the same observer from year to year.

A difficulty shared by both the relevé and seedling portion of the S-1 study is that the distribution of sample plots every 5m along the S-1 transects results in inadequate and uneven distribution of samples within forest cover and soil types. There are also possible problems of spatial autocorrelation in data analysis. The small sample area also results in tremendous variability and numerous zeros in the data set, which sometimes confounds the analyses.

Date: 4 DEC 87 File name: S1.INS

Figure 3–25. Seedlings and total coverage data sheet, page 1.

HOLT RESEARCH FOREST
S-1 DATA SHEET

Date 29JUL86 Observer DWL Recorder JWW Weather ________

	SEEDLINGS					GROUND		VEGETATION COVERAGE			
Plot#	Spec.	1	2	3	4	%	Comp.	%Cov	<0.25	0.25–1	1–5
287	7	4.1				80	dl		10	10	10
	1	2.1				10	bole				
						10	moss				
288	5		1.2			100	dl		10	10	20
	25		5.3	3.3							
	1	2.1	2.2								
	7	2.1									
289	None					10	moss		10	1	1
						10	dl				
290	7	3.1				100	dl		1	1	10
	25		1.2	1.3							
	1	•									
291	7	2.1				100	dl		10	1	10
	2		1.2								
	1	1.1									
292	7	2.1				90	dl		1	0	1
	1	1.1				10	moss				
293	5	1.1				10	moss		1	0	1
						90	dl				
294	7	2.1				100	dl		1	1	1
295	7	1.1				100	dl		1	1	0
296	None					100	dl		0	0	1

Figure 3–26. Species coverage data sheet, page 2.

HOLT RESEARCH FOREST
S-1 DATA SHEET

North

Date 1AUG86 Observer MLH Recorder MKM Weather overcast still cool

Plot#	Species	Num.	<0.25	.25–1	1–5	Species	Num.	<0.25	0.25–1	1–5
N301	Polypod	92	30			Acer	7	R		
	Juniper	103	R	1		moss	3000	1		
	lichens	2000	1				84	1	1	
N302	Juniper	103	1	1		lichens	2000	1		
	Polypod	92	30			Maianth	329	1		
	moss	3000	1			Pinus	1	1		
N303	Polypod	92	10			moss	3000	1		
	Pinus	1	R			Juniper	103	1	10	
	Maianth	327	1							
N304	Polypod	92	10			moss	3000	1		
	Maianth	327	1			Dschan	142	1		
	Juniper	103	10	R						
N305	Trient	764	R			Juniper	103	1		
	Polypod	92	10							
	Maianth	327	1							
N306	moss	3000	10			Juniper	103	1	10	
	polypod	92	10			Maianth	327	1		
	Picea	2								
N307	Aralia	710	1			Vacc	756	R		
	Maianth	327	1			Juniper	103	1	1	
	polypod	92	10			lichen	2000	1		

PLANT REPRODUCTIVE EFFORT

Introduction

We are determining reproductive effort and success of individuals of 16 plant species: *Mitchella repens*, *Gaultheria procumbens*, *Medeola virginiana*, *Maianthemum canadense*, *Viburnum acerifolium*, *Panax trifolium*, *Oryzopsis asperifolia*, *Epigaea repens*, *Cornus canadensis*, *Coptis groenlandica*, *Aralia nudicaulis*, *Trientalis borealis*, *Uvularia sessilifolia*, *Gaylussacia baccata*, *Juniperus communis*, and *Vaccinium angustifolium*. Individuals are selected for monitoring because they are of reproductive size, genetically unique, or from diverse sites along the sampling transect, or meet all three criteria. Transects run parallel to the north and south S-1 lines. Soil moisture data are also available from these transects. Five species, *V. acerifolium*, *M. virginiana*, *M. repens*, *C. canadensis*, and *P. trifolium*, are also sampled on 3 other transect lines (the 2/3, 8, and 5 transect lines) because there are not sufficient numbers of individuals in close proximity to the S-1 lines.

Methods

Marking

Each individual stem is marked with a pink flag which is labeled with a three- or four-letter species code and an individual number (1 to 50). Total number of individuals is shown in Table 3–14. Woody plants and *E. repens* are also marked with a separate aluminum tag that is loosely attached with grafting tape. These tags also indicate the species code and individual number. *M. repens* runners are delineated by a flag and another marker on either side of the stem. *A. nudicaulis* and *O. asperifolia* are conspicuous perennials that don't spread vegetatively so were marked with a flag only.

Since it was not known for some species if stems persist in the same location from year to year, various sampling methods were applied. *M. canadense* and *M. virginiana* were marked with 1.5" circles of white PVC pipe around the stems in 1988 and every year thereafter. Ramets of *T. borealis* and *U. sessilifolia* were marked with 1.5" circles of PVC pipe in 1988 and 1989, but then were sampled in a 100cm^2 quadrat because it was not possible to follow the same ramet year after year. The growth form of *C. canadensis*, *G. procumbens*, and *C. groenlandica* was unclear, so ramets were sampled within a 100cm^2 quadrat in 1987. The opposite corners of the quadrat are marked with a flag and another marker. In 1989 and thereafter, individual ramets of *C. canadensis* and *C. groenlandica* were sampled and marked with 1.5" PVC rings instead because we discovered that ramets persisted in the same place.

Biomass measurement

Observations and measurements to be collected for individual plants are summarized in Table 3–11. The specifics of each method are described below in detail.

Measure stem lengths by placing the end of the ruler on the ground where the stem emerges and measuring to where it terminates in a whorl of leaves (*M. virginiana*, *G. procumbens*, *T. borealis*, and *C. groenlandica*) or end leaf (*U. sessilifolia*). The longest leaf of *U. sessilifolia* is found usually second or third from the bottom; for *M. canadense*, at the bottom; for *O. asperifolia*, by holding all of the leaves upright; for *C. canadensis*, visually; and for *T. borealis* and *C. groenlandica*, by measuring several of the longer leaves. Measure the length of leaves from the base of the leaf or leaflet where it attaches to the petiole, to the tip. Measure the leaf widths of *M. canadense* at its greatest width which is usually 1/3 up from the base toward the tip. Measure plant height of *M. virginiana* by placing one end of a ruler on the ground near the base of the plant and measuring the highest point on the plant. Measure the narrowest stem diameter of *V. acerifolium*, *G. baccata*, *V. angustifolium*, and *J. communis* about 4cm from the ground at a point that is marked by a permanent black marker. This point may be arbitrary for some *J. communis* stems as it was hard to determine where the stem emerged from the ground without greatly disturbing it and the surrounding stems. The pink flag is usually near the marked measuring point on *J. communis* stems. The narrowest stem diameter at the base of an *A. nudicaulis* stem, below a bulbous swelling, is where this year's green stem inserts into the rhizome.

Flower and fruit measurement

Count the number of flowers for each species. It helps to use a hand counter when counting flowers and fruits of *G. baccata* and flowers of *V. acerifolium*. Count flowers just as they begin to open to avoid miscounts due to flower predation. In addition, note the sex of the flowers for *J. communis*, *A. nudicaulis*, and *P trifolium*.

Count fruit for all species. In addition, measure the length of the pod of *U. sessilifolia* (straight line distance from the point of insertion of the pedicel to the tip), and count the number of seeds in the fruits of *T. borealis* and *C. groenlandica*. Drop the seed next to the plant when finished. Count fruits when first fruits of a species are beginning to ripen to avoid miscounts due to removal. Count *O. asperifolia* and *E. repens* after the fruits have swollen, but before they are quite ripe. Count *U. sessilifolia*, *C. groenlandica*, and *T. borealis* after seed pods have dried, but before they open. When counting *J. communis* fruits, count this year's fruits (green, because they won't ripen until next year), last year's fruits (bluish black, have just ripened), and the year before last year's fruit (old, mealy bluish black).

Calendar of measuring

The timing of observations and measurements is outlined in Table 3–12. The phenology is outlined by species in Table 3–14, and a week-by-week schedule is listed in Table 3–13. Make all biomass measurements at the time of flowering. These dates are approximate; phenology can vary up to two weeks from this schedule. This variability is not consistent between species (i.e., not everything will be two weeks late though one species may be).

Data Sheets

A master list of all species, individual numbers, and locations can be found on the hard disk of the Zenith 248 at the office in Arrowsic and on a floppy disk labeled Holt Repro.Lists. File name on the floppy disk is MASTER.LST. On the hard disk, the file may be found in C:\HOLT\REPRO\MASTER.LST. In addition, there are directions for creating species specific data sheets (labeled FLOPDISK.INS AND HARDDISK.INS) and a large number of already created data sheets (usually labeled with SPECIES INITIALS.DS, e.g. VIBUCORN.DS for *Viburnum* and *Cornus* or COGAMETR for *Cornus*, *Gaylussacia*, *Medeola*, and *Trientalis*). See Figure 3–27 for a sample data sheet.

Setup of Reproductive Effort Master List

The master list contains a code string of four segments signifying plant location, species abbreviation, species number, and individual plant number for each plant. For example, if "1379.601 copt 460 14" is the code string, it is interpreted as follows:

1379.601 is the plant location number. From left to right,

1 = transect line (which are numbered 1 = south S-1, 2 = north S-1, 3 = 2/3 line, and 8 = 8 line from center of 8H);

379.6 = distance in meters along the transect line from the west side of the study area, except for the 8 line, where it is the distance north from 8I/8H, and for the 2/3 line, where it is the distance south from 2E/3E; and

01 = distance from the line to the plant. Plants located along the S-1s are always south of the line, whereas plants located along the 3 and 8 transect lines are located on either side of the line.

copt is the species abbreviation. The species abbreviations and the relevé I.D. numbers are shown in Table 3–14.
460 is the species relevé I.D. number.
14 is the individual plant number.

Equipment

Data sheets with selected species
Clipboard
Clear plastic metric ruler
Counter
Marker
Pencils
Small calipers for measuring stem diameter
Extra flags

Evaluation

This technique of sampling individual plants replaced a simple phenological observation of species located in a single subquadrat. The advantage of this method is that it provides information for species across the study area in a wider variety of microclimates. In addition, more information is recorded about individuals, including biometric parameters, to relate to reproduction. Marking individual plants provides information throughout the life of a plant. One difficulty of this method is that, in some species, individuals move from one year to the next and it can be difficult to ensure that the same individual is being sampled.

Date: 11 JAN 91 File name: REPRO2.INS

Table 3–11. Measurements for estimating biomass in the reproductive effort study.

Species	Flowers	Fruit/Seed	Biomass Method[a]
U. sessilifolia	number	length of pod	stem length, length of longest leaf
M. canadense	"	number of fruit	length, width of leaves
M. virginiana		" "	plant height, length of longest leaf, no. of leaves
O. asperifolia			length of longest leaf, no. of lvs, length of typical leaf
G. procumbens			sum of stem lengths, no. of lvs
C. canadensis		'	length of longest leaf, stem length
M. repens			no. of lvs
E repens			no. of lvs
T. borealis		& no. of seeds	stem length, length of longest leaf
C. groenlandica		" "	sum of stem lengths, longest leaf
V. acerifolium		no. of fruit	narrowest stem diameter at 4cm
G. baccata		" "	" " " "
V. angustifolium			
J. communis	no. & sex		
A. nudicaulis			narrowest diameter of base of stem
P. trifolium	no. & sex no. stems		no. of stems, no. of leaves

[a]lengths and widths are in mm and are measured with a clear 15 centimeter rule that has mm increments. Diameters are in 0.01mm and are measured with a plastic metric caliper.

Table 3–12. Time table for sampling by species.

Species	Biomass measurements and flower counts	Fruit/Seed
U sessilifolia	IV MAY*	AUG
M. canadense	I JUNE	II–IV JULY
M. virginiana	II JUNE	II–IV JULY
O. asperifolia	(at fruit count)	II JUNE
G. procumbens	III JULY	AUG–OCT
C. canadensis	II JUNE	II JULY
M. repens	I JULY	AUG–OCT
T. borealis	IV MAY	II JULY
G. baccata	I JUNE	I–IV JULY
V. angustifolium	IV MAY	I JULY
E. repens	I JUNE	I JUNE
V. acerifolium	IV JUNE–I JULY	AUG
J. communis	II–IV MAY	AUG
P. trifolium	I MAY	I–II JUNE
C. groenlandica	III MAY	III JULY
A. nudicaulis	IV MAY	I JULY

* Roman numerals refer to the lst, 2nd, 3rd, and 4th week of the month.

Table 3–13. Schedule for sampling by week.

I MAY
P. trifolium FL,BM*

II–IV MAY
J. communis FL,BM

III MAY
C. groenlandica FL,BM

IV MAY
U. sessilifolia FL,BM
T. borealis FL,BM
V. angustifolium FL,BM
A. nudicaulis FL,BM

I JUNE
M. canadense FL,BM
G. baccata FL,BM
E. repens FL,FR,BM
P. trifolium FR

II JUNE
M. virginiana FL,BM
O. asperifolia FL,FR,BM
P. trifolium FR
C. canadensis FL,BM

IV JUNE - I JULY
V. acerifolium FL,BM

I JULY
M. repens FL,BM
A. nudicaulis FR
V. angustifolium FR

II JULY
G. procumbens FL,BM
G. baccata FR
T. borealis FR
C. canadensis FR

II–IV JULY
M. virginiana FR
M. canadense FR

III JULY
C. groenlandica FR

AUGUST
U. sessilifolia FR
V. acerifolium FR
J. communis FR

AUGUST–OCTOBER
G. procumbens FR
M. repens FR

* FL = flowers, FR = fruit/seeds, and BM = biomass.

Table 3–14. Species I.D. number and number of individuals.

Species	Species Abbrev.	Relevé I.D. No.	No. of Marked Individuals
Juniperus communis	Jun	103	34
Oryzopsis asperifolia	Oryz	163	35
Maianthemum canadense	Maia	327	50
Medeola virginiana	Mede	328	48
Uvularia sessilifolia	Uvul	339	49
Coptis groenlandica	Copt	460	50
Aralia nudicaulis	Aral	710	50
*Panax trifolium**	Panx	713	40
Cornus canadensis	Corn	727	45
Epigaea repens	Epi	743	36
Gaultheria procumbens	Gaul	746	47
Gaylussacia baccata	Gay	747	43
Vaccinium angustifolium	Vac	756	50
Trientalis borealis	Tri	769	50
Mitchella repens	Mit	851	44
Viburnum acerifolium	Vibu	860	24

* *Panax* is not presently on the master list.

Figure 3–27. Sample reproductive effort data sheet

PLANT REPRODUCTIVE EFFORT DATA FORM

30JUL92 (uvul-fruit)

Date 28MAY92 Recorder EHM Weather Sunny, dry Page 1 of 3

Plant species A: Trientalis Parameter definitions: 1: #flowers
2: stem length 3: long leaf 4: ____ 5: ____ 6: ____ 7: ____

Plant species B: Uvularia Parameter definitions: 1: #flowers
2: stem length 3: long leaf 4: pod length 5: ____ 6: ____ 7: ____

		1	2	3	4	5	6	7
1034.801 tri 769	1	1	130	50				
1045.002 tri 769	2	0	42	19				
1057.101 tri 769	3	0	48	10				
1075.401 tri 769	4	0	40	7				
1090.300 uvul 339	1	0	100	38	0			
1109.204 tri 769	5	0	59	29				
1131.602 tri 769	6	0	80	27				
1146.001 tri 769	7	0	44	11				
1155.501 uvul 339	2	0	66	24	0			
1159.601 uvul 339	3	0	140	39	0			
1165.101 uvul 339	4	1	71	29	16			
1168.103 uvul 339	5	0	107	43	0			
1172.502 uvul 339	6	0	102	34	0			
1175.403 tri 769	8	0	74	26				
1175.903 uvul 339	7	0	101	48	0			
1206.703 uvul 339	8	0	105	31	0			
1218.002 tri 769	9	0	85	53				
1219.502 uvul 339	9	0	46	12	0			
1224.400 uvul 339	10	0	61	25	0			
1226.802 uvul 339	11	0	79	22	0			
1233.502 uvul 339	12	0	93	31	0			
1238.701 uvul 339	13	0	82	22	0			
1245.702 uvul 339	14	0	72	18	0			
1246.101 tri 769	10	0	74	16				
1266.101 tri 769	11	0	54	14				
1267.003 uvul 339	15	0	110	43	0			
1272.201 uvul 339	16	0	150	45	0			
1273.900 uvul 339	17	0	140	52	0			
1286.601 tri 769	12	1	123	50				
1291.401 uvul 339	18	0	96	45	0			
1301.401 uvul 339	19	0	100	41	0			
1305.001 tri 769	13	0	133	47				
1305.303 uvul 339	20	0	75	35	0			
1308.102 uvul 339	21	0	167	51	0			
1315.502 uvul 339	22	0	83	34	0			
1325.402 tri 769	14	0	172	43				
1331.102 uvul 339	23	0	118	55	0			
1342.001 uvul 339	24	0	80	27	0			
1344.701 uvul 339	25	0	121	41	0			

FRUIT PRODUCTION

Introduction

Fruit production is influenced by such factors as weather, soil type, and cover type, and may affect fruit predator populations. To assist in looking at these relationships, we are censusing fruit production of thirteen common fleshy-fruiting species found on 20 subquadrats throughout the forest. This census method indicates peak and trough years of these species, but does not quantify finer scale patterns.

Site Selection and Layout

The twenty sample subquadrats are paired: ten of the sites are in the managed half of the forest, and ten are in the control half. Sites are paired based on cover type and overall appearance. The selection of subquadrats from each of the cut blocks in the managed half of the forest is based on homogeneous cover and understory. Sites of similar cover and understory type are selected from the control part of the study area. No sites are located in the 5J block because of its irregular terrain.

Each 25x25m subquad contains five 25m transects running east-west. The beginning location of each transect is randomly selected from within each of the five 5m segments constituting the north-south line of the subquad (see Table 3–15 for locations of these transects). The transect is marked by nylon string which is held down at either end by an orange plastic or wooden stake and a tall pink flag. The flag and stake are marked with the subquadrat code and the distance of the transect from the northern edge of the subquadrat.

Fruit Sampling Period

The species being sampled for fruits are: *Maianthemum canadense*, *Medeola virginiana*, *Rubus allegheniensis*, *Rubus flagellaris*, *Rubus hispidus*, *Rubus idaeus*, *Ilex verticillata*, *Aralia nudicaulis*, *Cornus canadensis*, *Gaylussacia baccata*, *Vaccinium angustifolium*, *Mitchella repens*, and *Viburnum acerifolium*.

Fruits are counted three times during the season.

- In the first census, fruits of *Aralia nudicaulis* are counted during the first week of July, just before many have become ripe.
- In the second census, fruits of *Maianthemum canadense*, *Cornus canadensis*, *Gaylussacia baccata* and *Vaccinium angustifolium* are counted during the second half of July. The

fruits of *Maianthemum canadense*, *Gaylussacia baccata*, and possibly *Mitchella repens* are usually still green but mostly developed. Virtually all fruits of these species that are green at this time reach maturity. Also at this time, presence of flowers on remaining species is noted to facilitate locating their fruits in the third census.

- The third census, conducted at the end of August, should capture the *Rubus* species, *Ilex verticillata*, *Medeola virginiana*, *Viburnum acerifolium*, and possibly *Mitchella repens* if it wasn't fruiting in July.

Procedure

1. Print out the data sheets for each subquadrat. Each data sheet has starting points in meters for transects in that subquadrat (Figure 3–28). Print or photocopy a map of the study area with subquadrat fruit production transect lines, and plan a route (Figure 3–29).
2. At each subquad, start at the northernmost or southernmost transect, census the length of it, and come back censusing the next transect, until all transects have been censused in a weaving fashion.
3. Do the census by slowly walking along the string, scanning vegetation within a meter on either side for fruit. Tally the fruits using a dot-dash tally in the column indicating whether the fruit is north or south of the transect string. For some species with numerous fruits, a hand counter may be helpful. At the end of the transect, summarize the tally and write in the number. A height stick with a meter mark on it helps determine if a borderline fruit is within a meter of the string.
4. Every third year, ceptometer readings are taken to measure photosynthetically active radiation along the transects. Readings are taken at three permanent sampling points on each transect, at 30cm above the ground (see Table 3–15). These points were randomly selected the first year from each of the 0–8m, 9–16m, and 17–25m segments of the transect.

Equipment

Clipboard	Data sheets
Pencils	Hand counter
Map	Height stick
Ceptometer	

Evaluation

This method was adapted from a master's thesis project conducted at HRF by Andrew Whitman and represents a continuation of his three years of data collection. Changes to his methods include standardizing the search area to a 2m-wide strip and dropping uncommon fruiting species from the study.

Date: 10 JAN 91 File name: FRUTPROD.INS

Table 3–15. Sample locations of fruit production transects and ceptometer sampling points along transects.

Subquadrat	Transect (dist. from n. edge of subquadrat) (m)	Ceptometer sampling points (distance from west end of transect) (m)	(m)	(m)
3E31	1	3	16	17
	9	6	16	24
	11	6	12	21
	20	2	16	21
	22	5	16	20
3G23	3	11	21	
	9	8	12	21
	14	1	12	23
	20	5	10	22
	22	8	12	20
3J41	5	3	13	23
	8	1	10	23
	12	1	11	20
	17	6	14	17
	21	4	15	24
4F41	1	5	9	24
	6	6	12	18
	11	1	12	24
	19	3	14	20
	23	2	13	23
4G31	2	2	15	17
	7	3	12	22
	11	6	9	20
	19	7	16	19
	25	5	15	17
4G41	5	1	13	22
	10	3	11	19
	13	2	12	19
	19	6	11	18
	23	2	11	22
4I43	1	4	14	20
	10	8	13	24
	15	2	16	20
	20	6	16	24
	22	6	9	24
5E41	2	1	12	20
	6	8	14	20
	14	5	15	20
	17	1	13	20
	21	8	13	19

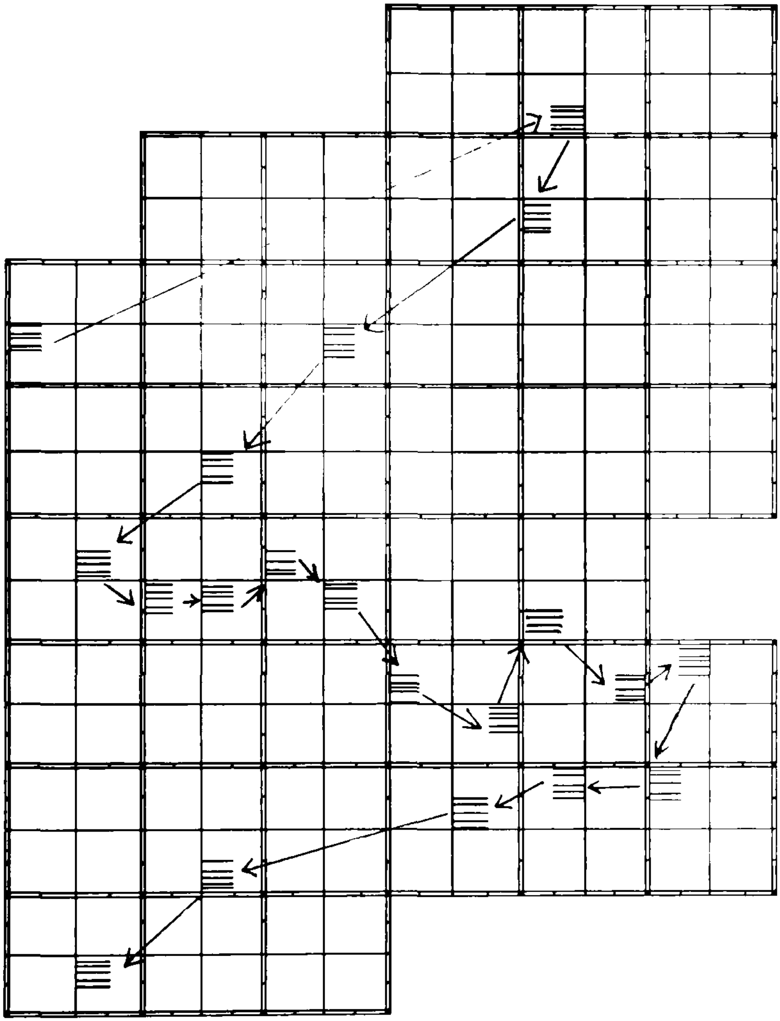
Figure 3–28. Fruit production transects subquad data sheet.

HOLT RESEARCH FOREST
FRUIT PRODUCTION TRANSECTS
SUBQUAD DATA SHEET

Year 92 Observer JWW Weather clear warm

SUBQUAD 4F41			NUMBER OF FRUIT										
Transect Location			1m		6m		11m		19m		23m		
Species	SP#	Date	N	S	N	S	N	S	N	S	N	S	Total
Maianthemum canadense	327	16 JUL	129	90	46	85	2	19	0	0	0	4	
Medeola virginiana	328	1 SEP	NP	→	→	→	→						0
Rubus allegheniensis	571	1 SEP	NP	→	→	→	→						0
Rubus flagellaris	576	"	P-O	P-O			34	31	34	62	16	10	
Rubus hispidus	577	"					14	12	14	12	0	0	
Rubus idaeus	580	"							3+	6+	16	P	
Ilex verticillata	639	"					P-O	P-O			NP	NP	0
Aralia nudicaulis	710	16 JUL	0	0	0	0	0	0	0	0	0	0	
Cornus canadensis	727	16 JUL	0	0	0	0	0	0	0	0	0	0	
Gaylussacia baccata	747	16 JUL	0	0	0	0	513	527	0	0	0	0	
Vaccinium angustifolium	756	16 JUL	0	8	19	11	38	23	12	88	85	40	
Mitchella repens	851	1 SEP	NP	→	→	→	→	→	→	→			0
Viburnum acerifolium	860	1 SEP	NP	→	→	→	→	→	→	→			0

Figure 3–29. Map of fruit production transects.



CHAPTER 4

ANIMAL ECOLOGY RESEARCH AT THE HOLT RESEARCH FOREST

BIRD BEHAVIOR OBSERVATIONS

Introduction

Bird behavior observations are made as often as possible from mid-May through early July. They are confined to mornings to minimize time-of-day effects. To limit observer bias, only the resident scientist and principal investigator make these measurements. They can be made anywhere within the study area, though the observer should stay on grid lines to avoid trampling vegetation. Ideally, the observer covers the entire study area in successive visits.

Procedure

1. At the top of each data sheet, record date, observer, page, weather, and time beginning and ending. Each time a bird is encountered, the parameters listed in the data sheet components are recorded.
2. *Repeat observations*. In any encounter with an individual bird, it is possible to make several observations. A new observation can be recorded each time the bird changes activity, or if it moves to a new tree and repeats the same activity. In encounters with more than one bird, it is preferable to observe as many different birds as possible. Whenever a repeat observation is made, write "Rep" in the species column. If the repeat observation is not immediately below the initial observation, connect them with an arrow. If five minutes elapse between observations of the same individual, it is not considered a repeat.

Data Sheet Components

LOC: (Quadrat) Record the quadrat number.

SPEC: (Species) Record the species using abbreviations or numeric codes from the "Bird Species List" (see Table 4–2). Repeat observations are recorded "Rep" in this column (see procedure 2).

SEX: 0 = male; 1 = female; 2 = unknown; 3 = juvenile.

TIME: Record in 24-hour time.

TREE: Record the numeric code of the species of tree or shrub in which the bird is located (see Table 3–1). If the bird is on slash or on the ground, then record "30" or "33," respectively. Put a "-1" after the species if the tree is dead.

TH: (Tree height) Estimate the height of the tree to the nearest meter (See Figure 4–1a).

BH: (Bird Height) Estimate the bird's height in the tree to the nearest meter (See Figure 4–1a). There are three trees marked at 2m intervals for training purposes. They are located where transect lines 4, 6, and 8 cross the center fence line (F/G).

CROWN: Record the bird's location within the tree as follows:
1=bole;
2=limb (>10cm diameter);
3=branch;
4=outer twigs and leaves; (see Figure 4–1b).
The assignment to a location should be based on where the bird's activity is focused rather than where it is perched. For example, a bird perched on a branch singing would be scored "3," but if it was reaching out to glean insects from leaves, it would be scored as "4." If the bird is on a dead branch, twigs, etc., the number should be followed by a "-1," e.g. 3-1.

CR*: (Crown radius) Estimate to the nearest meter the mean crown radius at the height where the bird is located. This is the mean horizontal distance from the bole to the tips of the branches within one meter above and below the bird (See Figure 4–1a). This should be within a 90° quadrant with the bird along the bisecting radius of this quadrant.

BB*: (Bird-bole distance) Estimate to the nearest meter the horizontal distance from the bird to the bole of the tree.

BEH (Behavior): The following behavior categories (with numeric codes) are recognized:

Forage: (10) Actively searching for food; usually characterized by small movements of the head. Whenever possible, the following subdivisions of foraging (12–16) are recognized.

Glean: (12) Picking insects from the surface of a substrate, usually leaves or bark.

Hawk: (13) Attempting to capture an insect from the air. Record perch from which it flew.

Hover: (14) Hovering in the air to forage, usually from a leaf.

Probe: (15) Foraging under or within a substrate.

Drill: (16) Creating a hole for foraging (e.g., woodpeckers).

Feeding: (20) Manipulating a food item.

Inactive: (25) No overt behavior except very small movements of the body. This must be preceded by a move >1m or must last at least 30 seconds to be recorded.

Sing: (30) Loud, repetitive, complex vocalization usually given by males during the breeding season.
Call: (35) Any vocalization that is not a song.
Flush: (40) When a bird flies in response to the observer or a warning call of another bird. Location is where the bird lands, not from where it flushes.
Preen: (45) Manipulating feathers, stretching, ruffling feathers, and other comfort movements.

Social Interactions. These are subdivided as follows:
Courtship: (51) Male-female interactions related to breeding, e.g., allopreening, displays, courtship feeding.
Parental care: (52) Carrying food or fecal sacs.
Begging: (53) Young birds soliciting food through calls and postures.
Aggression: (54) Fighting, chasing, displaying between species or between members of the same sex within a species.
Miscellaneous: (60) Only rarely will an activity occur that doesn't fit the above categories; in such a case, describe it.

*For both CR and BB distances, if a bird is on a portion of a tree where there is no crown, e.g., on the very top of a spruce, or on the bole below branches, record 0 and 0. If the tree effectively has no crown; e.g., a slender understory maple or a branchless snag, record - and - (dashes).

Equipment

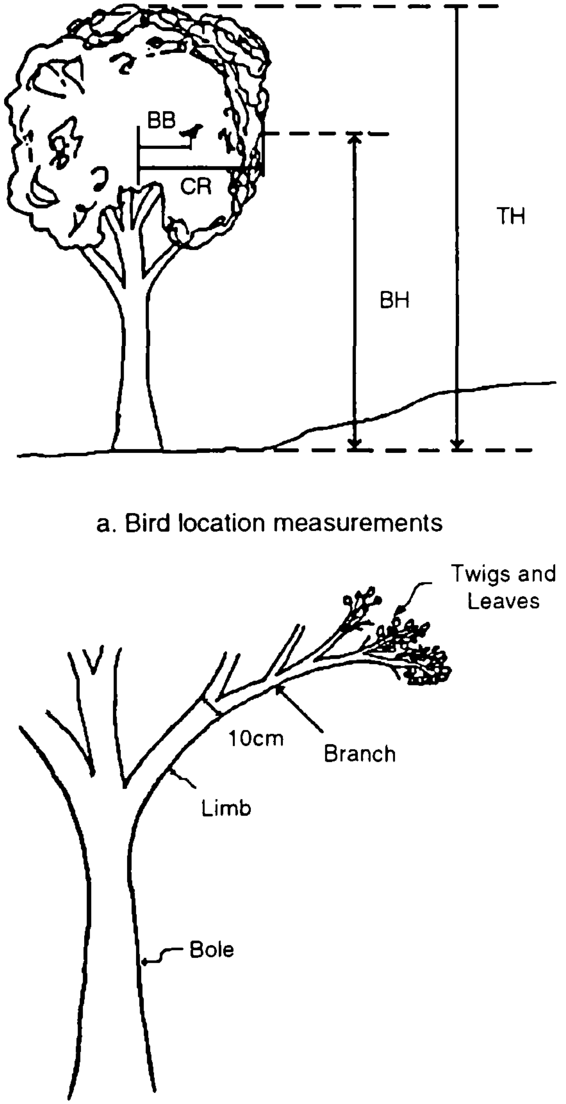
Binoculars
Data sheets
Study area map
Clipboard
Data sheet component list

Evaluation

This method requires a lot of time to obtain adequate sample sizes for each species sampled and the number of observations that can be obtained in any single morning is extremely variable. Differences in species visibility is demonstrated by low samples of relatively common species and reflects a bias in numbers for those species that are most easily detected. Restricting walking to lines may decrease the numbers that can be detected. With limited resources, concentrating on a smaller number of species may improve the chances of obtaining an adequate sample size.

Date: 4 NOV 87 File name: BBEH.INS

Figure 4–1. Bird location measurements and crown locations.



a. Bird location measurements

b. Crown locations

Figure 4–2. Bird behavior observation data sheet

HOLT RESEARCH FOREST
BIRD BEHAVIOR OBSERVATIONS

Date 8 MAY 84 Observer JWW Page 1 of 1

Weather partly sunny, warm Time begin/end 0600/0640

LOC	SPEC	SEX	TIME	TREE	TH	BH	CROWN	CR	BB	BEH
6F1	BCC	0	0604	WP	18	12	4	3	3	glean
6F1	repeat	0	0605	RO	14	13	3	3	2	sing
6F1	repeat	0	0607	RO	14	7	1	—	—	forage
6F1	BCC	2	0607	RO	14	8	2	4	1	forage
6E3	BTG	0	0613	BF D	12	11	D3	2	1.5	sing
6E3	repeat	0	0614	BF D	12	11	D3	2	1.5	glean
6E1	GCK	2	0618	RS	14	12	4	2.5	2.5	hover
6D4	WTS	0	0628	Ground		—	—			forage
6D4	WTS	1	0628	Ground		—	—			forage
6C4	YRW	1	0633	WP	11	9	4	2	1.5	glean

BIRD STRIP CENSUSING

Introduction

Bird censuses covering the entire study area are undertaken at least once every two weeks throughout the year. To minimize observer bias, data is collected primarily by the resident scientist.

Coverage

A complete census requires walking four 700m and two 600m transect lines (lines 3, 4, 5, 6, 7, and 8; see "Using the Grid System"). Only half the lines can be censused in one morning, so odd and even lines are censused on alternate days. Table 4–1 describes 24 route patterns which vary the order and direction in which transects are walked to minimize time-of-day bias. It is not necessary to complete the two halves of the census on successive mornings.

Table 4–1. The order and direction in which bird transect lines are walked.

	1st line	2nd line	3rd line	
1.	3(E to J)	5(J to D)	7(C to I)	13. same as 1
2.	4(D to J)	6(I to C)	8(C to I)	14. same as 2
3.	5(J to D)	3(E to J)	7(I to C)	15. 5(J to D) 7(C to I) 3(J to E)
4.	6(I to C)	4(D to J)	8(I to C)	16. 6(I to C) 8(C to I) 4(J to D)
5.	7(C to I)	5(J to D)	3(E to J)	17. same as 5
6.	8(C to I)	6(I to C)	4(D to J)	18. same as 6
7.	3(J to E)	5(D to J)	7(I to C)	19. same as 7
8.	4(J to D)	6(C to I)	8(I to C)	20. same as 8
9.	5(D to J)	7(I to C)	3(E to J)	21. 5(D to J) 3(J to E) 7(C to I)
10.	6(C to I)	8(I to C)	4(D to J)	22. 6(C to I) 4(J to D) 8(C to I)
11.	7(I to C)	5(D to J)	3(J to E)	23. same as 11
12.	8(I to C)	6(C to I)	4(J to D)	24. same as 12

Timing and Weather

Censuses are generally initiated within 30 minutes of sunrise. During the breeding season (May–July), they can begin up to 30 minutes before sunrise because dawn is longer and birds are active earlier then. Censuses should be completed by 1000 h at the latest; it is desirable to end by 0900 h, particularly on hot days. During the winter (December–March), when activity is greatest at mid-day, censuses should be initiated 3 hours after sunrise.

Censuses should be done only when the weather is fairly calm (wind velocities less than 3.6 m/s) and clear. Cloudy days are acceptable as long as there is no precipitation and it is not too dark to see well.

Procedure

1. At the beginning of each census, record the following information on each data sheet (Figure 4–3): date, observer, weather, lines censused, and page number.
2. Walk the transect lines quietly and slowly (ca. 1.5 km/hour), with occasional stops. If many birds are recorded, the pace may slow to 1 km/h.
3. Most birds are detected acoustically, but constantly scanning the vegetation also locates many. The observer should focus her/his attention on searching within 50m of the transect; birds over 50m away are difficult to locate accurately.
4. Record all detected birds, except those flying well above the canopy such as gulls and ospreys.
5. When locating a bird directly ahead or behind, it is especially important to keep track of the bird's movements to avoid making duplicate records.
6. If a bird cannot be accurately located, record it with a "?" in the location column.
7. It is sometimes necessary to leave the transect line to make an identification, determine a distance, or count individuals in a flock. During the period the observer is away from the line, the census has effectively stopped. Do not record any birds except those that were the reason for leaving the line. If you leave the line to investigate a flock, record all members of the flock, even those not detected from the line. Note time spent off the line in the Time Beg/End column.

Data Sheet Components

BLOCK: The number of the block where the observer is located.

B/E: (Time beg/end) The time the observer enters (beg) and leaves (end) a block.

LOC: (Location) The number of the quadrat where the bird is located. Birds flying low over the forest such as blue jays and crows should be recorded as "FO" in the LOC column.

SPEC: (Species) Abbreviated name of the bird species. See Table 4–2.

SEX: Sex of the bird; 0 = male, 1 = female, 2 = unknown or mixed, 3 = juvenile.

TIME: The time of the encounter.

DIST: (Distance) The perpendicular distance in meters from the transect line to where the bird was first detected. The

DISTANCE recorded for flocks is an approximate mean of the individual distances.

FLOCK: Number of individuals in a flock. For mixed flocks, a separate record is made for each species and an "M" is recorded after the number of individuals.

DETECT: Record how the bird was detected. Following are the symbols:

A = Acoustic,
C = Call,
F = Flush,
S = Song,
V = Visual.

Equipment

Clipboard
Data forms
Instructions and map
Pencils
Binoculars

Evaluation

Bird strip censuses in general are fraught with a number of inherent problems and this method has those same problems. (See, Ralph, C.J., and J.M. Scott. eds. 1981. Estimating Numbers of Terrestrial Birds. Studies in Avian Biology 6. Cooper Ornithological Society, 630pp.)

Date: 4 NOV 87 File name: BSTRIP.INS

Table 4–2. Bird species list—abbreviations[1] and number codes.

Bird Species	Abbr.	No.	Bird Species	Abbr.	No.
Sharp-Shinned Hawk	SSH	1	Red-Eyed Vireo	REV	46
Broad-Winged Hawk	BWH	3	Tennessee Warbler	Tenn	48
Ruffed Grouse	RG	4	Nashville Warbler	NV	49
Mourning Dove	MD	6	Northern Parula	NPW	50
Barred Owl	BOWL	9	Chestnut-Sided		
Ruby-Throated			Warbler	CSW	52
Hummingbird	RTH	11	Magnolia Warbler	MAG	53
Yellow-Bellied			Black-Throated		
Sapsucker	YBS	12	Blue Warbler	BTB	55
Downy Woodpecker	DWp	13	Yellow-Rumped		
Hairy Woodpecker	HWp	14	Warbler	YRW	56
Northern Flicker	Flick	15	Black-Throated Green		
Pileated Woodpecker	PWp	16	Warbler	BTG	57
Eastern Wood-Peewee	Pewe	18	Blackburnian Warbler	BW	58
Least Flycatcher	LF	20	Pine Warbler	Pine	59
Eastern Phoebe	Phb	21	Unknown Warbler	?Warb	60
Great Crested			Bay-Breasted		
Flycatcher	GCF	22	Warbler	BBW	61
Blue Jay	BJ	24	Black-and-White		
American Crow	Crow	25	Warbler	BWW	63
Common Raven	Raven	26	American Redstart	Redst	64
Black-Capped			Ovenbird	Oven	65
Chickadee	BCC	27	Common Yellowthroat	CY	68
Red-Breasted			Canada Warbler	Can	69
Nuthatch	RBN	29	Scarlet Tanager	ST	71
White-Breasted			Rose-Breasted		
Nuthatch	WBN	30	Grosbeak	RBG	73
Brown Creeper	BCrp	31	Rufous-Sided Towhee	RST	75
Golden-Crowned			Fox Sparrow	Fox	78
Kinglet	GCK	33	Song Sparrow	SS	79
Ruby-Crowned			White-Throated		
Kinglet	RCK	34	Sparrow	WTS	80
Veery	Veer	35	Dark-Eyed Junco	DEJ	81
Swainson's Thrush	SWT	36	Common Grackle	Grac	84
Hermit Thrush	HT	37	Purple Finch	PF	88
American Robin	Rob	39	Pine Siskin	PSis	92
Gray Catbird	Cat	40	American Goldfinch	GF	93
Cedar Waxwing	CWx	42	Evening Grosbeak	EG	94
Solitary Vireo	SV	44	Unknown	?	99

[1] If a species is recorded that is not on the list, the name should be written out in full until a unique abbreviation is assigned.

Figure 4–3. Bird strip census data sheet.

HOLT RESEARCH FOREST
BIRD STRIP CENSUS

Date 12 MAY 84 Observer JWW Page 1 of 4

Weather Clear, Cool Lines Censused S357

BLOCK	B/E	LOC	SPEC	SEX	TIME	DIST	FLOCK	DETECT
3J	0515/	3J4	RBN	2	0515	14	2	C
		3J2	BCC	0	0515	18		S
		3J3	YRW	0	0519	29		S
		3J3	WTS	1	0521	2		V
3I	0522/	3J1	CY	0	0523	31		S
		3I3	BTG	0	0524	42		S
		3I3	BTG	0	0526	8		S, V
		3I3	BTG	1	0526	7		V
		3I2	GCK	2	0528	12		V
3H	0530/	3H3	BCrp	0	0530	23		S
		3H1	WTS	0	0531	38		S
	/0534	3H4	HT	0	0533	16		S
	0537/	3H2	Veer	2	0537	40		C
		3H1	NPW	0	0538	32		S
3G	0538/	3H1	WBN	2	0539	17		C
		3G3	SV	0	0540	26		S
		3G2	BJ	2	0540	37		C
	/0544	3G4	OVEN	0	0542	6		S, V

BIRD TERRITORY MAPPING

Introduction

Bird breeding territories are mapped for the entire study area from mid-May through the first week of July. To minimize observer bias, this is undertaken by the resident scientist.

Coverage

Study area grid lines are the basis for the mapping observations. So that the lines are not always visited at the same time of day, a sequence of eight different routes (16 visits) has been devised to cover the grid lines in a variable pattern (Table 4–3). Since the area cannot be completely covered in one day, the transect lines and block lines are done on separate days.

Table 4–3. Pattern for covering grid lines during bird territory mapping. The numbers indicate the number of the grid line to walk; the letters indicate the end of the line (north or south) where the observer begins.

	Transect	Block
Coverage 1	A. 3N-4S-5N-6S-7N-8S	B. 2/3N-3/4S-4/5N-5/6S-6/7N-7/8S-8/9N
Coverage 2	A. 8N-7S-6N-5S-4N-3S	B. 8/9N-7/8S-6/7N-5/6S-4/5N-3/4S-2/3N
Coverage 3	A. 5N-4S-3N-8S-7N-6S	B. 5/6N-4/5S-3/4N-2/3S-8/9N-7/8S-6/7N
Coverage 4	A. 6N-7S-8N-3S-4N-5S	B. 6/7N-7/8S-8/9N-2/3S-3/4N-4/5S-5/6N
Coverage 5	A. 3S-4N-5S-6N-7S-8N	B. 2/3S-3/4N-4/5S-5/6N-6/7S-7/8N-8/9S
Coverage 6	A. 8S-7N-6S-5N-4S-3N	B. 8/9S-7/8N-6/7S-5/6N-4/5S-3/4N-2/3S
Coverage 7	A. 5S-4N-3S-8N-7S-6N	B. 4/5S-3/4N-2/3S-8/9N-7/8S-6/7N-5/6S
Coverage 8	A. 6S-7N-8S-3N-4S-5N	B. 5/6S-6/7N-7/8S-8/9N-2/3S-3/4N-4/5S

Timing and Weather

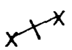
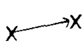
All visits must begin within 30 minutes before or after sunrise and end by 1100 h. Censuses should be conducted only on fair days with good visibility, no precipitation, and winds less than 3.6 m/s (8 miles/hour). Unseasonably cold days should be avoided.

Procedure

1. Two maps are used for each visit, one for the managed area and one for the control. At the beginning of each day, record date, observer, and weather on each map (see Figure 4–4). As each line is walked, record the beginning and ending time and direction of travel.

2. Walk the grid lines quietly and slowly (ca. 1.5 km/h) with occasional stops. Most birds are detected acoustically, but constantly scanning the vegetation will also produce sightings.
3. Record all contacts, including birds outside the study area. Exceptions are gulls and raptors flying well above the canopy.
4. Whenever a contact is made with a bird, indicate the bird's location on the visit map with a symbol (Table 4–4) that indicates the type of contact. The symbol is followed by the species abbreviation (see Table 4–2).

Table 4–4. Symbols used for territory mapping.

Symbol	Explanation
•	A bird heard calling but not seen (sex unknown).
O	A bird seen (sex unknown).
⊙	A bird seen and heard calling (sex unknown).
	If the sex of a bird is known, then the correct symbol is added to the circle.
♂	Male seen and heard calling.
♀	Female seen.
X	Adult male heard singing. Singing refers to a territorial vocalization and not various calls.
⊗	Adult male heard singing and also seen.
E	When the location of a singing bird can be estimated only generally, use a large E.
e	When the location of a calling bird can be estimated only generally, use a small e.
	If two birds of the same sex (usually two singing or fighting males) are detected simultaneously, mark a line between them and connect their location to the line. These observations are very important because they ascertain the presence of two distinct territories.
	Use an arrow to indicate any significant movements a bird makes during a census.
★	The location of a nest.

Make a note if the activity of the bird indicates that it is breeding. Examples of such activities include carrying nest material, food, or fecal sacks, courtship behavior, and aggressive interactions.

Composite Maps

At the end of a season, a composite map is made for each species with registrations compiled from the visit maps. A valid breeding territory is recognized as a cluster of a minimum of five registrations, of which at least three have high territorial significance (e.g., song).

Where a group of registrations might represent either one or two clusters, it is accepted as two clusters if (i) there is one pair of contemporary registrations, each supported by other observations; (ii) there are at least two pairs of non-contemporary registrations.

If the above requirements cannot be satisfied, then common sense, in combination with knowledge of the species' territory size, habit requirements, and general territorial behavior, must be used to evaluate the situation.

Clusters that overlap the edge of the plot are counted as belonging in the study area only if more than half of the registrations lie within the study area or on the boundary. Otherwise they are not counted.

Equipment

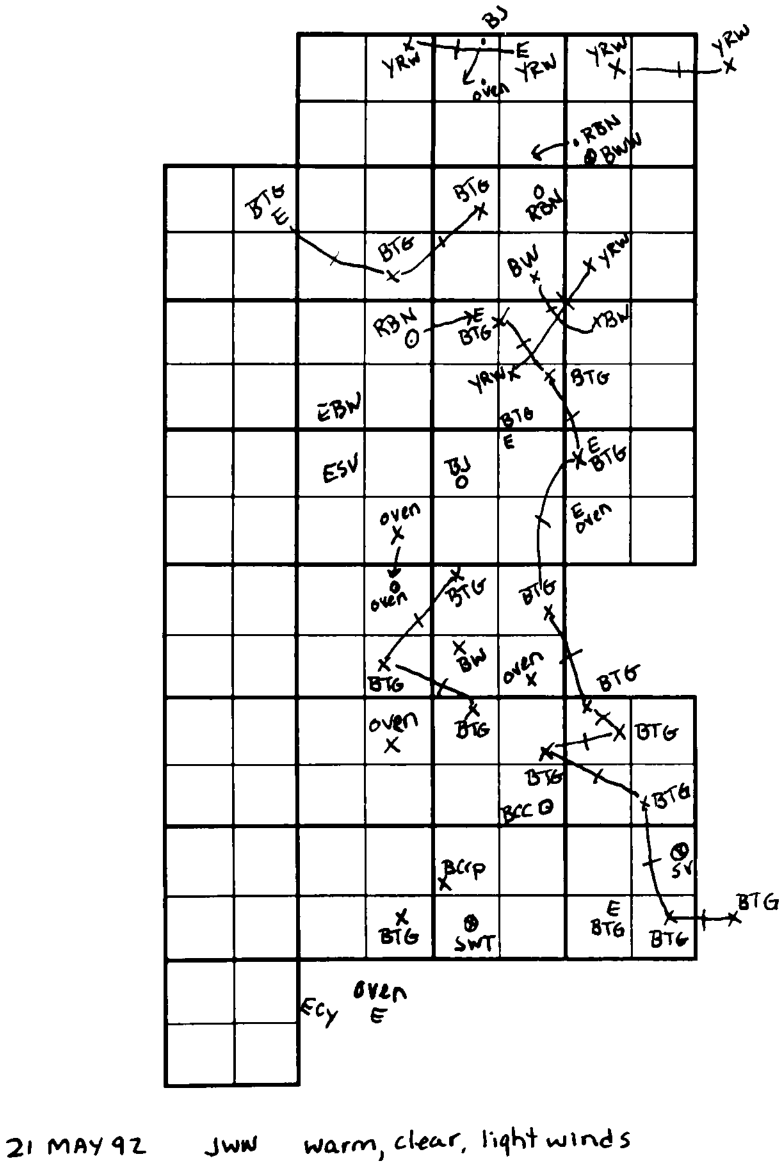
Clipboard
Field map data forms
Instructions
Colored pencils
Pencils
Binoculars
Blank composite maps
Light table

Evaluation

This is a generally accepted, standardized method with certain inherent problems and they apply here as well. Sixteen annual visits to the study area is probably over-sampling; it does provide good data, but with limited person-hours, it may be an inappropriate allocation of resources. (See, Ralph, C.J., and J.M. Scott. eds. 1981. Estimating Numbers of Terrestrial Birds. Studies in Avian Biology 6. Cooper Ornithological Society, 630pp.)

Date: 4 NOV 87 File name: BTERR.INS

Figure 4–4. Bird territory mapping.



NEST PREDATION STUDY INSTRUCTIONS

Introduction

For two back-to-back two-week periods in June, pairs of quail eggs are set out on the ground in predetermined locations in and adjacent to the study area. At the end of two weeks the eggs are retrieved; the incidence of opened or missing eggs indicates a relative rate of ground nest predation on the Holt Forest.

Procedure

1. *Ordering eggs.* Order 500 coturnix quail eggs from the Strickland Quail Farm, P.O. Box 9, Pooler, GA 31322 (912-748-5769), about a month before the study. The large number of eggs allows for extra eggs in case some are broken.
2. *Preparing eggs.* Approximately 190 eggs are needed for the transect study, and 250 are needed for the gap study. The morning that the eggs are to be set out, wash them in a sink of water only; remove and discard the floaters. Return the washed eggs to their cartons for transport into the woods.
3. *Locating nests.* Nests are marked by a pair of flags. ("Nest" refers to the location on the ground where the eggs are laid; actual nests are not used.) A green flag marks the nest location, and a yellow flag is located approximately 3m away. Nest locations are usually signalled by yellow flagging above or near the yellow flag on the ground. Green flagging marks the transects where they extend beyond the study area. Nests are also marked by a metal spike driven into the ground underneath the nest site. This provides a means for locating the nest site using a metal detector should the eggs be missing.

   Transect study. During the first two-week period, the eggs are set at 50m intervals along transect lines. The transect lines run from the Back River to Old Stage Road along the east-west quadrat lines. The yellow flag is on the transect line, and the green flag is found approximately 3m north or south (see data sheet). There are 93 "nest" sites, 15 each on the D, E, F, and G lines, 17 sites on the H line and 16 sites on the I line.

   Gap study. During the second two-week period, eggs are set in gaps. There are 72 sites in natural gaps, and 52 sites in harvest gaps; not all gaps have nests. In gaps, the green flag is always north of the yellow flag. The data sheets have a brief description of nest locations; it helps to take a map of the gaps and draw a route onto it before starting out.

3. *Setting out eggs*. Eggs can be put out by several one-person crews dividing up the study area. Each person takes enough eggs to do his/her stations plus some extras. It is important to wear rubber boots and use a pair of rubber gloves when handling the eggs to avoid leaving a human scent.
   Locate the green flag and place two eggs on the ground. Pick up the green flag and move it to the yellow flag. This prevents the possibility that predators might learn to associate flags with eggs. The transect eggs are set out for the first two-week period. Either the day that the transect eggs are picked up or the morning after, the gap eggs are set out for the following two-week period.
4. *Picking up eggs*. Two weeks after the set out date, the same person (if possible) retrieves the eggs. Rubber gloves are not necessary this time. At each nest location, pick up the remaining eggs, record the number of missing or disturbed eggs on the data sheet, and return the green flag to the nest site. Eggs can be put together in a plastic bag to be discarded. Eggs that appear to be missing are sometimes just so well camouflaged that they aren't visible. Carefully check the area immediately around the nest. (Watch where you put your feet.) If no eggs are found, it is very difficult to know where the green flag belongs. In such cases, return later the same day with the metal detector to locate the large nail driven into the ground under the nest site. Not only does this assure accurate replacement of the green flag, but sometimes the eggs are found.

Equipment

Eggs
Maps for gap locations
Extra yellow flagging
Plastic bag
Clipboard and data sheet
Rubber gloves
Metal detector

Evaluation

Questions about the reliability of artificial nests apply to this study as well. Our methods differ from other studies because nest baskets are not used. This does make it more difficult to locate eggs, but the overall time savings justifies this. There are no reports indicating the importance or necessity for using nest baskets. Artificial nest studies provide only relative information about nest predation because artificial nests can only mimic natural nests.

Date: 15 JUL 92 File name: NESTPRED.INS

Figure 4–5. Nest predation study sample data sheet.

NEST PREDATION DATA FORM: TRANSECT NESTS

HOLT RESEARCH FOREST: NORTH LINES

Date: 21 JUN 90 Crew: JWW SWG

D Line: nests are 9 meters east of pins = 15 nests
E Line: nests are 20 meters east of pins = 15 nests
F Line: nests are 7 meters east of pins = 15 nests

Quad	Predation	Quad	Predation	Quad	Predation
2D2-	0	2E4-	0	2F4-	0
3D1-	0	3E3-	0	3F1-	0
3D2-	0	3E4-	0	3F4-	0
4D3-	2	4E3-	0	4F3-	0
4D2-	0	4E4-	0	4F2-	0
5D1-	0	5E1-	0	5F1-	0
5D2-	0	5E2-	0	5F4-	2
6D1-	0	6E3-	1	6F3-	0
6D4-	0	6E2-	0	6F4-	0
7D1-	0	7E1-	0	7F3-	2
7D2-	0	7E4-	0	7F4-	0
8D3-	0	8E1-	0	8F3-	0
8D2-	1	8E4-	0	8F2-	0
9D3-	0	9E3-	0	9F3-	0
9D2-	0	9E2-	0	9F2-	0

SMALL MAMMAL TRAPPING INSTRUCTIONS

Introduction

Small mammal trapping is conducted twice a year in order to estimate population lows (after winter) and highs (end of summer). There are six census lines. Additionally, four assessment lines are used to assess the effective trapping range of the census lines. Other studies that occur along the census lines provide information about seedfall, tree regeneration, and cover type.

Trapping Period

Trapping occurs in April and August as close to the date used in prior seasons and the new moon as possible. Generally, this is the 3rd week of April and the 1st week of August. First, census lines are trapped for 5 nights, and after a 2-day break the assessment lines are trapped for 3 nights.

Trapping Layout

There are 284 trap stations laid out at 16.67m intervals along the census lines (144 stations) and the assessment lines (140 stations) (Figure 4–4). Each trap station is marked with orange-and-black-striped flagging, and each specific trap site is marked with a red plastic stake with an aluminum identification tag attached. Shingles to cover the traps are left at each station. Two traps are placed at each station. Caution: There are four regeneration plots located near each center pin; do not walk within 2m of the red and orange flags around the center pins.

Census lines. There are six parallel north-south census lines extending 400m from the E3 quadrats in the north to the I1 quadrats in the south. There are three trap stations on the line in each quadrat: north-1, center-2, south-3. Stations are identified by their quadrat number and their position within the quadrat, e.g., in quadrat 8I1 there are three stations, 8I11, 8I12, and 8I13.

Assessment lines. Four 565m assessment lines of 35 stations each are arrayed at 45° to the census lines (Figure 4–6). The A line begins at 2E/3E (which is the midpoint on the boundary between these blocks) and runs SE to 6I/7I. Stations are numbered 101–135 west to east. The B line begins at 4E/5E and runs SE to 8I/9I (stations 201 to 235). The C line begins at 2I/3I and runs NE to 6E/7E (301 to 335). The D line begins at 4I/5I and runs NE to 8E/9E (401 to 435).

Procedures

Set-up

1. Set out the census line traps using the south road and the F/G line to carry traps into drop locations as shown below.

	Number of traps at drop location
SOUTH ROAD	30 at 3I13 (carry in at beginning of setup)
	30 at 4I/5I
	30 at 6I13 (on road)
F/G LINE	36 at 3F3/3G1
	30 at 4F3/4G1
	36 at 5F3/5G1
	30 at 6F3/6G1
	36 at 7F3/7G1
	30 at 8F3/8G1

   Place two Sherman 9x8x23cm live traps immediately next to the station stakes on the day of the first trap-night.
2. Bait the traps with a mixture of one tablespoon of peanut butter to one cup of rolled oats (1/2 cup to 8 cups). Make forty cups of bait to begin a trapping session. Place approximately a tablespoon (or less) of bait on the trip door of the trap and about a teaspoon on the entrance door and just outside. Place a small wad of cotton batting (a "nestlet") in the trap and a cedar shingle over the trap. Spring the trap to ensure it is in working order at intervals throughout the trapping period. (This is especially important after rain when the bait is likely to "gum up the works.")
3. To move traps from the census lines to the assessment lines, first pick up and drop off the traps according to the following scheme:

Census line/Direction heading	# Traps	Drop location-Assessment line
3/N	48	2E/3E - A
4/S	22	4H12 - C
	26	4I/5I - D
5/N	22	5G32 - A
	26	6F12 - C
6/S	10	6F32 - B
	24	6H12 - D
7/N	20	7G32 - B
	20	7G12 - D
	22	7E31 - C
8/S	26	8H32 - B
	14	8I/9I - B

To put out the assessment line traps, begin at 2E/3E on the A line, proceed SE on this line, and return NW from 8I/9I on the B line. To put out the second set of lines, begin at 4I/5I on the D line, proceed NE, and return SW from 6E/7E on the C line. Traps are located at the following points:

Line A—48 at 2E/3E, 22 at 5G32
Line B—14 at 8I/9I, 26 at 8H32, 20 at 7G32, 10 at 6F32
Line C—22 at 7E31, 26 at 6F12, 22 at 4H12
Line D—26 at 4I/5I, 24 at 6H12, 20 at 7G12

Running the trap line

1. *Checking traps*. Check traps daily between ca. 0600 and 1000 hours. Normally this is undertaken by a two-person crew. The amount of bait to carry depends on the number of animals being caught. Carry a minimum of 8 cups. If a trap is not sprung but the bait is missing from the entrance, check it by tripping it, then rebait and set it. If a trap is sprung and empty, check the mechanism. Record sprung traps, birds, and herps on a separate data sheet for snapped traps (see Figures 4–9 and 4–10).
2. *Removing animals*. When a trapped mammal is found, carefully peek into the trap to determine the species (Table 4–5). Then transfer the animal to a handling bag as follows: (a) place the bag over the entrance and down the sides of the trap; (b) maintain a firm grip on the sides of the trap to prevent the animal from squeezing out between the bag and trap; (c) open the trap door with one finger; (d) shake the animal down into the bag with one firm shake; and (e) pull the closure on the bag tight. For all species, use a net bag. For *Sorex* and *Blarina*, use a small net bag. It is always important to prevent animals from chewing the bag and to watch for holes through which they might escape. Use caution with juveniles of all species as they easily slip out through the larger net bag.
3. *Marking*. The first priority is to mark the mammal with an ear tag, or, for voles and shrews, a clipped toe. Set the ear tag in the ear with tagging pliers as close as possible to the middle and base of the ear where the cartilage is strongest and least likely to tear. The tag should be parallel to the body and oriented to the animal's posterior so the number of the tag can be read easily (see Figure 4–7). Place the tags in the right ear in odd years and the left ear in even years unless

the appropriate ear is torn or missing. In this case, tag the other ear and note this on the data form.

Voles and shrews are marked by clipping a unique array of toes. Clip a maximum of one toe per foot. The toe should be cut above the toenail so it will not regenerate and so it will be obviously cut. Note that some mammals have only four front toes. Each toe is labeled according to the scheme depicted in Figure 4–7, e.g., the outer toe on the right rear foot is RR5. Record the toe clip pattern on the data form in the order left front (LF), right front (RF), left rear (LR), right rear (RR). The crew should have a card listing combinations to use and must record on a master list which combinations they have used.

4. *Taking Data*. See Figure 4–8 for a sample data sheet.
   Recapture. If an animal has been captured before, record its tag number or toe-clip pattern in the recapture column. Maintain a running tally of all tag and toe clip numbers used during the trapping session. Also note damaged ears from lost tags here, record 3 in the recapture column. If an animal was caught in a previous trapping session, record 4 in the recapture column.
   Sex and age. Determine and record the animal's sex and age (see Tables 4–7 and 4–8).
   Weight. Weigh the animal in a handling bag with a hand-held spring scale, and after releasing the animal, weigh the bag. It is very important to (a) hold the scale by the ring, and (b) read it carefully.
   Comments. Record anything unusual about an animal, such as presence of parasites (ticks or botflies) or an unusual pelage color. If an animal is found dead, it should be recorded and the animal saved with a tag listing date, station number, species, and weight.

Take-down

After a trapping session, it is essential to wash the traps thoroughly to remove residues of bait and feces.

Equipment

Packbasket
Hand-held spring scales (2) 100 g, 300 g
Plastic bags (for specimens)
Surgical scissors (for toe clipping)
Sherman 9x8x23cm traps (2 spare)
Handling bags (small and large)
Cardboard tags (for specimens)
Toe clip cards (1 for each species)

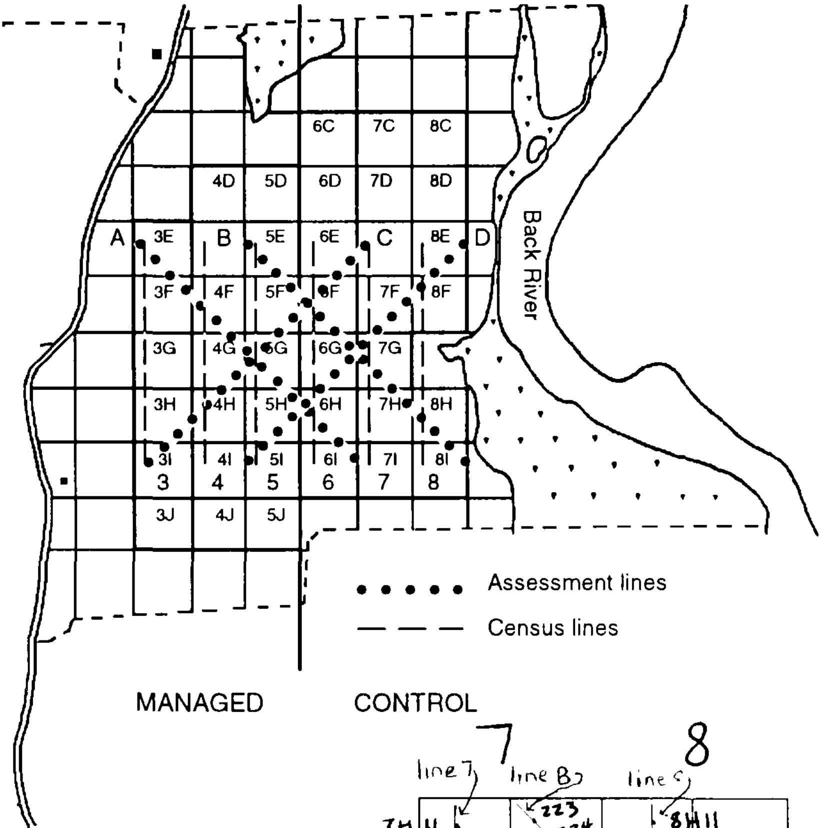
Ear tags
Data sheets and instructions
Ruler
Cotton batting squares ("Nestlets")
Spare pencils
Bait container (8 cups minimum)
Leather gloves (for handling shrews)
Ear tag pliers
Clipboard
Extra shingles (Map—layout of small mammal trapping lines)

Evaluation

This method works well for documenting changes in populations between seasons and from year to year. The modified census/assessment line method provides information about populations over a large portion of the study area, whereas a typical grid system method would limit sampling to a small area. The trap size limits the effectiveness for sampling larger mammals (particularly red and gray squirrels) and placing traps on the ground may limit its effectiveness for sampling flying squirrels. One problem associated with checking traps only once per day is high shrew mortality. Also, moving the August trapping session to later in the season would probably result in greater numbers of captures, but the limited availability of student help makes this difficult.

Date: 4 NOV 87 File name: MAMMAL.INS

Figure 4–6. Layout of small mammal trapping.



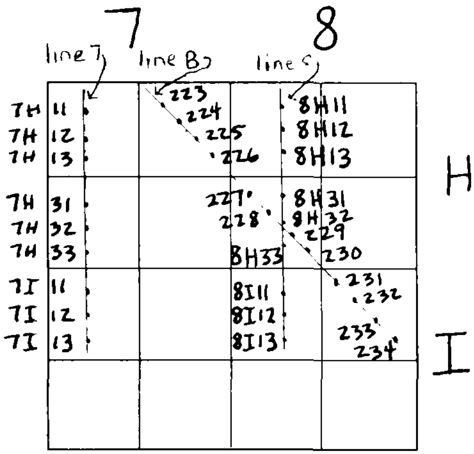


Figure 4–7. Marking small mammals.

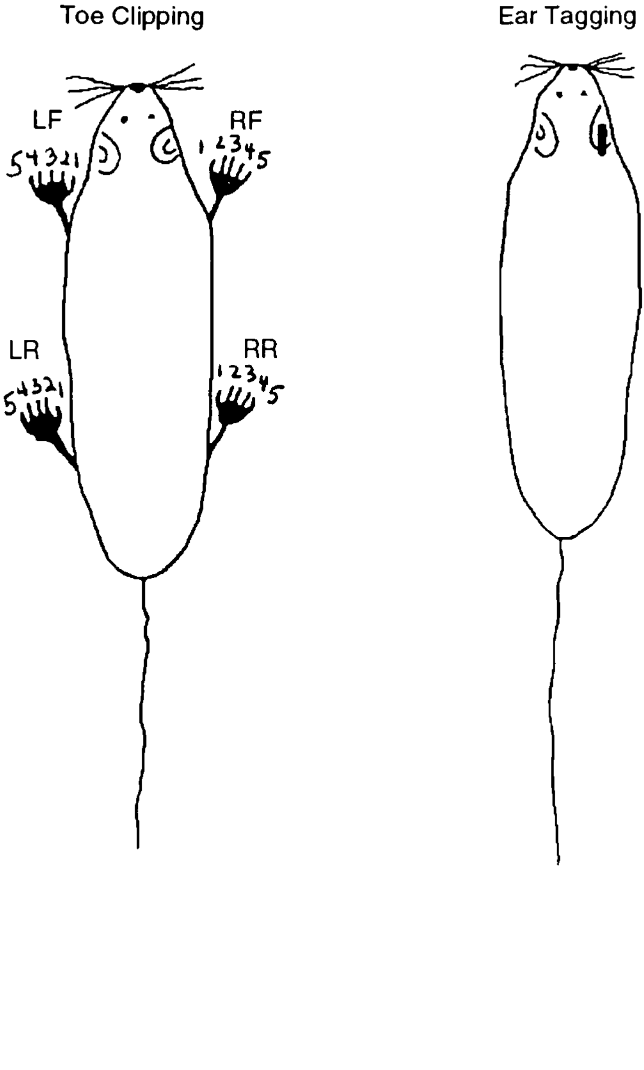


Figure 4–8. Small mammal trapping data sheet.

HOLT RESEARCH FOREST
SMALL MAMMAL TRAPPING DATA

(221)

Date 8 AUG 92 Observers JWW, KEM Page 1 of 2

Weather clear warm

Station	Species	Ear tag# or Toe Clip	Recapture	Sex	Age	------ Weight ---- Total	Bag	Net	Comments
3I12	Tamias		1408						
3I11	Tamias		1225						
3I11	Tamias	1389	4	F	A	138	60	78	
3H31	Pero		1409						ticks Ⓐ
3H11	Tamias		1809						
3G33	Pero		1390						
3G33	Sorex			M	A			3.4	dead
3G31	Pero		1339						ticks Ⓑ
3G13	Tamias		1392						
3G12	Tamias	1434		F	A	148	64	84	
3E31	Pero		1394						tick Ⓒ
4F12	Pero		1366						
4F12	Tamias		1410						dead
4F13	Pero		1430						
4G31	Tamias		1395						
4G32	cleth	RF4 RR3 403		M	A	40.7	61.4	28.8	
4H11	Pero	1435		M	J	75.7	65.1	10.6	
4H11	Pero	1436		M	J	74.8	61.8	13.0	
4H31	Pero	1437		M	J	76.3	61.7	14.6	
4I13	Pero	1438		M	J	77.4	61.9	15.5	
5I12	Pero	1439		M	A	78.5	61.4	17.1	
5H33	Pero	1398	4						
5H11	Pero	1440		M	J	75.0	62.2	12.8	
5G33	cleth	RF4 LR3 410		F	A	83.5	62.0	21.5	
5G32	cleth	RF2 LR3 230→	recap 230						
5G13	Tamias		1415						
5G12	Cleth	RF3 RR2 recap →	302						
5F33	Tamias		1416						
5F11	Tamias		1400						

Figure 4–9. Snapped traps data sheet.

HOLT RESEARCH FOREST
SMALL MAMMAL TRAPPING

SNAPPED TRAPS-CENSUS LINES

Trapping Session April 90 Julian Dates 111-115

	# snapped						# snapped						# snapped				
Dates	111	112	113	114	115		111	112	113	114	115		111	112	113	114	115
3I13	2					5I13						7I13					
3I12	1			1		5I12	2					7I12	2	2			
3I11						5I11	2					7I11	2	2			
3H33	1					5H33			1			7H33	2	2			
3H32			2	2		5H32						7H32	2	2			
3H31						5H31					1	7H31			1		
3H13						5H13			1			7H13					1
3H12		2	2			5H12						7H12					
3H11		2	2			5H11		2				7H11		1			
3G33		2	1			5G33		2				7G33					
3G32		2	2			5G35		2				7G32					
3G31		2	1	1		5G31						7G31					
3G13		2	2	1		5G13			1			7G13					
3G12						5G12	1					7G12	1		1		
3G11					1	5G11						7G11					
3F33						5F33						7F33					
3F32						5F32	1					7F32	1				
3F31	1					5F31						7F31					
3F13			2			5F13						7F13					
3F12						5F12						7F12					
3F11						5F11	1					7F11	1				
3E33	2					5E33				2		7E33					
3E32				1		5E32				2		7E32			2		
3E31						5E31				2		7E31					
4E31	2					6E31						8E31					
4E32			1			6E32						8E32		1			
4E33	2					6E33						8E33				2	
4F11						6F11		1		1		8F11					
4F12			1			6F12						8F12					
4F13						6F13			1			8F13				1	
4F31						6F31						8F31		1			
4F32	2					6F32	1					8F32					
4F33		2	2			6F33	2					8F33			1		
4G11		2	2			6G11			1			8G11	1				
4G12		2	2			6G12		2				8G12	1				
4G13		1				6G13		2				8G13		1			
4G31		2				6G31					1	8G31					
4G32						6G32						8G32			1		
4G33						6G33						8G33					
4H11	2					6H11			1			8H11					
4H12				1		6H12						8H12	1			2	
4H13			1			6H13		1				8H13					
4H31						6H31	2					8H31					
4H32						6H32	2					8H32		1			
4H33	1			1		6H33			1			8H33	2				
4I11			2			6I11						8I11			1		
4I12						6I12				1		8I12					

Figure 4–10. Snapped traps data sheet page 2.

HOLT RESEARCH FOREST
SMALL MAMMAL TRAPPING

SNAPPED TRAPS-ASSESSMENT LINES

Trapping Session April 90 Julian Dates 118-120

Dates	118	119	120	Dates	118	119	120	Dates	118	119	120
101			2	223				425			
102			2	222	1	1	1	426			
103	1			221				427			
104				220				428	1		
105				219				429			
106		1		218			2	430	1		
107		1		217			2	431			
108				216				432			
109	1	1	1	215				433	2		
110	1	1	1	214				434			
111	1			213		1		434			
112	1			212				435	1		
113	1			211				335			
114				210	2			334			2
115				209				333			2
116				208	2			332			2
117				207				331			
118				206				330			
119				205				329			
120		2		204		1		328		1	
121				203				327			
122				202	1			326			
123				201		1		325			
124				401				324	1	1	
125				402				323	1		
126			1	403				322			
127		1		404		2		321			
128				405		2		320			
129				406		2		319		1	
130				407		2		318			
131				408				317	2	2	
132		2	2	409				316			
133		2	2	410				315			1
134		2	2	411				314			
135		2	2	412				313			
235				413				312		1	
234				414	1			311			
233				415	1			310			1
232				416	2			309			
231	1			417	1			308	1		
230				418				307			
229		1	1	419				306			
228				420				305	2	1	
227				421		1		304			2
226		1		422				303			2
225				423			1	302			2
224				424		2		301			

Table 4-5. Species characteristics.

Species Name	Common Name	Description
	Species previously caught	
Blarina brevicauda	Short-tailed shrew	largest shrew, venomous bite, difficult to sex and age, look for nipples
Sorex cinereus	Masked shrew	total length less than 111 mm, 5 upper unicuspids, difficult to sex and age
Tamiasciurus hudsonicus	Red squirrel	reddish fur, 4 toes front feet, 5 toes rear feet
Glaucomys sabrinus	Northern flying squirrel	belly hairs are white at tip, slate at base
Glaucomys volans	Southern flying squirrel	belly hairs are white at base, smaller than northern flying squirrel
Peromyscus leucopus	White-footed mouse	see Table 4–6
Clethrionomys gapperi	Red-backed vole	short tail, reddish color
Microtus pennsylvanicus	Meadow vole	short tail, thick bodied, chestnut-yellow brown
Tamias striatus	Eastern chipmunk	reddish-orange brown, stripes on back
	Species not caught to date	
Sorex fumens	Smoky shrew	bigger, heavier, and darker than masked shrew
Microsorex thompsoni	Pygmy shrew	hind foot length less than 9mm, 3 upper unicuspids
Parascalops brewari[1]	Hairy-tailed mole	furry tail
Condylura cristata	Star-nosed mole	pink tentacles on nose, naked tail
Peromyscus maniculatus	Deer mouse	see Table 4–6

[1] One found dead in NE corner of 4D1, 1 JUL 87; also NW 3E1, 14 AUG 87.

Table 4–6. Identification of *Peromyscus*.

	P. leucopus	*P. maniculatus*
Tail:	seldom as long as head and body; usually darker than white on ventral surface; seldom with well-defined pencil	usually as long or longer than head and body; usually distinctly white on ventral surface; frequently with well-defined pencil
Pelage:	reddish; usually with well-defined middorsal stripe; seldom soft or luxuriant	grayish; usually with only a slight middorsal stripe; characteristically soft and luxuriant

Table 4–7. General sex and age criteria.

	Adult Criteria	Juvenile Criteria	Sex Criteria
Female	presence of nipples	no nipples	urogenital opening and anus adjacent
Male	descended scrotal sac	scrotal sac not descended	presence of baculum (still bone in penis) can be felt with pencil tip; urogenital opening and anus separated

Table 4–8. Sexing adult shrews.

Males:	Swollen inguinal areas from enlarged testes, penis may be everted—(manipulate with pencil), development of lateral glands that emit a strong distinct odor. On dead individuals, the penis will pop out if the urogenital area is squeezed.
Females:	Lack of above characteristics, signs of pregnancy or lactation

WINTER TRACK COUNT INSTRUCTIONS

Introduction

Winter track counts are undertaken in conjunction with bird strip censuses when adequate snow is present. Track counts provide data for an index of abundance for mammals greater than squirrel size and grouse.

Procedure

1. Take data sheets and track identification book when bird strip censusing on mornings with snow on the ground.
2. Record date, observer, page number, lines censused, weather, date and amount of last snowfall, and snow depth at the top of each data sheet.
3. Observe all animal tracks crossing the census line, and record information described under data sheet components.
4. After recording the observation, erase the track at the transect line to avoid duplicating records.

Data Sheet Components (see Figure 4–11)

BLOCK: Block number of the transect line.

SPEC: Species of animal. If unknown put "?" and a description of the track with measurements.

TR: The number of tracklines at this location, i.e., probable number of individuals.

DESCRIPTION: A description of the animal's activity and locations, e.g., crossing 3H4 to 3H3, 16m N of 3H/3I.

Equipment

Data sheets — Track identification book

Ruler

Evaluation

Track counts provide an estimate of species abundance, but are limited by the irregularity of snowfall, difficulty in distinguishing species, and the fact that some mammals, particularly deer and fox, use the transects as trails.

Date: 4 JAN 1988 — File name: WINTRACK.INS

Figure 4–11. Winter track counts data sheet.

HOLT RESEARCH FOREST
WINTER TRACK COUNTS

Date 5 FEB 90 Observer JWW Page 1 of ____

Weather CCC Line Censused S648

Last Snow Date 4 FEB Amount 25 cm Snow Depth 20-40 cm

BLOCK	SPEC	#TR	DESCRIPTION
6I	porcupine	1	cross 10m N 6I/J
6F	deer	3	cross 10m N cent 6F
6E	"	3	cross 20m S cent 6E
"	"	2	on trans 15m N cent 6E → 15m S 6I
"	"	2	cross 10m S 6D/6E
4H	fox	1	cross 4m N 4H/I
8I	deer	1	cross 6m N 8I/J
"	↓	3	cross 20m N 8I/J
"	↓	1	cross cent 8I
"	↓	2	cross 8m N cent 8I
"	↓	3	cross 25m S 8H/I
"	↓	2	cross 7m S 8H/I
8H	"	6-9	cross 10-15m N 8H/I 3+ beds off trans 1
8H	"	1	on trans 3m S to 4m N cent 8H
8F	"	1	on trans 16m N 8F/G → 14m S cent
"	"	1	cross 3m S cent 8F
"	"	1	on trans 12m N cent 8F → 7m N cent
8E	deer	2	cross 14m N 8E/F
"	"	2	cross 18m S cent 8E
"	"	2	on trans 16m S 8D/E → 4m S 8E
8D	deer	1	cross 17m N 8D/E

SALAMANDER POPULATION STUDY

The techniques used at the Holt Research Forest to assess salamander populations have changed significantly over the course of the study. Because we feel that the techniques we no longer use may be both useful in understanding why we do what we do now and also may be of value at other research stations, we have included them here with a discussion of our experience.

Following are three sets of instructions: "Salamander Shingle Set-up Instructions," "Salamander Shingle Station Instructions," and "Salamander Censusing Instructions." The first two involving shingles detail our current methods. The third includes both strip censusing and quadrat searching methodologies; we no longer use strip censuses, and rarely conduct a quadrat search.

Evaluation

The methods for assessing salamander populations have changed since we began. Rainy night censusing and quadrat searches were used initially. The rainy night censusing was dropped because it produced low numbers of salamanders, and it was hard on crew morale. Another difficulty was having an adequate crew available when the weather was appropriate for sampling. Quadrat searches are still used but on a limited basis; they, like censusing, are labor intensive and weather dependent. Quadrat searches also have the disadvantage of being destructive in an area where disturbance needs to be minimized. Micro-site differences tend to produce variation that is sometimes difficult to explain. The presence of many zeros and ones in the data makes analysis more difficult. As with any sampling method for salamanders, there is always the question of what portion of this fossorial species population is being sampled.

The shingle method provides a non-destructive sample from a consistent location by providing an artificial refuge for salamanders to utilize. If individuals were marked, more information about use of surface refugia and territoriality of individuals could be obtained.

Date: 20 JAN 93 File name: SALPOP.INS

SALAMANDER SHINGLE SET-UP INSTRUCTIONS

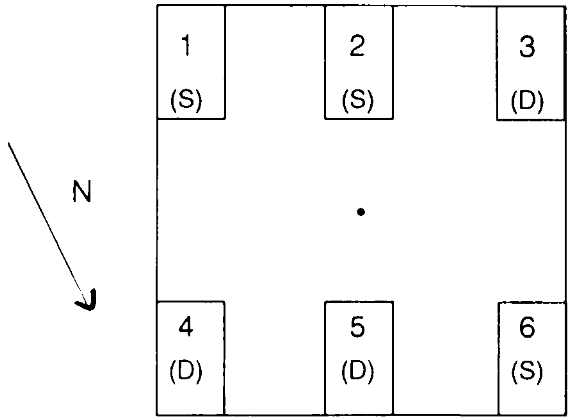
Introduction

Cedar shingles on the forest floor act as refugia for salamanders. We have set out shingles along two transect lines in stations of six in order to collect information about salamander populations. The arrangement of the shingles at the station and the station locations provide coverage in a range of habitat types. Set-up of the shingles is described here. See "Salamander Shingle Station Instructions" for censusing procedures.

Procedure

1. Cut cedar shingles into 10x25cm size. Prepare enough for six at every station.
2. There are thirty stations along the north S-1 line and thirty along the south S-1. Each station is south of the S-1. Prepare sixty tall yellow flags to mark the station's location by marking each with an "N" or "S" followed by the distance in meters from the west end of the line, e.g., N120 or S505.
3. Upon reaching a station, put the appropriate yellow flag in the actual center point of the station. Stations are generally 2–3m south of the S-1 where the ground is most level.
4. Measure a 1m square around the flag and place the shingles in the corners and midpoints as shown below in Figure 4–12. The shingles are numbered according to their position at the station; though they are not actually labelled by these numbers, they are referred to using this arrangement.

Figure 4–12. Salamander shingle layout and placement.



5. Within each pair of shingles (1–4; 2–5; 3–6), place one on the surface of the litter and one in a 5cm deep hole in the litter. Determine the placement by flipping a coin: heads=shallow (S) and tails=deep (D) as shown in Figure 4–12. Only one coin toss is required for each pair. Mark on a blank data sheet the placement of each shingle with an S (shallow) and D (deep).
6. Shingles will need to be maintained over time. During a census, note any shingles that have disintegrated. In a visit separate from a census, replace those shingles and check that all shingles designated D (deep) are lying squarely at 5cm depth.

Equipment

Tall yellow flags
360 10x25cm cedar shingles
Clipboard
Pencil
Meter tape
Trowel
Black marker
Data sheet from "Salamander Shingle Station Instructions"
Ruler
Coin

Date: 01 DEC 92

File name: SS-SETUP.INS

SALAMANDER SHINGLE STATION INSTRUCTIONS

Introduction

Estimating salamander populations is difficult. We have set up permanent stations along two transects using cedar shingles which act as refugia. Periodically throughout the field season (May–October) each station is checked and data recorded for the salamanders found under the shingles.

Sixty salamander shingle stations are located south of the S-1 lines, thirty each along the north and south lines. Each station is composed of six shingles arranged in two rows of three in a $1m^2$ area. The shingles are numbered by their position in the array as shown in Figure 4–12.

Procedure

1. Walk the S-1 lines. The stations are all south of the S-1 and are marked with a large yellow flag with a number on it. The number is the distance along the S-1 starting from the west end.
2. At the station, check the shingles in numerical order to avoid overlooking one. Push aside any litter and carefully turn over one shingle at a time. When a salamander is found, put it in a resealable bag moistened with some water. Do not put salamanders from different shingles in the bag together.
3. For each salamander, record the following three data items in the block for the appropriate station and shingle number (see Figure 4–13).

   Color phase. It will probably be either the red-back (RB) or lead-back (LB) color phase of the red-backed salamander (*Plethodon cinereus*).

   Snout-vent length. Measure in millimeters the straight distance from the end of its nose to its vent. Sometimes rolling it into a fold or the end of the bag helps keep the salamander from curling around.

   Sex. Sex is determined for *Plethodon cinereus* by the shape of the nose. Females are roundish, males are blunt.

Female

Male

If two salamanders are found under one shingle, record the data in a nearby empty space and make it clear which shingle it came from.

4. Return the salamander to its shingle. Replace each shingle after it is checked, but do not re-cover it with litter. If salamanders are found above the shingle or in the duff around it, do not count them. Count only salamanders under the shingle.

Equipment

Clipboard and data sheet
Small resealable bag moistened inside
Clear ruler

Date: 13 JUL 92

File name: SALSHING.INS

Figure 4–13. Salamander shingle data sheet.

HOLT RESEARCH FOREST
SALAMANDER SHINGLE COUNT

Date 25 Sep 92 Observer EHM

Line	Station	SHINGLE NUMBER 1	2	3	4	5	6	Line	Station	SHINGLE NUMBER 1	2	3	4	5	6
North	5	—	—	—	RB ♂ 44	—	RB ♂ 28	South	5	—	—	—	—	—	—
North	20	—	—	—	—	—	—	South	60	—	—	—	—	—	—
North	35	—	—	—	—	—	—	South	70	—	—	—	—	—	—
North	70	—	—	—	—	RB ♀ 20	—	South	80	—	—	RB ♀ 30	—	—	—
North	80	—	—	—	—	—	—	South	90	—	—	—	—	* —	LB ♀ 26 *
North	90	—	—	RB ♀ 40 *	—	—	—	South	105	—	—	—	—	—	—
North	100	RB ♀ 42	—	—	—	RB ♂ 30 *	—	South	135	—	—	—	—	—	—
North	110	—	—	—	—	RB ♀ 41	RB ♂ 39	South	165	—	—	RB ♀ 43	—	—	—
North	120	—	LB ♀ 29	RB ♀ 26 *	—	—	—	South	175	—	—	—	—	—	—
North	165	—	—	—	—	—	—	South	185	—	—	—	—	—	—
North	190	—	—	—	—	—	—	South	195	—	—	* —	LB ♀ 28	—	—
North	220	LB ♂ 41 *	—	—	—	—	—	South	225	—	—	LB ♀ 44	—	—	—
North	230	—	—	—	—	—	—	South	245	—	—	—	—	—	—
North	245	—	—	—	—	—	—	South	265	—	—	—*	—	LB ♀ 34	—
North	260	—	—	—	—	—	—	South	280	—	—	—	—	—	LB ♀ 35
North	280	—	—	—	—	—	—	South	290	—	—	—	—	—	RB ♂ 35
North	325	—	LB ♀ 41	—	—	—	—	South	325	RB ♂ 26	—	—	—	RB ♂ 42	—
North	340	RB ♀ 38	—	—	—	—	—	South	345	—	—	—	—	RB ♂ 38	LB ♀ 27
North	360	—	—	—	—	—	—	South	365	RB ♂ 38	—	—	—	—	—
North	380	—	—	—	—	—	—	South	380	LB ♀ 31 *	—	—	—	—	—
North	395	—	RB ♀ 26	—	—	—	RB ♀ 39	South	415	—	—	—	—	—	—
North	410	—	—	—	—	—	—	South	430	—	—	—	—	—	* —
North	440	—	—	—	—	—	—	South	445	—	—	—	—	—*	—
North	470	—	—	—	—	—	—	South	480	—	—	—	—	—	—
North	495	—	—*	—	—	—	—	South	495	—	—	—	—	—	—
North	508	—	—	—	—	LB ♂ 40	—	South	505	—	—	—	—	—	—
North	520	—	—	RB ♂ 40	—	—	—*	South	520	—	—	—	—	—	—
North	535	—	—	—	—	—	—	South	560	—	—	—	—	—	—
North	560	—	—	—	—	—	—	South	575	—	—	—	—	—	—
North	580	—	—	—	—	—	—	South	595	—	—	—	—	—	—

* needs new shingle

SALAMANDER CENSUSING INSTRUCTIONS

Strip Censusing

1. Strip censuses for salamanders will be conducted on rainy nights in June when the woods are dripping wet.
2. On the first three rainy nights all of the bird census lines (4200m) will be censused. From these censuses, the five most and five least populous 100m sections will be identified and these sections will be censused on three additional nights.
3. Censuses will begin after 2000 hours.
4. Crews will consist of two people. Three crews are necessary to census 4200m in a reasonable time.
5. To census a line, the crew members walk beside each other, slowly scanning a 2m-wide strip centered on the census line. Salamanders >1m from the census line are not counted; thus the effective census area is 2m wide x 4200m long = $8400m^2$.
6. For each block (100m of census line) the block number and beginning time are recorded. Record the ending time if it is not the same as the beginning time for the next block.
7. The species of salamander and number of individuals (use slashes) are recorded for each block. If any individuals are above the ground, their height should be estimated in centimeters. If no individuals are found write "None" in the species block. Place any unidentifiable specimen in a plastic bag and bring it back to the field station.

Quadrat Searching

1. On the day following the strip censuses 40 randomly located $1m^2$ quadrats will be searched for salamanders. One search will be conducted in each block.
2. The plots will be located by reference to a four-digit number from a random number table. Record the random number in the left margin. The first two digits will determine how many meters to proceed into a block along the transect line. The third digit determines whether the quadrat is on the right (even number) or left (odd number). The fourth digit determines the perpendicular distance from the transect line to the $1m^2$ quadrat center.
3. The quadrat is delineated by a collapsible PVC frame. Because it is possible that salamanders will move deeper

into the litter in response to disturbance, it is advisable to talk quietly and walk softly during the following steps.

4. Vegetative characteristics will be determined as follows:

Tree layer (>5m):	% coverage (nearest 10%) dominant species
Shrub layer (1–5m):	% coverage dominant species
Herb layer (<1m):	% coverage dominant species
Ground cover:	% each component

See "Relevé Instructions" for how to estimate percentage coverage. A species must account for at least 25% of the strata coverage to be considered dominant. Write "mixed" if no species is dominant. The ground cover components are: dry litter, wet litter, log, tree bole, tree root, moss, lichens, soil, rock, and water (see "Tree Regeneration Instructions" for more detailed definitions).

5. Sift through all leaf litter and the loose organic pad searching for salamanders. Begin by removing the litter from the perimeter of the quadrat in case salamanders try to escape by moving laterally. Turn over rocks; tear apart rotten logs. Remove material as it is searched.
6. Identify and count all salamanders found. If a female with a clutch is found count the number of eggs and describe its location as precisely as possible (e.g., species of log, depth in log, etc.). If no salamanders are found write "None" in the species column.
7. Replace the litter and salamanders on the quadrat.

Equipment

Flashlights or headlamps	Compass
Clipboard	Data sheets
Pencils	Plastic bags and labels
Watch	Quadrat frame
Tape measure	

Date: archive File name: Herparch.ins

Figure 4–14. Archive salamander strip censusing data sheet.

HOLT RESEARCH FOREST
SALAMANDER STRIP CENSUSING

Date 13JUN83 Observers ASK, JWW Weather Rainy, cool, dark

Block Number	Time Begin	Time End	Species	Number	Height
3J	2010		None		
3I	2019		None		
3H	2029		Redback S.	IIII	15, 20
3G	2046		Redback S.	~~IIII~~ I	50, 10, 40
			Toad	I	
3F	2052		Redback S.	II	25, 20
3E	2107	2117	Redback S.	~~IIII~~ III	15, 5, 25, 30, 50
4D	2128		None		
4E	2139		Redback S.	I	
4F	2151		Wood frog	I	
4G	2202	2211	None		

Figure 4–15. Archive salamander quadrat search data sheet.

HOLT RESEARCH FOREST
SALAMANDER QUADRAT SEARCH

Date 14 JUN 83 Observers MLH JWW Weather drizzle, cool

	Location	Species	Number	Trees %	Trees Species	Shrubs %	Shrubs Species	Herbs %	Herbs Species	Ground %	Ground Component
5489	3J2	Redback	1	85	RM	40	Corylus	20	Maianthem	10	rock
	—	—	—	—	—	—	—		Gaultheria	60 10	moss dry litter
0463	3I4	None		80	WP/RO	60	Gayluss.	5	Vacc. angust.	30 20	tree bole lichen
	—	—	—	—	—	—	—	—	—	50	dry litter
6875	3H1	None		40	RO/WP	10	BF	15	Pteridium Ly. obsc.	20 80	moss dry litter
1131	3G3	Redback	2	75	RM	0	—	30	Anenome Panax	30 70	log wet litter
7812	3F1	Redback	1	100	WP	15	WP	10	Aralia	100	dry litter
2239	3E3	None		85	RO	20	RS	30	Juniperus	40 10	moss lichen
	—	—	—	—	—	—	—	—	—	50	dry litter
4913	4D4	Redback	1	70	HM	0	—	20	Mixed	100	dry litter

INSECT FRASS SAMPLING INSTRUCTIONS

Introduction

Insect frass is collected and counted to provide an index of insect abundance, especially of foliage-foraging insects, primarily larvae of lepidoptera and coleoptera. These insects form an important food source for foliage-gleaning birds. This method is particularly useful for quantifying any insect infestation (e.g., gypsy moth) that may occur.

Set-up

There are 40 sample sites located under white pine (8), red spruce (8), red oak (8), red maple (8), isolated hemlock (4), and hemlock groves (4) along the E/F and H/I lines (see Figure 4–16 for map of locations). Sites are marked with orange flagging and consist of a 5x5cm stake, 15cm above ground level with a finish nail on its top to hold the sample card in place. Sample sites are located under the selected tree species where drift from another species cannot easily fall.

Procedure

1. Sample only when the weather predicted for the next 24 hours is clear, low winds, and seasonal temperatures. Try to sample every other week during the period from late May to late August.
2. *Card preparation.* Cards are 25x25cm white corrugated cardboard. On sample days, label each card with a sample number and date. Cover each card on one white side with a light coat of tree tanglefoot, spreading it to within 2cm of the edge using a wide blade putty knife. Stick together cards from adjacent sample sites (see Table 4–9) and poke a hole in their centers (use a nail mounted in a vice). Carry them by these pairs into the study area.

Table 4–9. Pairings of frass cards.

E/F	RS1–RM1	RM2–RO1	RO2–WP1	WP2–RS2	HM1–HM2
Line	RS3–HM3	RO3–RS4	WP3–RM3	RM4–WP4	RO4–HM4
H/I	HM5–HM6	RO5–RM5	RS5–RS6	WP5–RM6	WP6–RO6
Line	RM7–RM8	RO7–WP7	WP8–RO8	RS7–HM7	RS8–HM8

3. Locate each card on its appropriate stake (the stakes are labelled) with the sticky side up and the finish nail through the hole in the card. Make sure each card is properly balanced.
4. Pick up cards 24 hours after placement and cover each with clear plastic film.
5. *Counting frass*. Count the frass as soon as possible after collecting, using a template to define the sample sections (Figure 4–16). There are two different sampling areas on each card, a 10x10cm section for large frass and eight 1x5cm sections for small frass.

   Count all large frass (>1mm on at least one dimension) in the large center sampling block. Use a ruler and a hand lens when necessary. It is helpful to circle qualifying frass with a red pen on the clear film, and then count the circles. Only small frass (<1mm) is counted in the 1x5cm sections. Use a dissecting scope to count. Count first in the section labelled 1; if a zero count is found in 1, then count three more sections (same location on other sides, labelled 2, 3, 4). If a zero count is still found, then the remaining four sections (5, 6, 7, 8) are counted. On the data sheet, record both the number of frass (large and small) and, for the small frass, the number of 1x5cm sections counted (see Figure 4–17).

Equipment

Insect frass cards (25x25cm corrugated cardboard with at least one white side)	Tree tanglefoot
	Putty knife
	Markers
Nail mounted in vice	Clear plastic film wrap
Dissecting scope	Hand lens
Red pen	Pencils
Sample template	Data sheets

Evaluation

This sampling technique provides an effective but coarse estimate of abundance, useful for general indices of abundance. Difficulties sometimes arise in distinguishing small frass from other debris, but if the samples are counted as soon as possible this problem is minimized. Finding good weather conditions at proper intervals for setting out the cards is sometimes difficult.

Date: 4 NOV 87 File name: FRASS.INS

Figure 4–16. Location of frass collection stations and sample template used for frass counts with an example of counting 1x5 sections (not to scale).

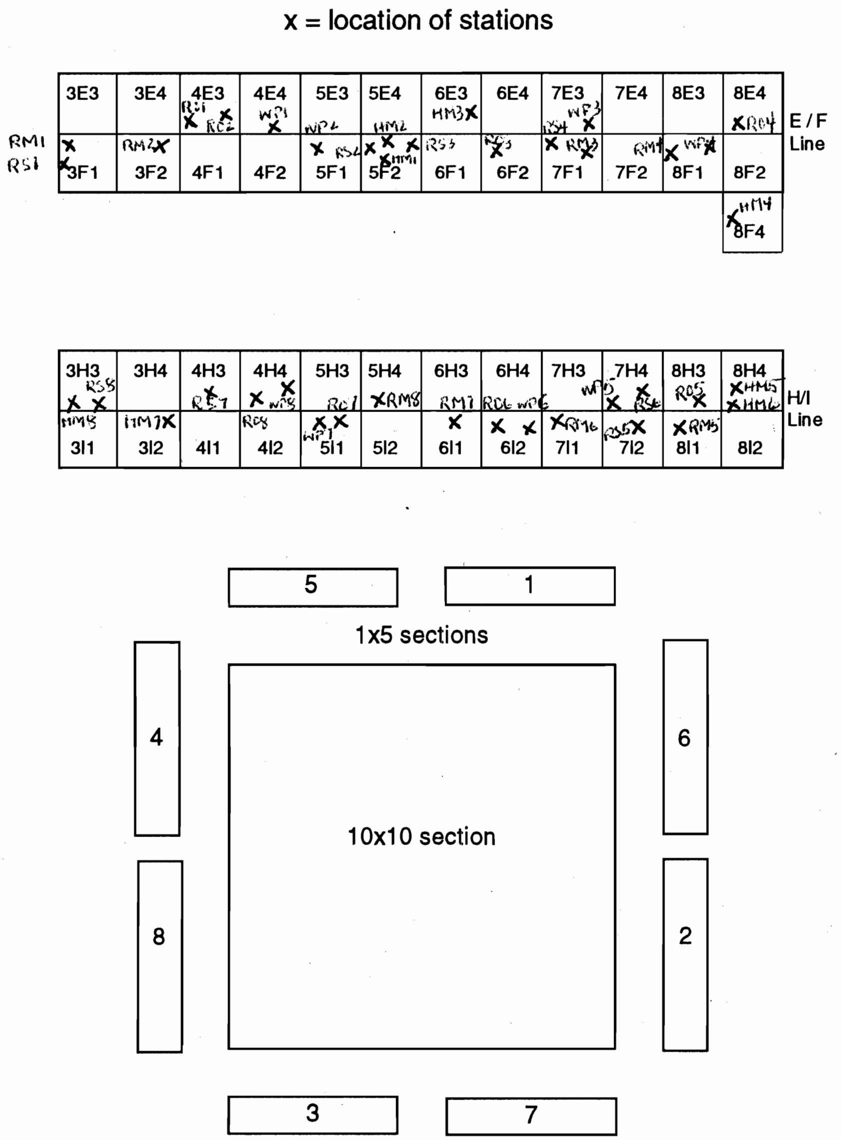


Figure 4–17. Insect frass data sheet.

HOLT RESEARCH FOREST
INSECT FRASS DATA SHEET

Date 20/21 JUN 91 Observer EHM 11SEP91

Sample #	#Large Frass	#Small Frass	#Sections Used	Sample #	#Large Frass	#Small Frass	#Sections Used
WP1	31	3	1	HM1	4	14	1
WP2	4	7	1	HM2	4	8	1
WP3	1	8	1	HM3	2	7	1
WP4	6	10	1	HM4	2	12	1
WP5	13	12	1	HM5	12	19	1
WP6	3	9	1	HM6	13	18	1
WP7	34	7	1	HM7	6	11	1
WP8	21	11	1	HM8	27	9	1
RS1	5	6	1	RM1	2	4	1
RS2	3	8	1	RM2	3	3	1
RS3	1	5	1	RM3	1	8	1
RS4	7	7	1	RM4	3	5	1
RS5	6	11	1	RM5	6	5	1
RS6	13	15	1	RM6	4	9	1
RS7	14	8	1	RM7	10	3	1
RS8	15	25	1	RM8	10	9	1
RO1	19	14	1	RO5	2	7	1
RO2	4	13	1	RO6	11	5	1
RO3	6	9	1	RO7	18	7	1
RO4	4	9	1	RO8	3	8	1