United States
NORTH AMERICAN
Department of Agriculture
MAPLE PROJECT

Forest Service

* Forest Health Protection
Northeastern Area
State and Private Forestry

* Northern Stations Global Change
Research Program
Cooperative Field
Manual

(Eighth Revision from
1988)
* National Forest Health
Monitoring Program

Canadian Forest Service
June 5, 2001
Canadien Service des forets

In Cooperation with Participating
States and Provinces

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ABSTRACT

This manual provides instructions for field work in the North American Maple Project. The original methods are described in the 1991 publication North American Sugar Maple Decline: Organization and Field Methods. Some revisions were introduced in 1991 Field Manual. This revision updates changes recommended and approved by the cooperators through 2001.

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PROJECT CONCEPTION AND ORGANIZATION

Public concern for air pollution and its environmental effects on the environment in the late 1970's resulted in legislation that created an interagency effort in the United States to research and assess the environmental impacts from acid rain. This group became known as the National Acid Precipitation Assessment Program (NAPAP). Seven task groups were created to concentrate on particular aspects of the problem. Concern over decline of spruce forests and sugar maples in the eastern United States resulted in the creation of the Forest Response Program as one of the groups within the NAPAP. Declining sugar maples, *Acer saccharum* Marsh., were reported frequently in the 1980's (Millers et al. 1989). Extensive mortality has occurred in New York (USDA 1982, 1983), Pennsylvania (Pa. Dep. Environ. Resour. 1985), New Hampshire (Rush 1986), Missouri (Mo. Dep. Conserv. 1982), Massachusetts (MacConnell et al. 1986), and Vermont (Rush 1986). Similar sugar maple declines were reported in Canada: McLaughlin et al. 1985, Carrier 1986, and Environment Canada 1986. In addition, newspapers and popular magazines often included articles about declining sugar maples. This public concern became an important factor in the development of a sugar maple decline project.

A scientific evaluation of the problem was conducted in Burlington, Vermont, January 28-30, 1987, where 35 scientists concluded that an international approach to the problem was needed. A draft research program was prepared and later developed into the North American Sugar Maple Decline Project (McFadden 1987).

A scientific core team met several times to elaborate the plan that had been proposed at the Burlington meeting. The North American Sugar Maple Decline Project Work Plan was written to provide background, purpose, and overall direction of the project. The Cooperative Field Manual gives detailed instructions for plot selection, establishment, and data collection. This publication documents the methods and provides them to the scientific community. The methods represent the Cooperative Field Manual dated February 10, 1988, as revised July 7, 1988, and include clarifications and changes made through the 1996 field season.

Monitoring Programs

United States: Scientists in forest pest management annually conduct surveys to monitor unusual damage in the forest. These local surveys serve the needs of each political unit. Frequently, survey results from one state are difficult to compare with the results of another state. Therefore, a regional approach was needed and the North American Sugar Maple Decline Project was created within the Eastern Hardwoods Research Cooperative (EHRC) of the Northeastern Forest Experiment Station in cooperation with Forest Pest Management of Northeastern Area, State and Private Forestry, both of the U.S. Department of Agriculture, Forest Service (McFadden 1988). EHRC is part of the Forest Response Program (FRP), an interagency research effort that operates under the auspices of the Terrestrial Effects Task Group of the National Acid Precipitation Assessment Program (NAPAP) (Blair et al. 1986). The objective of the FRP was to provide information in addressing the following environmental policy question: "Is there a significant problem of forest damage in North America which might be caused by acidic deposition alone, or in combination with other pollutants?" The policy question was developed into two scientific questions: 1. Are changes in forest condition greater than can be attributed to typical trends and levels of natural variability, and, 2. What spatial patterns, if any, exist in forest condition, and how do these patterns relate to spatial patterns of pollutant exposure?

In 1991 the Project was transferred to State and Private Forestry, Northeastern Area to continue for another three years. A Project Review was held in 1992, when a Scientific Review Panel made a recommendation to continue the project for an additional 10 years. The Joint Management Team of NAMP agreed to continue for 5 years after which a review will be made to decide on further continuation.

Canada: Annual forest damage surveys in Canada are the responsibility of the Forest Insect and Disease Survey (FIDS) units of the Canadian Forest Service . A nationwide system of observation plots, referred to as the Acid Rain National Early Warning System (ARNEWS), was established to detect, clearly and accurately, early signs of acid rain damage to Canada's forests before damage becomes obvious (Magasi 1988). Research efforts by Forestry Canada include nutrient cycling, symptomatology of air pollution, and monitoring tree health (Addison and Rennie 1988). Provincial governments and Universities in New Brunswick, Ontario, and Quebec have established major sugar maple condition monitoring systems and research teams (McLaughlin et al. 1985, Morselli 1985, Gagnon et al. 1986). These agencies assess tree condition, severity and effects of sugar maple decline, and geographical extent and location of decline.

Canada- U.S. Joint Project Organization

A workshop for scientists from Canada and the United States was held in Burlington, Vermont, early in 1987 to review the status of maple decline information (McFadden 1987). The major outcome of the workshop was a proposal for joint investigation to determine the impact and probable causes of sugar maple decline. The proposal recommended that standard methods be used to collect and analyze data on sugar maple conditions over a wide geographic area. This effort was implemented under a Memorandum of Understanding between the U. S. Department of Agriculture and Forestry Canada. The various cooperators in Canada and United States agreed to a common workplan. The project was intended to supplement existing studies and not to replace them. The Memorandum Of Understanding and the joint agreement for the North American Sugar Maple Decline Project provide the authority for the cooperative effort in project administration (Fig. 1). Overall administrative guidance is given by the Joint Management Team, co-chaired by Dr. L. W. Carlson, Forestry Canada, and Dr. G. D. Hertel, USDA Forest Service. Two other members complete the Joint Management Team: C. Eagar, USFS; P. Hall, Forestry Canada. A Scientific Core Team was formed to provide early planning of the project. This team was dissolved after the Work Plan and Field Manual were developed. Technical guidance in the field is provided by the National Coordinators: Bruce Pendrel, Canadian Forest Service, and Robert Cooke, USDA Forest Service. Provincial or state coordinators supervise data collection in local areas. Dr. D.C. Allen, College of Environmental Science and Forestry, State University of New York, Syracuse, New York, is contracted for data analysis, and C. Barnett, USFS, coordinates the quality assessment and quality control activities.

Cooperators: In Canada, the following provincial agencies cooperate with the Canadian Forest Service:

1. New Brunswick: Department of Natural Resources and Department of Municipal Affairs and Environment
2. Nova Scotia: Department of Lands and Forests
3. Ontario: Ministry of Environment
4. Quebec: Department of Energy and Resources

In the United States, the project is administered by the USDA Forest Service, Forest Health Protection, Northeastern Area, State and Private Forestry, in cooperation with Northeastern Forest Experiment Station and the following state agencies:

1. Maine: Bureau of Forestry, Department of Conservation
2. Massachusetts: Division of Forests and Parks
3. Michigan: University of Michigan and Department of Natural Resources
4. Minnesota: Department of Natural Resources
5. New Hampshire: Division of Forests and Lands
6. New York: State University of New York at Syracuse and State Department of Environmental Conservation
7. Ohio: Division of Forestry (Temporarily continued through NEFES)
8. Pennsylvania: Pennsylvania State University and Bureau of Forestry
9. Vermont: Department of Forests, Parks, and Recreation
10. Wisconsin: Department of Natural Resources

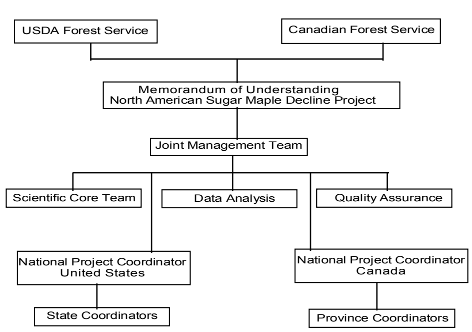


Figure 1. Organization of the North American Sugar Maple Decline Project (1989).

Objectives

The objectives of the project are to:

1. Determine the rate of change in sugar maple tree-condition ratings from 1988 through 2001

2. Determine if the rate of change in sugar maple tree-condition ratings is different among:

a. Various levels of pollution measured as wet deposition
b. Sugarbush and non-sugarbushes, and
c. Various levels of initial stand decline condition

3. Determine the possible causes of sugar maple decline and the geographical relationship between causes and extent of decline.

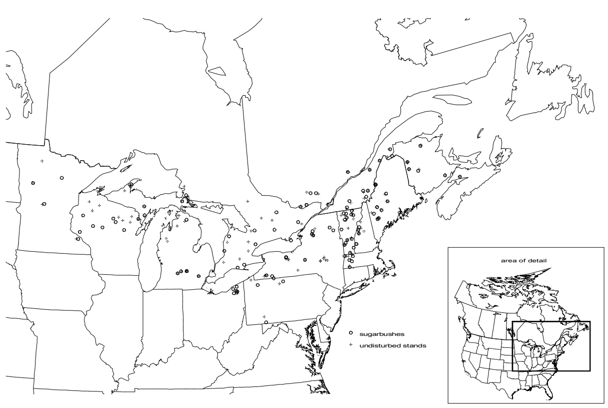
General Approach

The project began in the summer of 1987 with the development and testing of field methods. In 1988, 165 plots were established across eastern North America, from Ontario and Wisconsin in the west and to Maine and Nova Scotia in the east. The North American Sugar Maple Decline Project: Organization and Methods (1991) provides background on the start of the project. The Cooperative Field Manual gives detailed instructions for plot selection and establishment, and data collection. A general overview of quality assurance, data analysis, and interpretation methods is included, but more specific guidance is provided in separate appendixes of the Cooperative Field Manual. The original field methods used for plot establishment are in the Cooperative Field Manual dated February 10, 1988 as revised July 7, 1988; subsequent clarifications and changes were made during the Project Review at Montreal in 1989. A few minor clarifications were added in 1990 and 1991. This revision of the manual incorporates all the changes through 2001.

Experimental Design

Several plots and regions have been added over the years, so a total of 231 plot clusters will examined in 2001 for crown dieback and crown transparency. Each plot cluster has five plots in similar stand conditions. One-half of the plot clusters represents maple stands managed as sugarbushes and one half in non-sugarbushes, where human disturbance is minimal. The plot clusters were distributed to represent a range of exposure to pollution and a range of initial stand decline conditions (although extremely declining stands were avoided to allow for trend determination): from Minnesota and Ontario to Maine and Nova Scotia to

Figure 2.--Distribution of plot clusters of the North American Maple Project (2001).



represent a wide geographical area and to cover a variety of physical and biological conditions in Southeastern Canada and the Northeastern United States (Fig. 2).

The number of established sample clusters in 2001, by state or province, are:

United States		Canada	
Maine	18	New Brunswick	10
Massachusetts	10	Nova Scotia	2
Michigan	24	Ontario	24
Minnesota	8	Quebec	24
New Hampshire	10		
New York	27	Total	60
Ohio	6		
Pennsylvania	10		
Vermont	40		
Wisconsin	18		
Total	171		

FIELD METHODS

PLOT ESTABLISHMENT

Stand Selection

Approximately one-half of the samples in a province or state is located in each of two management categories -- sugarbush or non-sugarbush -- and where possible, stands are paired for the two management options. The initial plan was to establish eight sets of clusters in two pollution zones, and to select for specific stand decline conditions. However, it was abandoned later when it was determined that the regional pollution maps might not reflect actual pollution, because of local pollution effects, and adequate declining sugar maple stands could not be located in all the areas. Instead, sites were selected in 1988 to represent a gradient of pollution between the extremes within a state or province. In addition, efforts were made to select sample stands to represent a range of original stand decline-conditions.

Originally, the plot-clusters were established for a two year project, which then was extended to 5 years. The current project is expected to continue until the fall of 2001, with a the possibility to continue further. Therefore, some cooperating landowners may be experiencing hardships in abstaining from cutting in the non-sugarbushes. The present NAMP policy is to permit logging, although the recommendation is to continue without it as long as possible. When logging occurs, a 132 ft buffer around the plots is recommended, if possible.

Stands

The featured stand (term describes the main component of the dominant trees, excluding the remnants of a previous stand) is a hardwood stand in which more than 50 percent of upper story trees are sugar maples 50 to 150 years old. The two major types of stands, based on management history, are sugarbush and non-sugarbush. Portions of stands with dissimilar tree damage conditions were considered as separate stands. Care was taken to avoid unusual stands and sites not typical of the area, such as artificially established stands outside the natural range, and severely logged or grazed stands.

The following definitions and codes were used to describe the two stand management categories:

Sugarbush - A hardwood stand where more than half the upper canopy trees are sugar maples, 10 cm diameter at breast height (d.b.h.) and larger. These stands had evidence of sugaring in the last 5 years and at least a quarter of the trees had to have tapholes. Other disturbances associated with sugarbushes, such as logging or grazing, were accepted. (Code 1)

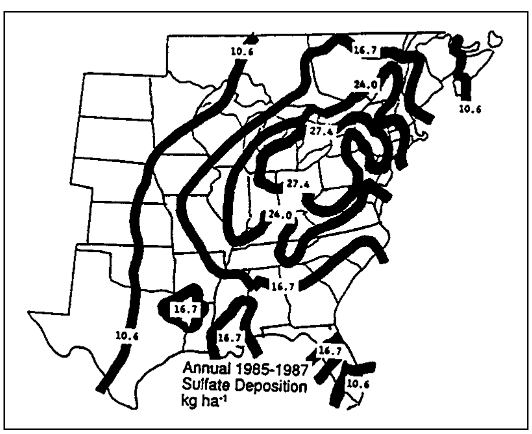
Non-sugarbushes - A hardwood stand with sugar maple, 10 cm d.b.h. and larger comprising more than half of the upper canopy. The stand could not have evidence of disturbance in the previous 5 years before establishment, such as sugaring or logging and it had to be at least 2 ha in area, preferably larger. (Code 2)

Range of initial damage

Each province or state coordinator was advised to choose stands with a wide range of stand-decline conditions, but to avoid stands where the majority of trees were declining (the trend might be difficult to measure).

Pollution gradient

The selected stands represent a gradient from approximately 12 kg/ha/yr of sulfate wet-deposition to more than 34 kg/ha/yr (Sisterson et al.). Nitrate wet-deposition ranged from approximately 8 kg/ha/yr to approximately 22 kg/ha/yr (Fig. 3).



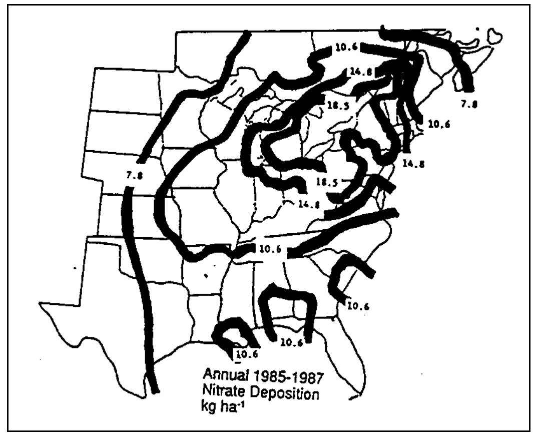


Figure 3.--Sulfate and nitrate deposition in kg/ha/yr in eastern North America (Adapted from Sisterson et al.).

CLUSTER AND PLOTS

Cluster

In each stand a cluster of five plots is established to describe average site, stand and tree conditions. The sample is the average of the five plots. Extreme variability in stand conditions between plots was avoided.

Plot

Each plot is a 20-m x 20-m square, or 400 m^2 (66 ft x 66 ft, or 1/10th acre); the corners are at 45° from the cardinal compass directions and 14.2 m (47 ft) from the center stake. The outside boundaries of the plots are a minimum of 20 m (66 ft) from the edge of the nearest plot or from the edge of the stand. The preferred distribution of plots in a cluster consists of one plot in the center and four around it; one in each cardinal compass direction. Other designs are used where stand shape does not permit the preferred arrangement. Similar 20-m (66 ft) buffer is required between plots and on the outside when an alternative plot arrangement is used.

Identification and marking

The center of each plot is marked with a plastic (PVC) pipe, 2 cm in dia. and 1 m long (1 in by 3 ft) driven into the ground at least half way (rocks were used to surround the stakes when they could not be driven into the ground). The stake is marked showing the cluster and plot number. The corners of the plot are marked with flagged stakes. A map is prepared showing the location of the plot and instructions for later relocation. The plot identification code number includes in a left-to-right sequence:

1. Management type: 1. Sugarbush, or 2. non-sugarbush

2. State or province letters: ME, MA, MI, MN, NB, NS,

NH, NY, OH, PA, ON, QU, VT, WI

STAND AND PLOT DESCRIPTION FORM

1.Sugarbush___ ___________ ____ Location ______________________
2.Undisturbed___ State/Prov. Plot Town County
UTM __ __ __ __ . __ __ ; __ __ __ . __ __
Zone Easting Northing

REGIONAL DESCRIPTION:

Weather (Record from__________________station):
Temperature: Annual mean___°C; Max.____°C; Min.___°C
Precipitation: Annual mean______mm; Summer mean(May-Aug)______mm

Terrain (circle): 1.flat 2.hilly 3.mountainous Soil Series:______________

Watershed: water flows into_______________________major river

SITE DESCRIPTION: Circle the code number or enter proper values

Landform: 1.ridgetop 2.spur ridge 3.noseslope 4.headslope 5.sideslope
6.cove 7. draw 8.flat
Slope position: 1.summit 2.shoulder 3.backslope 4.footslope 5.terrace
6.floodplain 7.flat
Slope % __(nearest 1%) Elevation____m (nearest 10m)

Microrelief: 1.planar 2.concave 3.convex

Site exposure___°;(Use 0 for flat area)

Soil texture: 1.silt/clay 2.fine sand 3.medium sand 4. coarse sand
5.fine gravel 6.coarse gravel 7.rocks
Soil drainage: 1.well drained 2.wet

Site rockiness: 1.one or none boulder in plot 2.two to 10 boulders,no bedrock
3.bedrock showing, or more than 10 boulders

STAND DESCRIPTION:

Disturbance: 1.present 2.absent
Logging: 1.never 2.old 3.recent 4.current (last 5 years)
Forest type: 1.same 2.changed (assume same, unless sure of change)
Grazing: 1.no signs 2. old, but none now 3.current,light 4.current,heavy

Tapping: 1.currently active 2.at least once in last 5 years 3.older 4.none
Method: 1.bucket 2.gravity tube 3.vacuum tube 4.no chemicals used
5.chemicals used _____________(type) 6. combinations (Explain)

Vegetation:
Crown closure: 1.full (90%+) 2.moderate (10% to 50%) 3.open (less than 50%)
Crown structure: 1.single story 2. two story 3. multistory (3cm stems +)
Site quality (in relation to most sugar maple stands in the region):
1.average 2. worse 3.better

Stand age___years, based on _________________________ records.

Figure 4.--Exhibit of the Stand and Plot Description Form of the North American Maple Decline Project.

3. Cluster number: 3 digits including zeros to the left, as needed

4. Plot number: (1, north; 2, east; 3, south; 4, west; 5, center). When plots are arranged in different pattern, the first plot is coded 5, and the following plots are 6,7,8, and 9.

For example, the plot identification code 1 VT005 4, is a sugarbush in Vermont, cluster 5, west plot.

SITE DESCRIPTION

A suite of general site information indicators are recorded for the plots. However, since site descriptions are not critical data, more precise measurements are taken only if analyses suggest significant relationships. Plot establishment data are recorded on the Stand and Plot Data Form (Fig. 4).

Site description includes location and physiographic conditions usually obtained from published materials. The descriptions include a general regional description covering approximately 10 km^2 (4 sq mi) around the cluster and a local description at each plot.

Location

Plot-cluster location is recorded to within 100 m (330 ft) using the Universal Transverse Mercator System (UTM). Political geographic descriptions, such as county and township, are added as needed for local identification.

Regional physiography

Information regarding regional physiography was obtained from published records and maps and consists of four types:

a. Terrain, coded into three kinds--1, flat; 2, hilly; and 3, mountainous.

b. General watersheds--such as major rivers, lakes, or oceans--to which local waters flow were included.

c. Weather data--The nearest weather station was used, with at least 30 year data on temperature (°C): maximum; minimum; mean annual; and precipitation (mm): annual; summer average (May-August).

d. Soil series--Local soils scientists or recently published soil surveys were consulted to obtain the soil series.

Local physiography

The terminology used by the North American Sugar Maple Decline Project is the same as that used by the other NAPAP Forest Response Program projects (Zedaker and Nicholas 1990). Nine categories are used (Figure 5):

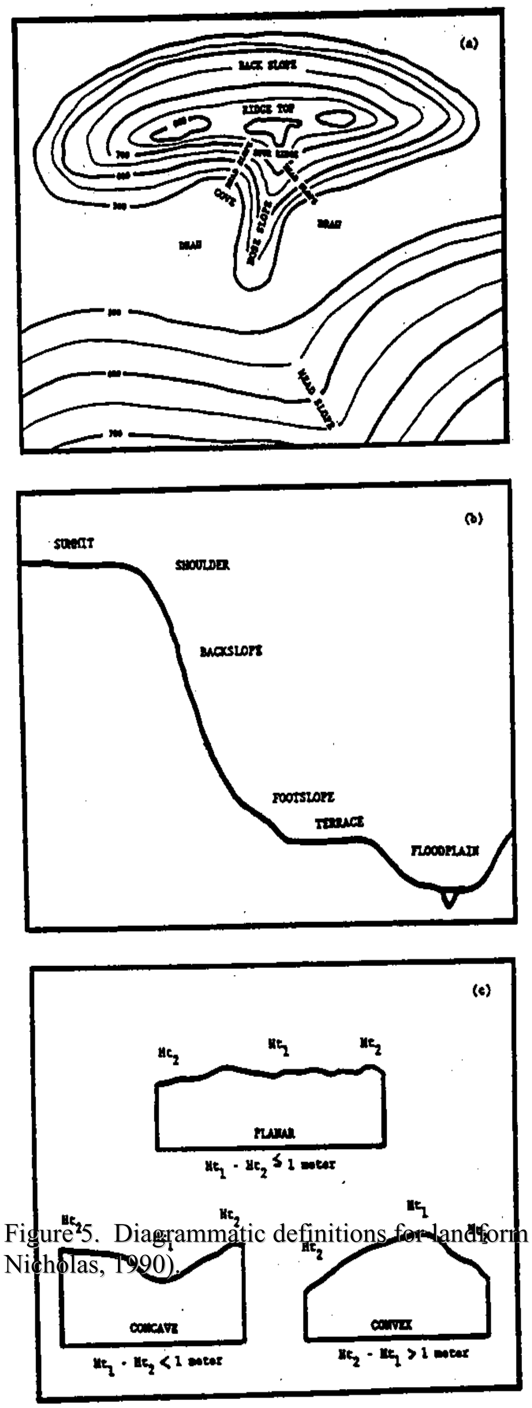


Figure 5. Diagrammatic definitions for landform (a), slope position (b), and microrelief (c). (Adapted from Dedacker and Nicholas, 1990).

a. Landform (Fig. 5a); coded into 8 descriptions:
   1- ridgetop (primary ridge of a mountain system)
   2- spur ridge (secondary or lateral ridge from primary ridge)

3- noseslope (diverging drainage at end of ridge)
4- headslope (convergent drainage above cove)
5- sideslope (parallel drainage along side of ridge)
6- cove (deep, narrow depression in the slope or bowl with one end open)
7- draw (depression open on both ends but bounded by steep sideslopes or noseslopes.
8- flat (the entire area typically is flat)

b. Slope position (Fig. 5b); coded into 7 types of slopes, as follows:
1- summit (highest point of landform)
2- shoulder (transitional zone between summit and backslope; the slope is always convex and has the greatest erosion loss on a mountain)
3- backslope (midportion of landmass, convex or concave)
4- footslope (between backslope and terrace, convex, has the greatest colluvial deposition on a mountain)
5- terrace (flat, but clearly above the floodplain)
6- floodplain (flat area flooded during high water periods)
7- flat (similar to terrace and floodplain, but not adjacent to hills or bodies of water)

c. Microrelief (Fig. 5c) is separated in three projections: 1, planar; 2, concave; and 3, convex.

d. Percent slope, is determined with a clinometer to the nearest one percent.

e. Elevation is shown to the nearest 10 m (33 ft), and determined from a topographic map.

f. Exposure designates the direction that the slope faces, to the nearest compass degree; 0 is used to show a flat area; 360 indicates north.

g. Soil coarseness is determined for soil immediately below the humus layer, as follows: A pinch of soil is rubbed in the palm of the hand or between fingers to estimate particle size. The average size of the particles is then classified:

		Particle size limits	
Code	Soil Texture	Lower	Upper
		-----in millimeters------	
1	Silt or clay	0.001	0.07
	Sand :		
2	Fine	0.07	0.42
3	Medium	0.42	2.0
4	Coarse	2.0	4.8
	Gravel:		
5	Fine	4.8	19.5
6	Coarse	19.5	76.2
7	Rocks	76.5	305

h. Rockiness. Three degrees of rockiness are coded:

1 - not more than 1 protruding large rock (cannot be moved easily by one person; usually more than 2 ft, or 61 cm, diameter) per plot; no bedrock exposed
2 - two to ten large rocks; bedrock not showing
3 - ten or more large rocks per plot or bedrock showing

i. Drainage is described in two classes: 1, well drained (no signs of prolonged flooding) or; 2, wet (signs of perched water such as presence of wetland indicator plants)

STAND DESCRIPTION

Stand descriptions indicate the general character of the sample areas and are not critical measurements; more precise measurements are taken when data analyses suggest significant relationships. The data are recorded on the Stand and Plot Description Form (Fig. 4). Six methods are shown.

Disturbance

At the time of establishment, disturbance is coded as 1,absent; 2, present (if present, disturbance is identified):

a. Logging, based on one of the four criteria:

1 - reasonably sure the stand was never logged in the last 50 years
2 - old, but no firm stumps present
3 - recent, but older than five years (firm stumps present)
4 - recent, logging in the last 5 years (stumps and logging residue present)

b. Forest type change assessment: 1, probably has not changed since European settlement, and; 2, changed from one forest type to another

c. Grazing assessed in 4 classes:

1 - no signs of grazing
2 - old damage, but no recent signs of grazing
3 - current, light; no tree damage apparent
4 - current, heavy; soil compaction obvious, tree damage present and very little reproduction present.

d. Tapping is rated in four classes:

1 - currently active
2 - at least once in last 5 years, but not in current year
3 - old, none in the last 5 years
4 - none ever

e. Tapping method (obtained from landowner) is coded as:

1 - bucket
2 - gravity tubing
3 - vacuum tubing
4 - no chemicals used
5 - type of chemicals used in tap
6 - combination; codes in notes

For other methods, descriptions should be included in the notes.

After plot establishment, presence of recent disturbance caused damage (since the last plot visit) is recorded annually, on a tree by tree basis, on the Field Form in the appropriate field. A supplementary form is completed when recent disturbance is indicated on the Field Form. We are still trying to get historic natural disturbance records for all the plot-clusters. If there is no disturbance record for the last 20 years, a negative report is submitted.

When logging disturbance occurs in a non-sugarbush, the disturbance is indicated on the Field Form and on the Disturbance History form. In addition, data may be provided to show how much basal area remains. The sample is a minimum of 9 points.

Vegetation

This is not a critical measurement;. The three methods used to measure stand vegetation are:

a. Crown closure:

1 - full, less than 10 percent sunlight penetration
2 - moderate, 10 to 50 percent of ground receives sunlight
3 - open, more than 50 percent of ground receives sunlight

b. Crown structure

1 - single-story
2 - two-story
3 - multistory (stems smaller than 3 cm in dia. are not considered)

c. Site quality. In the opinion of the observer, past growth of sugar maple on the plot (before decline, if present) apparently was:

1 - average; similar to maples nearby (about 10 km2 area)
2 - less than maples nearby
3 - better than the maples nearby

The notes are used to show why the stand quality is below average, if known.

Stand age

Stand age was determined from five increment cores, one per plot, taken at the time of plot establishment. The stand age is assumed to be the age of the oldest of the five trees sampled. A codominant sugar maple was selected from the buffer zone adjacent to each plot. Unusual trees, such as severely damaged or wolf trees, were avoided. Trees with seams or cankers in the lower bole were avoided also because of the likelihood of rot. If a sample tree was hollow, another tree was chosen. The cores are taken at breast height.. When a core breaks, pieces are placed in sequence into the storage container. The storage container is a firm cardboard tube or straw. The ends of the tube are crimped and stapled. The plot identification number and the date of collection are recorded on the tube. Long cores require several straws; each part is labeled clearly. The cores are kept dry without chemical additives.

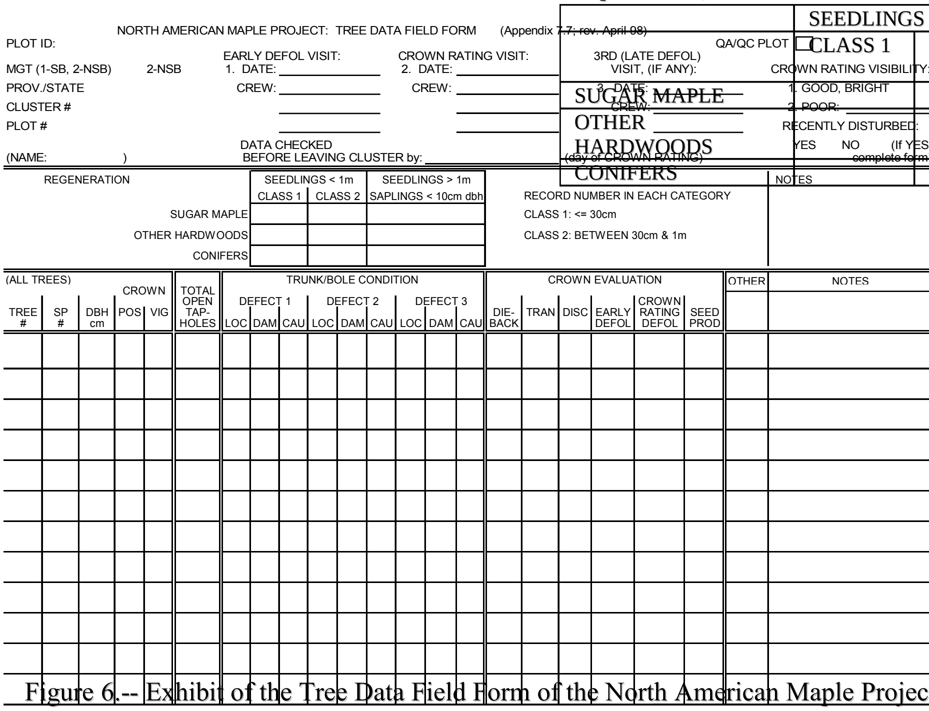
Laboratory core analysis follows standard operating procedures (Zedaker and Nicholas 1990). The tree age is determined at the USDA Forest Service, Northeastern Forest Experiment Station, Tree Ring Laboratory, Durham, New Hampshire.

REGENERATION

Regeneration will be collected on each of the 5 plots within the plot-cluster. It will be counted on a circular milacre plot (3.7 foot radius) located at 6.6 m (20 feet) from the plot center, in the East direction (90 degrees) If E is unavailable, go clockwise (S, W, N). This milacre plot will be permanent, so mark the center with a ½ inch pvc pipe.

Regeneration will be counted on the milacre plot in 3 categories: Sugar maple, Other hardwoods, and Conifers. Other hardwoods include all commercial tree species. Each category will contain 2 divisions: Seedlings < 1 m in height, and Seedlings & Saplings > 1 m in height, but < 10 cm dbh. Further, the Seedling < 1 m will be divided into 2 classes: < 30 cm in height, and from 30 cm to 1 m in height.

The data sheet will resemble:



NORTH AMERICAN MAPLE PROJECT: TREE DATA FIELD FORM (Appendix 7.7; rev. April 98)

PLOT ID:
MGT (1-SB, 2-NSB) 2-NSB
PROV./STATE
CLUSTER #
PLOT #
(NAME:)

EARLY DEFOL VISIT:
1. DATE: ____
CREW: ____

CROWN RATING VISIT:
2. DATE: ____
CREW: ____

3RD (LATE DEFOL) VISIT, (IF ANY):
3. DATE: ____
CREW: ____
(day of CROWN RATING)

QA/QC PLOT ☐
CROWN RATING VISIBILITY:
1. GOOD, BRIGHT
2. POOR: ____
RECENTLY DISTURBED:
YES NO (If YES, complete form)

DATA CHECKED BEFORE LEAVING CLUSTER by: ____

REGENERATION	SEEDLINGS < 1m		SEEDLINGS > 1m
	CLASS 1	CLASS 2	SAPLINGS < 10cm dbh
SUGAR MAPLE			
OTHER HARDWOODS			
CONIFERS			

RECORD NUMBER IN EACH CATEGORY
CLASS 1: <= 30cm
CLASS 2: BETWEEN 30cm & 1m

NOTES

(ALL TREES)			CROWN		TOTAL	TRUNK/BOLE CONDITION									CROWN EVALUATION						OTHER	NOTES
						DEFECT 1			DEFECT 2			DEFECT 3										
TREE #	SP #	DBH cm	POS	VIG	OPEN TAP-HOLES	LOC	DAM	CAU	LOC	DAM	CAU	LOC	DAM	CAU	DIE-BACK	TRAN	DISC	EARLY DEFOL	CROWN RATING DEFOL	SEED PROD		

	SEEDLINGS < 1 m		SEEDLINGS > 1 m
	CLASS 1	CLASS 2	SAPLINGS < 10 cm dbh
SUGAR MAPLE			
OTHER HARDWOODS			
CONIFERS			

Figure 6.-- Exhibit of the Tree Data Field Form of the North American Maple Project.

RECORD NUMBER IN EACH CATEGORY

CLASS 1: <=30 cm
CLASS 2: BETWEEN 30 cm & 1 m

Count all seedlings/saplings with greater than 2 leaves (cotyledons) for each category and record in the appropriate box. If stump sprouts or coppice generate multiple shoots, each shoot will be considered a separate seedling. Include only seedlings whose stem is within the milacre plot.

TREE MEASUREMENTS

The following section describes methods used to inventory individual tree condition. All the data were recorded at the time of plot establishment (Fig. 6). Thereafter, the primary emphasis is to record crown condition. Evidence of new bole or trunk damage and tree crown position changes are recorded annually.

Some cooperators prepared maps showing the relative location of each tree on a plot. This was not a general requirement, but was done when some decline data suggested need-to-know locations of neighboring trees.

Tree Selection and Identification

All the trees 10 cm (4 in) and larger were marked with aluminum tags and nails at d.b.h.; identified to species, or as close as possible; and inventoried for condition and damage. Major emphasis was placed on proper identification of sugar maple. Difficulties were encountered separating black maple from sugar maple so a few black maples may be included among the sugar maples.

Common names used were from Little (1953). Each species, or species group is assigned a code number. Unused code numbers are added to accommodate other species not listed below. The new code number is marked with an asterisk on the data sheet, and the species name recorded in the notes when used the first time on a plot.

The ingrowth was measured in 1993 and again in 1997.

Angiosperms		Angiosperms		Gymnosperms	
10	Maple	30	Birch	91	E. White pine
11	sugar	31	yellow	92	Other pine
12	black	32	paper	93	Hemlock
13	red	41	Ash	94	Balsam fir
14	silver	42	Hickory	95	Spruce
15	striped	43	Poplar, Aspen	96	white
20	Oak	44	Basswood	97	red, black
21	white	45	Ironwood, Hophornbeam	98	Tamarack
22	bur			99	Other conifers
23	northern red	46	Cherry		
24	black	47	Elm		
		48	Beech		
		49	Other hardwoods		

Diameter

Tree diameter was measured at d.b.h., 1.37 m or 4.5 ft above ground, in 1988, 1992, and 1997. The diameter measurement is taken every 5 years. The diameter measurement was not a critical measurement at the time of establishment because tree growth was not expected to be significant during the first 3 years. The measurements are recorded to the nearest 1 cm.

Crown Position (All species - changes only)

Crown position ratings were recorded for all the species in 1988, and changes are recorded annually. Crown position rating of each tree was done by two observers. The lower rating was given when the two raters failed to reach an agreement. When crown positions had changed during the previous 5 years because of a disturbance the rating was given according to the best estimate of what the crown position was at the time of disturbance (tree and crown size were weighed more heavily than the light factor). Changes observed after the original plot establishment are entered as corrections of the previous entry. The following codes and definitions were used (USDA 1984):

1 -dominant (trees with crown extending above the general canopy and receiving full light from above and partly from the sides; larger than the average trees in the stand; crowns well developed, but somewhat crowded on the sides)

2 -codominant (trees with crowns forming the general level of the canopy and receiving full light from above, but relatively little from the sides; usually with medium size crown, more or less crowded on the sides)

3 -intermediate (trees shorter than in the preceding classes, but with crowns just below or extending into the canopy of dominant and codominant trees; receiving little direct light from above and none from the sides; usually with small crowns considerably crowded from the sides)

4 -suppressed (trees with crowns entirely below the main canopy and receiving no direct light from above or sides)

Vigor Rating (All species)

General crown vigor was recorded for all species in 1988, and changes are recorded annually. The vigor rating is done in broad classes similar to those used in other forest decline projects. These are not considered critical measurements. The acceptable error is plus-or-minus one vigor class. **Vigor ratings must be done before crown rating. The percentages of damage used for defining vigor rating classes are independent estimates, not related to the sums of crown rating percentages**. The codes are used as follows:

1 -healthy; tree appears to be in reasonably good health; no major branch mortality; crown is reasonably normal within the stand situation; less than 10 percent branch or twig mortality, defoliation or discoloration present.

2 -light decline; branch mortality, twig dieback, or foliage discoloration present in 10 to 25 percent of the crown; broken branches or crown area missing based on presence of old snags is less than 26 percent.

3 -moderate decline; branch mortality, twig dieback, or foliage discoloration in 26 to 50 percent of the crown; broken branches, or crown area missing based on presence of old snags is 50 percent or less.

4 -severe decline; branch mortality, twig dieback, or foliage discoloration present in more than 50 percent of the crown, but foliage is still present to indicate the tree is alive; broken branches, or crown area missing based on presence of old snags is more than 50 percent; branch breakage and crown are missing is recorded in the 10-percent classes in the notes.

5 -dead, natural; tree is dead, either standing or down; phloem under bark has brown streaks; few epicormic shoots may be present on the bole; no further entries needed.

6 -dead, **human caused**; tree removed; tree has been sawed or girdled by humans.

Tapping Record (Sugar maple only)

The number of tapholes is recorded annually for all the sugar maples. One entry is made for the total number of open tapholes. A taphole is considered open when the point end of a pencil pushed into the hole hits cambium. When not certain the hole is not counted. Unusual observations, such as predominance of multiple taps on one side of a tree, are recorded in the notes.

Bole Quality (All hardwoods)

Severe bole damage that might affect tree vigor was recorded for all species in 1988. Annually, **new damage** thought to have occurred since previous year, is recorded. The Field Form permits entry of a maximum of three types of damage. If more damage is noted, the numbers may be entered in the notes.

Location of bole defects

1 - lower half (above the stump, 30 cm above ground, but in the lower half of the bole)
2 - upper half (upper half of the bole, but below crown or branch forks)

3 - whole bole (defects in both halves or continuous)
4 - stump/roots (defects visible on the buttress roots or stump within 30 cm from the ground)
5 - whole tree (includes bole, stump, and roots)

Type of injury,damage, and defects on the bole

As many as three major defects or type of damage on the bole were recorded in 1988. Thereafter, any **new** growth-impairing injury is added annually. These defects are registered as:

21- sweep or crook (at some point within a 3-m length, curve of bole sufficiently severe that the curved section is completely outside the cylinder, above and below).
22- swelling (the swollen area exceeds one quarter of the bole diameter; slowly healing branch stubs with large swellings are included)
23- dead branches or stubs (dead branches larger than 10 cm on the bole or any dead stubs of that size creating open wounds; bole above the base of the crown, or any major branch fork, not included)
31- large open wounds (area of exposed wood larger than 4 cm^2; includes cankers that have exposed wood)
32- small open wound (area of exposed wood 4 cm^2 or less; holes created by tapping not included)
33- dead bark, dry & tight (old bruise or other damage extending more than 10 cm, covered by dead bark; includes cankers)
34- sloughing bark (bark is splintering and separating from the wood)
35- closed wound (large wounds healed and completely closed as indicated by overgrown live bark; may include large overgrown branch stubs)
36- seams or cracks (elongated narrow wounds, at least 1 m, not more than 2 cm wide; open or closed, including scars)
37- other (damage described in the notes)

Causal agents for trunk or bole defects

The probable agents responsible for trunk or bole defects are entered only when the observer is reasonably sure of the cause of damage. If more detailed identification is possible, such as wood-boring insect, it is recorded in the notes. Observations such as "windthrow", "hail damage", "frost damage" also are recorded in the notes. Probable agent groups and their designated codes are:

0 - causal agent not identified; or no damage present.
1 - insect - In the notes record what signs were present.
2 - fungus - Describe fruiting bodies or other signs.
3 - weather - Blowdown, leafscorch, hail, water level change, frost, etc.
4 - animal - Rubbing, gnawing, girdling, birdpecking, root damage from grazing, etc.
5 - human - Logging, blazing, girdling, etc.(Do not include tapping).
6 - fire - Fire scars near base, burnt wood.
7 - silvicultural - Damage probably caused by shading, competition, rotten branch stubs.
8 - tapping - Wound or decay that appears to have started at the taphole.
9 - overmaturity (only the largest trees affected; hollow bole; tree appears to be over 150 years old)

Notes

The notes section of the data sheets was used to record any unusual damage not covered in the Methods Manual, such as causes of defoliation, occurrence of heavy seed crops, presence of tattered or wrinkled leaves. Causal organisms also were recorded in the Notes when the observers could identify them.

CROWN DAMAGE ASSESSMENT

Crown measurements in 1988 included estimates of dieback, crown transparency, discoloration, dwarfed foliage, and presence of epicormic shoots. These were selected for the purpose of measuring annual changes and not to evaluate tree vigor or condition. Therefore, the emphasis in method selection was placed on repeatability of measurements between individual raters and timing of the measurements. Initially, crown condition ratings were made for sugar maples only. However, the following year (1989) the cooperators agreed to expand crown condition estimates to include all hardwood species. In the original plan, all the crown-condition rating elements were considered as critical measurements. However, because in difficulties of repeating measurements, the rating of dwarfed foliage and epicormic shoot measurements was dropped. When the situation suggests that these may provide additional information on tree health, estimates may be added in the notes.

Uncertainty about definitions for discoloration resulted in removal of this measurement from the critical measurement list, but the measurement continued.

Estimates of branch dieback and foliage transparency of sugar maples are retained as critical measurements. Data quality guidelines are followed for the critical measurements in order to determine measurement errors between individual raters. The acceptable variation between observers is 1 percentage class higher or lower than the average, for dominant-codominant and intermediate trees; and a 2-percentage-class difference for suppressed trees. Two certified raters are required to make the estimate. When the two estimates disagree, the percentage class nearest the average of the two is recorded.

The timing of measurements extends from early July to the end of August. The purpose is not to initiate crown rating until leaves are mature and to complete the rating before the appearance of fall colors.

Description of Crown

A tree crown may be described in many ways. In this project, the crown is the silhouette, or single plane, outlined by the periphery of branch tips. The bottom of the crown is the lowest foliated area (excluding epicormics); it does not include the large branch stems that support the crown. For percentage estimates, large open areas within the crown are excluded; for example, openings created by the breakage of large branches. Likewise, areas on the periphery of the crown where the remnants of dead branches still remain, so called "snag" branches without small twigs, are excluded. The assumption is that the size of the crown remains relatively similar over time, but dieback, crown transparency, and discoloration are likely to change annually. A training aid and a calibration technique, the Crown Grid, are used for beginners to measure total crown and proportions of crown affected by dieback and other stress-induced symptoms.

Foliage Crown grid

The Crown Grid (Fig 7a) was developed from similar grids used to estimate areas on maps. The crown grid area does not represent a quantitative measure of the crown, rather it is used to determine the proportions of damage. The central square has 100 dots, and each peripheral square has 25 dots.

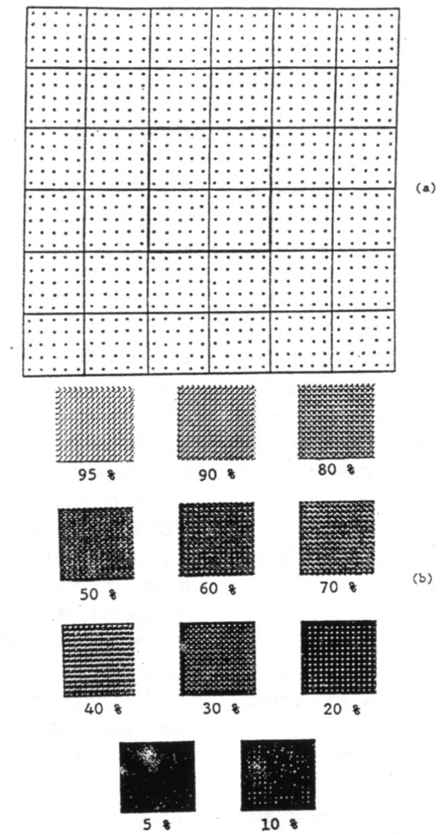


Figure 7.--Crown Grid (a) and the Foliage Transparency Grid (b) used in the North American Maple Project.

Instructions for use of the Crown grid:

1. Hold the transparency approximately 30 cm (1 ft) from the eyes.

2. Center the crown outline on the grid so that the entire middle square is within the crown perimeter, but none of the crown is outside the margins of the grid. This is done by moving the grid closer or farther from the eye. After the crown is centered, do not change the distance while the crown and damage are being outlined.

3. Draw the outline of the entire tree crown by connecting the tips of major branches and branch clusters, that is, draw a curve of the lines from branch tip to branch tip to avoid creating large open spaces between branches on the periphery of the crown. When outer portions of branches are dead, draw a line between terminals of dead twigs in order to obtain the crown outline. A very large hole in the crown, such as that caused by broken branches, should be excluded.

4. Trace the outline of the damaged portion of the crown within the outline produced in step 3.

5. Determine the number of dots or squares encompassed by the whole crown and the damaged portion separately.

6. Divide the smaller number (damaged area) by the larger number (entire crown) and multiply by 100 to get the percentage of crown damaged. Record the damage in one of the 12 damage classes (Table 1).

This procedure is intended to help the beginner gain confidence, to calibrate estimates, and to learn the area-estimation method. It is recommended that during the training phase, the observer first make an estimate of the percentages, and compare this with the value obtained from the Crown Grid.

Twelve-class Damage Rating System

After experimentation with various crown-rating classification systems, the cooperators agreed to a 12-class system (Table 1). The system consists of a 10-percent class rating system, except that the first class of 0 to 5 percent was subdivided into two classes. The "0" class is reserved for absolute zero, while the 5-percent class includes trace to 5 percent. Table 1 shows the codes used, the percentage class, and the range included in the class. The acceptable variability range shows the percentage limits included because of the allowable +/- 1 class acceptance of observer rating differences. For example, when the average rating of foliage transparency is 20 percent, individual observer ratings of 10 and 30 percent are considered acceptable.

Table 1.--Percentage classes and acceptable range of observer variability for estimates of branch dieback, foliage transparency, and discoloration

Class code	Class range	Acceptable observer variability
0	0	0-5
5	1-5	0-15
10	6-15	1-25
20	16-25	6-35
30	26-35	16-45
40	36-45	26-55
50	46-55	36-65
60	56-65	46-75
70	66-75	56-85
80	76-85	66-95
90	86-95	76-100
99	96-100	86-100

Branch Dieback (All hardwoods)

Branch dieback is used as a measure of an unhealthy condition and is defined as branch mortality that begins at the terminal portion of a limb and progresses downward. Branch dieback is assumed to be the result of stress on the tree. Short-term stresses such as excessive seed production, weather extremes, or insect defoliation may cause temporary dieback, but when the stress is removed the trees may recover. Prolonged stresses may result in increase of dieback, and eventual decline and death of the tree.

This measurement is an estimate of the proportion of the crown silhouette involved in dieback. Two certified raters are required to make the estimate from opposite sides of the tree. Branches with prematurely dead terminals are considered to have dieback down to the next lower fork of equal size branch. Assume that large dead branches within the upper crown area died from the terminal down unless signs of girdling or breakage are present indicating that they died at the base first. To be considered for dieback, a branch must be 1 inch or less in diameter, at the point of attachment of the branch to another branch or bole. Snag branches -- large branches without small twigs under 2.5 cm (1 in) diameter, and usually with the bark absent or with dead bark peeling away -- are assumed to have died much earlier. They are not considered as part of the crown and are not included in the dieback percentage. Likewise, branch mortality at the base of the crown, assumed to be the result of shading, is not included in the measurement. The proportion of crown with crown dieback is rated using the 12-percentage-class system (Table 1). The presence of one dead branch tip, at least 10 cm (4 in) long, in the upper portion of the tree crown, is rated as the lowest class with dieback in the 5-percent class. When dead twigs are scattered throughout the crown, an estimate is made of the approximate proportion of foliage lost from the dead twigs, which is then recorded as the dieback percentage.

In addition to normal dieback, extensive branch mortality, including snag branches, that might be affecting tree growth will be recorded in the notes The extent of the crown lost will be recorded in the same 10-percent classes.

Foliage Transparency (All hardwoods)

Foliage transparency is determined by estimating the amount of skylight visible through the foliated portions of branches and averaged for the crown as a whole. It includes normal tree characteristics of foliage density as well as reduced foliage density resulting from insect damage, disease, or environmental stresses. Areas included in dieback are not rated for foliage transparency. It is assumed that an increase of foliage transparency over time indicates reduced tree vigor that eventually may lead to branch dieback. Recovery is expected from short periods of defoliation events. Two certified raters are required to make the transparency estimates from opposite sides of the tree. The standard 12 class rating system will be used to estimate foliage transparency (Table 1). Foliage transparency is a critical measurement that requires extensive training to achieve standardization among observers and consistency among years.

Foliage transparency grid

The Foliage Transparency Grid (Fig. 7b) is a visual presentation of varying proportions of black and white squares. The black areas represent the foliated portion of the crown, while the white areas represent the skylight visible through the crown. The percentage class is shown beneath the square. The Foliage Transparency Grid is used as a training aid. Comparisons are made between the grid and foliated portions of the branches on the periphery of the crown as well as in the midcrown areas.

Foliage transparency standards

The Foliage Transparency Standards (Fig. 8) are used to standardize foliage transparency estimates among observers and to provide a reference guide for subsequent years. These are photographs of actual sugar maple crowns showing the amount of skylight visible through the crown. The "0" class, not shown, indicates a very dense crown where practically no skylight is visible through the crown (a rare condition). Pocket size laminated cards of the standard is issued to every certified rater.

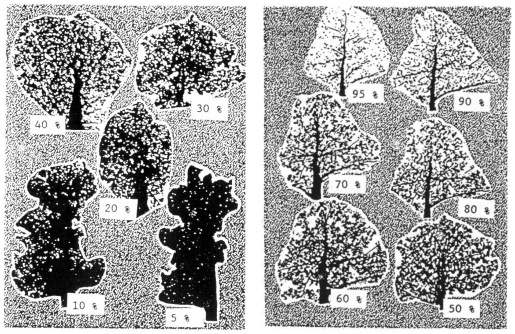


Figure 8.--Foliage Transparency Standards used in the North American Maple Project.

Foliage Discoloration (All hardwoods)

The estimate of foliage discoloration is based on the foliated portion of the crown and does not include areas where branches are dead or absent. Foliage is considered discolored when the overall appearance of a leaf is more red or brown than green. Fifty percent or more of the leaf has to be discolored for the leaf to be rated as discolored. Then, the area of the crown occurpied by leaves with that condition is rated with the 12 class scale. When the observer is not sure whether the foliage is green, it is rated green. Two certified raters are required to make the discoloration estimates from opposite sides of the tree.

Patterns and types of off-green coloration on diseased trees are reconized as an indicator of tree health problems. These indicators are not measured in this study, because of the difficulty of standardization between raters. However, the condition may be recorded in the notes. Marginal leaf scorch and similar partial discoloration will not be recorded unless more than half of all the leaves are affected. Premature fall coloration of leaves has been associated with the decline of sugar maple. Rapid changes over time and regional differences preclude use of early fall coloration as a critical measurement. After the 1988 field season, foliage discoloration was removed as a critical measurement, but its presence is still documented. Early leaf coloration and partial leaf discolorations may be recorded in the notes. When special conditions exist, a special rating scheme may be developed to measure the unique foliage damage condition. Data entries may be made in the blank columns provided for that purpose and a detailed description will be provided to the national coordinator and the data analyst.

Defoliation (All hardwoods)

The original work plan required only one field visit per year to conduct measurements, including defoliation estimates. However, it later was agreed that both early spring and midsummer defoliators may contribute to tree decline; that early defoliation (pear thrips, forest tent caterpillar, gypsy moth, etc) could substantially modify the overall crown condition ratings made in late summer, and that these pests could be missed with a single mid- or late summer visit. In 1989, the cooperators agreed to make an early entry on the plots to assess spring defoliation. Defoliation later in the growing season is accounted for when the plots are entered for annual crown ratings. The early entry is made when most of the defoliation by a given pest is expected to be complete. The site is revisited when it is obvious that much additional defoliation is likely to occur. If it is determined during the spring visit that none of the trees is expected to have greater than 30 percent defoliation, a 0 value is entered on the Tree Data Field Form and a line is drawn vertically to the bottom of the page, indicating that an individual tree defoliation rating was not made. Otherwise, all trees are individually rated.

Defoliation is estimated in four classes:
0 - none to light defoliation.
1 - less than 30 percent of crown defoliated.
2 - 31 to 60 percent defoliation.
3 - more than 60 percent defoliation.

The causal agent, if identifiable, is recorded in the Notes section. No other tree condition ratings are made during the spring defoliation visit.

Occasionally, late season defoliation may occur (for example, saddled prominent). When the potential for this is detected during the scheduled crown rating visit, a return visit to more accurately rate the degree of defoliation is encouraged. The rating is done in the manner used for spring defoliation rating.

Seed Production (Sugar maple only)

Excessive seed production is believed to weaken a tree and result in increased dieback the following year. Therefore, it was agreed by cooperators in 1993 to have seed abundance recorded as follows:

1. None (no seed is visible with binoculars)

2. Light to moderate seed present, BUT NOT abundant enough to cause noticeable discoloration in the upper crown

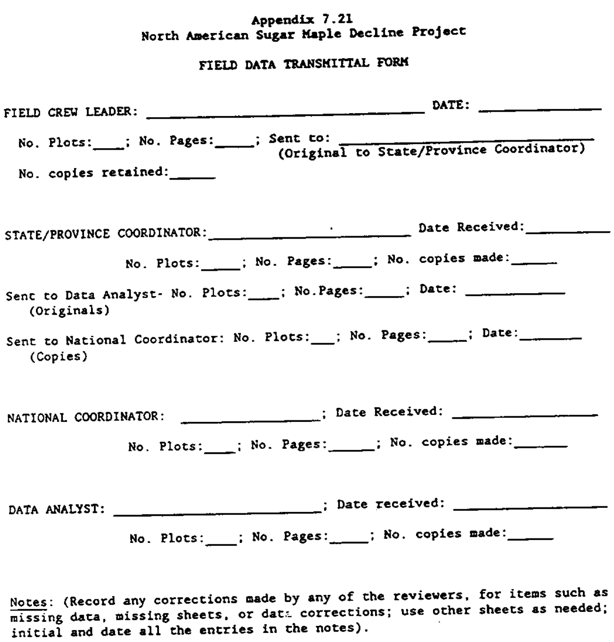
3. Heavy (branches in the upper crown with reddish-brown cast in mid- to late summer as a result of color change of samara from green to reddish-brown)

DATA MANAGEMENT AND QUALITY

ASSEMBLY

Data Collection and Transmission

Standard field forms are used to record data (Figs. 4, 6) in the field. Previous years data are carried forward for the first 5 items on the form. Indelible ball point pens are used to permit photo copying and prevent erasures. Changes are initialed and dated by the person making the change. When data must be transcribed because of damage to the original data sheets, another person checks the transcript, initials, and dates each page. The original data sheet is attached to the transcript. In the field, the recommended practice for the recorder is to repeat measurements audibly before data are recorded. Absence of an item is recorded as "0" to indicate that a measurement or an observation was made. Absence of an entry on the data sheet is considered as missing data unless specifically permitted. The crew leader is responsible for checking completeness of data sheets before leaving the plot. The names of the crew and the date of collection are recorded on each data sheet.



Appendix 7.21
North American Sugar Maple Decline Project

FIELD DATA TRANSMITTAL FORM

FIELD CREW LEADER: ______________________ DATE: ____________

No. Plots:____; No. Pages:_____; Sent to: ______________________
(Original to State/Province Coordinator)

No. copies retained:______

STATE/PROVINCE COORDINATOR:__________________ Date Received:__________

No. Plots:_____; No. Pages:_____; No. copies made:______

Sent to Data Analyst- No. Plots:____; No.Pages:_____; Date: ___________
(Originals)

Sent to National Coordinator: No. Plots:___; No. Pages:_____; Date:________
(Copies)

NATIONAL COORDINATOR: ________________; Date Received: ________________

No. Plots:____; No. Pages:______; No. copies made:_______

DATA ANALYST: ______________________; Date received: ________________

No. Plots:____; No. Pages:_____; No. copies made:______

Notes: (Record any corrections made by any of the reviewers, for items such as missing data, missing sheets, or data corrections; use other sheets as needed; initial and date all the entries in the notes).

Figure 9.-- Field Data Transmittal Form of the North American Maple Project.

Data sheets from all clusters are stored in a single envelope with proper plot identifications. Three copies are made of each data sheet. One copy of the field sheets is kept in the office of the field crew, a second copy is sent to the state or province coordinator, and the third copy is mailed to the appropriate national coordinator. The original Tree Data Field Form is mailed to the data analyst. In 2001, data will also be delivered in electronic form. Each Canadian Province uses data recorders, so the data is downloaded and mailed to the data analyst. The US cooperators are provided with an electronic template, which is to be used to double-enter the data (by 2 different people). These two files are used to verify the data entry. All forms and electronic data is due to the data analyst by OCTOBER 1, 2001. The data transmissions are accompanied by a Field Data Transmittal Form to document the number of pages transmitted (Fig. 9).

Entry, Validation, and Storage

NAMP provides information for up to 26 variables on approximately 22,000 trees of which approximately 80 percent are sugar maples. In addition, more than 25 variables are recorded for regional, stand, and site conditions in each of 231 clusters distributed among seven states and four provinces. Because of the size of the data set, it is important that the data be entered correctly and that an efficient method of validation be developed to ensure accuracy. Three separate files, Tree Data; Site Description; Regional and Stand Description, are maintained for each state or province. The files are stored on hard disks as well as diskettes. Once a file has been entered, checked, and validated, the file is write-protected to reduce the chances of accidental elimination. Annually, one copy of all files, in the form of a floppy disk, is submitted to the appropriate proper national coordinator for storage in a fireproof vault.

File 1 (Tree Data), arranged by cluster, contains the information for each of 26 variables for each plot. The information is entered directly from the Tree Data Field Form. The variables include: cluster identification, tree number, species, d.b.h., crown position, and vigor for each species; and taphole information, bole quality defects (if any), and crown conditions for sugar maples. The information for these variables is entered into the file twice. Corresponding values are checked for agreement, and disagreements between values are checked and corrected at the time of entry.

In addition to checking the information as it is entered, the information for 5 percent of the trees is rechecked. This 5 percent sample is divided proportionately among the states and provinces based on the number of clusters per state or province. If one or more errors is found, the information for all the clusters in that state or province is rechecked.

File 2 (Site Description) contains the site description variables, by each plot in each cluster. The information is entered directly from the Stand and Site Description Form. These variables include cluster identification, landform, slope position, percent and aspect, elevation, microrelief, soil texture and drainage, and site rockiness. The information for this file and the following file are visually checked as the data are entered into the file. Hard copies of these files also are checked after all the information for a state or province has been entered.

File 3 (Regional and Stand Description) contains the regional and stand description variables for each cluster. The information is entered directly from the Stand and Plot Description Form. These variables include cluster identification, weather information, terrain, watershed, disturbance and tapping history, crown closure and structure, relative site quality, and stand age.

Copies of field forms are stored in the offices of the state coordinators and provincial Forest Insect and Disease Survey, Forestry Canada, provincial headquarters; with the national coordinators; and, with the data analysis contractor.

QUALITY ASSURANCE

Quality assurance consists of an organized group of activities defining the way in which tasks are to be performed to ensure an expressed level of quality. These activities ensure that the operations and procedures requiring control are defined, documented, and implemented. Because of the large number of cooperators in the Project, which, involves many field crews, quality assurance activities in the North American Maple Project are of major importance. A separate Quality Assessment and Quality Control Plan was prepared as an appendix to the Cooperative Field Manual. This plan prescribes proper handling of critical equipment, specifications for critical measurements, training requirements to achieve necessary data standardization, and required field checks to document and assure data comparability.

Data Quality

Crown-condition measurements are critical for determining changes in the condition of sugar maple. The crown-condition ratings are subjective, quantitative, ocular estimates. The repeatability of measurements is assured through intensive training, standardized guides, and the use of two persons, minimum, to rate each tree. The first 2 years of cross-checking showed that approximately 95 and 90 percent of remeasurements were within one class for dieback and crown transparency, respectively. Discoloration and dwarfed foliage remeasurements also showed high measurement repeatability, but a majority of the measurements were in the very low percentage classes. Crews are trained and tested annually for satisfactory performance. Field situations may occur when a measurement cannot be taken. Documentation must be provided for any measurement not taken by leaving blank the space in the record. That portion is deleted in the analysis and does not appear as 0 or 1.

Standards and Critical Measurements

In 1988, the five crown-rating measurements were: branch dieback, foliage transparency, foliage discoloration, dwarfed foliage, and presence of epicormic shoots. Because of poor remeasurement precision for epicormic shoots and dwarfed foliage, these measurements were deleted from subsequent annual measurements. Foliage discoloration measurements were down-graded to non-critical measurements and their quality is not checked for compliance with minimum standards. In 1989, a new measurement was added to assess the degree of insect defoliation. It is not considered a critical measurement and is not checked for repeatability precision. Also in 1989, crown ratings of hardwoods other than sugar maple were added, but these are not checked for compliance with minimum standards.

Data quality requirements for the critical measurements were outlined at the beginning of the project. Acceptable variability between raters, for example, tolerance limits, was established at +/- 1 class for dominant, codominant, and intermediate crown-class sugar maples, and +/- 2 classes for suppressed trees. Exceeding these limits is considered an error in measurement. The average of two or more experienced raters is considered as the correct measurement. Plot measurements were acceptable with less than 10 percent error.

Data quality was achieved by implementing the following activities:

1. Each critical measurement is rated by two certified crown raters from opposite sides of a tree. When the two raters do not agree, the class corresponding to the average ratings of the two is recorded.

2. Each rater is required to attend an annual training session and pass a rating qualifications examination. Records are maintained from all training sessions, examinations, and certifications.

Analysis of the remeasurement data showed that in 1988 approximately 5 percent of branch dieback and 9 percent of foliage transparency remeasurements exceeded the allowable tolerance limits (Burkman et al. 1990; Cline et al. 1989). With improved training in 1989, less than 5 percent and approximately 8 percent of the remeasurements exceeded the tolerance limits (Burkman et al. 1990).

Training and Certification

Annual training is provided to the field crews involved with the crown rating. The crown raters are required to attend the training and to complete certification for performance. Certifications are received when a person demonstrates ability to rate dieback and foliage transparency within the specified tolerance limits more than 90 percent of the time.

Large group training requires preselection of practice and certification trees. Training is provided in groups of approximately five persons under the guidance of an experienced crown rater. Approximately 20 trees are evaluated to achieve proper standardization. Then 20 trees previously rated by at least two experienced crown raters, are rated by each trainee. Trees are rated from one side only, usually indicated by a tag, to assure that the persons are rating the same condition. Trainees are given the opportunity to rerate a tree when their assessment deviates more than two classes from those of experienced raters.

A similar approach is used for small groups, except that the experienced raters and the trainees evaluate the trees at the same time, then discuss the ratings. The trainees are asked to record their ratings. Deviations from the experienced raters are discussed and the trainees are permitted to change their values. Usually, acceptable standardization is achieved after the first six trees. The rating exercise is terminated after the trainees agree within the acceptable 1-class limits for five successive trees. The experienced crown raters usually are the national coordinators and the quality assurance officers.

DATA QUALITY CONTROL

Data Verification and Transmittal Procedures

To ensure valid data, internal checking procedures were implemented. Data verification ensures that the final data are of a known and documented data quality and that valid data codes are in the final data set. A schematic flow chart shows the internal checking procedures for data completeness and transmittal (Fig. 10).

FIELD CREWS ARE ASKED TO EXAMINE ALL DATA SHEETS FOR COMPLETENESS AND TO VALIDATE DATA CODES BEFORE DEPARTURE FROM THE FIELD.

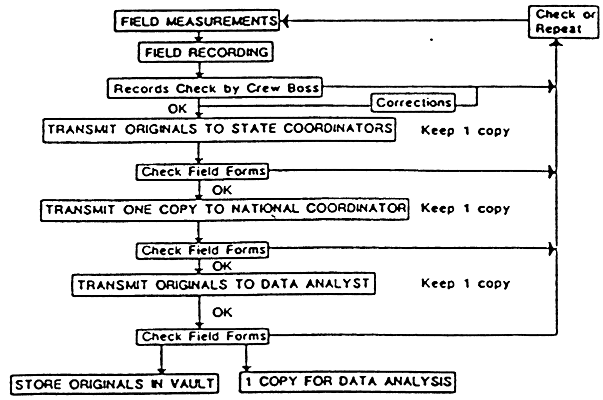


Figure 10.-- Data completeness and transmittal flow chart

Each state or province coordinator examines all the data sheets for proper entries before submission to the data entry staff. Errors are documented and the reviewer identified on the cover sheet. When data entries are completed by data entry personnel, the original data sheets are stored in a fireproof vault for safekeeping.

A transmittal form is used as a cover sheet for all the data packages, showing the number of pages transmitted, person transmitting the data, and the date (Fig. 9). Copies of all the data sheets and transmittal form are retained at the field station, by the state or province coordinator, and by the national coordinator. The person responsible for the transmission of the field data, checks all the data sheets for missing data. The fact of omission and the actions taken to correct it is documented on the cover sheet. Revisiting the plot is required when missing data can be obtained.

Audits

The purpose of the audit is to determine if the field and data entry procedures prescribed in the guidelines are being implemented correctly. All the cooperators and the data analysis facility are scheduled for a visit once a year by quality assurance personnel. In practice, each cooperating state or province was audited once in 2 years. A memorandum report documenting observed deficiencies is prepared and copies sent to the appropriate state or province coordinator and the national coordinator. During the audit, the field crews are solicited for opinions on improving the field work.

Remeasurements

The precision of critical crown-rating measurements is determined each year using QA/QC remeasurements. Precision is defined as the level of agreement among multiple measurements of the same sample or repeated measurements by the same individual. Accuracy cannot be determined for most of the field measurements because the "true value" is not known and cannot be determined. Each crew is checked at least once in a season. The check-cruise method is used to determine the precision of measurements. About 25 percent of the plot clusters are scheduled to be checked and within each cluster at least one plot is remeasured for critical measurements. Remeasurements done without reference to the previous measurements, are completed either by the same or different crews. Some of the remeasurements are done by exchange between states and provinces. Results from the remeasurements show that crew precision is greater with same-crew remeasurements than with different crews, but no significant differences were observed between crews of the same state or province and crews from different states or provinces (Burkman 1990; Burkman et al. 1990).

Crews with allowable errors in more than 5 percent of their sample are reported to the state or province coordinator and to the national coordinator. A problem resolution report is prepared on the remeasurements that were made and submitted to the national coordinators and to the quality assurance personnel. Lack of documentation of corrective action requires deletion of all the data collected by that crew.

Data Quality Reporting

Data quality is presented as part of all published reports. Annual summaries of the data quality assessments are provided to all the cooperators before the next field season begins. The report includes a summary of the quality of the critical data and, where needed, provides recommendations for improvement.

Implementing Changes

Major changes that may affect the objectives must be approved by the Joint Management Team. These changes must be agreed to by the cooperators before recommendation to the Joint Management Team. Minor changes in the Project require the approval of the national coordinators and may include items such as substitution of stands; addition of new plots or replacement of permanent plots destroyed by natural disaster; or changes in the plot design. All the cooperators must collect the specified data. Failure to collect proper data may cause deletion of those plots from data analysis for that year. However, cooperators are free to collect additional data for their own studies.

ANALYSIS

The analysis and management of data are contracted with Dr. D.C. Allen, College of Environmental Science and Forestry, State University of New York, Syracuse, New York (SUNY) and are described in the Data Management and Analysis Plan (Appendix 7.3, Cooperative Field Manual).

Analyses of the data were designed to meet the stated objectives of the project and to test the following hypotheses:

1. Significant changes in tree condition ratings are explained through natural variability between stands.

2. The rate of sugar maple decline in high pollution areas is similar to that in low pollution areas and the differences can be explained by natural variability between stands.

3. The condition of sugar maple is similar in sugarbushes and non-sugarbushes.

4. Similar crown-condition trends occur in all the stands regardless of the initial stand-decline ratings.

The information collected after 1988 was insufficient to meet all of the objectives or to test all the hypotheses stated for this project. However, the data were summarized, relationships among the variables examined, and differences among groups were tested. This section outlines some of the procedures followed in the data analysis.

Tables are used to present summary information for each cluster, each state or province, and for the overall project. Much of this information is in the form of averages; that is, average number of trees per cluster, average number of tapholes per tree, average d.b.h., and averages of the critical variables (dieback, transparency, and discoloration). The ranges for the variables are given in addition to their averages.

In addition to averages, the frequency distributions of trees in various crown-position and vigor classes, number and types of defects present, and species composition in each cluster (especially the proportion of sugar maples) is tabulated. Stand and plot information has been provided to the cooperators in the form of tables showing actual entries.

REPORTS

A major emphasis of the Project is to inform cooperators of the overall situation each year and to provide significant information to the various government agencies and the public.

The first-year report (Allen and Barnett 1989) included a summary of the data collected during plot establishment in 1988. Stand age determinations, based on increment core analyses, were distributed separately to the cooperators.

Annual reports are prepared for distribution to the cooperators (Allen and Barnett 1990). Site specific information is provided to the cooperators for their specific sites, only. Regional summaries are provided for public distribution. The reports are sent to each state and province and include an overall summary of changes in crown conditions as well as a more detailed presentation of the plot clusters of that state or province. The target is to distribute the reports before the next season.

An annual brochure summarizing the status of sugar maple health is published every year.

An analytical report of 7 years of data has been published (Allen et.al. 1997). This includes much more detailed analyses than the annual reports, and includes other information such as mortality rates and correlations with deposition data.

EQUIPMENT AND SUPPLIES

At the time of plot establishment, several land surveying and forestry tools were used. Binoculars, however, are the only specialized equipment used for crown-rating remeasurements. The crown-rating guide is carried by the crews for field reference. The following list includes most of the equipment and supplies used by the field crews in:

Plot establishment:

Compass
Increment borer, 3 to 5 mm dia.
Tree identification manual
Measuring tape (metric)
Clinometer
PVC pipe, 2 cm dia., 1 m long; 5 per plot, 25 per cluster
Numbered aluminum tree tags and aluminum nails
Cardboard tubes or paper straws for increment cores
Stand and Plot Description Form
Tree Data Field Form
Tree flagging
Indelible pen

Annual crown rating:

Binoculars
Foliage Transparency Standards
Tree Data Field Form
Indelible pen

Plot remeasurement:

Compass
Measuring tape
Diameter tape
extra PVC pipe
aluminum tree tags and aluminum nails
Tree Data Field Form
Indelible pen

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