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North American Sugar Maple Decline Project: Organization and Field Methods

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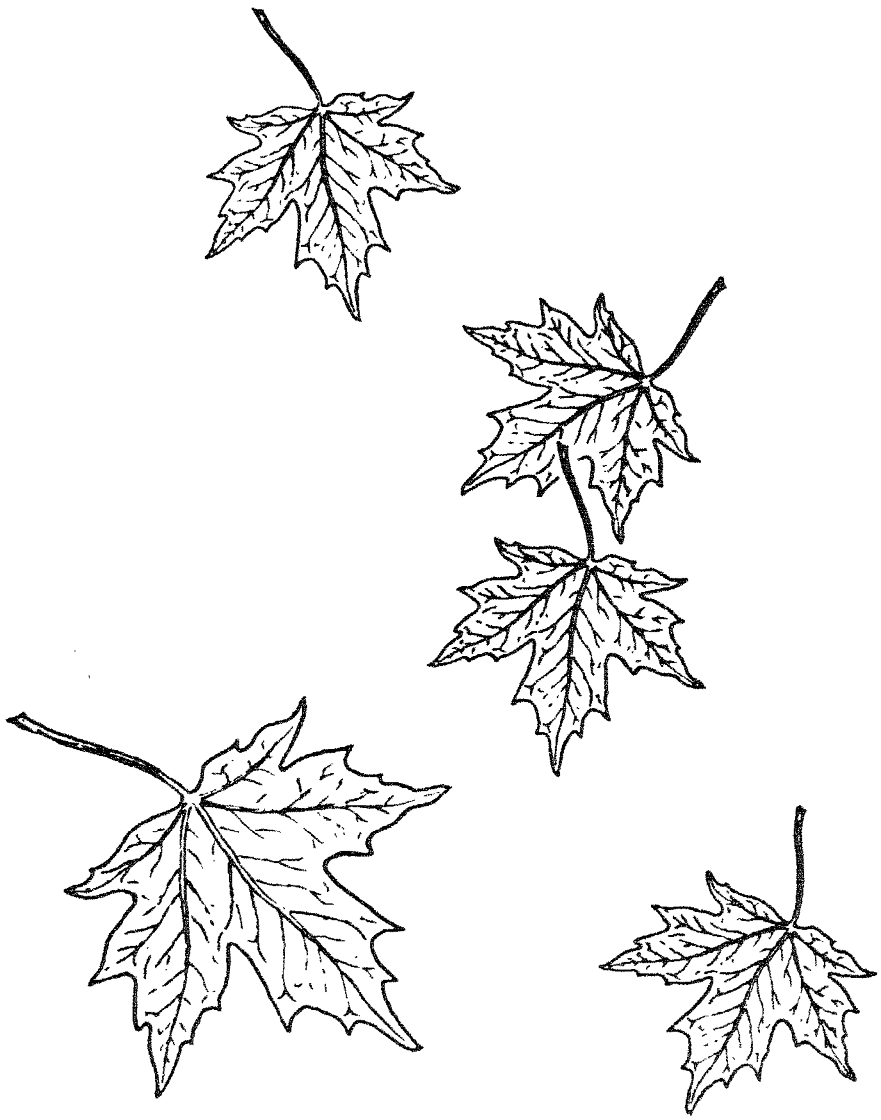

Forest Response Program
Eastern Hardwoods
Research Cooperative

Abstract

Describes the organization and field methods used in the North American Sugar Maple Decline Project. New methods were developed and tested to measure crown damage. Quality assurance and quality control of the data are given high priority because of the large number of people involved. The instructions in the field methods were translated into French for the benefit of Quebec Cooperators. As a result, 95 percent repeatability of crown rating estimates within the prescribed tolerances was achieved among the crews.

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North American Sugar Maple Decline Project: Organization and Field Methods

Executive Summary

Recent reports of decline and mortality in the sugar maple forests of eastern North America generated intense interest in determining the severity of the decline, its geographical extent, and the probable causes. To delineate the problem and identify appropriate avenues of research, the Eastern Hardwoods Research Cooperative of the National Acid Precipitation Assessment Program initiated a joint research effort with Forestry Canada. Eventually, the project grew into a large international cooperative effort among various provinces and states, and the two federal governments.

A Scientific Core Team was selected to develop field procedures during the 1987 field season. A Joint Management Team was established and National Project Coordinators were appointed to administer the project. In 1988 a total of 166 plot clusters was established with seven states and four provinces cooperating. Two additional plot clusters were added in 1989 for a total of 168. Changes in dieback and crown transparency are determined by annual crown rating. The project augments projects in progress within various cooperating agencies. Also, it provides an opportunity to evaluate cooperatively the sugar-maple decline problem over a greater range of conditions than exist within any one state or province.

The North American Sugar Maple Decline Project is an example of a highly successful cooperative project involving Canada and the United States — federal governments, provinces, states, and universities. Project success is largely the result of cooperative planning and management. The data are collected in a standardized way after common training, and a sample of the data is cross-checked to establish remeasurement differences. All data are analyzed in one location.

The Project was administered by the Joint Management Team, Dr. L. Carlson, Forestry Canada, and Dr. M. W. McFadden, U.S. Department of Agriculture, Forest Service, co-chairmen. A technical core committee developed the workplan. National coordinators prepared the Field Survey Manual and coordinated data collection. Field procedures were developed during the 1987 field season.

Contents

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) (see appendix A for list of participants).

A scientific core team (appendix B) 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 1990 field season.

Monitoring of 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 that 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?

Canada. Annual forest-damage surveys in Canada are the responsibility of the Forest Insect and Disease Survey (FIDS) units of Forestry Canada (the parent agency has changed its name several times). 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 of 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 Agreement. 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 betwen the U.S. Department of Agriculture and Forestry Canada. The various cooperators in Canada and the United States agreed to a common work plan. 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 (replacement for the late Dr. P.J. Rennie), Forestry Canada, and Dr. M.W. McFadden, USDA Forest Service. Three other members complete the Joint Management Team (Appendix B). A Scientific Core Team was formed to provide early planning of the project

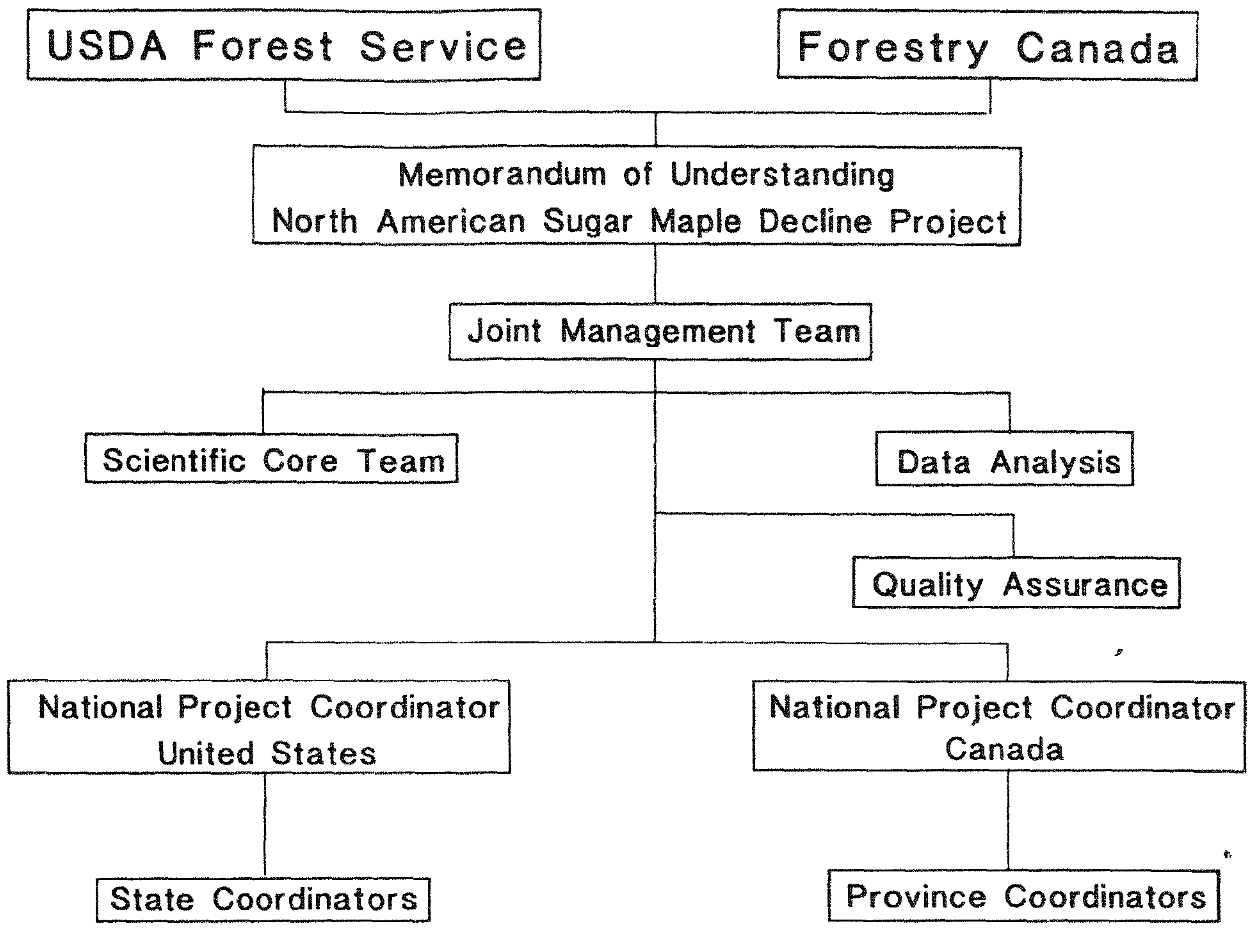

Figure 1.—Organization of the North American Sugar Maple Decline Project (1989).

(Appendix B). This team was dissolved after the Work Plan and Field Manual were developed. Technical guidance in the field is provided by the National Coordinators: Denis Lachance, Forestry Canada, and Imants Millers, 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 W. Burkman, NSI Technology, contracted by the U.S. Environmental Protection Agency, coordinates the quality assessment and quality control activities. A complete list of cooperators, with their addresses, is shown in Appendix C.

Cooperators

In Canada, the following provincial agencies cooperate with Forestry Canada:

New Brunswick: Department of Natural Resources and Department of Municipal Affairs and Environment
Nova Scotia: Department of Lands and Forests
Ontario: Ministry of Environment
Quebec: Department of Energy and Resources

In the United States, the project is administered by the USDA Forest Service through the Northeastern Forest Experiment Station in cooperation with Forest Pest Management, Northeastern Area, State and Private Forestry. The following state agencies are cooperating (see appendix C for contact addresses):

Maine: Bureau of Forestry, Department of Conservation
Massachusetts: University of Massachusetts and Division of Forests and Parks
Michigan: Michigan State University and Department of Natural Resources
New Hampshire: Division of Forests and Lands
New York: State University of New York at Syracuse and State Department of Environmental Conservation
Vermont: Department of Forests, Parks, and Recreation
Wisconsin: Department of Natural Resources

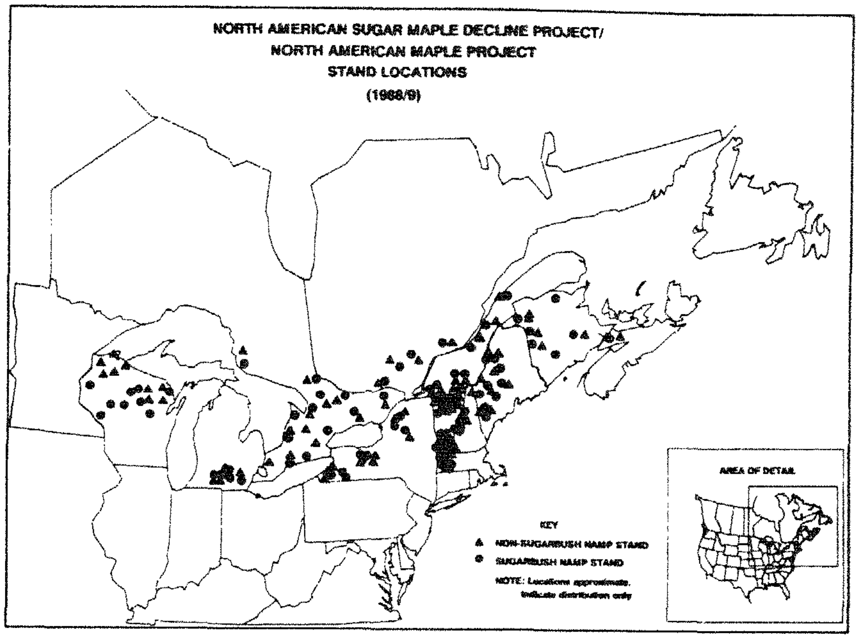

Figure 2.—Distribution of plot clusters of the North American Sugar Maple Decline Project (1989).

Objectives

The objectives of the project are to:

1. Determine the rate of change in sugar maple tree-condition ratings from 1988 through 1990.

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 undisturbed forest, 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.

The project has been extended to 1993 when a reassessment will be made for its continuation.

General Approach

The project began in the summer of 1987 with the development and testing of a field manual. In 1988 plots were established across eastern North America, from Ontario and Wisconsin in the west to Maine and Nova Scotia in the east. The North American Sugar Maple Decline Project Work Plan provides the background, purpose, and overall direction 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 here, 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. The methods documented here result from these changes.

Experimental Design

A total of 168 plot clusters are examined annually 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 undisturbed forest stands. In addition, 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 Wisconsin and Ontario to Maine and Nova Scotia to 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, by state or province, is as follows:

United States		Canada	
Maine	18	New Brunswick	12
Massachusetts	10	Nova Scotia	2
Michigan	10	Ontario	24
New Hampshire	6	Quebec	24
New York	18		62
Vermont	26		
Wisconsin	18		
	106		

In New Brunswick, 10 plot clusters were established in 1988 and 2 more added in 1989.

Field Methods

The field methods were developed by the Scientific Core Team and field tested before implementation in 1988. Minor changes to improve the methods and to provide better interpretation to the field crews during the first 3 years of the project are incorporated here.

Plot Establishment

Stand Selection. One-half of the samples in the province or state is located in each of two management categories — sugarbush or undisturbed forest — 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.

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 undisturbed forest. 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)

Undisturbed Forest – 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 in the last 5 years of disturbance, 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). Generally, stands in the United States were healthier than those in Canada.

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 in preparation). Nitrate-wet deposition ranged from approximately 8 kg/ha/yr to approximately 22 kg/ha/yr (Fig. 3).

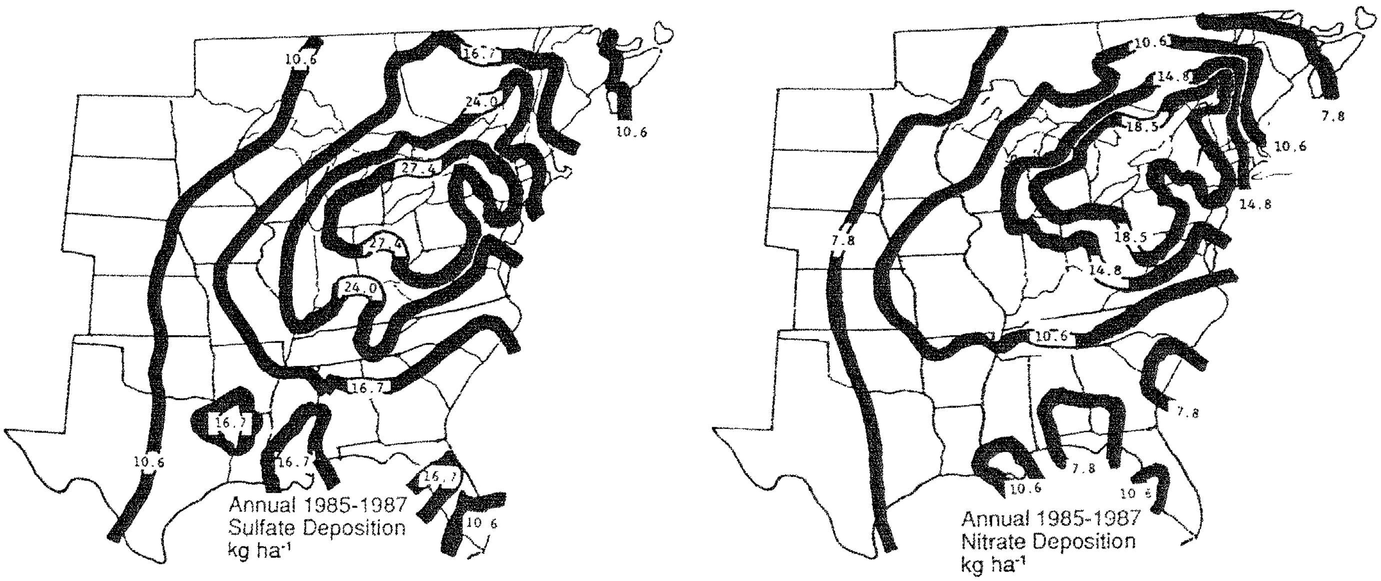

Figure 3.—Sulfate and nitrate deposition in kg/ha/yr in eastern North America (Adapted from Sisterson and others [in preparation]).

Cluster and Plots

A permanent fixed-boundary plot-cluster sampling method was chosen to describe stand and site conditions. The primary intent was to sample about 100 sugar maples at each site.

Cluster. In each stand a cluster of five plots was 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 was 20 m by 20 m, or 400 m^2; the corners are at 45° from cardinal compass directions and 14.2 m from the center stake. The outside boundaries of the plots are a minimum of 20 m from the edge of the nearest plot or from the edge of the stand. Dirt roads or trails that do not open the crown canopy beyond normal stand conditions are not considered as 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. A similar 20-m 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 diameter by 1 m long, 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 and 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, undisturbed forest
2. State of province letters: ME, MA, MI, NB, NS, NH, NY, ON, QU, VT, WI;
3. Cluster number: Three digits including zeroes to the left, as needed.
4. Plot number (1, north; 2, east; 3, south; 4, west; 5, cênter. When plots are arranged in a different pattern, the first plot is coded 5, and the following plots as 6, 7, 8, and 9.

The plot identification code 1 VT005 4, is a sugarbush in Vermont, the fifth cluster, and the west plot.

Site Description

A variety of general site information is 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 Description 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 around the cluster and a local description at each plot.

Location. Plot-cluster location is recorded to within 100 m 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:

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

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

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).

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:

LANDFORM (Fig. 5a); coded into eight 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 (not shown in illustration) (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 (not shown in illustration) (the entire area typically is flat)

SLOPE POSITION (Fig. 5b). There are seven types of slopes, coded 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)

North American Sugar Maple Decline Project Field Manual Appendix 7.6 (3/18/88)
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 Sugar Maple Decline Project.

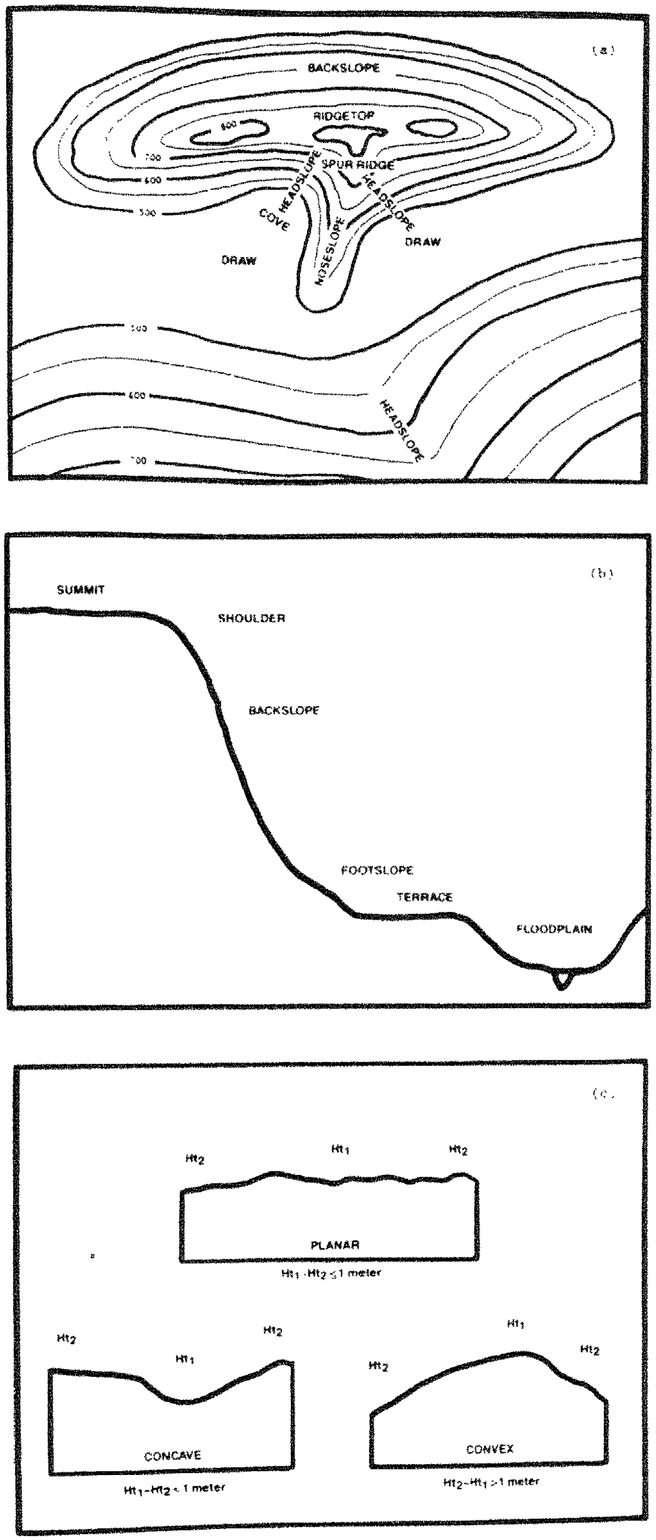

Figure 5.—Diagramatic definitions for landform (a), slope position (b), and microrelief (c) modified from Zedacker and Nicholas, 1990.

7 – flat (not shown in illustration) (similar to terrace and floodplain, but not adjacent to hills or bodies of water)

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

PERCENT SLOPE is determined with a clinometer to the nearest 1 percent.

ELEVATION is shown to the nearest 10 m and determined from a topographic map.

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

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:

Code	Soil texture	Particle size limits	
		Lower	Upper
		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	76.2 –	305

ROCKINESS is coded in three degrees:

1 – not more than one protruding large rock (cannot be moved easily by one person; usually more than 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.

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 will be taken when data analyses suggest significant relationships. The data are recorded on the Stand and Plot Description Form (Fig. 4).

Disturbance. Disturbance is coded as 1, absent; 2, present (if present, disturbance is identified):

LOGGING, based on one of the four following 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 5 years (firm stumps present)
4 – recent, logging in the last 5 years (stumps and logging residue present)

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

GRAZING is assessed in four 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

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 last 5 years
4 – none ever

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 are included in the notes.

Vegetation. Since this is not a critical measurement, the data will be collected more precisely when apparent relationships are detected. There are three ways to measure stand vegetation.

CROWN CLOSURE is recorded in three classes; classification is based on the proportion of ground receiving sunlight:
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

CROWN STRUCTURE is described as: 1, single-story; 2, two-story; and 3, multistory (stems smaller than 3 cm in diameter are not considered).

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 km^2 area)
2 – less than maples nearby
3 – better than the maples nearby. The notes are used to show why the observer rates the stand quality 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.

Sugar maples in sugarbushes and forests often require long increment borers to reach the center of the tree. The borers should be about 50 cm long with a diameter of 3 to 5 mm, but smaller or larger cores are acceptable. The instrument must be sharp, clean, and well lubricated to avoid breakage.

The cores are taken at breast height. If a tree is not round, the oval side is chosen. The increment borer is aimed toward the expected center of the tree and twisted by applying even pressure and keeping the stem straight.

The core is removed by first pulling out about 1 inch, then the bark and wood are held with the fingers as the rest of the core is removed; both bark and wood are required for proper age estimate. 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 and the plot identification number and date of collection are recorded on the tube. Long cores require several straws, each part being 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.

Tree Measurements

The following section describes methods used to inventory individual tree condition. All the data were recorded at the time of plot establishment on a standard Tree Data Field Form (Fig. 6). Thereafter, the primary emphasis is to record crown condition. Evidence of new bole or trunk damage and 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 of the trees 10 cm and larger were marked with aluminum tags and nails at d.b.h., identified by 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 in separating black maple from sugar maple and a few black maples may be included among sugar maples.

Common names used were from Little (1979). 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 codes are as follows:

Angiosperms		Gymosperms
Code	Code	Code
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, hophornbeem	98 Tamarack
22 bur	46 Cherry	99 Other conifers
23 northern red	47 Elm	
24 black	48 Beech	
	49 Other hardwoods	

Diameter. Tree diameter was measured at d.b.h., or 1.37 m above ground, in 1988. 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. Crown position ratings were recorded for all the species in 1988, and changes are recorded annually as they occur. 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 weighted 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. 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; less than 10 percent branch or twig mortality, discoloration, or dwarfed leaves present)

2 – light decline (branch mortality, twig dieback, foliage discoloration, or dwarfed leaves present on from 10 to 25 percent of the crown)

3 – moderate decline (branch mortality, twig dieback, foliage discoloration or dwarfed leaves on from 26 to 50 percent of the crown)

4 – severe decline (more than half of the crown with branch mortality, dieback, discoloration, or leaf dwarfing, but foliage still present to indicate that the tree is alive)

5 – dead, natural (tree is standing dead; phloem under bark has brown streaks; few epicormic shoots may be present on the bole; no further entries needed)

6 – dead, tree removed, or dropped (tree has been sawed or girdled by humans)

Tapping record. The number of tapholes is recorded annually for all the sugar maples. A zero value is used to indicate that signs of tapping are absent. One entry is

NORTH AMERICAN SUGAR MAPLE DECLINE PROJECT - FIELD MANUAL APPENDIX 7.7 - (REVISED 1 MAY 89)

TREE DATA FIELD FORM

PLOT ID

PAGE _____ OF _____

MGT (1-SB;2-NSB) _____ 1.DATE:____________ 2.DATE:____________ 3.DATE:____________ VISIBILITY

STATE/PROV _____ CREW:____________ CREW:____________ CREW:____________ 1. GOOD, BRIGHT

CLUSTER # _____ ____________ ____________ ____________ 2. POOR _____

PLOT # _____ ____________ ____________ ____________

DATA CHECKED BY:____________ DATE:__________ DATA CHECKED BY:____________ DATE:__________

ALL TREES					TRUNK/BOLE CONDITION					CROWN EVALUATION						OTHER		NOTES
			CROWN		TAPPING		NEW DEFECT							EXTENT OF				
TREE #	SPP	DBH (CM)	POS	VIG	CURR TAPS	OPEN TAPS	LOCA-TION	DAM-AGE	CAUSE	DIE-BACK	TRANS PAREN	DIS-COLOR	LEAF DWARF	EARLY DEFOL	LATE DEFOL			

Figure 6.—Exhibit of the Tree Data Field Form of the North American Sugar Maple Decline Project.

made for the number of current tapholes and another entry is made for the total number of open tapholes, including both current and old tapholes. A current taphole may be open or closed. A taphole is considered open when a pencil may be pushed into the hole. An uncertain 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. Severe bole damage that might affect tree vigor was recorded for all species in 1988. Annually, new, severe trunk damage such as caused by wind, animal, or human activity is noted.

LOCATION OF BOLE DEFECTS. The location of defects is recorded as follows:

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 the stump within 30 cm from the ground)

5 – whole tree (includes bole, stump, and roots)

TYPE OF INJURY, DAMAGE, AND DEFECT ON THE BOLE. As many as three major defects or types of damage on the bole were recorded in 1988. Thereafter, new growth-impairing injury is added annually. Codes of defects primarily affecting timber quality, but not likely to affect the growth or survivorship of the tree, 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)

Codes of damage, injury, signs, and symptoms that are likely to impair growth and survival of the tree are:

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 and tight (old bruise or other damage extending more than 10 cm but 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 long, but not more than 2 cm wide; open or closed, including scars)

37 – other (damage described in the notes)

CAUSAL AGENTS. The probable agents responsible for trunk or bole defects are entered only when the observer is reasonably sure of the cause of damage. Special training is required to identify 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)
4 – animal (rubbing, gnawing, girdling, birdpecking, root damage from grazing)
5 – human (logging, blazing, girdling; does 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)

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 of difficulties in repeating measurements, the rating of epicormic shoot measurements was dropped. Uncertainty about definitions for discoloration and dwarfed foliage resulted in removal of these measurements from the critical measurement list, but the measurements continued. Thus, only the estimates of branch dieback and foliage transparency of sugar maples are retained as critical measurements. Data quality guidelines are followed 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 extended from early July to the end of August. The purpose is not to initiate crown rating until leaves are matured 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; 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, discoloration, and leafdwarfing are likely to change annually. A training aid and 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.

Crown Grid. The Crown Grid (Fig. 7) was developed from similar grids used to estimate areas on maps. Accompanying the grid is a Foliage Transparency Grid, a set of screens to assist in assessing the percent damage. The crown grid area does not represent a quantitative measurement of the crown. The central square (bold face box) has 100 dots, and each peripheral square has 25 dots. The Grid may be copied on a transparency and mounted on a thick plastic sheet with clear cellophane tape.

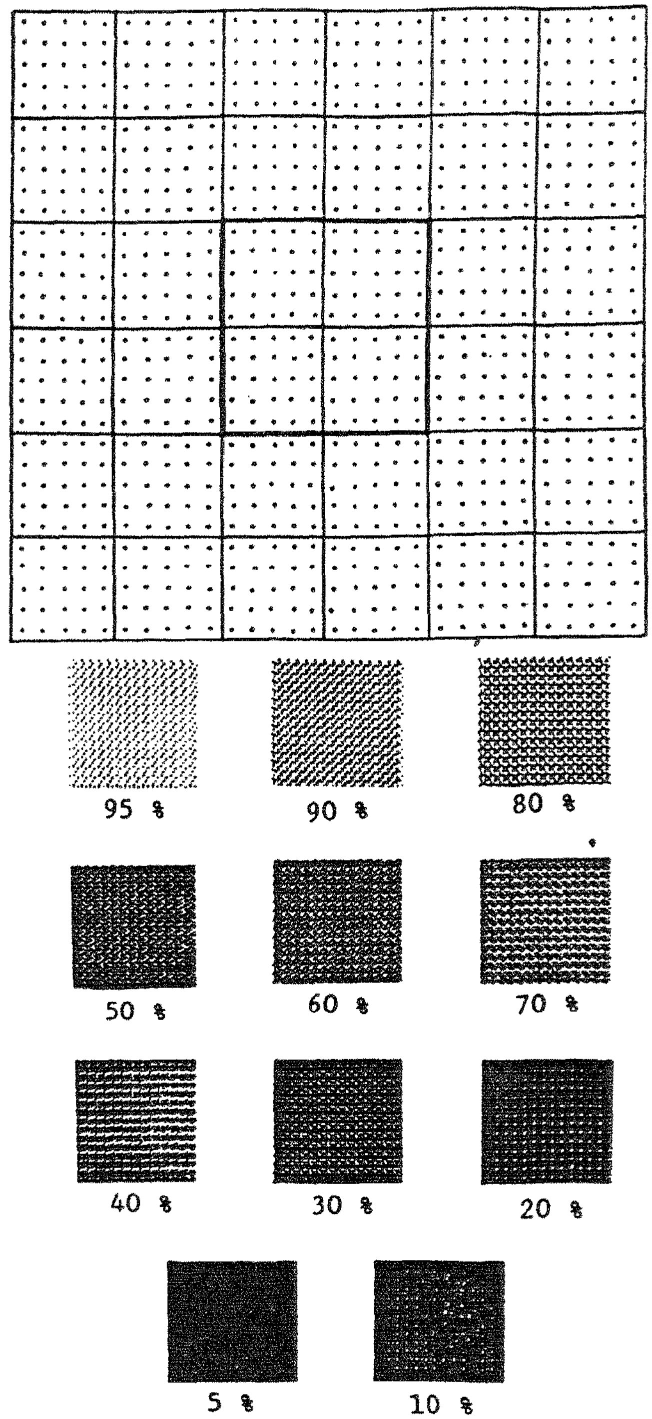

Figure 7.—Crown Grid (a) and the Foliage Transparency Grid (b) used in the North American Sugar Maple Decline Project.

Using the Crown Grid

1. Hold the transparency approximately 30 cm 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 marked out.

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.

12-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. Therefore, in the interpretation of the data, the 12-percentage-class ratings could be narrowed down to the four crown-damage classes: 1. none-to-light, 2. moderate, 3. heavy, and 4. severe.

Branch dieback. 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, however, result in increase of dieback, and eventual decline and death of the tree.

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

Class code	Percentage class	Class range	Acceptable observer variability	Damage class
00	0	0	0–5	None
05	5	1–5	0–15	to
10	10	6–15	1–25	Light
20	20	16–25	6–35	
30	30	26–35	16–45	Moderate
40	40	36–45	26–55	
50	50	46–55	36–65	
60	69	56–65	46–75	Heavy
70	70	66–75	56–85	
80	80	76–85	66–95	
90	90	86–95	76–100	Severe
99	100	96–100	86–100	

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. Snag branches — large branches without small twigs under 2.5 cm 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 long, in the upper portion of the tree crown, is rated as the lowest class with dieback the 5-percent class. Occasionally, dead twigs are scattered throughout the crown. Technically, in this case, the crown silhouette has evidence of dieback, that is, code 99. For a more realistic assessment, however, an estimate is made of the approximate proportion of foliage lost from the dead twigs, which is recorded then as the dieback percentage.

Foliage transparency. 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. Foliage transparency is the opposite estimate of foliage density. 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 (adjacent to the Crown Grid in Fig. 7) is a 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. A similar aid was prepared using actual tree-crown transparency pictures.

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). The Foliage Transparency Standards may be copied and laminated in plastic for field use.

Foliage discoloration. Foliage discoloration is estimated in percentage classes similar to dieback estimates. The percentage 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 yellow, red, and brown, than green. 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. The proportion of crown with discolored foliage is rated in the 12-class system.

Forest pathologists recognize certain types of off-green coloration on diseased trees. 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 discoloration 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.

Dwarfed foliage. Severe stresses may result in smaller than normal leaves. A leaf will be considered dwarfed when it is less than half normal size. Maple leaves in the shade tend to be very large, while on upper twigs near the terminals, leaves tend to be small. On the other hand, stresses such as disease and refoliation following insect defoliation reduce leaf size. Dwarfed foliage is most easily recognized by comparing the sample with neighboring trees and undergrowth. Regional stresses, such as drought, may cause leafdwarfing of all the trees in a stand and it becomes difficult to define at which point the leaves are dwarfed. For these reasons leafdwarfing was dropped as a critical measurement following the 1988 season. When the observer has doubts whether foliage is dwarfed it should not be recorded. Two certified raters are required to make estimates of dwarfed foliage on opposite sides of the tree. The percentage estimates are made using the 12-class system.

Epicormic branches. The presence of epicormic branching on the trunk of sugar maples was recorded in 1988 as an indicator of stress. However, cross-checking crews revealed only approximately 80 percent agreement in remeasurements because of great variation in interpretation of what constituted an epicormic branch. The cooperators decided in 1989 to eliminate the epicormic branch variable, because an adequate definition could not be developed.

Defoliation. 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 and spring and midsummer defoliators may contribute to tree decline; that early defoliation (pear thrips, forest tent caterpillar, gypsy moth, and so on) 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. The first class, stand rating, is coded by: 0, none to light defoliation; individual trees not rated. The remaining three are: 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 rate the degree of defoliation more accurately is encouraged. The rating is done in the manner used for spring defoliation rating.

Data Management and Quality

Major effort was devoted to the development of data management, measurement standardization, and documentation of data quality.

Assembly

The large number of cooperators and the decentralized management of field crews required specific directives on data management to assure their completeness and arrival at the data analysis center.

Data Collection and Transmission

Standard field forms are used to record data (Fig. 4, 6) in the field. Indelible ball-point pens are used to permit photocopying 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 sheet.

Data sheets from all clusters are stored in a single envelope with proper plot identifications. Three copies are made of each. One copy of the field sheets is kept in the office of the field crew, a second 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. The data transmissions are accompanied by a Field Data Transmittal Form to document the number of pages transmitted (Fig. 9).

Entry, Validation, and Storage

The primary data entry and storage vehicle is the LOTUS 1-2-3[1] spreadsheet program. This project provides information for up to 26 variables on approximately 15,000 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 168 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 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 tree. 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 condition 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 time of entry.

In addition to checking the information as it is entered, the information for 1 percent of the trees is rechecked. This 1-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. The 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.

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[1]The use of trade, firm, or corporate names in this publication is for the information and convenience of the reader. Such use does not constitute an official endorsement or approval by the Department of Agriculture or the Forest Service of any product or service to the exclusion of others that may be suitable.

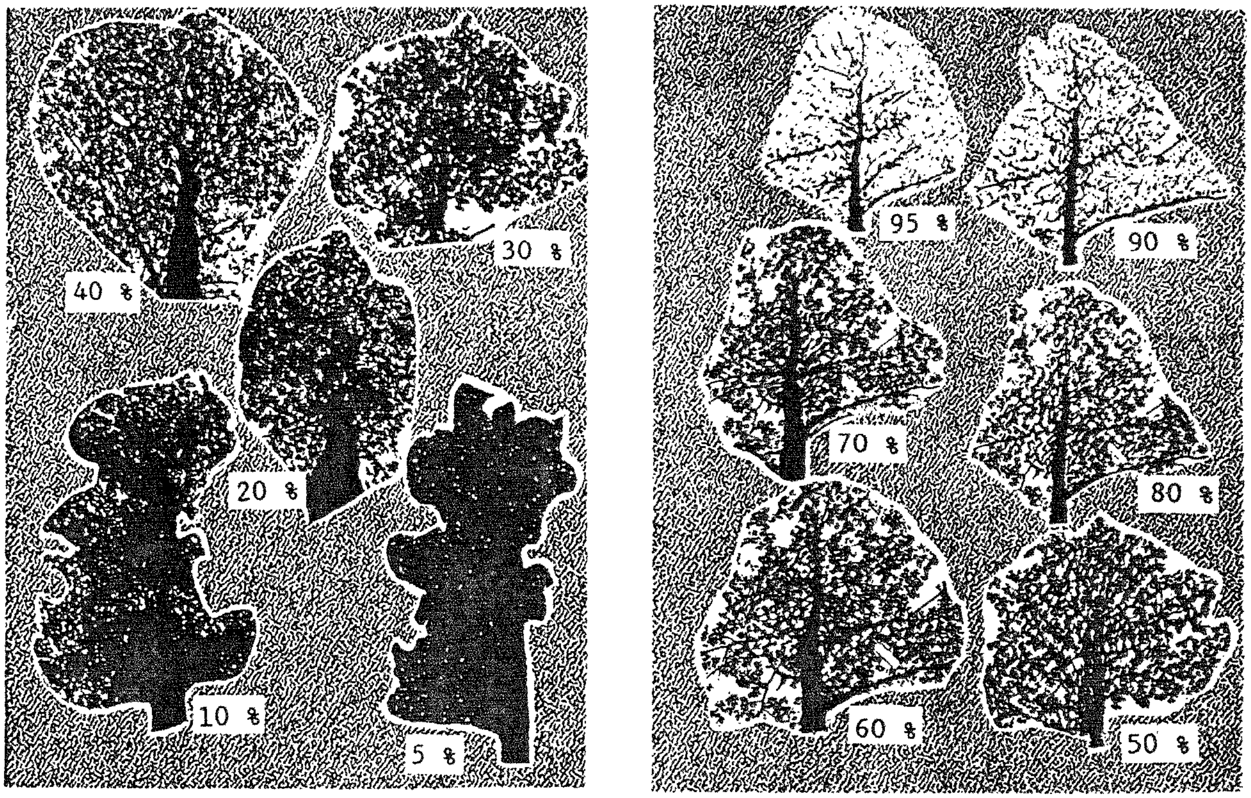

Figure 8.—Foliage Transparency Standards used in the North American Sugar Maple Decline Project.

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. The 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 Sugar Maple Decline 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.

Work Plans, Manuals, and Guidelines. The project work plan, field manuals, and supplements to the field manual are available from the Project management and cooperators listed in appendix C. Also, many of the supplements and appendixes are incorporated into this text. The basic guides are listed with the principal authors of each:

COOPERATIVE WORK PLAN. Prepared by Imants Millers for the Joint Management Team of the North American Sugar Maple Decline Project: M.W. McFadden, U.S. Department of Agriculture, Forest Service and P. Rennie, Forestry Canada, Co-chairmen.

COOPERATIVE FIELD MANUAL. Imants Millers, U.S. Department of Agriculture, Forest Service; Denis Lachance, Forestry Canada.

GUIDE D'OPERATION SUR LE TERRAIN. Imants Millers, U.S. Department of Agriculture, Forest Service; Denis Lachance, Forestry Canada, (in French).

COOPERATIVE FIELD MANUAL. Revised and Updated for 1989. Imants Millers, U.S. Department of Agriculture, Forest Service; Denis Lachance, Forestry Canada.

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:______

<u>Notes</u>: (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.—Exhibit of the Field Data Transmittal Form of the North American Sugar Maple Decline Project.

An annual activity schedule is prepared before the field season and distributed as appendix 7.1 to the Cooperative Field Manual. It outlines the target dates for field data collection, data transmittal, analyses, and reports.

QUALITY ASSESSMENT AND QUALITY CONTROL PLAN. Appendix 7.2 to the Cooperative Field Manual. Millers, I. and D. Lachance. U.S. Department of Agriculture, Forest Service and Forestry Canada.

DATA MANAGEMENT AND ANALYSIS PLAN. Appendix 7.3 to the Cooperative Field Manual. Allen, D.C.; Barnett, C.J. State University College of Environmental Sciences and Forestry, Syracuse, New York.

CROWN RATING GUIDE. Appendix 7.4 to the Cooperative Field Manual. Millers, I. U.S. Department of Agriculture, Forest Service.

Four other items were produced as appendixes to the Cooperative Field Manual: Instructions for the Collection of Increment Cores – appendix 7.5; Stand and Plot Description Form – appendix 7.6; Tree Data Field Form – appendix 7.7; and Cooperators Contact List – appendix 7.8.

Data quality. Crown-condition measurements are critical for determining changes in the condition of sugar maple. The crown-condition ratings are subjective, quantitative, ocular estiamtes. 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 deleated 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, the shoots were deleated from subsequent annual measurements. Foliage discoloration and dwarfed foliage measurements were down-graded to informal 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 measurements 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 figured by two or more experienced raters is considered as the correct measurement. Plot measurements were acceptable with less than 10 percent error.

Data quality requirements were 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 approximately 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.

National and state or provincial coordinators also could provide individual training and give field tests in emergency situations.

Data quality control. Data quality control involves data verification and transmittal procedures, observations of field data collection procedures, and remeasurements in the field to determine variability between crews, and between two measurements of the same crew.

DATA VERIFICATION AND TRANSMITTAL. Valid and verified data are very important to this project. 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. 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 entries are completed by data entry personnel, the original data sheets are stored in a fireproof vault for safekeeping.

The transmittal form mentioned earlier is used as a cover sheet for each data package, showing the number of pages transmitted, person transmitting the data, and the date (Fig. 9). Copies of all the data sheets and the 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 are documented on the cover sheet. Revisitation of the plot is required when missing data can be obtained.

AUDITS. The purpose of audits 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. 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-crews 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 significiant 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 producing measurements that exceed allowable errors more than 5 percent of the time are reported to the state or province coordinator and to the national coordinator. A report is prepared on the problem resoluton and 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. Changes in critical measurements must be kept to a minimum. The basis for any change usually is the result of the data quality assessment. 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. Minor changes include items such as substitution of stands, addition of new plots or replacement of permanent plots destroyed by natural disaster, or major 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.

IMPLEMENTING CHANGES. Changes in critical measurements must be kept to a minimum. The basis for any change usually is the result of the data quality assessment. 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.

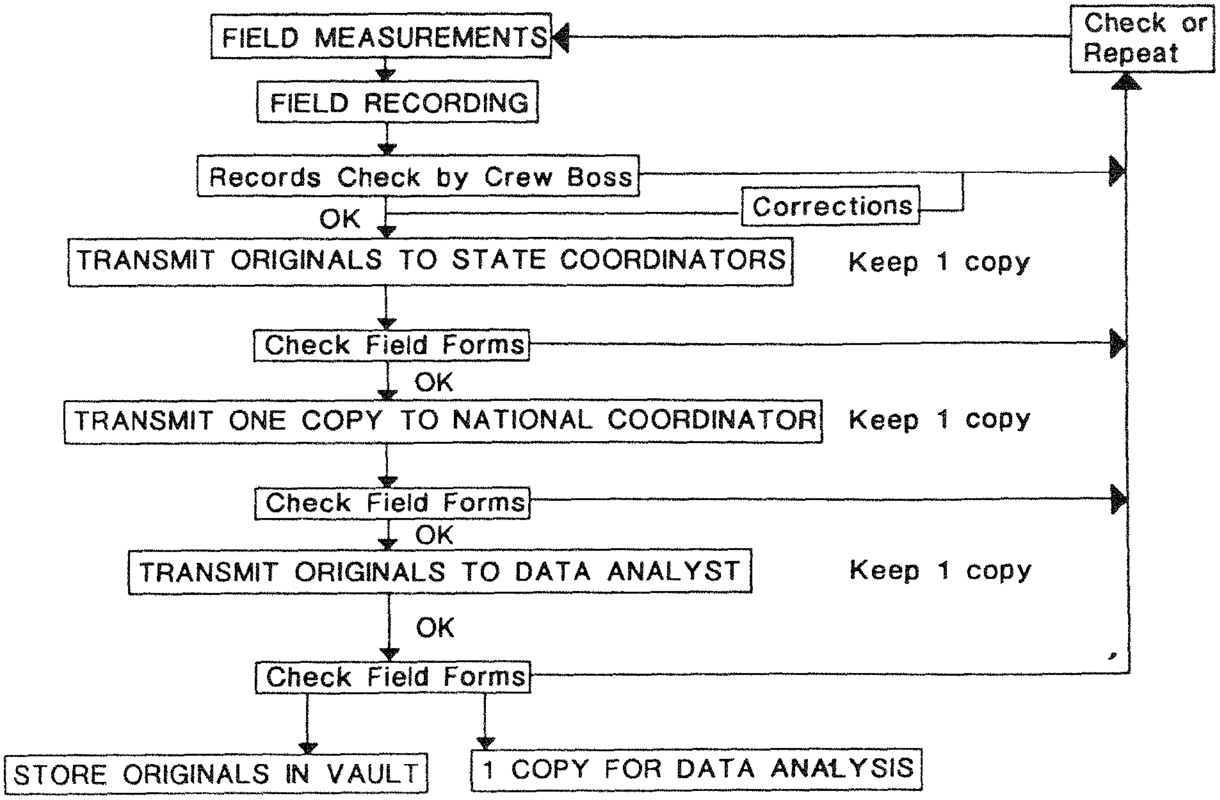

Figure 10.—Data completeness and transmittal flow chart.

Minor changes include items such as substitution of stands, addition of new plots or replacement of permanent plots destroyed by natural disaster, or major 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). Additional anlyses may be done as indicated by the field data.

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 undisturbed forest stands.

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. For many of the summaries, and for testing relationships and differences, the SAS™ statistical packages were used (SAS Institute Inc. 1985 a,b). 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 informaiton 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, discoloration, and dwarfed leaves). The ranges for the variables are given in addition to their averages. These statistics are taken directly from the collected data. Somewhat more meaningful statistics, such as number of trees and tapholes per hectare or basal area also could be summarized for each state or province, if desired.

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.

Relationships of the dependent critical variables (dieback, transparency, discoloration, and dwarfed foliage) to independent variables such as management type, pollution level, bole quality, crown position and vigor, number and types of defects, and site and stand characteristics may be examined initially using graphic methods. Also, attempts will be made to develop a crown condition index that combines dieback and transparency for each tree. This index will be used as another dependent variable in graphic comparisons with the independent variable. Statistical correlations are computed to test the validity of some of the more promising relationships revealed in graphic analyses. Differences between groups, especially between types of management and levels of pollution, are tested using analysis of variance (ANOVA) techniques. Testing the difference between groups of critical variables is of primary concern, but differences in such variables as crown vigor and bole quality also could be tested. Other analytical techniques may be explored as data become available.

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) who receive annual data results for their stands only. 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.

Special reports may be prepared for administrative purposes and for public information. The reports are reviewed by the Joint Management Team before release.

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, 3-5 mm diameter
- Tree identification manual
- Measuring tape (metric)
- Clinometer
- PVC pipe, 2 cm diameter, 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

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Appendix A

Participants at Burlington, Vermont, Meeting, January 28-30, 1987

North American Sugar Maple Decline Project

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Appendix B

Early Project Planners, 1987-88

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Appendix C

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Millers, Imants; Lachance, Denis; Burkman, William G.; Allen, Douglas C.
1991. **North American Sugar Maple Decline Project: organization and field methods.** Gen. Tech. Rep. NE-154. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 26 p.

Describes the organization and field methods used in the North American Sugar Maple Decline Project. New methods were developed and tested to measure crown damage. Quality assurance and quality control of the data are given high priority because of the large number of people involved. The instructions in field methods were translated into French for the benefit of Quebec Cooperators. As a result, 95 percent repeatability of crown rating estimates within the prescribed tolerances was achieved among the crews.

Keywords: Sugar maple, decline, crown rating

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