USDA FOREST SERVICE RESEARCH NOTE NE-128
1971

Northeastern Forest
FOREST SERVICE, U. S. DEPT. OF AGRICULTURE, 6816 MARKET STREET, UPPER DARBY, PA.
Experiment Station

MULGRES: A COMPUTER PROGRAM FOR STEPWISE MULTIPLE REGRESSION ANALYSIS

Abstract.—MULGRES is a computer program source deck that is designed for multiple regression analysis employing the technique of stepwise deletion in the search for most significant variables. The features of the program, along with inputs and outputs, are briefly described, with a note on machine compatibility.

MULGRES is a new user-oriented computer program for multiple regression analysis.

Regression programs have been with us for some time, but generally they are of the canned variety at a computer center. Most programs of this type are efficient in terms of computer time and money, but they usually require an adjustment period for the user to gain familiarization with control cards, input of data, etc. Some can be baffling to the non-programmer and may require consultation with members of the computer staff or with other users.

A second difficulty with canned programs arises when you change job locations or for other reasons must use a new computer facility. Changing your computer hardware usually means changing the software as well; and you must now learn the idiosyncrasies of a new system. You will have to read a new user's manual, become familiar with new system control cards, a new data format, and a new presentation of the output.

Another feature of the canned library version—objectionable to many analysts—is lack of accessibility to the program's internal structure. Frequently the user would like to change the program to suit his personal whims. He might wish to modify the output format (adding labels, rearranging results, placing items in publishable form, etc.), add sections to compute other statistics, delete portions, or change the manner of inputting data. Such flexibility is impossible with the canned program because it is stored on magnetic tape or as an object deck and is inaccessible to the user.

MULGRES attempts to alleviate the first problem and definitely solves the last two difficulties. The input requirements are short and simple to apply; and once learned they will not become obsolete because the user will have his own copy of the program source deck and can quickly adapt it for use at any computer center. These features are helpful when one considers the importance of regression analysis in the various areas of research. Effort should be spent analyzing data and interpreting results — not on analyzing computer programs and interpreting their instructions.

Features of MULGRES

1. The program is coded in FORTRAN IV.
2. One scratch or work tape is required.
3. The maximum capacity of the program is 15 variables and 600 observations on each. However, it is possible to alter the DIMENSION statement to include either more variables (and fewer observations) or more observations (and fewer variables).
4. A variable format approach is used for data input. This permits the user to prepare a FORMAT card to suit his data, rather than forcing his data (which may have been previously punched on cards) to conform to fixed format specifications.
5. The computation procedure for performing the regression analysis is the Abbreviated Doolittle Method *(Ezekiel and Fox 1959; and Ostle 1963)*.
6. A 3-way option is available so that the user may:
   a. Perform a regression analysis utilizing stepwise deletion *(Draper and Smith 1966, Mantel 1970)*. This approach involves a repetitious solving of the problem, starting with all variables in the solution. Next, the least significant variable is removed and the

analysis is repeated; and this process is continued until only one independent variable remains. Significance is based on the absolute value of the respective beta coefficients for each variable *(Ezekiel and Fox 1959).*

b. Choose not to use the stepwise procedure and instead select specific variables to be removed from the analysis. This is useful when the researcher wishes to duplicate a previous analysis, using only the most significant variables, or to examine variable combinations not included in the stepwise deletion. This option does not require the preparation of a new FORMAT card — a time-saving feature, especially for those who obtained help in writing the original specifications.

c. Perform a straightforward regression analysis on all independent variables with no deletions.

'. Nine common transformations are available in the program (X^2, 1/X, Log X, etc.) and are selected by appropriate codes. These may be used separately or in combination on any or all of the variables. This option permits the original values to be replaced by new values; or the old values may be saved and new variables may be created as well.

3. MULGRES is structured to permit the stacking or batching of any number of problems in a single computer run. A separate data deck is required for each problem; these are grouped with the source deck for analysis.

). The program provides for detailed labeling of all printed output.

MULGRES Inputs

1. Problem title.
2. Number of observations.
3. Number of independent variables.
4. Codes for performing transformations — optional.
5. Codes for deletion alternatives — optional.
6. Variable format for reading in the data.
7. Alphanumeric labels for the independent variables.
8. Units of measure for independent variables.
9. Alphanumeric label for the dependent variable.

0. Units of measure for the dependent variable.
1. Data values for the dependent and all independent variables.
2. An end-of-problem indicator.

MULGRES Outputs

1. The first observation on each variable.
2. The transformation code and the variables so changed — when applicable.
3. The variables deleted from the analysis — when applicable.
4. Means and standard deviations for each variable.
5. The coefficient of variation for each variable.
6. Simple correlation coefficients between the dependent variable and all independent variables.
7. Simple correlation coefficients between all independent variables.
8. The matrix elements from the Doolittle solution.
9. Analysis-of-variance table.
10. Multiple correlation coefficient — R.
11. Coefficient of determination — R^2.
12. Regression coefficients, with their:
    a. Standard errors.
    b. T-values for testing significance.
    c. Beta coefficients.
13. Standard error of the estimate.
14. A table of observed Y values, predicted Y values, and the corresponding residuals.
15. The Durbin-Watson coefficient for determining the existence of serial correlation *(Salzman 1968)*.

Machine Compatibility

The MULGRES program was written in FORTRAN IV specifically for the IBM System/360, Model 65 Computer. However, it can be adapted readily to most computers simply by changing the system control cards, logical unit numbers for the READ and WRITE statements (if necessary), and supplying the appropriate scratch-tape unit number. These unit numbers are defined at the beginning of the source program, hence only three numbers would need to be changed to insure hardware compatibility.

Program Availability

Complete program documentation is available upon request from the USDA Forest Products Marketing Laboratory at Princeton, West Virginia. It includes a user's manual (containing a program listing, flow chart, list of variables, input instructions, diagram of deck structure, sample input, and sample output), punched copies of the source deck, and a sample problem deck.

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N ortheastern Forest
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E xperiment Station

INDIVIDUAL TREE DIFFERENCES CONFOUND EFFECTS OF GROWTH REGULATORS IN ROOTING SUGAR MAPLE SOFTWOOD CUTTINGS

Abstract.—Softwood stem cuttings from three mature sugar maple trees were treated with several types and concentrations of growth regulators. Lack of statistical significance was due to extreme variability in tree response: low levels of auxin stimulated rooting in two study trees, while auxins inhibited rooting in the other tree. It is postulated that variations in rooting response may have been caused by corresponding differences in endogenous levels of naturally-occurring auxins.

In vegetative propagation by stem cuttings, it is generally recommended that the basal portion of the cuttings be treated with a growth regulator to stimulate development of adventitious roots (*Hartmann and Kester 1968*).

In our research into developing methods for vegetatively propagating superior sugar maple trees, we were interested in determining the type and concentration of stimulant that would bring about the best rooting. Several commercially prepared rooting compounds are available, so we designed an experiment to determine the relative effectiveness of various types and concentrations of these growth regulators.

However, results of the study did not completely achieve this objective. Rather, the results suggest that there is an important relationship between the use of growth substances and individual tree responses to the chemical used.

Materials and Methods

One hundred eighty softwood cuttings—the current year's shoots—were collected from each of three mature sugar maple trees in late June 1967. The cuttings were wounded by making slits approximately ½-inch long on two sides of the basal end. Before being placed in the rooting medium, the lower wounded ends of 20 cuttings from each tree were dipped into one of the following auxin treatments:

- Hormodin No. 3—a commercially prepared powder containing 0.8 percent indolebutyric acid (IBA).[1]
- Jiffy Grow—a commercially prepared liquid containing 0.5 percent IBA and 0.5 percent naphthalene acetic acid (NAA). Cuttings were dipped into the liquid for approximately 5 seconds.
- Jiffy Grow diluted 1:1 with distilled water. Cuttings were dipped into the liquid for approximately 5 seconds.
- Diluted Jiffy Grow plus Hormodin No. 3. Cuttings were dipped into the liquid for about 5 seconds, followed by the powder dip.
- 0.5 percent IBA powder. IBA concentrations were prepared by mixing IBA crystals with the required amounts of talc powder (percents calculated on a weight basis).
- 1.0 percent IBA powder.
- 2.0 percent IBA powder.
- 4.0 percent IBA powder.
- Control (distilled water).

The cuttings were rooted in a 20- x 60-foot plastic-covered greenhouse. Maximum daytime air temperature was approximately 80 to 90°F.; minimum night air temperature was approximately 60°F. The rooting medium was 50 percent by volume of coarse perlite and 50 percent of shredded sphagnum moss. Heating cables maintained the rooting medium temperature at approximately 80°F. The cuttings were watered with intermittent mist and were fertilized with a complete nutrient solution (Rapid Grow) incorporated into an electronically controlled mist system. Supplemental lighting (150-watt incandescent lamps) provided a 20-hour daylength.

[1]Mention of commercial products is for purposes of information only, and should not be taken as an endorsement by the Forest Service or the U.S. Department of Agriculture.

The cuttings were checked for the presence of roots on 26 October 1967, 4 months after they had been collected. The data were analyzed as a randomized block design by the analysis of variance. The trees were considered as blocks with nine treatments (auxins) per block.

Results and Discussion

In general, when the rooting responses of the three trees to auxin treatment were averaged and compared with the untreated controls (table 1), it was found that:

- Undiluted Jiffy Grow and 0.5 percent IBA appeared to stimulate rooting.
- 1.0 percent IBA, 2.0 percent IBA, diluted Jiffy Grow, and Hormodin No. 3 had no effect.
- 4.0 percent IBA and the combination of diluted Jiffy Grow plus Hormodin No. 3 inhibited rooting.

Average effects of a specific concentration of auxin tended to be similar whether the auxin was applied as a powder or as a liquid: 42 percent of the cuttings rooted when treated with Hormodin No. 3 (0.8 percent auxin), and 50 percent rooted when treated with Jiffy

Table 1.—*Response of sugar maple softwood cuttings to applied auxins*

Treatment	Auxin concentration	Rooting Response[1]			
		Tree 1	Tree 2	Tree 3	Average
	Pct.	*Pct.*	*Pct.*	*Pct.*	*Pct.*
Hormodin No. 3	0.8	20	60	45	42
Jiffy Grow	1.0	25	75	50	50
Diluted Jiffy Grow	.5	40	50	35	42
Diluted Jiffy Grow plus Hormodin No. 3	1.3	0	50	30	27
0.5 percent IBA	.5	30	75	40	48
1.0 percent IBA	1.0	10	75	45	43
2.0 percent IBA	2.0	15	75	40	43
4.0 percent IBA	4.0	0	55	35	30
Control	.0	60	60	5	42

[1]Each value represents the rooting percent of 20 cuttings.

Grow (1.0 percent auxin). However, results of the combination Hormodin No. 3 plus diluted Jiffy Grow (1.3 percent total auxin content) were much lower than would be expected: only 27 percent of them rooted when treated with this combination, whereas 43 percent of them rooted when treated with either 1.0 or 2.0 percent IBA powder (table 1). The reason for this apparent anomaly is unknown.

Although, on the average, low concentrations of auxin tended to stimulate rooting, overall treatment effects were not statistically significant. Lack of statistically significant treatment differences was undoubtedly due to the fact that each study tree tested exhibited its own individual response to changes in hormone concentration. Three more or less distinct patterns of response were evident (fig. 1):

- Cuttings from tree No. 1 rooted well without auxins. Auxins, at any concentration, retarded rooting.
- Cuttings from tree No. 2 rooted well without auxin treatment; auxins at low levels caused a moderate increase in rooting; auxins at high levels tended to inhibit rooting.
- Without auxins, tree No. 3 rooted poorly; low levels of auxin caused a substantial increase in rooting, but rooting was reduced at high auxin levels.

The reason for differential tree responses to applied growth hormones is unknown, but these differences may reflect corresponding

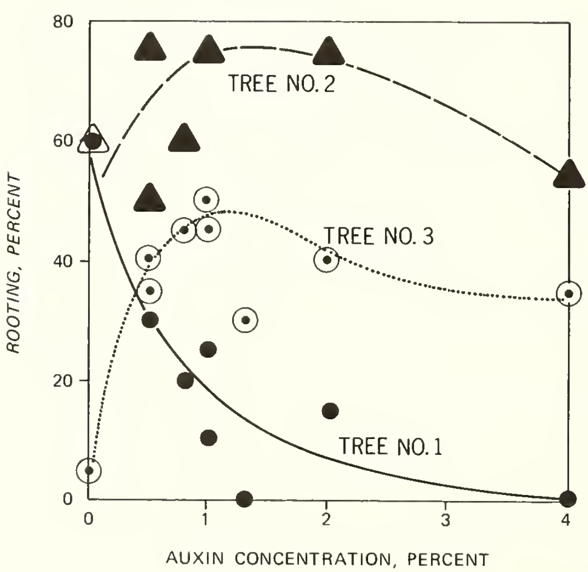

Figure 1.—Rooting response of sugar maple softwood cuttings to applied auxins.

variations in endogenous auxin concentrations within the individual trees. Endogenous auxin concentrations were not measured in the study, but indirect evidence suggests significant tree differences.

Excessive auxin concentrations tended to burn the cutting: the lower stem turned black and rotted. Snow (*1941*) reported similar toxic effects of concentrated solutions.

For tree No. 1, 95 percent of the cuttings treated with 4.0 percent IBA and 90 percent of those treated with diluted Jiffy Grow plus Hormodin No. 3 were burned. In contrast, for study tree No. 2 comparable values for 4.0 percent IBA and diluted Jiffy Grow plus Hormodin No. 3, respectively, were only 40 and 50 percent. And for study tree No. 3, respective values were only 30 and 35 percent. Therefore, the percentage of cuttings burned by concentrated solutions was greater for tree No. 1 than for tree No. 2, and greater for tree No. 2 than for tree No. 3. This suggests that endogenous auxin concentrations may have been higher in study tree No. 1 than in study tree No. 2, and higher in study tree No. 2 than in study tree No. 3.

Each tree's response to applied auxins was in direct opposition to its apparent endogenous auxin content: tree No. 1 had the highest apparent auxin content, and applied auxins inhibited rooting; tree No. 3 had the lowest apparent auxin content, and applied auxins caused significant increases in rooting response.

This inverse relationship between apparent endogenous auxin concentration and the tree's response indicates that effects of endogenous auxins and applied growth regulators may be additive. This relationship also indicates that there may exist an optimum level of total auxins for maximum rooting response. If the auxin concentration within cuttings is low, applied auxins stimulate rooting; but if cuttings possess high concentrations of endogenous auxins, additional amounts may be toxic and may inhibit rooting.

If significant tree differences do exist in the response of sugar maple softwood cuttings to growth regulators, this should be considered when attempting to vegetatively reproduce selected individuals of this species. Although the effects of growth regulators have been tested in numerous studies, differential tree responses to treatment have seldom been reported. However, Doran (*1946*) detected clonal differences in the response of *Tsuga canadensis* cuttings to auxin treatments, and Achterberg (*1959*) reported that effects of growth substances were often obscured by individual tree differences.

The possibility of tree differences in the response of cuttings to applied auxins has important implications in the development of a program for vegetatively propagating selected sugar maple trees. Significant tree differences in rooting response, observed here in the past and by other workers with other species, could well be due to differential response to applied auxins. This concept deserves a closer look.

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Northeastern Forest
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Experiment Station

COLLECTING MAPLE SAP WITH UNVENTED SPOUTS, USING AERIAL AND GROUND LINES

Abstract.—Two methods of using plastic tubing to collect sugar maple sap were tried: aerial lines and ground lines. Unvented spouts were used in both. We found that the sap yields collected from the aerial and ground lines were not statistically different from each other.

Plastic tubing used to collect sap from sugar maple trees (*Acer saccharum* Marsh.) is hung in two ways: in the air (aerial line) or on the ground (ground line). Two types of spouts are used with these lines—vented or unvented. Because there are a number of ways to install tubing, and because every sugaring operation is different, it is difficult to recommend a tubing method that can be successful for all sugar producers. Some sugar producers have had problems getting tubing to work.

Since 1966 our sugar maple sap project at Burlington, Vermont, has done a series of studies on methods of hanging tubing and methods of spout venting. In 1969 we compared yields collected from aerial lines and ground lines, both with unvented spouts. The study results indicated that either plastic tubing method works well when unvented spouts are used.

The Study

300 sugar maple trees, on a 10- to 15-percent southern slope, were separated into 15 groups of 20 trees each. Two tapholes were drilled into each tree to a wood depth of 3 inches. The two tapholes were approximately 6 inches apart. We assigned one taphole to an aerial line and the other taphole to a ground line.

On the aerial line we used an 18-inch dropline, and on the ground line we used a 4-foot dropline (fig. 1). Both lines were unvented. All

Figure 1. — Comparison of ground line (below) and aerial line (above) plastic tubing methods for collecting sap yields.

the unvented aerial droplines were hooked to one line for each 20-taphole group, and the yields from this line were then collected in a 55-gallon drum. The same was done for the ground line installation. Thus we had a total of 15 aerial lines and 15 ground lines, and the yields were collected from each line.

Sap yields were measured periodically to the nearest 0.25 liter, beginning 1 March and continuing to mid-April. We also measured vacuum at the upper end of each tubing line, using a vacuum gage graduated in millimeters of mercury (fig. 2).

Figure 2. — Measuring vacuum with a gage graduated in millimeters of mercury.

Results

We collected approximately 11.7 percent more sap from the aerial line than from the ground line (table 1). However, this difference was not statistically significant at the 5-percent level of testing.

Table 1. — *Summary of sap yields from two unvented tubing installations*

Replication number	Sap yields	
	Aerial line	Ground line
	Liters	*Liters*
1	420.0	469.0
2	460.0	824.0
3	768.0	489.5
4	728.0	493.0
5	603.5	597.5
6	606.0	342.5
7	468.0	360.0
8	415.0	492.0
9	648.0	620.0
10	560.0	375.0
11	421.0	545.5
12	426.5	395.5
13	539.0	376.5
14	630.0	491.5
15	594.0	549.0
Average	552.5	494.7

In previous work we found that unvented aerial lines hung on a 10- to 15-percent slope develop a natural vacuum. This natural vacuum was largely responsible for the collection of more sap yields through unvented lines. In this study, we measured good natural vacuums in both the aerial lines and ground lines. Some of our vacuum measurements reached as high as 350 to 400 millimeters of mercury.

Summary

The results of this study indicate that it makes little difference whether a producer uses an aerial line or a ground line tubing method when the lines are *unvented*. In a previous study, we found that if a producer prefers to use only *vented* spouts, he could also use either a

ground line or aerial line tubing installation.[1] However, where the topography is sloped, we suggest using *unvented* spouts to gain the advantage of increased yields resulting from natural vacuum.

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[1] Smith, H. Clay. USE EITHER AERIAL LINE OR GROUND LINE TUBING WITH VENTED SPOUTS. Natl. Maple Syrup Dig. 8: 6-7, 1969.

[2] Mr. Gibbs, Formerly with the Station's research unit at Burlington, Vt., is now serving as project leader of the Experiment Station's research unit at Orono, Maine.

NE Research Note #131 was abandoned.

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SPEED OF TAPPING DOES NOT INFLUENCE MAPLE SAP YIELDS

Abstract.—Results of this study showed no statistical difference in the quantity or sweetness of sugar maple sap collected from tapholes that were drilled with a variety of tappers running at different drilling speeds.

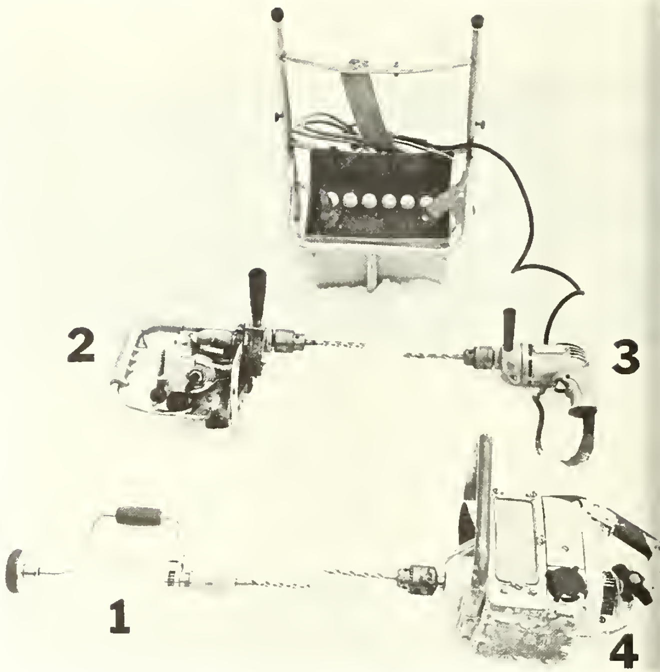
In recent years, with the modernization of the sugar maple industry, new tappers have been developed for drilling holes into sugar maple trees. A few people in the industry are concerned about using tappers that have the drill revolving at a high rate of speed. Several have said that the high speed of the drill scorches or burns the taphole tissues, in effect cauterizing the tissues surrounding the taphole. This, they feel, results in the plugging of cells where the sap comes from.

Our study indicated that there was no statistical difference in the amount of sap or the sweetness of the sap collected from tapholes made with drills revolving at various speeds.

The Study

Fifteen trees were used in this study. Four tapholes were drilled in each tree. These tapholes were drilled to a wood depth of 3 inches, using a 7/16-inch drill bit; and a 250-milligram paraformaldehyde pellet was placed in each taphole to increase sap yields by preventing the buildup of micro-organisms that clog the woody sap-producing cell tissues.

The four types of tappers used to drill tapholes in sugar maple trees. 1, a hand auger. 2, a small gasoline-powered drill. 3, a battery-powered electric drill. 4, a gasoline-powered chainsaw drill.



Four types of tappers were used to drill the tapholes: a hand auger, a battery-powered drill, a gasoline-powered drill, and a chainsaw drill (fig. 1). The drill speeds for these tappers were:

	R.p.m.
Hand auger	120
Battery drill	400
Power drill	935
Chainsaw drill	6,600

In drilling the tapholes, a new drill bit was used for each tapper, and the tapping treatments were assigned at random to one of the four tapholes on each of the 15 trees. All tappers were used at the above designated speeds (the speed for the hand auger was an estimated speed).

The trees were tapped on 3 March 1970. The temperature at this time was between 20 and 22°F. When the trees were tapped, sap oozed out of the tapholes; and steam was observed coming from some tapholes made with the high-speed tappers. This presence of sap and steam, common at cold temperatures, may cause producers using the faster tappers to believe that the steam is smoke from burning wood.

Sap-volume yields, measured to the nearest 0.25 liter, were collected from each taphole during each sap-flow period, and sap-suger yields were recorded and measured to the nearest 0.1 percent, using a sugar refractometer. We used an F-test to analyze total seasonal sap yields and average sap-sugar concentration for each taphole treatment.

Results

Though many sap producers believe that high-speed tapping might be detrimental to sugar production, we found no statistical differences in sap-volume yields collected from any of the drilling-speed treatments used. Also, no difference in sap sugar yields resulted because of drill speed. The average seasonal sap-volume yields and sap-sugar percentages for each tapper treatment were:

	Sap-yield (*liters*)	*Sap-sugar* (*percent*)
Hand auger	805.5	2.5
Battery drill	965.5	2.4
Power drill	756.5	2.5
Chainsaw drill	857.5	2.4

It might appear that the sap-volume yields would be statistically different from one another, but due to the variation in volume yield among treated tapholes, differences were non-significant ($F_{42,3} = 1.89$; $F_{.05} = 2.83$). The variation in these data did not follow any discernible pattern or trend among sample trees. Sap-sugar values varied by only 0.1 percent for the four treatments.

Conclusion and Application

Sap-volume yields and sap-sugar concentrations were not affected by the speed of the tappers used to drill tapholes in the sugar maple trees. Tapping speeds varied from slow (hand auger at an estimated 120 r.p.m.) to 6,600 r.p.m. (chainsaw drill). This range of tapping speeds was considered adequate to cover the tappers presentiy available to the producers.

Although we found no difference with the various types of tapping speeds used in this study, we want to emphasize that the trees were tapped when the temperatures were in the low 20's, and sap oozed out of these fresh tapholes. We do not expect that tapping at a time when temperatures are either higher or lower than those encountered in this study will yield any different results. However, other temperatures were not tested.

Sugar producers should not hesitate to use the higher speed tappers to drill tapholes into sugar maple trees.

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Northeastern Forest

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Experiment Station

EFFECT OF MOISTURE LOSS ON RED OAK SAWLOG WEIGHT

Abstract.—A study was made to determine the effect of moisture loss on the weights of red oak sawlogs. The logs, ranging from 9 to 21 inches in scaling diameter and from 8 to 14 feet in length, were dried for a 12-week period. The 21-log sample lost 7.6 percent of the total green sawlog weight. The weight loss for individual logs ranged from 5.3 to 14.5 percent. In general, as log size and weight increased, the percent of weight loss decreased.

Many sawmill operators and researchers are looking into the possibilities of weight-scaling hardwood sawlogs. A few sawmill operators are already buying hardwood logs by weight. All are asking: How does moisture loss affect hardwood sawlog weights?

We conducted an exploratory study of red oak logs to answer the following questions:

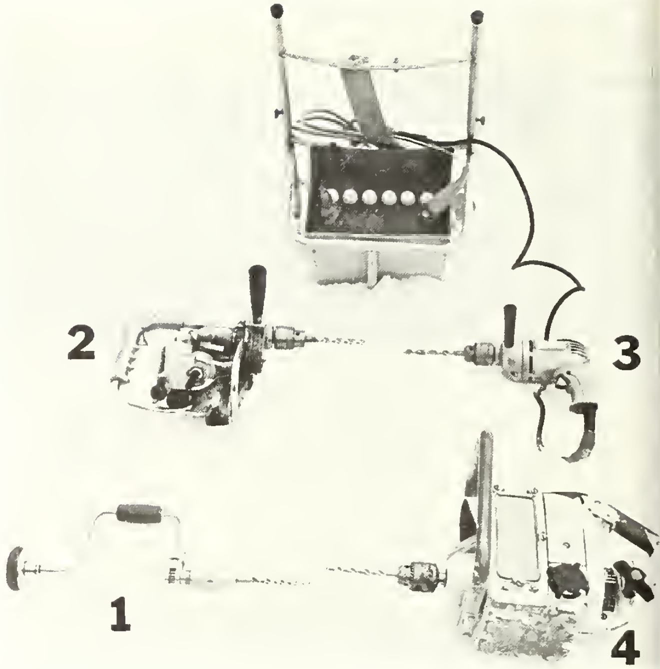
1. How much does moisture loss affect sawlog weights?
2. Does sawlog size affect moisture los

We conducted the study under extreme drying conditions, thus providing the maximum effect of moisture loss for the existing weather conditions found in southern West Virginia.

Method

To obtain a well-distributed sample of log sizes, we selectively chose 21 red oak sawlogs. These sawlogs, ranging from 9 to 21 inches in scaling diameter and from 8 to 14 feet in length, were cut and delivered to the study area on the same day to assure true green sawlog

The four types of tappers used to drill tapholes in sugar maple trees. 1, a hand auger. 2, a small gasoline-powered drill. 3, a battery-powered electric drill. 4, a gasoline-powered chainsaw drill.



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Chainsaw drill	6,600

In drilling the tapholes, a new drill bit was used for each tapper, and the tapping treatments were assigned at random to one of the four tapholes on each of the 15 trees. All tappers were used at the above designated speeds (the speed for the hand auger was an estimated speed).

The trees were tapped on 3 March 1970. The temperature at this time was between 20 and 22°F. When the trees were tapped, sap oozed out of the tapholes; and steam was observed coming from some tapholes made with the high-speed tappers. This presence of sap and steam, common at cold temperatures, may cause producers using the faster tappers to believe that the steam is smoke from burning wood.

Sap-volume yields, measured to the nearest 0.25 liter, were collected from each taphole during each sap-flow period, and sap-suger yields were recorded and measured to the nearest 0.1 percent, using a sugar refractometer. We used an F-test to analyze total seasonal sap yields and average sap-sugar concentration for each taphole treatment.

Results

Though many sap producers believe that high-speed tapping might be detrimental to sugar production, we found no statistical differences in sap-volume yields collected from any of the drilling-speed treatments used. Also, no difference in sap sugar yields resulted because of drill speed. The average seasonal sap-volume yields and sap-sugar percentages for each tapper treatment were:

	Sap-yield (*liters*)	*Sap-sugar* (*percent*)
Hand auger	805.5	2.5
Battery drill	965.5	2.4
Power drill	756.5	2.5
Chainsaw drill	857.5	2.4

It might appear that the sap-volume yields would be statistically different from one another, but due to the variation in volume yield among treated tapholes, differences were non-significant ($F_{42,3} = 1.89$; $F_{.05} = 2.83$). The variation in these data did not follow any discernible pattern or trend among sample trees. Sap-sugar values varied by only 0.1 percent for the four treatments.

Conclusion and Application

Sap-volume yields and sap-sugar concentrations were not affected by the speed of the tappers used to drill tapholes in the sugar maple trees. Tapping speeds varied from slow (hand auger at an estimated 120 r.p.m.) to 6,600 r.p.m. (chainsaw drill). This range of tapping speeds was considered adequate to cover the tappers presentiy available to the producers.

Although we found no difference with the various types of tapping speeds used in this study, we want to emphasize that the trees were tapped when the temperatures were in the low 20's, and sap oozed out of these fresh tapholes. We do not expect that tapping at a time when temperatures are either higher or lower than those encountered in this study will yield any different results. However, other temperatures were not tested.

Sugar producers should not hesitate to use the higher speed tappers to drill tapholes into sugar maple trees.

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Northeastern Forest

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Experiment Station

EFFECT OF MOISTURE LOSS ON RED OAK SAWLOG WEIGHT

Abstract.—A study was made to determine the effect of moisture loss on the weights of red oak sawlogs. The logs, ranging from 9 to 21 inches in scaling diameter and from 8 to 14 feet in length, were dried for a 12-week period. The 21-log sample lost 7.6 percent of the total green sawlog weight. The weight loss for individual logs ranged from 5.3 to 14.5 percent. In general, as log size and weight increased, the percent of weight loss decreased.

Many sawmill operators and researchers are looking into the possibilities of weight-scaling hardwood sawlogs. A few sawmill operators are already buying hardwood logs by weight. All are asking: How does moisture loss affect hardwood sawlog weights?

We conducted an exploratory study of red oak logs to answer the following questions:

1. How much does moisture loss affect sawlog weights?
2. Does sawlog size affect moisture los

We conducted the study under extreme drying conditions, thus providing the maximum effect of moisture loss for the existing weather conditions found in southern West Virginia.

Method

To obtain a well-distributed sample of log sizes, we selectively chose 21 red oak sawlogs. These sawlogs, ranging from 9 to 21 inches in scaling diameter and from 8 to 14 feet in length, were cut and delivered to the study area on the same day to assure true green sawlog weights. Upon delivery, we collected the following information about each log:

1. Scaling diameter (to nearest inch).
2. Log length (to nearest foot).
3. Green log weight (to nearest 5 pounds).

After taking these measurements, we placed the logs in a single tier on an asphalt slab. To increase the air circulation, we elevated the logs on 6- by 6-inch stringers. This arrangement allowed maximum drying, thus permitting more rapid moisture loss than any system of decking presently used in the woods or mill yards.

The logs were exposed to the weather from 30 May to 22 August 1969. During this 12-week period, we reweighed the logs every seventh day. The difference in the periodic sawlog weights represented moisture loss in pounds. To compare these moisture losses among logs of different sizes, we expressed the weight lost by each log as a percent of the green sawlog weight.

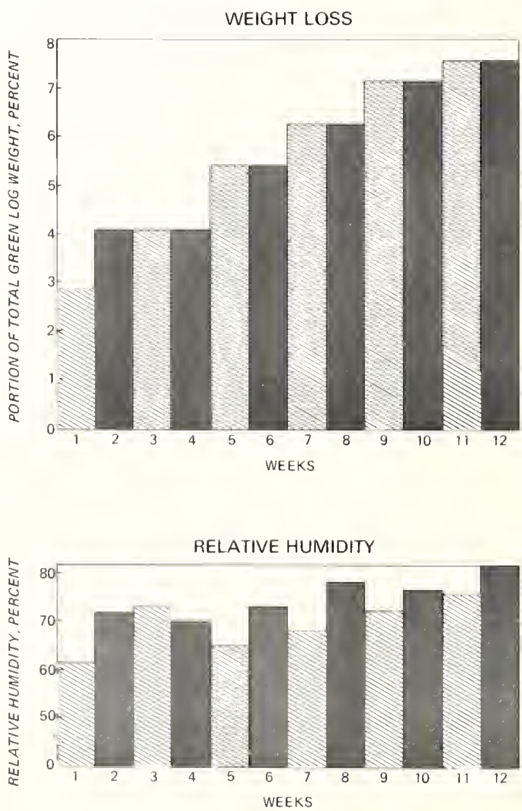

Figure 1.—Cumulative weekly weight loss due to moisture loss for 21 red oak sawlogs, and associated relative humidity record.

Along with the above measurements, we also collected information on the average weekly relative humidity, average weekly maximum and minimum temperatures, and weekly rainfall. However, since rainfall and temperature showed little relationship with moisture loss, they will not be discussed in this note.

Discussion

Since the study was based on freshly cut red oak logs only, the answers to the following questions cannot be confidently transferred to other species or localities.

Question 1.—*How much does moisture loss affect sawlog weights?*

Answer.—During the 12-week study period, the 21-log sample lost only 7.6 percent of the total green sawlog weight. Slightly over half of this total loss occurred during the first two weeks. For 6 of the remaining 10 weeks, the logs lost no moisture. These periods of no

Table 1.—*Total weight loss due to moisture loss for individual red oak logs during a 12-week period*

Log No.	Scaling diameter	Length	Green weight	12th week weight	Weight loss	Weight loss
	Inches	*Feet*	*Pounds*	*Pounds*	*Pounds*	*Percent*
1	10	8	340	305	35	10.3
2	10	9	345	295	50	14.5
3	9	10	350	315	35	10.0
4	10	9	380	335	45	11.8
5	12	12	675	605	70	10.4
6	11	12	680	605	75	11.0
7	14	10	745	665	80	10.7
8	12	11	755	675	80	10.6
9	11	14	790	730	60	7.6
10	12	14	995	920	75	7.5
11	15	12	1,020	935	85	8.3
12	16	14	1,425	1,320	105	7.4
13	16	12	1,525	1,405	120	7.9
14	17	14	1,620	1,465	155	9.6
15	17	12	1,920	1,815	105	5.5
16	18	14	1,945	1,805	140	7.2
17	18	13	2,055	1,895	160	7.8
18	18	14	2,245	2,100	145	6.5
19	21	14	2,395	2,240	155	6.5
20	20	14	2,405	2,255	150	6.2
21	20	14	2,550	2,415	135	5.3

moisture loss were closely related to periods of high relative humidity (fig. 1).

Question 2.—*Does size affect moisture loss?*

Answer.—As a result of moisture loss, the total weight losses in individual sawlogs ranged from 5.3 to 14.5 percent of the green saw-log weights (table 1). In general, as log size and weight increased, the percent of weight loss decreased.

Remember that the weight losses observed in this study occurred under extreme drying conditions. We would expect that logs piled in the woods or decked in the mill yard would lose less weight than our sample. Therefore we believe that if a sawmill operator is weight-scaling hardwood sawlogs or if he is considering this possibility, the effect of moisture loss should not be a major concern at this time.

As forest researchers learn more about other log weight relationships, they may find that moisture loss is one of the more important factors. However, we believe that additional studies on sawlog moisture loss should be delayed until the links between log weight and other elements such as bark loss, seasonal weight differences, and regional weight differences have been established.

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MAPLE SUGARING WITH VACUUM PUMPING DURING THE FALL SEASON

Abstract.—Vacuum pumping of sugar maple trees during the late fall and early winter months is not advisable in northern Vermont. However, fall pumping may be profitable in other areas of the sugar maple range. It is recommended that the weather pattern in a given locale be observed; and if conditions are favorable, vacuum pumping should be tried on a small scale before attempting a larger operation.

Tapping of sugar maple trees for sap yields during the fall and early winter months is of questionable value. Some sugar maple producers in certain localities have reported collecting enough sap by gravity flow to make tapping profitable in November and December (*1*). In other areas, weather conditions have not been favorable for sap production at this time of year.

Two other adverse factors govern the success of fall tapping. Koelling (*3*) reported that in marginal fall tapping areas such as north-central Vermont, the sap-sugar concentration of fall-collected sap will be about 33 percent lower than the sap-sugar concentrations for the same tree as recorded for the spring sugaring season. Also, if fall sap volumes are high, spring sap volumes from the same tree are reduced.

Blum and Koelling (*2*) studied the vacuum technique as a means of collecting sap during the spring sugaring seasons. Based on the success of this spring vacuum research, we thought that using vacuum to pump sap from sugar maple trees during the fall might be practical.

A study was established in north-central Vermont for the purpose of evaluating fall vacuum pumping. Results indicated that sap yields did increase, but based on the data we collected in Vermont, pumping in the fall was not practical. We must emphasize that fall tapping, with or without a vacuum pump, should be restricted to areas where weather conditions are generally favorable (freezing and thawing) and consistent from year to year.

Methods

An examination of past weather records for the study area indicated that temperatures were above and below freezing several times during November and December. These temperatures seemed to be suitable for maple sap flows.

A study was established in November 1968, using 16 trees. The trees were between 20 and 30 inches in diameter (d.b.h.). Each tree had two tapholes, which were drilled to a wood depth of 3 inches. The trees were tapped during the last week of October 1968 and again in the fall of 1969. One paraformaldehyde pellet was placed in each taphole.

One taphole was randomly selected for vacuum; the other taphole on the same tree was used for collecting sap by gravity. Sap from each vacuum taphole was collected in a 55-gallon drum, and a 20-gallon plastic container was used to collect sap from each gravity taphole (fig. 1).

Sap volumes were measured to the nearest 0.25 liters. We also measured the sweetness of the sap to the nearest 0.1 percent. A vacuum of 12 to 14 inches of mercury was maintained at the tapholes by a recirculating jet-type vacuum pump.

Sap Volume Yields

We were not successful in collecting much sap from sugar maple tapholes during either of the two fall seasons tested in this study. The ideal freezing and thawing weather conditions were very limited; once the temperatures dropped below freezing, very few thaw periods occurred.

During the 1968 fall season we ran the pump for a total of only 15 hours; and on a practical basis, we did not collect sufficient sap to make the operation profitable. The sap yields from the vacuum tapholes averaged 3 liters per tap, while the gravity setup averaged 1 liter per tap. Although the vacuum tapholes yielded 220 percent more sap than the gravity tapholes, this increase is not important because of the low volume yield per taphole.

Figure 1.—Sap-volume yields were collected for each taphole, using a 55-gallon drum for the vacuum yield and a 20-gallon container for the gravity yields.

Sap yields collected while the pump was shut off were also very low for the 1968 fall season. Gravity tapholes averaged about 8 liters per taphole, and the vacuum tapholes averaged nearly 9 liters per taphole. Fall sap yields from individual trees are extremely variable (table 1). Although vacuum pumping increased sap yields in all trees, the total amount varied from 0.5 liters to a maximum of 7.0 liters. This variation was also evident with gravity sap yields, but the extremes of volume yield were even greater—0.1 liters to 29.0 liters.

We did not collect any sap with the vacuum pump during the 1969 fall season, and the sap yields from both the vacuum and gravity tapholes were nearly zero. Sap-volume yields were low because the temperatures were below freezing during most of the fall season.

Table 1.—*Summary of vacuum and gravity sap yields collected from trees tapped during November and December 1968, in liters*

Tree number	Sap yields during pumping		Sap yields when pump turned off	
	Vacuum tapholes	Gravity tapholes	Vacuum tapholes	Gravity tapholes
11	1.8	0.2	0.6	1.4
17	3.2	.9	6.6	12.0
23	3.2	1.0	11.0	18.0
24	3.0	1.9	8.0	1.6
35	3.2	.3	4.0	2.4
36	1.2	.2	.2	.1
38	4.5	1.6	17.5	14.0
41	3.5	.4	4.8	3.0
48	1.0	.6	2.0	6.0
54	2.0	1.6	3.0	8.0
56	.5	.0	3.1	4.0
59	6.0	2.0	29.0	9.0
68	5.0	1.6	20.5	15.0
71	7.0	1.8	21.0	19.0
77	2.8	.8	4.0	6.5
81	3.5	1.1	7.0	11.0
Total	51.6	15.8	142.2	131.0
Average per taphole	3.2	1.0	8.9	8.2

Sap-Sugar Yields

The 1968 fall sap-sugar values were low, as expected. These values averaged 2.2 percent for both the vacuum and gravity tapholes. The same trees were also tapped during the spring seasons, and the average sugar readings of 3.5 percent strongly confirmed Koelling's previous research.

Conclusions

Although fall tapping can be made to work, and vacuum pumping seems to help, caution is advised in starting fall sugaring operations. Initially, trial setups on a small-scale basis should be attempted. This will allow the sap producer to determine whether the average fall weather conditions for his locality are such that a profitable fall sap season is possible. According to available information, it *is* possible to collect sap during the fall season in some areas; but there are also locales where fall tapping definitely cannot be recommended.

The sap producer should also realize that fall tapping is a more marginal operation than spring tapping for several reasons. First, the sap sweetness is lower in the fall, thus increasing overall evaporation costs. Also, the total sap volume may not be great enough to defray the costs of field installations and use of the sugarhouse. Another factor of possible importance is the potential of reduced spring sap yields as reported by Koelling.

Drilling new tapholes in the trees during both the fall and spring seasons can also lead to taphole spacing problems. Thus, tapping trees in the fall must be profitable or the producer is sacrificing good spring sap-producing wood.

Finally, vacuum pumping in the fall can increase yields, but our results indicated that there is also considerable variation from tree to tree. Some trees will not pay their way while others will. This is true for fall gravity systems, too. Keeping track of the sap yields of individual trees used in fall tapping is strongly advised.

Although we are expressing caution in tapping with vacuum or gravity during the fall and early winter season, some producers, such as those in the southern range of sugar maple, may find conditions highly favorable for sugaring during November and December. However, most producers in the northern portion of the sugar maple range will not be able to depend on consistent sap flows during the fall sugaring season.

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USDA FOREST SERVICE RESEARCH NOTE NE-135
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POWER MULCHERS CAN APPLY HARDWOOD BARK MULCH

Abstract.—Two makes of power mulchers were evaluated for their ability to apply raw or processed hardwood bark mulch for use in revegetating disturbed soils. Tests were made to determine the uniformity of bark coverage and distance to which coverage was obtained. Moisture content and particle-size distribution of the barks used were also tested to determine whether or not these factors limited machine performance.

Power mulchers (straw blowers) can be used to apply hardwood bark mulch. By creating a high-speed air stream, these machines are capable of blowing straw, hay, and other long-fibered mulches over relatively large areas. Because of this capability, power mulchers are commonly used by seeding contractors and landscapers in the revegetation of highway roadsides, strip mines, watershed dams, and other large areas of disturbed soils.

In our efforts to find uses for the hardwood bark residues from sawmills, pulpmills, and veneer plants, it occurred to us that bark might be used as a revegetative mulch to substitute for straw. With more and more mills installing debarkers, hardwood bark is available in substantial quantities whereas, straw, corncobs, and other mulch materials are scarce and expensive in the Appalachian Region.

In addition, preliminary experiments have shown that hardwood bark mulch performs at least as well as straw mulch. Hardwood bark not only aids seed germination; but, because of its fibrous nature and ability to resist wind and water action, it minimizes soil erosion during the period between seeding and grass establishment.

Even though hardwood bark is a good revegetative mulch material, we realized that it would be necessary to show that it could be applied over large areas efficiently, quickly, and at low cost. Only then could we show that hardwood bark has commercial possibilities as a revegetative mulch.

Because we knew about power mulchers and that many seeding contractors already owned them, we decided to determine if they could be used to apply hardwood bark mulch. We also sought answers to the following related questions:

- Could power mulchers handle bulk bark directly from the mills, or would bark have to be reduced by hammermilling or other processing?
- Would power-mulcher performance be affected by the moisture content of bark?
- Could power mulchers apply bark evenly over the ground, and to what distance?

Recognizing that these questions would have to be answered before power mulchers could be recommended for use in applying bark mulch, we set about testing two models of currently manufactured power mulchers in the fall of 1969.

Methods

At present power mulchers are manufactured by two companies. Both companies manufacture models of different sizes, but both makes and all models incorporate the same blower designs. In this study we tested a large machine from one manufacturer and a small machine from the other (figs. 1 and 2).

In our testing we used both processed and raw bark mulch of mixed hardwood species. Raw bark from two sawmills was delivered to the test sites in bulk form. The processed bark (raw bark that had been hammermilled, screened, and aged) was obtained from a bark mulch manufacturer and delivered to the test sites in plastic bags, each containing about 50 pounds of material.

The actual tests were conducted by feeding 1,000 pounds of raw bark and 15 bags of processed bark through each machine.

Currently manufactured power mulchers have feed-tray systems designed for baled straw and hay. Our test bark, in bulk and bags, had to be

Figure 1.—Large power mulcher.

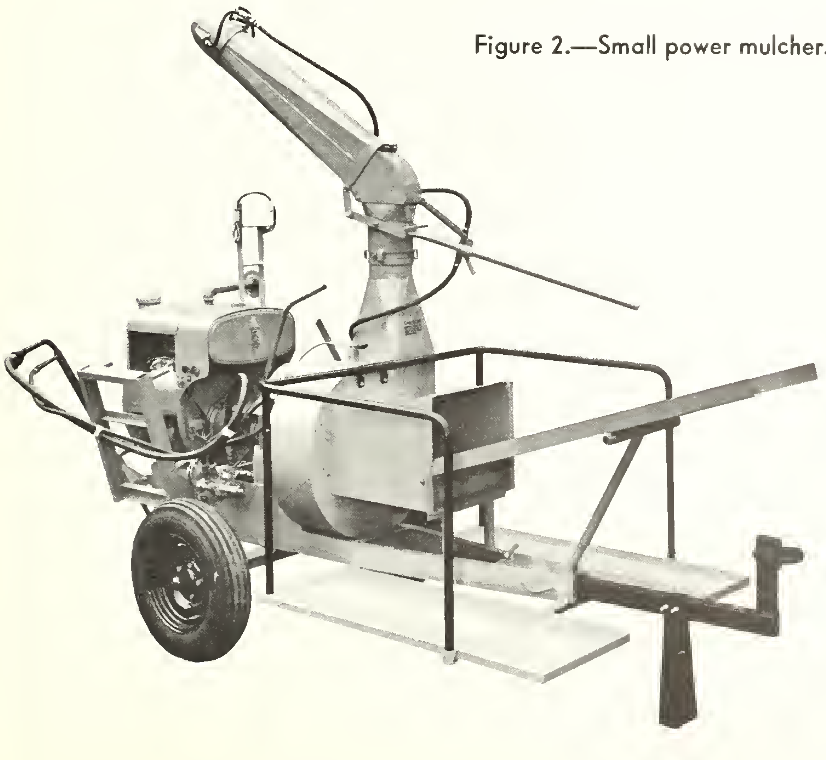

Figure 2.—Small power mulcher.

Conclusion

Hardwood bark, either raw or processed, can be applied using power mulchers. Tests showed neither the moisture content nor the particle size of the bark to be a limiting factor. However, because of the extra labor required to manually feed bark into the straw blowers, the total process is not efficient for large-scale commercial use.

Research is needed to overcome the problem of feeding bark into currently manufactued power mulchers. Two lines of research are suggested: (1) baling of bark and (2) development of a mechanized feed system for bulk bark. If either of these can be accomplished, then bark can be used commercially as a revegetative mulch on large areas of disturbed soils.

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Acknowledgment

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1971

Northeastern Forest

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A MODIFIED LOWRY PROTEIN TEST FOR DILUTE PROTEIN SOLUTIONS

Abstract.—A modified Lowry protein test was compared with the standard Lowry protein test. The modified test was found to give estimates of protein concentration that were as good as the standard test and has the advange that proteins can be measured in very dilute solutions.

During our studies to separate proteins by column chromatography, we found it necessary to detect very low levels of proteins. These concentrations were below the detectable limits of the standard Lowry protein test.[1] Because concentrating the proteins may denature them, the standard test was modified by increasing the concentration of the reagents in the alkaline copper solution and the volume of the protein sample five times. The objective of this study was to compare this modified test with the standard Lowry test on a Gilford spectrophotometer and a Spectronic 20 colorimeter.[2]

Materials and Methods

The alkaline copper solution in the standard test contained 50 parts of 2% Na_2CO_3 in 0.1 N NaOH and 1 part of 0.5% $CuSO_4 \cdot 5H_2O$ in 1% sodium tartrate. The alkaline copper solution in the modified test contained 50 parts of 10% Na_2CO_3 in 0.5 N NaOH and 1 part of 2.5% $CuSO_4 \cdot 5H_2O$ in 5% sodium tartrate. The solutions were mixed fresh daily.

[1] Lowry, O. H., N. J. Rosebrough, A. L. Farr, and R. J. Randall. PROTEIN MEASUREMENTS WITH THE FOLIN PHENOL REAGENT, J. Biol. Chem. 193: 265-275, 1951.

[2] Mention of a particular product should not be taken as endorsement by the Forest Service or the U. S. Department of Agriculture.

The standard test was run by using 1 ml. of protein solution containing from 0.005 to 0.500 mg. of human serum albumin. At zero time, 5 ml. of alkaline copper solution was added to the protein solution, and the mixture was placed on a shaker for 15 seconds. After 10 minutes, 0.5 ml. of 1 N Folin-Ciocalteau reagent (Fisher Scientific Co.) was added, and the mixture was again placed on the shaker for 15 seconds. After a 30-minute interval, the absorbance was measured at 500 nm.

The modified test was run on the same time schedule as above. The difference was that 5 ml. of protein solution containing from 0.005 to 0.500 mg. of human serum albumin was mixed with 1 ml. of alkaline copper solution at zero time. Therefore, after mixing at zero time, both tests contained the same amount of protein and reagents.

The protein solutions were replicated nine times. The solutions contained protein concentrations at 0.005-mg. intervals from 0.005 to 0.050 mg. and at 0.050-mg. intervals from 0.050 to 0.500 mg. These amounts of protein were in 1 ml. for the standard test and 5 ml. for the modified test.

Data for the low-protein concentrations (0.005 to 0.050 mg.) were compared by linear regression analysis, and data for the high protein concentrations (0.050 to 0.500 mg.) were compared by curvilinear regression analysis.

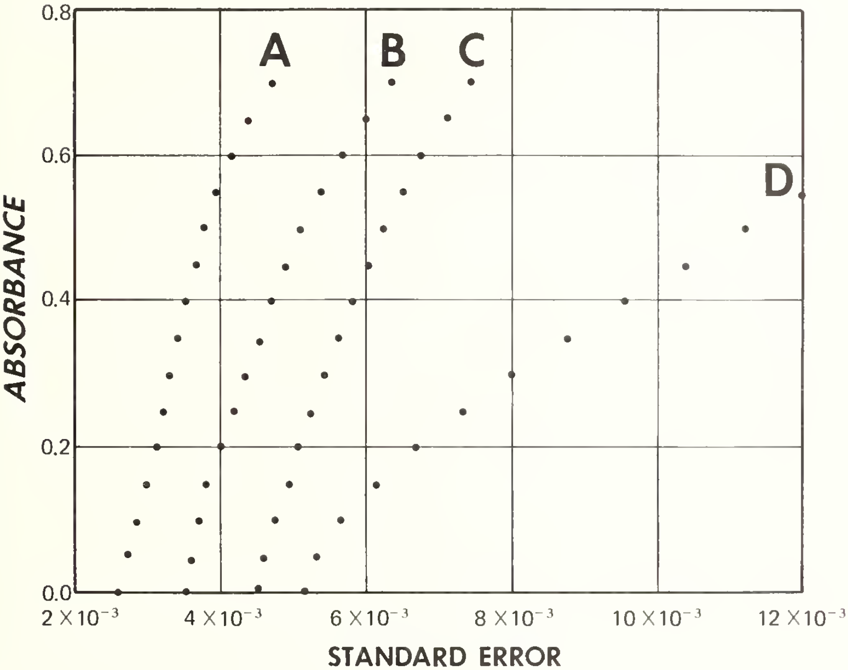
Results and Discussion

The modified test was found to be uniformly better than the standard test on both the spectrophotometer and the colorimeter for the protein range of 0.050 to 0.500 mg. This conclusion was reached after a quadratic equation that passed through zero was fitted to the data and was confirmed by the plot of absorbance against the standard error of prediction of concentrations (fig. 1). The standard error of the results from both instruments was uniformly lower for the modified than for the standard method. The spectrophotometer had a lower standard error than the colorimeter.

In the low-protein range, 0.005 to 0.050 mg., the two methods were comparable, but the standard method was slightly better. The linear regression analysis of the results from the spectrophotometer accounted for 99.8% of the variation for both methods; but linear regression analysis of the results from the colorimeter accounted for 99.7% of the variation for the standard method and 99.5% for the modified method. Thus, the spectrophotometer gave more uniform results than the colorimeter.

Therefore, the modified test is as good as the standard test for measur-

Figure 1.—A comparison of the standard error of prediction of protein concentrations for the standard and modified Lowry tests. (A) Modified test on the spectrophotometer; (B) standard test on the spectrophotometer; (C) modified test on the colorimeter; (D) standard test on the colorimeter.



ing proteins. Even though the standard test gave slightly more uniform results at low protein concentrations, the modified test has the major advantage that it can measure proteins in a fivefold more dilute solution.

The large volume of the protein solutions used in this test may be a disadvantage when sampling for protein in fractions collected in column chromatography. The test volume can be reduced at least by half so that only 2.5 ml. of protein solution is needed. This volume can probably be reduced severalfold further by the use of microcells. This would depend on the protein concentration and the spectrophotometer used.

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SAP VOLUME FLOW AS INFLUENCED BY TUBING DIAMETER AND SLOPE PERCENT

Abstract.—The amount of sugar maple sap that can move through plastic tubing is controlled by several factors. The most important are tubing diameter and slope percent. Estimates are given of the number of tapholes that can be used with combinations of these variables.

The tubing used to collect sugar maple sap is expensive. The larger the diameter, the higher the cost. A sugar producer who uses tubing could minimize his cost and increase his efficiency if he had a way to estimate the proper size of tubing to use in his sugarbush.

This note offers a way. Data are presented for maximum flow rates for various tubing diameters and slopes. Flow rates in gallons per hour can be related to number of tapholes.

Though these data are only estimates, the information should be adequate for the sugar producer to use in selecting the size of tubing necessary to transport sap from the sugarbush trees to the collection tanks.

Assumptions

Before discussing the tubing size needed for various slopes, we must make three assumptions.

First, the information available for water movement by gravity through plastic tubing can be used for estimating sugar maple sap movement. This assumption is logical because sap is composed of 96 to 98 percent water.

Second, we assume that the maximum sap flow during an excellent flow period would be ½ gallon of sap per hour per taphole. Thus, if a producer were collecting sap from 1,000 tapholes, during an excellent flow period he could expect a maximum of 500 gallons of sap per hour.

Third, we realize that the data estimates in this report are for tubing lines that are filled with a column of water. However, when sugar maple sap moves through tubing, the lines are not completely filled with sap. Some air enters the tubing from leaks in the line fittings, and gaseous compounds (mainly CO_2) are also exudated from the taphole during sap flow. However, we believe that these data should be satisfactory for our purposes.

Slope percentage as used in this note refers to the increase or decrease in land elevation or topography for a given horizontal distance. A 20-percent slope means the elevation rises or falls 20 feet for every 100 feet of horizontal distance.

Normally, tubing installed on a slope will have some bends and crooks. However, the data as used in this paper are more applicable for tubing installed as straight as possible, with a minimum of sharp bends or crooks.

Plastic Tubing Diameters

Picture a tubing system used for collecting sugar maple sap as a network of plastic lines of various diameters. There will be many small lines hanging from tree to tree, with approximately 20 tapholes connected to a single line. The lower end of these small lines will be connected to larger tubing lines, and as the sap moves by gravity down the slope, these lines merge with increasingly larger sizes of plastic tubing (fig. 1 and fig. 2).

The sizes of plastic tubing used by producers for collecting sugar maple sap range from ¼ or 5/16 inch to 2 inches (inside diameter measurement). The smaller tubing is normally used to collect sap from tree to tree, and the lower ends of these small tubing lines are connected

Figure 1.—From the spout in the tree, sugar maple sap is transported through small tubing to larger mainlines.

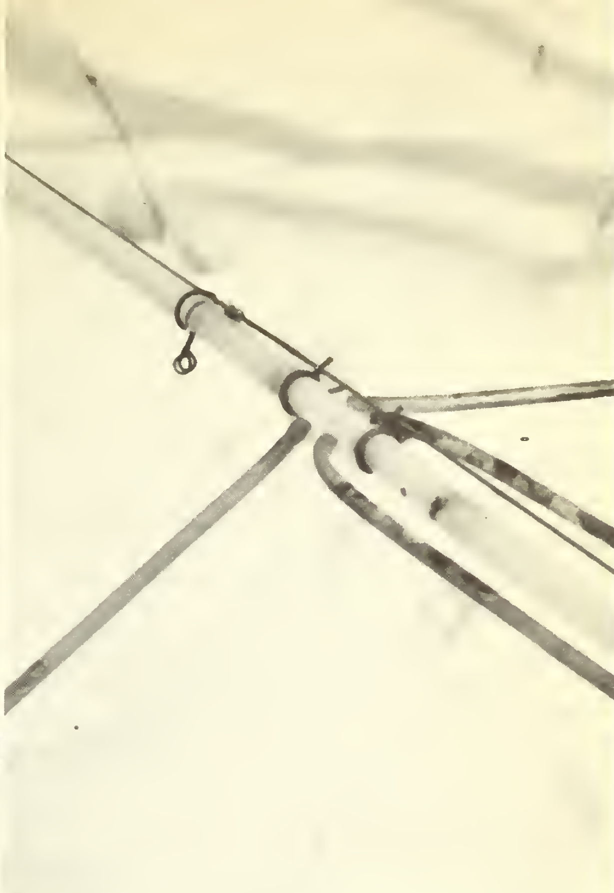

Figure 2.—Feeder lines of 5/16-inch tubing join a suspended line of ¾-inch tubing.

to larger tubing lines. If the tubing operation involves several thousand trees, sap from a taphole may be transported through several sizes of tubing before reaching the collection tank.

Flow Rates

A search was made for information about the flow rates of water through various sizes of pipe and tubing (fig. 3). We were able to use data published by the Republic Steel Corporation (table 1). These data include the number of gallons of water moved per hour through tubing diameters from ½ inch to 2 inches, for each of seven slopes ranging from 6 to 40 percent.

We converted the flow-rate values for these data, given in gallons per hour, to taphole equivalent (table 2). This was done by assuming a maximum sap flow of ½ gallon of sap per hour per taphole. For

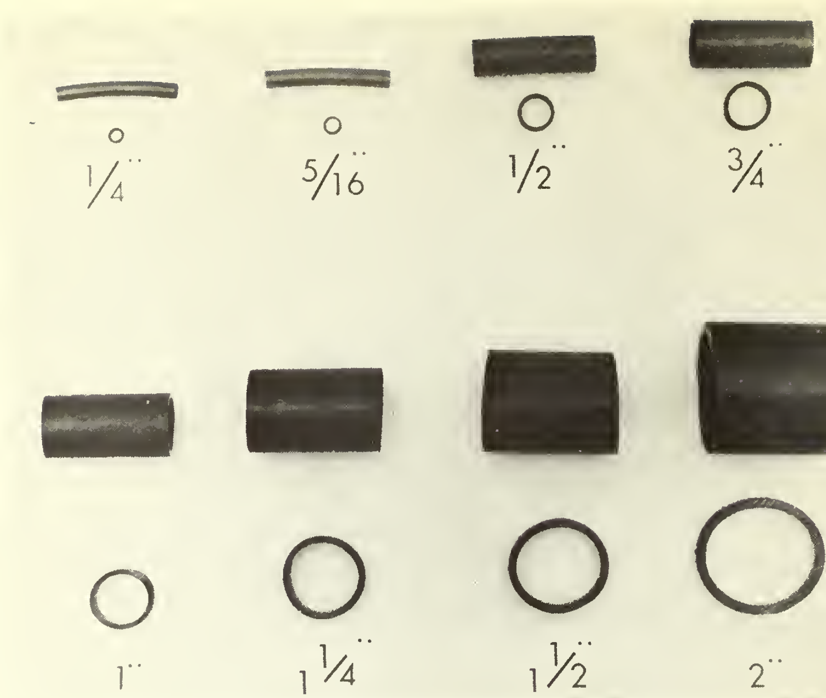

Figure 3.—The plastic tubing used in sugarbush operations ranges from 1/4 inch to 2 inches in diameter.

example, if a given diameter of tubing on a given slope can carry a maximum of 100 gallons of water per hour, we assumed it could handle the peak sap flow from 200 tapholes. This conversion can be easily modified for areas where it is felt that maximum flow rate from a single taphole is more or less than the assumed 1/2 gallon per hour. However, we believe this is a good average estimate for planning purposes.

Application

Using the information in table 2, a sugar producer installing tubing on a steep slope—40 percent—could use 1/2-inch lines for transporting sap from about 900 tapholes (888). At tubing junction points where more than 900 tapholes would be attached to a single 1/2-inch line, the tubing size would be increased to 3/4-inch. On a 40-percent slope 3/4-inch tubing would be adequate for 1,866 tapholes.

Slope percent does influence the gravity movement of sap through plastic tubing. For example, on a 15-percent slope a 1/2-inch tubing line would be adequate to handle the sap from about 500 (516) tapholes.

Table 1.—*Water delivered per hour by gravity movement through plastic tubing of various diameters on a designated slope*

[In gallons per hour]

Slope percent	Plastic tubing diameter, in inches					
	½	¾	1	1¼	1½	2
40	444	933	1,752	3,600	5,400	10,450
30	378	795	1,500	3,120	4,620	8,940
25	342	720	1,350	2,820	4,200	8,040
20	303	640	1,215	2,520	3,720	7,140
15	258	549	1,050	2,160	3,180	6,120
10	207	444	840	1,740	2,526	4,860
6	156	336	630	1,320	1,920	3,720

Source: Republic Steel Corporation, Water delivery tables using Republic flexible plastic pipe, 12 pp., 1956.

Table 2.—*Approximate maximum number of tapholes that can be used for collecting sap by gravity flow using various diameters of plastic tubing on a designated slope.*

Slope percent	Plastic tubing diameter, in inches					
	½	¾	1	1¼	1½	2
40	888	1,866	3,504	7,200	10,800	20,900
30	756	1,590	3,000	6,240	9,240	17,880
25	684	1,440	2,700	5,640	8,400	16,080
20	606	1,284	2,430	5,040	7,440	14,280
15	516	1,098	2,100	4,320	6,360	12,240
10	414	888	1,680	3,480	5,052	9,720
6	312	672	1,260	2,640	3,840	7,440

If sap from additional tapholes were added to this 500-taphole ½-inch line, it would be necessary to change to a ¾-inch line at this point to carry the volume of sap down the slope to the collection tanks. A ¾-inch line on a 15-percent slope could handle the sap from nearly 1,100 (1,098) tapholes.

Data for other slope percentages (6, 10, 20, 25, and 30 percent) and tubing sizes (1-, 1¼-, 1½- and 2-inch lines) are also included in this table, and the applications are similar. To be efficient, a producer should use the diameter of tubing that will adequately transport the maximum amount of sap for his slope and number of tapholes. Tubing that is either too large or too small will result in an inefficient tubing installation.

Although no research information was available on sap movement by gravity through plastic ¼- or 5/16-inch tubing, our experience indicates that 20 tapholes per line appear to work satisfactorily. Some sugar-makers have as many as 75 tapholes on one of these smaller lines. However, we have had good success collecting sap by gravity using 20 tapholes per 5/16-inch line, and we recommend this 20-taphole figure.

Discussion

The gravity sap-flow data indicate the number of tapholes that can be used with a given diameter of plastic tubing installed for several slope percentages. This information is based on the assumption that during a maximum flow period a producer can expect ½ gallon of sap per hour per taphole. We realize that this estimate may not apply to all sugarbushes, and the ½ gallon per hour sap flow may occur only once or twice during a sugaring season. However, the producer must have enough tubing of a given diameter to handle the available sap during a peak flow period.

For using this tubing size-slope-number of tapholes information, several points should be emphasized. The tubing must be installed with a minimum of severe bends or crooks. The sap should move by gravity through the tubing to the collection tank. Average slope percentages should be estimated accurately, because this factor is critical in choosing the correct size of tubing to use. Also, in installation, the slope of the lines should be as uniform as possible to suit the tubing size used.

The basic data in this note should assist new producers who are installing tubing for the first time. The information may also benefit producers who are having problems with their tubing installations, especially if the problem is too many tapholes on a given size tubing line. Successful sugar producers who use tubing say that it is better to have tubing that is too large than tubing that is undersized and inadequate to handle the volume of sap during a peak flow period.

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TESTING SUGAR MAPLE SAP FOR SWEETNESS WITH A REFRACTOMETER

Abstract.—We studied the consistency of refractometer sugar readings as influenced by sap evaporation, temperature, and the drying, cleaning, and calibration of the instrument. From the study results, we suggest field procedures for using the refractometer to insure reliable measurements.

The amount of sugar in sap collected from maple trees is extremely important to the sugar maple industry. Sweeter sap means lower cost in converting sap to syrup.

Sugar values are determined by measuring the percentage of sugar in the sap. A sugar refractometer is a handy instrument for doing this in the sugarbush or at the sugarhouse (fig. 1). However, improper techniques can result in inaccurate measurements.

We studied the variation in sap-sugar readings as measured with a refractometer, observing effects of sap evaporation, temperature, and the drying, cleaning, and calibrating of the refractometer. From this information we recommend procedures for using the instrument.

How to Use It

A sugar refractometer is a fast and dependable device for measuring the amount of sugar in the sap. A drop of sap is placed on the dark circular area of the refractometer (fig. 2). The cover is then closed and the sugar reading is observed through the eyepiece. Sugar in the sap changes the angle of light as the light passes through the prism of the instrument. The amount of sugar in the sap can be determined to the nearest 0.1 percent.

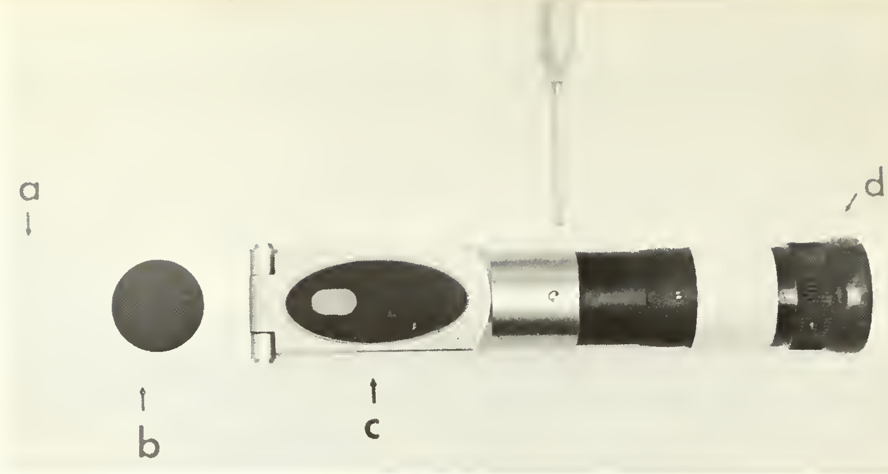

Figure 1.—The sugar refractometer: a, cover; b, dark circular area where drop of sap is placed; c, glass prism; d, eyepiece. Not shown in photo is a small adjustment screw used in calibrating the instrument.

Calibrating the Refractometer

Consistent sap-sugar readings depend on calibrating or "zeroing in" the refractometer. The optical parts of the refractometer change slightly at different temperatures. Therefore the refractometer must be adjusted immediately before the first reading and must be checked for consistency. Without proper calibration, sap-sugar readings will be inaccurate.

To calibrate a refractometer, place a drop of water on the dark circular area and close the cover. Distilled water is preferred, but any source of water could be used. A shadow or dark area is visible on the scale inside the eyepiece (fig. 3). Turn the calibration screw until the shadow falls on the zero mark. Open the refractometer cover and dry the cover and glass prism, using soft tissue paper or a clean cotton

Figure 2.—A drop of sap about to fall on the dark circular area of the refractometer cover. The refractometer can be used at the tree as well as in the sugarhouse.

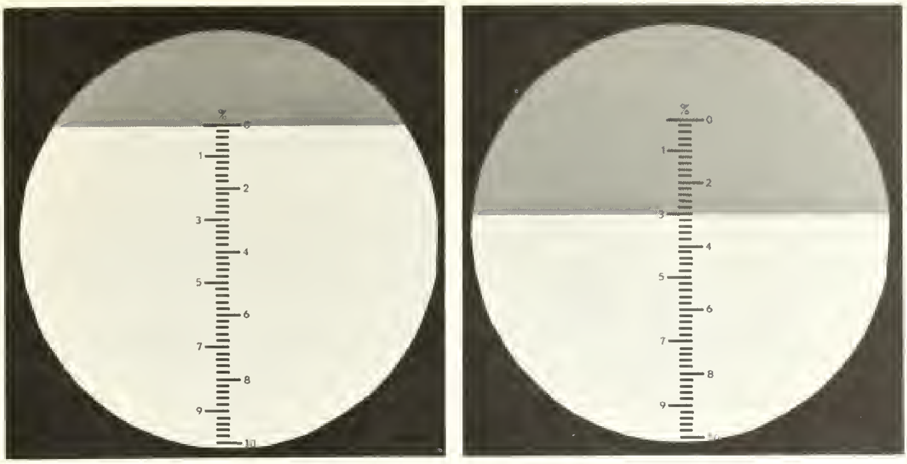

Figure 3.—View through the eyepiece of the refractometer. Left: with water, the meter is calibrated by bringing the shadow line onto zero. Right: in testing sap, the meter shows a sugar content of 3.0 percent.

cloth material. The instrument is now calibrated, and the sap sweetness measurements can be recorded.

Calibrate the refractometer immediately before the first sugar reading. If a number of sugar readings are taken in a short time (one per minute), the refractometer should be calibrated after each reading until the shadow consistently reads zero. Once stable, the calibration should be checked after every 15th reading or after each cleaning. If only an occasional sap-sugar reading is taken, the instrument should be calibrated before each sugar measurement.

Procedures and Recommendations

1. Focus the refractometer scale. The eyepiece can be adjusted; and once it is in focus, a piece of tape can be placed around the eyepiece to keep it from moving.
2. Calibrate the refractometer, using water.
3. After calibrating, put a drop of sap on the dark circular area, close the refractometer cover, look through the eyepiece, and determine the sugar reading from the scale (fig. 3). A drop of sap can be exposed on a refractometer cover for about 1 minute without changing sugar concentration. However, the refractometer cover should be closed and the sap-sugar measured as soon as possible.
4. Observe the sap-sugar concentration value on the refractometer scale viewed through the eyepiece (fig. 4). The sugar content can be read to the nearest 0.1 percent.

Figure 4.—Using a refractometer to measure the sap sugar concentration.

5. After each sugar measurement, use a soft piece of tissue paper or cotton cloth material to dry the refractometer cover and glass prism. After 15 consecutive sugar readings (at 1 minute intervals or less) the refractometer parts should be cleaned with water and then thoroughly dried before the next series of sugar readings. It is also convenient to check the calibration during the cleaning of the instrument. If only occasional sugar measurements are to be taken, the instrument should be cleaned, washed, dried, and recalibrated after each reading.
6. In the field, sap-sugar measurements can be made if the sap is dripping more than 1 drop every 8 seconds. This 8-second estimate is conservative; it was determined from laboratory experiments where a drop of sugar water was exposed to several wind velocities (6, 8, and 10 miles per hour).
7. The temperature of the sap does not appear to influence the sugar reading. Tests were made at 36°F. and 72°F.

If these procedures and recommendations are followed, sugar producers can confidently measure the sweetness of the sap at the taphole, in collection tanks, or at the sugarhouse. The refractometer is useful not only during a sugaring operation, but can also be used in selecting sweet trees for sugarbush-management purposes. Refractometers can be purchased from most sugaring equipment dealers for about $40 to $50.

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GEOGRAPHICAL VARIATION IN CAMPER EXPENDITURES

Abstract.—Daily expenditures by families camping in New Hampshire State parks in 1967 averaged $11.81. Considerable variation was found between the northern, central, and southern regions of the State in both the average amount of money spent and the way in which the money was spent. Daily expenditures in the north were higher, but average visit lengths were shorter, resulting in less local spending per family. The ratio of campground visit length to total trip length is shown to vary with several categories of trip expenditure. Campers who spent all or most of their trip at one campground spent substantially less per day in total and spent less on specific items of entertainment and automotive expenses.

Expenditures by campers and other tourists are generally thought to be an important source of income for rural economies *(Church 1969)*. However, reliable figures on how much money campers actually spend are scattered and highly variable. Results of a 1967 Forest Service study suggest that we need further information on the nature of camping expenditures if we are to properly assign measures to the economic impact of camping.

In 1959, family groups camping in State parks in Maine were reported to have spent an average of $19.80 per day *(Maine State Park Commission 1960)*. In a 1967 study of campers at just one State park in Maine, the average daily expenditure for camping families was $13.83 *(Buxton and Delphendahl 1970)*. A study of Wisconsin State park visitors (not all were campers) in 1958 revealed an average daily expenditure for car parties of $16.38 *(Hutchins and Trecker 1961)*. A profile of Delaware campers in 1967, revealed an average daily camper expenditure of $2.70 or $12.69 for an average party of 4.7 persons *(Roenigk and Cole 1968).*

Camping groups along the Androscoggin River, in northern New Hampshire, were reported to spend an average of $11.20 per day in 1967 *(Wallace and Olson 1969).* Visitors (reported to be "typically campers") to two reclamation reservoirs in Colorado during the summer of 1968 were reported to have spent widely different daily average amounts of $5.22 and $13.73 *(Milliken 1970).* A study of local spending patterns at one New Hampshire State park revealed the average daily expenditure per family to be $3.98, $4.22, $5.45, and $4.54, respectively, for the years 1966 through 1969 *(Jansen and others 1970).*

The extreme variation in reported expenditures by campers is probably attributable to two major sources: (1) the methods used in identifying camping-related costs are probably not comparable between studies; and (2) relative opportunity to spend varies with a number of geographic factors such as quality of the attraction and intensity of tourist-economy development, which, in turn, may influence such things as lengths of visit and styles of camping participation.

During the summer of 1967, a sample of campers at New Hampshire State parks supplied information about their daily expenditures for camping fees, gas and oil, food, equipment, entertainment, and miscellaneous trip costs. Campers were randomly selected throughout the summer at all State-operated campgrounds. Sampling methods, campground descriptions, and a partial analysis of the survey have been previously reported *(LaPage 1968).*

Total daily costs, and costs in several of the expenditure categories, varied with park locations, and with whether the park visit was a major, or incidental, part of the camping trip.

Geography and Costs

Expenditure data were collected from 642 camping families at New Hampshire's six major camping parks (figure 1). The average daily expenditure by these families while on their camping trip was $11.81. However, the total daily expenditure, as well as the daily cost for gas and oil, entertainment, and equipment varied significantly between parks and increased distinctly from the southern to the northern part of the State. Expenditures for camping fees and for food tended to remain relatively constant throughout the State (table 1).

The average expenditure for a day's camping at three northern parks —Lafayette, Moose Brook, and Coleman—was $3.23 higher than at the

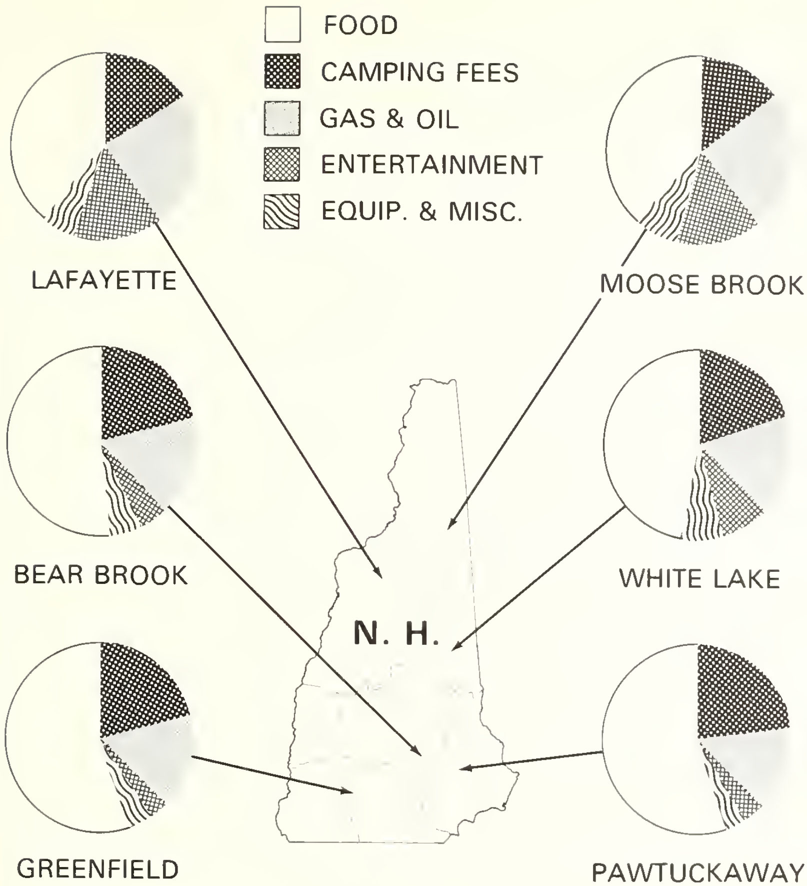

Figure 1.—Where the average daily camping expenditure goes, at six State operated campgrounds in New Hampshire.

five southern parks—Bear Brook, Pawtuckaway, Greenfield, Monadnock, and Pillsbury—($14.00 and $10.77, respectively). The bulk of this difference occurs in two classes of expenditures: gas and oil expenses and entertainment expenses each averaged $1.55 more in the north. While all campers incurred some expense for gas and oil, relatively few reported expenditures in the entertainment, equipment, and miscellaneous categories (table 2).

Campers at White Lake State park, which is more or less centrally located, reported expenditure patterns almost exactly in the middle of the north and south extremes in total daily costs, gas and oil expenses, and entertainment.

Campers in the northern part of the State not only spent more money each day, they also averaged more days away from home. But, since a

Table 1.—*Mean trip expenditures and standard deviations[1] by camping families at six major State parks in New Hampshire, by expenditure classes*

Item	Camping location						
	Pawtuckaway	Greenfield	Bear Brook	State-wide average[2]	White Lake	Lafayette	Moose Brook
Cost/day/family ($)	10.03	10.52	11.71	11.80	12.11	13.87	14.64
Std. dev.[1] ($)	(4.69)	(3.96)	(4.70)	(5.32)	(4.88)	(6.23)	(7.60)
Camping fees ($)	2.30	2.27	2.35	2.29	2.42	2.31	2.23
Std. dev. ($)	(.49)	(.49)	(.59)	(.54)	(.60)	(.55)	(.55)
Food ($)	5.53	5.73	6.12	5.70	5.70	5.50	5.59
Std. dev. ($)	(2.90)	(2.84)	(3.20)	(2.70)	(2.30)	(2.56)	(2.34)
Gas & Oil ($)	1.41	1.64	2.01	2.18	2.10	3.18	3.64
Std. dev. ($)	(1.24)	(1.56)	(1.63)	(1.75)	(1.25)	(1.52)	(2.45)
Entertainment ($)	.35	.35	.54	.90	1.00	2.07	2.13
Std. dev. ($)	(.78)	(.83)	(1.09)	(2.34)	(2.28)	(4.45)	(3.47)
Equipment ($)	.12	.28	.25	.43	.68	.61	.53
Std. dev. ($)	(1.07)	(1.31)	(1.31)	(1.68)	(2.10)	(2.08)	(1.67)
Miscellaneous ($)	.32	.25	.44	.30	.21	.20	.52
Std. dev. ($)	(1.06)	(.89)	(1.20)	(1.15)	(.67)	(.48)	(2.56)
Number of families	107	172	91	689	123	83	66

[1]The standard deviation expresses the range around the mean which includes about ⅔ of the campers.
[2]Includes 642 campers interviewed at the six major campgrounds and 47 additional families interviewed at four lesser campgrounds.

Table 2.—Number of camping families having made expenditures for entertainment, equipment, and misceallaneous camping purchases and mean expenditures and standard deviations

Item	Camping location						
	Pawtuckaway	Greenfield	Bear Brook	State-wide	White Lake	Lafayette	Moose Brook
Entertainment							
Purchasers (No.)	27	45	25	245	51	49	38
Mean cost ($)	1.39	1.35	1.97	2.52	2.42	3.51	3.71
Std. dev. ($)	1.00	1.14	1.24	3.37	3.03	5.36	3.89
Equipment							
Purchasers (No.)	2	11	6	57	16	7	7
Mean cost ($)	6.44	4.45	3.73	5.16	5.22	7.28	5.03
Std. dev. ($)	6.28	2.95	3.90	3.11	3.27	1.59	1.95
Miscellaneous							
Purchasers (No.)	14	26	18	110	18	15	8
Mean cost ($)	2.48	1.64	2.24	1.90	1.42	1.09	4.26
Std. dev. ($)	1.86	1.74	1.82	2.30	1.16	.57	6.54

Table 3.—Average lengths of camping trips and visits and average total expenditures by campgrounds

Item	Camping location						
	Pawtuckaway	Greenfield	Bear Brook	State-wide	White Lake	Lafayette	Moose Brook
Mean trip (days)	8.14	6.31	7.19	8.70	10.14	11.39	11.95
Std. dev. (days)	5.77	4.87	4.89	7.24	5.61	10.45	6.81
Mean cost ($)	81.64	66.38	84.19	102.75	122.80	157.97	176.50
Mean visit (days)	6.43	4.88	5.30	5.44	8.15	3.88	2.68
Std. dev. (days)	4.05	3.78	4.19	5.18	5.31	3.27	3.08
Mean cost ($)	64.49	51.34	62.06	64.25	98.70	53.82	39.58
On first visit (%)	44	45	34	49	32	75	88

much smaller portion of their total trip was spent at these campgrounds, their total expenditures while at the campground were lower than were those by campers at either the central or southern parks (table 3).

Those parks having a high incidence of transient visitors (short visits) also have a much higher proportion of campers who are visiting for the first time. The majority of visitors to Moose Brook spent less than one-fourth of their trip at that campground, and 88 percent had never been there before. By contrast, at White Lake, four-fifths of the average trip was spent at the campground, and only 32 percent were visiting the park for the first time.

Visit/Trip Ratios and Costs

Although the ratio of visit-length to trip-length varies from park to park, 65 percent of all families were spending their entire camping trip at a single campground. When this ratio dropped below 1, or when campers visited more than one campground on a single trip, daily expenditures increased. When the campground visit represented less than one-third of the total trip, mean automobile expense almost doubled, mean entertainment expense increased by 124 percent, and the proportion of campers incurring an expenditure for entertainment nearly tripled.

The transient (visit/trip ratios of less than 1) campers were typically tourists in both their expenditures and their trip characteristics. For

Table 4.—*A comparison of selected camping-family expenditures and trip characteristics by visit/trip ratios*

Item	Length of visit/length of trip ratio		
	less than 1/3	1/3 to 9/10	1/1
No. of families	115	126	448
Mean total daily expenditure	$15.26	$11.68	$10.94
Mean gas & oil expense	$ 3.51	$ 2.32	$ 1.81
Listing entertainment expense	65%	50%	24%
Mean entertainment expense by those listing	$ 3.92	$ 2.15	$ 1.75
Visiting campground for the first time	84%	63%	37%
Residing in N. H. and neighboring states	28%	48%	85%
Mean trip length (days)	15	11	7
Mean visit length (days)	2	5	7

example, they were much more likely to be on a long trip, to be visiting the campground for the first time, and to have traveled a greater distance in getting there (table 4). While transient campers spend more per family per day, their per-family local spending impact is much lower than that of the campers who stay at a single campground (2 days × $15.26 per day, versus 7 days × $10.94 per day). However, collectively the transient campers' impact could be much higher because their shorter visit permits more transient campers to use the same campsite during the season.

Implications for Economic Impact

Aside from the obvious need for more comparative data on the amount of camper expenditures, this study suggests a need for further research into the nature of camping expenditures if we are to properly assign meaures of economic impact to camping activity. For example, there appears to be a paradoxical relationship between the intensity of tourist area development and the average length of a camping visit. Highly-developed tourist areas, such as those which exist around the two northern parks, seem to produce more expenditures but shorter visits. On the other hand, the three southern parks have relatively few spending opportunities nearby and longer visits. Further confounding an attempt to measure the impact of camper spending at the southern parks are their much higher rates of: (1) repeat visitation (better knowledge of what to bring and what to buy locally?), and (2) local visitation (resulting in less new money being introduced into the local economy?). Our existing knowledge of camper expenditure patterns strongly suggests that the single goal of trying to maximize local area impact would provide a poor rationale for locating new public camping facilities.

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NOISE ABATEMENT IN A PINE PLANTATION

Abstract. — Observations on sound propagation were made in two red pine plantations. Measurements were taken of attenuation of prerecorded frequencies at various distances from the sound source. Sound absorption was strongly dependent on frequencies. Peak absorption was at 500 Hz.

Forest vegetation has been shown to be effective in deadening unwanted sounds. However, people often attribute such vegetation with almost mystical qualities in filtering out unwanted noise. To help clarify the complex effect of forest vegetation on sound, we studied the attenuating effect of two red pine plantations on selected frequencies of sound.

When considering a medium for sound propagation, such as a stand of trees, it is important to have some feeling for what the sound field looks like. An environment in which there are no reflecting or absorbing objects is known as a free field. In such a field, attenuation of sound is predictable. Attenuation in non-free fields is more than that in free fields and is much more difficult to predict. In nature, there are few free fields; reflecting and absorbing objects may range from a few sunflower plants to a dense thicket of vegetation.

Referring to sound abatement by trees is not definite enough to be of use. It is necessary to specify the physical aspects of the vegetation by species composition, plant density, average height, and so on. Of course, these aspects are only indirect indicators of the absorptive, refractive, and reflective properties of the vegetation.

For the relatively simple case of a planted group of trees, the evaluation must include tree heights, diameters, height of clear boles, number of trees per unit area, and other descriptive information. Along with a description of the physical aspects of the vegetation, the orientation of the vegetation arrangement in respect to the source of sound (highway, factory, etc.) must be included.

Stand Descriptions

The two red pine plantations used in this investigation were 37 years old, located on a level glacial outwash plain. Trees were spaced 2 by 2m. in both plantations. Mensurational information for both plantations, henceforth designated as "good" and "poor", is presented in table 1. A more detailed stand description has been published *(Leaf and Leonard 1967)*.

Table 1.—Mensurational data for "Good" and "Poor" pine stands.

Stand	Stem d.b.h.		Height		Height to live crown	Basal area
	Max.	Min.	Max.	Min.		
	Cm.	*Cm.*	*M.*	*M.*	*M.*	*M.²/ha.*
Good	12.7	10.9	16.2	13.4	8.4	35.0
Poor	11.2	7.4	12.6	7.9	4.9	16.6

These stands constitute two layers: the lower layer of bole space and the fairly dense upper layer of twigs, branches, and needles.

Method

The effect of the forest on the attenuation of sound was determined by measuring the sound pressure level (SPL) at a given audio frequency at several distances from a point source. The resulting SPL's were then plotted as a function of distance from the source of sound. From this plot, the attenuating effect of the forest can be calculated.

This procedure was carried out for frequencies of 125, 250, 500, 1,000, and 2,000 Hz. at 2.6, 16.5, 33, 66, and 82 m. from the source. The human ear can perceive a frequency range from about 20 to 10,000 Hz. (1 Hz. = 1 cycle per sec.).

The sound source was a V. M. Model 27 high fidelity loud speaker driven by an EICO HF-20 amplifier.[1] In order to insure that identical frequencies were used in all experiments, a set of pure tones of the various frequencies were recorded on a tape loop played into the amplifier from a Wolensack tape recorder. An oscilloscope was used during playback to insure that the signal was not distorted. During field trials, the speaker was placed about 1 m. from the ground and was aimed visually along the selected radii. The speaker had no measureable directivity within 20° of a line parallel to the speaker axis.

A General Radio 1551-C sound level meter was used to measure the SPL at the selected distances. The 1551-C was operated in the "flat" mode with the response in the "slow" position. The microphone was mounted on a tripod about 1.5 m. from the operator. This arrangement placed the microphone about 1 m. from the ground. The 1551-C was calibrated for the extra microphone cable required by this arrangement.

Markers were placed at the required distances along a line of sight determined by a staff compass. If the mark fell too close to a tree or behind a tree, it was moved in an arc until it was midway between stems. During the trials, the microphone was placed directly over the mark. A measurement of the background level was made. If the background was normal—about 40 db. (decibels) SPL—the source operator was signaled to play the first tone. The SPL meter operator watched the meter for the 30-second duration of the tone signal and recorded the "average" SPL. Observation of the same trial by two different operators indicated that this method of estimation yielded results that differed by only 1 or 2 db.

Results and Discussion

The data, consisting of SPL measurements at a given distance, were corrected for background levels when the signal was 10 db. above the background. Plots of SPL over log distance were then prepared. The general equation for the reduction in SPL with distance is:

$$SPL_{r_2} - SPL_{r_1} = 20 \log_{10} (r_1/r_2) + A_e$$

where: r_2, r_1 = distances from source, $r_2 < r_1$, feet and A_e = excess attentuation, db. SPL. The first term on the right accounts for the reduction of SPL in a free field (a field in a homogeneous, isotropic medium free from boundaries). The second term (A_e) includes the attenuating effects of: (1) atmospheric absorption; (2) wind, turbulence,

[1] Mention of a particular product should not be taken as endorsement by the Forest Service or the U. S. Department of Agriculture.

temperature, gradients, ground effects; (3) trees. The term A_e can be evaluated by noting the differences between the measured SPL and that given by the term for the free field losses. The free field loss is a straight line on semilog paper showing a loss of 6 db. SPL for each doubling of distance (fig. 1).

The excess attenuation is the distance between the line for free field loss and measured points.

These experiments were carried out in nearly calm wind and under an overcast sky. Thus the losses due to wind, turbulence, and temperature gradient are small. We assume that the forest floor is a good absorber of acoustic energy. A_e then consists almost entirely of atmospheric absorption and losses attributable to the forest.

The data for frequencies 125 and 2,000 Hz. were scattered about the theoretical loss line, indicating that the forest has little effect at these frequencies (fig. 1). However the excess attenuation for 500 Hz. is quite large. The line for 250 Hz. shows a negative loss, while that for 1,000 Hz. shows a fairly strong loss at distances over 50 feet. These results are confirmed by the data taken in the poor pine stand.

Again, when excess attenuation is plotted over frequency (transfer function), the strong attenuation as 500 Hz. is evident (fig. 2). The clear-cut visual and mensurational differences between the good and poor stands are not reflected in the transfer functions for the two stands.

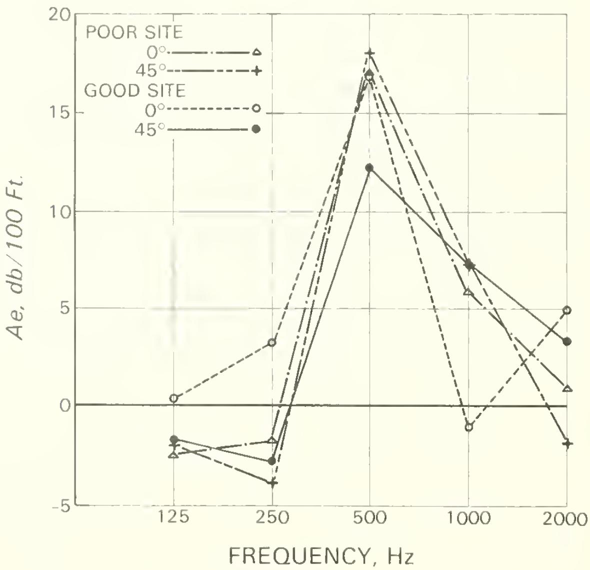
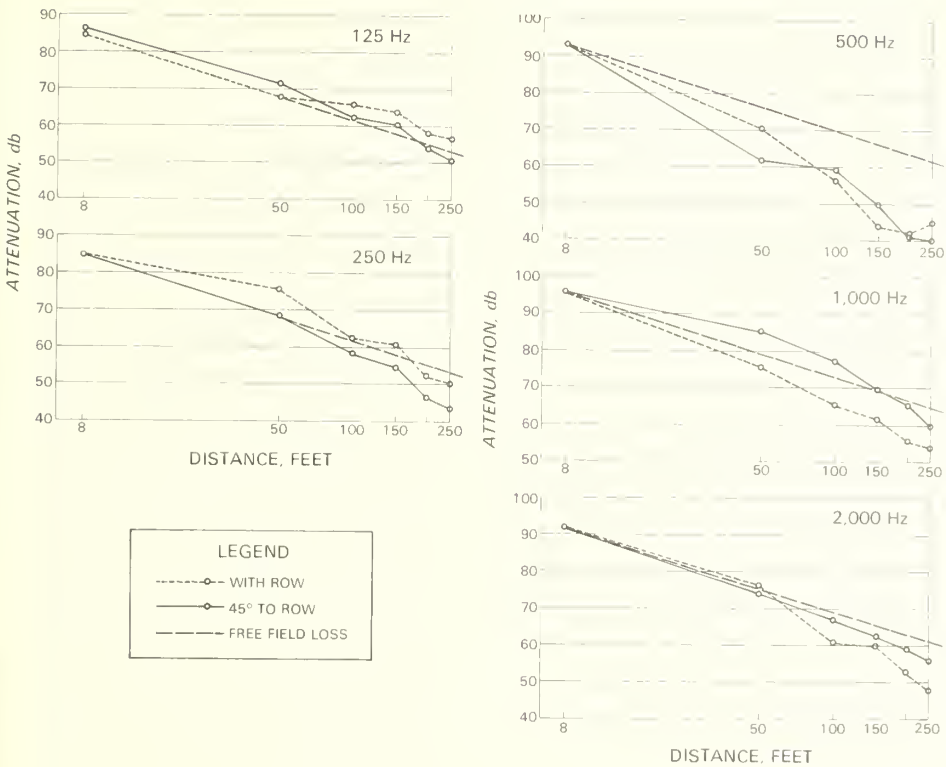


Figure 1. — Sound pressure levels at various distance for the given frequency. Theoretical lines show attenuation due to the inverse square law (free field loss).

Figure 2. — Average excess attenuation at given frequencies.



The presence of strong absorption of sound by a pine forest at 500 Hz. was also shown by Embleton *(1963)*. Embleton attributed the loss to the resonate action of tree branches. Accelerometers attached to selected branches indicated that they did indeed resonate. However, the theory for this action did not predict losses of the order measured.

Our results could be due, at least in part, to reflections from the forest floor. Measurements of the absorptivity of the forest floor are needed. A better practice would be to place the source directly on the ground.

Conclusions

Our results tend to confirm Embleton's work and indicate that the effect of the forest on sound propagation may be quite complex. Studies of physics of sound propagation in the forest are indicated and will promote a better understanding of the effects involved. We feel such studies are preferable to the play-some-sound-and-see-what-happens approach.

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EFFECTS OF SPOIL TEXTURE ON GROWTH OF K-31 TALL FESCUE

Abstract.—Growth of K-31 tall fescue (*Festuca arundinacea*) was significantly affected by the particle-size distribution, or texture, of four spoils from eastern Kentucky. Growth on spoils having no toxic chemical properties generally was greatest where texture consisted of about equal quantities of soil-size material and a coarser fraction (2 mm. to 6.4 mm.), probably because moisture and aeration were favorable. However, on two spoils, adverse chemical properties modified the effect of physical properties associated with texture. Toxic levels of Mn found in the smaller-size fractions probably reduced yields on one spoil. On another, the effect of texture was masked by toxic levels of Al in each of the three particle-size fractions.

Success or failure of attempts to revegetate spoil banks formed in the process of strip mining for coal depends on both chemical and physical properties of the spoil material. Effects of spoil chemical factors, such as pH and nutrient deficiencies, on plant establishment and growth have received some study. Effects of spoil physical properties, such as texture, on plant growth have received little investigation, yet the coarseness of the spoil surface is one of its most striking features. This note deals with the effects of spoil texture on the growth of K-31 tall fescue (*Festuca arundinacea*), a species commonly used in spoil reclamation.

Texture of *soils* commonly refers to the relative proportions of sand, silt, and clay in a soil mass, thus indicating its relative coarseness. Since spoil banks in the Appalachian region initially contain only a small amount of soil-size material, a textural classification of spoils based on relative amounts of sand, silt, and clay is meaningless. Spoil banks consist of a mixture of rock fragments and soil-size material; and, in contrast to soils, the particle-size distribution changes rapidly as spoil weathers. Therefore, spoil texture refers to a distribution of particles ranging from large rocks to soil-size material.

Spoil texture depends on the nature of the overburden from which the spoil was derived and on its degree of weathering. Spoil derived primarily from sandstone strata usually is initially coarser than spoil derived mainly from shale. Furthermore, shale fragments break down more rapidly into smaller particles during chemical and physical weathering than do sandstone fragments.

Methods

The effect of texture on plant growth may be influenced by chemical properties of the spoil, especially if the spoil is very acid. For this reason, four spoils from eastern Kentucky that varied widely in parent material and pH (index of acidity) were used in this study (table 1). Variation within individual spoils was minimized by collecting material of similar color, parent rock, and age (time since mining).

Each spoil was arbitrarily separated into three particle-size fractions:

A $<$ 2 mm. (soil size)
B 2 mm. to 6.4 mm.
C 6.4 mm. to 12.7 mm.

A series of 13 pots containing 2,000 g. of various proportions of each particle-size fraction was prepared for each spoil (table 2).

Table 1.—Some characteristics of the four spoils used in evalauating effects of texture on growth of K-31 tall fescue

Spoil number	Derived from predominantly—	pH	Age (since mining, years)
1	Acid sandstone	4.7	2
2	Sandstone	6.2	2
3	Calcareous shale	7.2	1/4
4	Shale	3.5	7

Table 2.—Percentage by weight of three particle-size fractions in each of 13 pots

Texture-class number	Particle-size fraction		
	A	B	C
	< 2 mm.	2 to 6.4 mm.	6.4 to 12.7 mm.
	Percent	*Percent*	*Percent*
1	100	0	0
2	80	20	0
3	60	40	0
4	50	50	0
5	40	60	0
6	40	40	20
7	30	30	40
8	25	25	50
9	20	80	0
10	20	20	60
11	10	10	80
12	0	100	0
13	0	0	100

This series represented extremes of textures found in spoils, ranging from all soil-size material to completely coarse fragments. The series of pots was replicated three times. Since growth of grasses on most spoils is often nil unless phosphorus (P) and nitrogen (N) are supplemented, all pots were fertilized with 50 p.p.m. P from monocalcium phosphate and 50 p.p.m. N from ammonium nitrate. Fertilizer was thoroughly mixed into the spoil material, after which about 50 fescue seeds were planted in each pot. Distilled water was applied as required, and the grass grew in pots in the greenhouse for 3 months.

Results and Discussion

Herbage yield of tall fescue was markedly influenced both by texture and by spoil type (fig. 1). Furthermore, the texture x spoil interaction was highly significant, indicating that similar textures produced different growth responses on different spoils.

Top growth was generally greatest in spoils 2 and 3, both of which had relatively high pH values (table 1). In these two spoils,

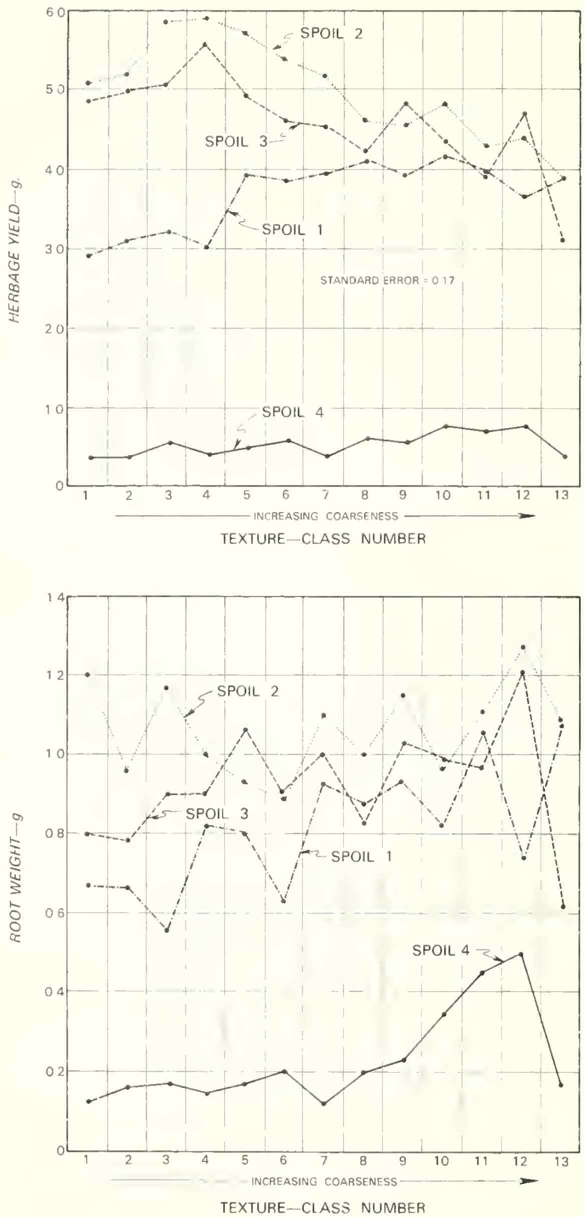

Figure 1.—Oven-dry top (herbage) and root weights of K-31 tall fescue as affected by particle size (texture) and four spoil types.

neither Al or Mn approached suspected toxicity levels (table 3). Pots containing equal portions of the soil-size fraction and fraction B gave greatest yields. As texture became coarser (increasing percentages of larger-size fractions), yields generally declined on these spoils (fig. 1). Several factors are likely involved in the de-

Table 3.—Some chemical properties of three particle-size fractions of four spoils

Spoil number	Size fraction	Mn[1]	Total acidity N KC1	Extractable Al	Extractable H
		p.p.m.	*me./100 g.*	*me./100 g.*	*me./100 g.*
1	A	58	0.95	0.85	0.10
	B	58	.95	.70	.25
	C	20	.35	.20	.15
2	A	12	.10	.00	.10
	B	9	.15	.00	.15
	C	5	.10	.00	.10
3	A	28	.10	.00	.10
	B	13	.05	.00	.05
	C	9	.10	.00	.10
4	A	17	8.00	6.50	1.50
	B	14	7.65	6.25	1.40
	C	13	6.55	5.18	1.37

[1] Extracted with *N* NH_4 OAc (pH 4.8).

creased yields. First, available moisture possibly reached critical levels in the coarsest spoils at times, especially in the top few inches since percolation through the coarse spoil was rapid. Secondly, the larger-size fraction possibly was unable to supply ample nutrients to meet plant requirements. Unpublished data indicate that size-fraction C yields considerably smaller quantities of plant nutrients than does the soil-size fraction.

Herbage yield in spoil 1 generally increased as texture became coarser (fig. 1). The reason for this different response, as compared to that of spoils 2 and 3, is probably adverse chemical properties of spoil 1 associated with the smaller particle sizes (table 3). Spoil 1 yielded 58 p.p.m. Mn from both fractions A and B, but only 20 p.p.m. in the coarser fraction C. Mn toxicity symptoms on legumes have been reported on acid spoils in eastern Kentucky (*1*).

Another possible reason for greater yields on coarser textures of spoil 1 is that Al may have been present in toxic amounts especially in the finer textures. Extractable Al ranged from a low of 0.20 me./100 g. (fraction C) to a high of 0.85 me./100 g. (fraction A). These figures are within the range of critical values of exchangeable Al for various species, soils, and methods of extraction, as summarized by Reeve and Sumner (*2*).

Herbage yield for all textures of spoil 4 was very low, ranging from 0.30 to 0.71 g. These poor yields are attributed to extremely high levels of exchangeable Al (6.50, 6.25, and 5.18 me./100 g. for fractions A, B, and C, respectively). Since all three size fractions contained toxic quantities of Al, the effect of texture on plant growth was masked by the adverse nutritional regime.

Root growth was generally greatest for fescue growing on spoils 2 and 3, and least for fescue growing on spoil 4 (fig. 1). No clear trend was apparent between spoil texture and root growth, except in spoil 1 and 4 where growth generally increased as texture became coarser. This is probably because high levels of Mn and Al were reduced to more tolerable levels. Poor root growth observed on spoil 4 is attributed to toxic levels of exchangeable Al in all size fractions.

Conclusions

Results of this study indicate that, in spoils having no adverse chemical properties (such as spoils 2 and 3), fescue growth is greatest where texture consists of about equal portions of soil-size material and particles 2 to 6.4 mm. Such a particle-size distribution probably provided optimum physical properties, such as aeration and moisture retention, for plant growth under the conditions of this study. However, in spoils with chemical properties that limit plant growth, such as in spoil 1 with its high Mn levels, coarser textures yield better growth, since less Mn is available from the larger particle-size fractions. Toxic amounts of exchangeable Al severely limited fescue growth on all textures of spoil 4. High rates of lime would have to be applied to this spoil to reduce exchangeable Al to plant-tolerable limits before adequate plant growth could be expected.

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VEGETATIVE CHANGES AT ADIRONDACK CAMPGROUNDS 1964 to 1969

Abstract.—The vegetation on campsites in the Adirondacks was measured and mapped, and changes in vegetation on the sites were studied from 1964 to 1969. Results indicate that well-maintained sites deteriorated little during the study period.

Picture in your mind the perfect tent site: partial shading from the afternoon sun, a variety of trees and shrubs providing a screen from other tent sites, and little or no drainage problem. Now let's put 100 families on that tent site during the course of a summer, so that it accommodates about 400 camper-days per season. How do you suppose that tent site would look 5 years from now or 10 years from now?

This case study in the Adirondack Forest Preserve of New York revealed very little physical site deterioration on well-maintained tent sites. Results of this study may be helpful to campground managers throughout the Northeast. If managers anticipate some changes in vegetation, they can take steps to see that the quality of their campgrounds is maintained.

STUDY PROCEDURE

In 1964, Shafer and Thompson *(8)* took measurements of 32 physical site characteristics at each of 210 tent sites scattered throughout 25 campgrounds in the Adirondack Forest Preserve. A map of each tent site was drawn to identify the relative positions of the fireplace, four dominant trees within a 50-foot radius of the fireplace, and the dominant tree of that group.

Table 1.—*Campgrounds studied in the Adirondack Forest Preserve of New York State*

Campground	Tent sites studied	Average annual use per tent site 1964-69
	No.	*Camper-days*
1. Rollins Pond	6	330
2. Wilmington Notch	5	663
3. Lake Eaton	2	301
4. Lewey Lake	6	283
5. Eagle Point	4	455
6. Rogers Rock	7	373
7. Glen Islands	6	324
8. Hearthstone Point	10	484
9. Northampton Beach	3	464

In 1969, 5 years later, 8 of the original site characteristics were measured on 49 tent sites at 9 of the campgrounds (table 1). Measurements were taken during July and August in both 1964 and 1969 to minimize error due to weather conditions or variation in use patterns. The variables that were remeasured are:

1. Overstory density of all trees—as measured with a spherical densiometer *(10)*. This instrument is accurate to within ±2 percent of the actual overstory density.
2. Vertical component of aesthetic screen—as measured with a pantallometer *(7)*. This instrument is accurate to within ±5 percent.
3. Lateral component of aesthetic screen—also measured with a pantallometer.
4. Average d.b.h. of four dominant trees—measured to the nearest 1/10 inch with a diameter tape.
5. Height of the dominant tree—measured to the nearest foot with an Abney level.
6. Number of white birch stems per tent site; minimum height—20 feet.
7. Number of softwood stems per tent site; minimum height—20 feet.
8. Number of hardwood stems per tent site; minimum height—20 feet.

In addition, field crews took off-site measurements at six of the nine campgrounds during the 1969 field work. Each set of off-site measurements consisted of the height of four dominant trees and the d.b.h. of one-half the number of trees measured at the campground. If a campground had seven tent sites where 28 trees were remeasured, a nearby off-site area of similar slope, aspect, soil, and vegetation characteristics was located. The field crew marked the center of that off-site area with a stake driven into the ground. Then the positions, heights, and diameters of four dominant trees were recorded. Finally the positions and diameters of an additional 10 nearby trees in the dominant and codominant classes were recorded.

Tree growth between 1969 and 1974 at the off-site areas will be compared to tree growth between 1969 and 1974 at the campgrounds. The off-site data will be used as a control since little or no recreational activity should have occurred there.

RESULTS

Overstory Density

Overstory density consists of the vegetation over a tent site. It was measured as a percent of the total amount of vegetation that could provide shade. Overstory density increased an average of 3 percent between 1964 and 1969. On an individual basis, tent sites with the greatest increase in overstory density (30 to 50 percent) were well stocked with vigorously growing (4- to 15-inch d.b.h.) white pine and white birch trees. These two species are native to the Adirondack region and should be expected to grow well.

Two campgrounds had overstory density increases greater than 10 percent. Stocking of these campgrounds was 87 percent white birch and white pine. Both campgrounds had young vigorously growing trees on them that averaged 5.4 and 14.6 inches d.b.h. and 42 and 78 feet high, respectively.

Annual use of these two campgrounds was 373 and 464 camper-days per tent site. (A camper-day per tent site is one camper occupying a tent site for 1 day.) These use figures are similar to those of the other seven campgrounds studied. The average use for all 9 campgrounds was 408 camper days per tent site per year.

Three tent sites had large decreases in overstory density (29, 31, and 49 percent). Species composition was only 17 percent white birch and white pine. The average diameter of the trees measured was 17.5 inches, and the average height was 78 feet.

Four campgrounds accommodated an average of 516 camper-days per tent site per year. The other five campgrounds accommodated an average of 322 camper-days per tent site per year. The change in the overstory density in relation to use was as follows:

Average annual use per tent site (camper-days)	*Average overstory density* 1964 (percent)	1969 (percent)	*Sample size (tent sites)*
Over 400	74	75	22
Under 400	76	81	27

It would appear that use intensity of tent sites and change in overstory density are not strongly related.

Vertical Screening

Vertical screening (site characteristic 2) consists of tree trunks and other upright objects that contribute to privacy within a tent site. It was measured as a percent of the total possible. On the average for all tent sites, vertical screening increased 2 percent. This small difference may have occurred in the sample by chance, or in measurement error, because two people measuring the same site may differ by as much as 5 percent. None of the campgrounds had an average decrease in vertical screening, and only 10 of 49 tent sites had a decrease. The average decrease in vertical screening for the 10 tent sites was 3 percent. Again, this could have been due to measurement error.

The change in vertical screening in relation to use intensity was as follows:

Average annual use per tent site (camper-days)	*Average vertical screening* 1964 (percent)	1969 (percent)	*Sample size (tent sites)*
Over 400	15.5	19.0	22
Under 400	13.0	16.0	27

These data do not support the notion that there may be a relationship between high use and decrease in vertical screening.

Lateral Screening

Lateral screening consists of low-hanging branches and their leaves, bushes, shrubbery, and other low vegetation that provides the major portion of any privacy a tent site may offer. Lateral screening, like overstory density and vertical screening, is measured on a percent basis.

Average lateral screening decreased 5 percent during the study period; from 30 percent in 1964 to 25 percent in 1969. Although this decrease is not alarming and may have been naturally associated with the 3-percent increase in overstory density reported earlier, it may be part of a

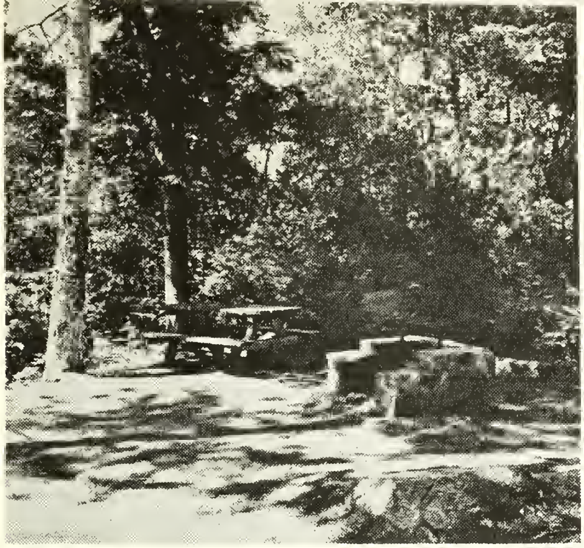

Figure 1.—Vegetative screening around each tent site was one of the features mentioned most often as desirable in a survey of campers in the Adirondack forest preserve.

trend that could detract seriously from the amenities of the Adirondacks. "Vegetative screening around each tent site" was one of the features mentioned most often as desirable in a survey of campers in the Adirondack Forest Preserve *(9)* (fig. 1).

The loss in lateral screening is punctuated by the fact that, in 1964, 10 of the 49 tent sites were surrounded by 50 percent or more lateral screening. By 1969, only five of the tent sites were able to provide this kind of privacy. Eight of the nine *campgrounds* studied had a decrease in average lateral screening, while one showed no change. Nearly 70 percent of the individual *tent sites* revisited in 1969 had less lateral screening than they had in 1964 (fig. 2).

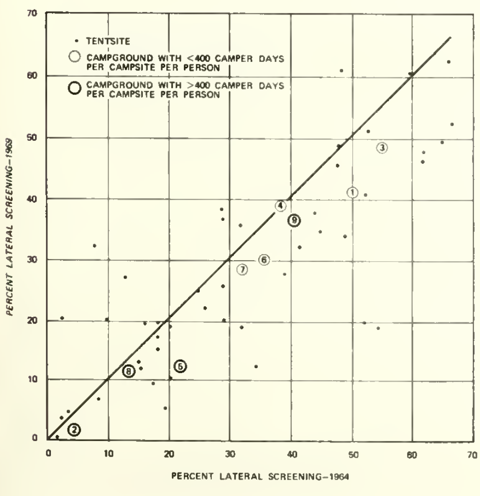

Figure 2.—Tent sites and campgrounds to the right of the diagonal line displayed a decrease in lateral screening between 1964 and 1969.

The decrease in lateral screening is further emphasized by the loss of tree stems per tent site (site characteristics 6, 7, and 8). Even though trees included in these measurements had to be over 20 feet tall, their lower branches made significant contributions to lateral screening. The loss in stems per tent site in relation to use-intensity was as follows:

Average annual use per tent site (camper-days)	*Average No. stems per tent site*			*Sample size (tent sites)*
	1964 (No.)	*1969 (No.)*	*Loss (percent)*	
Over 400	42	17	59.5	22
Under 400	29	13	59.2	27

These data do not show a relationship between intensity of use and the loss in number of stems per tent site.

Tree Diameter and Height

Diameter growth of the trees remeasured at each tent site averaged about 1/10 inch per year (table 2). By most standards, this is a fairly slow growth rate. It was apparently uninfluenced by use. Lightly and heavily used campgrounds had equal changes in d.b.h. measurements. On the average, diameters increased about ½ inch between 1964 and 1969.

The height growth of the dominant tree remeasured at each tent site averaged less than ½ foot between 1964 and 1969. But measurement precision is suspect for this characteristic. The 1969 height measurements of the live dominant tree on each tent site ranged from —18 feet to +22 feet around the 1964 height measurements. Even double and triple

Table 2.—*Species composition and growth of trees*

Species	Composition[1]	D.b.h. growth 1964 to 1969
	Percent	*Inch*
White pine	33	0.6
White birch	15	.5
Eastern hemlock	12	.4
Hard maple	7	.5
Red pine	6	.2
Soft maple	5	.7
Red spruce	5	.2
Red oak	5	.4
Others	12	—

[1]The four dominant trees measured at each tent site are represented in this column; 33 percent of the trees measured were white pine, 15 percent were white birch, etc.

checks of some tree heights resulted in illogical differences between 1964 and 1969 measurements.

DISCUSSION

From a manager's standpoint, none of the variables measured deteriorated appreciably. In fact, overstory density and the vertical component of aesthetic screening increased slightly during the 5-year period. The lateral components of aesthetic screening—composed of shrubs, bushes, and low hanging branches—decreased by only 5 percent between 1964 and 1969. Although this characteristic should be watched closely during the next 5-year period, it would be incorrect to conclude that tent sites in the Adirondack Forest Preserve are in danger of losing the seclusion they have previously supplied.

Overall results are in somewhat close agreement to a similar study conducted in California between 1961 and 1966. Magill *(5)* found a general improvement in the condition of the campground vegetation. The improvement was interpreted as an "adjustment" to recreational use and was attributed to barriers placed in the campgrounds and to abundant precipitation.

Ground-cover response to recreational use was studied over a 3-year period at a campground in Pennsylvania. In that study, LaPage *(4)* found that the average percent ground cover, although of different species composition than the original, had begun to increase after the original species had experienced an initial drastic decrease; another apparent "adjustment" to recreation pressure.

Wagar *(11)* showed that recreation pressure caused ground cover to deteriorate rapidly at first; but, after the early loss, the rate of deterioration was very slow, even with increased pressure. He concluded that "large changes in use may cause only small changes in damage on the highly-developed areas where use is already heavy." Of course, this conclusion would not be applicable to very fragile soils or to steep slopes *(2, 6)*.

Considering the diameters, heights, and species that were measured in this study, we see no major vegetative changes that can be directly related to the levels of recreational use at the campgrounds. Comparison of on-site and off-site measurements in 1974 should shed more light on this.

It would be difficult to accurately compare campers' opinions about the aesthetic appeal of the campgrounds in 1964 and 1969. There may be a different breed of camper, or the camper may have changed his tastes about what is or is not aesthetically appealing. But the brief evidence presented here leads us to believe that:

1. Established tent sites, well-stocked with native species, should not deteriorate very rapidly.
2. Tent sites given normal maintenance (kept clean and safe) should not lose their aesthetic attractions.
3. Occasional plantings of shade-tolerant trees and shrubs should help maintain the present level of vegetative screening around tent sites in the Adirondacks.
4. Levels of present use-intensity (about 400 camper-days per tent site per year) do not appear to be detrimental to the factors that contribute to the aesthetic qualities of the campgrounds studied.

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Northeastern Forest Experiment Station

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SOME CORRELATIONS BETWEEN SUGAR MAPLE TREE CHARACTERISTICS AND SAP AND SUGAR YIELDS

Abstract.—Simple correlation coefficients between various characteristics of sugar maple trees and sap sugar concentration, sap volume yield, and total sugar production are given for the 1968 sap season. Correlation coefficients in general indicated that individual tree characteristics that express tree and crown size are significantly related to sap volume yield and total sugar production. However, there was little evidence of a strong relationship between such tree characteristics and sap sugar concentration. Correlations presented were for one sap season only.

Sugarbush operators have always shown considerable interest in the relationships between sap yield and various characteristics of sugar maple trees. The sweetest sap, for instance, is thought by many to come from trees with wide, deep crowns characteristic of open-grown trees; and large trees in general are often thought to be particularly high sap volume yielders.

In the summer of 1968, researchers at the Sugar Maple Laboratory of the Northeastern Forest Experiment Station, in Burlington, Vermont, measured a number of characteristics of individual sugar maple trees, including diameter at breast height (d.b.h.), total height, average crown width, live crown length, crown ratio, and past growth (measured as the average width of the last 10 annual rings). Sap volume yields, sap sugar concentration, and total sugar yield had been measured for the same trees for the 1968 sap season. In all, 30 trees in each of 3 sugarbushes are reported on here.

There are differences in the stand characteristics of the three sugarbushes. Sugarbush 1 is a dense stand about 75 years old. It has an average d.b.h. of about 12 inches and an average height of 57 feet. Sugarbushes 2 and 3, on the other hand, are old-growth bushes that are over 150 years old. Sugarbush 2 has an average d.b.h. of 24 inches and an average height of 80 feet. Sugarbush 3 has an average d.b.h. of 22 inches and an average height of 66 feet.

In the process of analyzing the data, correlation coefficients were calculated for simple linear relationships among the variables measured. Some of the correlation coefficients are presented here for each sugarbush, to illustrate the magnitude of relationships often observed in the field.

The relationship between two measures of tree size—d.b.h. and total height—and the yields of individual trees were examined. The correlation coefficients are:

Tree size variable	*Yield Variable*	*Sugarbush number—* 1	2	3
D.b.h.	Sap sugar concentration	0.34NS	0.11NS	0.21NS
	Sap volume yield	0.62**	0.55**	0.60**
	Total sugar production	0.67**	0.51**	0.58**
Total height	Sap sugar concentration	0.11NS	—0.13NS	0.33NS
	Sap volume yield	0.70**	0.46**	0.36*
	Total sugar production	0.61**	0.38**	0.39*

NS = Non-significant.
* = Significant.
** = Highly significant.

Correlation coefficients between the two measures of tree size and sap sugar concentration are very low and non-significant. However, there is a significant relationship between the two factors and sap-volume yield and total sugar production in all three sugarbushes. For sap yield and total sugar production, then, the data support the often-heard statement that, in general, larger trees yield more sap. However, there is no evidence that sap sugar concentration is related to tree size as measured by d.b.h. and total height.

The most talked about relationships in connection with yields from sugar maple trees are those between measures of crown size and yield:

Crown size variable	Yield Variable	Sugarbush number— 1	2	3
Average crown width	Sap sugar concentration	0.36*	—0.24NS	0.32NS
	Sap volume yield	0.50**	0.61**	0.66**
	Total sugar production	0.59**	0.46**	0.68**
Live crown length..	Sap sugar concentration	0.08NS	0.20NS	0.30NS
	Sap volume yield	0.59**	0.64**	0.54**
	Total sugar production	0.55**	0.63**	0.55**
Live crown ratio...	Sap sugar concentration	0.03NS	0.39*	0.21NS
	Sap volume yield	0.30NS	0.46**	0.56**
	Total sugar production	0.30NS	0.51**	0.55**

There are relatively large and, in most cases, highly significant correlations between sap volume yield, total sugar production, and the three measures of crown size, the only exception being with live crown ratio on sugarbush 1. However, correlation coefficients between these measures of crown size and sap sugar concentration are surprisingly low considering the emphasis most people give to crown size as related to sap sweetness. These relationships were non-significant on all of the sugarbushes except number 1.

There has been some speculation among maple producers about the relationship between tree vigor and yields of sap and sugar. In our study we measured past tree growth (an average width of the last 10 annual rings), which could be considered an index of relative tree vigor. Correlation coefficients between this variable and the yield variables are:

Yield variable	Sugarbush number— 1	2	3
Sap sugar concentration	0.36*	0.05NS	0.16NS
Sap volume yield	0.40*	0.34NS	0.55**
Total sugar production	0.49**	0.32NS	0.48**

There is a highly significant relationship between past growth and sap volume yield in sugarbush 3 and between past growth and total sugar production on sugarbushes 1 and 3. Translated into coefficients of determination, about 30 percent of the variation in sap volume yield is associated with past growth on sugarbush 3, and about 23 percent of the variation in total sugar production is associated with past growth on sugarbushes 1 and 3. However, no consistent trend is apparent.

The correlation coefficients between sap volume yield and sap sweetness for the three sugarbushes were non-significant. It should be remembered however, that these correlations are for only one season. Marvin et al. *(1969)* found a significant correlation between the two variables over an 18-year period.

Correlation coefficients between sap volume yield and total sugar production (calculated from volume yield and sap sugar concentration) were 0.95**, 0.93** and 0.96** on the three sugarbushes respectively. The correlation coefficients between sap sugar concentration and total sugar production were 0.57**, 0.42* and 0.49**. Thus there is a stronger relationship between sap volume yield and total sugar production. With the use of labor-saving devices such as plastic tubing and vacuum systems, as well as the introduction of sophisticated processing techniques, the previous cost advantage of handling and processing sap with a higher than average sugar concentration may be unimportant. Of course, high sap sugar concentration combined with high sap volume yield will always be desirable.

The correlations presented in this paper indicate that individual tree characteristics that express tree and crown size, such as d.b.h., tree height, average crown width, live crown length and live crown ratio, are significantly related to sap volume yield. In general, we can say that big, large-crowned trees will yield more sap than small trees. However, contrary to popular belief in many quarters, there is little evidence of a strong relationship between these variables and sap sugar concentration. Obviously other variables that we did not measure are involved.

It should be mentioned again that the correlations presented in this paper are short-term correlations, for one season only. Correlations over many years may be quite different.

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Northeastern Forest Experiment Station

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A GUIDE FOR AUTHORS OF SYMPOSIUM PAPERS

Abstract.—Suggestions for preparing a symposium paper for publication, including length, general style, manuscript format, and details of handling tables, illustrations, footnotes, literature references, etc. Also suggestions for typing.

GENERAL

Presenting a paper at a symposium is really two jobs for the author: a talk to be given and a paper to be published. Often they are not the same.

First prepare the paper to be published, using as much detail as space allows and the reader needs. Use this as the basis for your talk.

But make your talk a *talk*. Don't hide behind a lectern and put your head down and *read* your paper. Reading makes dull listening. Stand up downstage, like an actor, and make your talk as much of a show as you can.

In your talk you will not need all the details you have in the paper. Hit the highlights. Brighten up your talk with color photo slides or other visuals. You can use many more visual aids in a talk than you can in a printed publication. In a talk you can use a breezier style. You can repeat to put a point across.

This guide has been prepared to help you in preparing the paper for publication. It will also make the job easier for the fellow who has to edit all the papers and put them together for publication.

Timing

Allow plenty of time for writing your paper and getting it reviewed and approved. Be wary about accepting a symposium assignment if the time allowed is too short. Submit your paper before the deadline begins to snap at your heels. Allow as much time as you can for review and editing.

(Note to the symposium committee: Be tough about deadlines. Enforce them. Don't make exceptions. If an author does not submit his paper in time, do not hesitate to cut him out of the proceedings. It isn't fair to the conscientious on-time authors to hold up the proceedings for a few laggards.)

Length

Keep your paper brief and to the point. About 3,000 words is a comfortable length for the reader. A longer paper may tax his attention span.

Also consider the cost. Publication costs about 6¢ a word; so don't be windy: make every word meaningful.

Count the number of words in the text part of your paper, and mark the word count on the title page. In counting words, count articles ("a", "an", "the"), numbers ("2", "10", "12,000"), and abbreviations ("d.b.h.", "p.p.m.") as one word each. Count each element of a compound expression as one word; for example, count "rate-of-value-increase concept" as five words.

Style

Get to the point as quickly as possible. In the first paragraph or two (about 100 words), tell the reader in a general way—no details at all—what the paper is all about, so he can decide at once whether he wants to read the rest.

The reader wants to know what's new about YOUR work. He wants to know what you did, why you did it, what you found out, and what it means. Don't drag in a lot of irrelevant detail about what others have done.

Don't drown the reader with details. Don't try to tell him everything you know: tell him only what he needs to know.

Write in simple, easy, natural English that can be understood by people not trained in your specialty. Avoid jargon. Avoid strings of long words. If you must use technical terms that your readers are not apt to know, define them.

Use active direct sentences. Use first person rather than third ("I" for a single author, "we" for multiple authors).

Where possible, use metric equivalents (meters, etc.) for items expressed in the English system of weights and measures.

Use fairly short paragraphs. Two or three sentences make a comfortable bite-size for the reader. The NATIONAL GEOGRAPHIC is a good model for paragraph length.

In details of style—capitalization, abbreviations, spelling, compounding, use of numbers and symbols, headings—be consistent throughout the manuscript. Consult a good general style manual. I recommend the STYLE MANUAL FOR BIOLOGICAL JOURNALS, published by the American Institute of Biological Sciences, 3900 Wisconsin Avenue, NW, Washington, D. C. 20016.

Design

Keep your paper fairly simple. A paper that is loaded with footnotes and literature references and complex tables and illustrations costs more to print, takes longer to edit and publish, and is harder to read. The finished paper should follow this general sequence:

1. Title page. This should contain the author's or agency's mailing address at top left, the date and word count at top right. Put the title of the paper in the upper center of the page; and below it put the author's name, title, affiliation, and location.
2. Text pages. Text only: do NOT insert footnotes or figure legends or other accessory parts in the text.
3. List of literature references (separate page).
4. List of figure captions (separate page).
5. List of footnotes, if any (separate page).
6. Tables, each on a separate page.
7. Any other accessory parts such as acknowledgments or credits.
8. Envelope containing illustrations, if any.

9. Abstract (separate page). An abstract, 50 to 100 words long, should accompany each paper. This abstract should tell in a general way what the paper is all about and the significance of it. Use only essential details.

Designing and packaging your paper this way will make the jobs of editing and printing easier and will speed publication.

DETAILS

Headings

A reasonably short paper (say 12 pages) should need only three or four simple subheads. If all subheads are of the same rank, use center heads, this way:

CENTER HEAD

If you need more than one rank of subheads, use side heads for the second rank, this way:

Side Head

Paragraph heads.--Paragraph heads can also be used. This is an example of the form for a paragraph head.

References

In general, do not overload your paper with references to what other people have done: this detracts from YOUR story. Use only essential references when you must discuss the work of others. *Do not cite unpublished works.*

You do not need to mention everything you have read on the subject. Your list of references shows that you know the literature. In fact, if you have five or more references on one point, you may assume that it is common knowledge and that no literature reference is needed.

Use the author-date method of citing literature references in the text. For example:

...and in Vermont, Blue (1963) found...

or

...some successes have been reported (Blum 1963).

List all references—even if you have only one or two—at the end of the text, in alphabetical order by authors, in this style:

```
Chapman, H. H.
  1922.  A NEW HYBRID PINE.
  J. Forest. 20: 729-734, illus.

Dorman,  Keith  W., and John C. Barber.
  1956.  TIME OF FLOWERING AND SEED
  RIPENING IN SOUTHERN PINES.
  U. S. Forest Serv. SE. Forest Exp.
  Sta. Pap. 72, 15 pp.
```

Note that the author's name is used exactly as it appeared on the publication, either spelled out or abbreviated.

Footnotes

Avoid footnotes altogether if you can. They increase the cost of publishing; they slow the reading. Whenever possible, if you have an afterthought that must be added, work it into the text rather than in a footnote. Don't use footnotes just to make a scholarly display of footnotes.

Tables

Tables should be used to supplement or support text material, or to show relationships that cannot be told easily in prose.

Use tables sparingly; they are expensive to print. Avoid large tables of raw data: use small summary tables instead.

Don't let tables get inextricably tangled up with the text, so that they dominate the text. The text by iself should tell the story. In the text, refer to tables only parenthetically, this way:

```
...mortality was greatest among the pines
   (table 3).
```

Number all tables consecutively, using arabic numbers. Keep your tables simple.

Illustrations

Photographs and drawings should help the reader visualize and understand the subject matter. Make sure each one is really needed.

If possible, provide 8 x 10 glossy prints of photographs. Identify each one by writing the author's name and the figure number lightly on the back with soft pencil (hard pencil or ballpoint might show through). Don't put paper clips, staples, or sticky tape on photos.

Sketches, graphs, and charts should be prepared with black India ink on heavy white paper. Glossy photo prints are satisfactory, but blueprints or photomachine copies are not because they will not reproduce well. Lettering and lines on drawings should be large enough so they will be legible after reduction. Clear capital letters, evenly spaced, are preferred for the lettering.

In the text, refer to each illustration only parenthetically, like this: (fig. 1). Like tables, illustrations should not be allowed to dominate the text.

Prepare an appropriate figure caption for each illustration. List these figure captions on a separate page. Do not put them on the photo or drawing.

TYPING THE MANUSCRIPT

Type the manuscript on fairly heavy white bond paper 8 x 10½ inches or 8½ x 11 inches, on one side only. Type everything double-spaced. Leave margins of at least 1 inch on all sides. Leave extra space around formulas, equations, and headings for editor's and printer's marks.

Don't break words or end a line with a hyphen. Don't spill paragraphs over from one page to the next.

Number each page consecutively at the upper right-hand corner, beginning with the title page. Precede the page number with the author's name. This is necessary to prevent manuscript mixups. Example:

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Schaeffer : 12
```

On the title page, put the number of words directly below the page number, this way:

```
Watson & Leonard : 1
         3,641 words
```

Submit the ribbon copy—never a carbon copy or photocopy—for the use of the editor and printer, and a carbon or photo copy to expedite review. Keep a carbon or photo copy for your files.

Make sure that the finished manuscript is carefully proofread for typographical errors, paying special attention to names of persons and places, technical terms, quotations, citations, formulas, and equations. Check all numerical data in text and tables and figures.

A few minor corrections can be written in by hand. But retype any page that needs lengthy corrections or insertions.

Never staple or bind the manuscript. Fasten it with paper clips or rubber bands.

Checking Copy

After the manuscript has been typed, check it carefully to make sure all facts, figures, dates, names, etc. are correct and consistent. This is the author's responsibility. This is the time to make changes or corrections. After the paper has been set into type, and you inspect galley proofs, changes are expensive and time-consuming.

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USDA FOREST SERVICE RESEARCH NOTE NE-145
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Northeastern Forest Experiment Station

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NUTRIENT PROPERTIES OF FIVE WEST VIRGINIA FOREST SOILS

Abstract.—Nutrient levels in five well-drained forest soils of the northern mountain section of West Virginia were generally associated with the type of parent rocks from which the soils had formed. But in some instances, different rock types yielded soils of similar nutrient composition. Soils formed from limestone and calcareous shale were usually higher in fertility than soils formed from acid sandstone, siltstone, or shale. However, considerable variation in nutrient levels occurred within as well as among most of the different soil series.

Most of the upland forest soils in the northern mountain section of West Virginia (fig. 1) have developed in residuum from several different geological rock formations. Consequently the chemical properties of these soils could be influenced considerably by the mineral content of the rocks from which they developed. To gain an understanding of these relationships, we compared soil nutrient levels within and between modal soil series derived from five geologically different parent materials important in this section of the State. Although several additional geologic formations also occur in this area, they are thin and inconsistent in occurrence and therefore were not considered in this study.

The soils selected for study were well drained, were derived from the most extensively occurring geologic formations in the area, and represented the soil series normally developing from each of the individual formations. These soils occur on about 60 percent of the study area. The parent rocks, each of sedimentary origin, belonged to either the Devonian, Mississippian, or Pennsylvanian systems. Collectively, they included: (1) acid red and gray sandstone, siltstone, and shale; (2) limestone; and (3) calcareous red and gray shales (table 1).

The geology of the area is such that the formations that were studied generally occurred in a definite topographic sequence between elevations of 1,500 and 3,500 feet. The Chemung formation, located at lowest elevations, is capped by the slightly higher Catskill formation. Next in elevation is the Greenbrier, then the Mauch Chunk; and the Pottsville formation occupies the highest topographic positions. Greater precipitation and cooler temperatures are associated with higher elevations.

Although fertility of agricultural soils in West Virginia is reasonably well documented *(1, 2, 3, 4, 9)*, there is only limited information about the virgin forest soils in this part of the State *(5, 6)*. In this study we learned that nutrient concentrations in five locally important forest soils were related in general to the type of rocks from which the soils had developed. It is possible, therefore, to roughly characterize soil-nutrient levels in the field by identifying the soil series and its underlying geologic formation. Such prediction may ultimately prove useful in evaluating and as-

Figure 1.—The location of the study area in West Virginia.

signing research treatments that might be influenced by varying levels of soil fertility.

Methods

A total of 75 soil samples were collected from five well-drained upland soil series in Tucker and Randolph Counties, West Virginia. Each soil was sampled at five independent locations that were well distributed over the two-county area. At each sampling location, three soil samples were randomly taken from a topographically uniform ¼-acre plot. Each sample was drawn from a thoroughly mixed volume of soil obtained from an 8-inch section of the profile located just beneath the A_1 horizon. All samples were analyzed separately in the laboratory.

Differences in soil fertility due to variation in local climate and to species composition were minimized by limiting sampling to southern exposures and to stands containing a high proportion of red oak (*Quercus rubra*, L.), chestnut oak (*Q. prinus* L.), or scarlet oak (*Q. coccinea* Muenchh.). However, other less important factors that also influence soil fertility, such as position on slope, slope gradient, land form, and elevation were allowed to vary among the different sampling sites.

Chemical analyses were made on the fraction of oven-dry soil smaller than 2 millimeters. Total nitrogen (N) was determined by the macro-Kjeldahl method; phosphorus (P) was determined colorimetrically after extraction with 0.002 *N* H_2SO_4; and exchangeable potassium (K), calcium (Ca), magnesium (Mg), and manganese (Mn) were measured by atomic absorption following extraction with NH_4OA_c.

Results and Discussion

A wide range in nutrient concentrations occurred within and between the different soil series (table 2). Except for N, where there were no clearly defined differences between the soils, the data suggest that levels of other nutrients are generally associated with the various types of rocks from which the soils formed. However, it cannot be stressed too strongly that variation in nutrient concentrations between different sites on the same soil series can be considerable. For the six elements examined in this study, N and K consistently had the smallest coefficients of variation within the five soils, whereas Ca had the largest (fig. 2).

Table 1.—*Characteristics of soils and their geologic parent materials*

Geologic system[1]	Geologic formation	Soil series	Parent material composition	Subsurface soil texture	Soil color
Devonian	Chemung	Gilpin	Acid, gray sandstone and shale	Silt loam	Yellowish-brown
Devonian	Catskill[2]	Calvin	Acid, red sandstone and shale	Silt loam	Reddish-brown
Mississippian	Greenbrier	Belmont	Calcareous shale, sandstone and limestone	Silty clay loam	Dark reddish-brown
Mississippian	Mauch Chunk	Teas	Slightly calcareous red shale, and sandstone	Silt loam	Reddish-brown
Pennsylvanian	Pottsville	Dekalb	Acid, gray sandstone and siltstone	Loam	Yellowish-brown

[1] Geologic classification according to Reger *(7, 8)*.
[2] Currently classified as Hampshire formation.

For the metallic elements, lowest nutrient levels were generally associated with the loamy Dekalb series of the Pottsville formation, whereas highest nutrient levels were usually associated with Belmont soils, which formed from limestone and calcareous shales. Although there is little information about critical soil nutrient concentrations for satisfactory growth of the various hardwoods, this study suggests that the Dekalb soils formed from Pottsville material are the most likely to be nutrient-deficient.

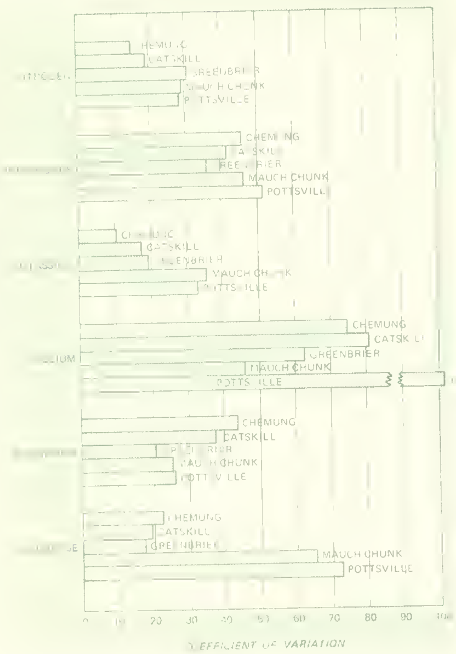
Gilpin and Calvin soils from the acid sandstones and shales of the Devonian system had similar nutrient levels except for P, which was significantly lower in the Gilpin series. K concentrations in these soils compared favorably with those of the Belmont series, but

Table 2.—*Average nutrient values and standard deviations of soils derived from different geological parent materials*[1]

Item	Parent Material				
TOTAL NITROGEN *(percent)*					
Formation	Chemung	Catskill	Mauch Chunk	Greenbrier	Pottsville
Soil	Gilpin	Calvin	Teas	Belmont	Dekalb
Mean	0.088	0.096	0.124	0.137	0.148
Standard deviation	0.013	0.018	0.036	0.043	0.043
PHOSPHORUS *(ppm.)*					
Formation	Chemung	Pottsville	Catskill	Mauch Chunk	Greenbrier
Soil	Gilpin	Dekalb	Calvin	Teas	Belmont
Mean	3.4	5.8	7.0	9.6	12.4
Standard deviation	1.6	3.0	2.9	4.4	4.5
POTASSIUM *(ppm.)*					
Formation	Pottsville	Mauch Chunk	Catskill	Greenbrier	Chemung
Soil	Dekalb	Teas	Calvin	Belmont	Gilpin
Mean	26	48	66	73	74
Standard deviation	9	17	12	14	8
CALCIUM *(ppm.)*					
Formation	Pottsville	Catskill	Chemung	Mauch Chunk	Greenbrier
Soil	Dekalb	Calvin	Gilpin	Teas	Belmont
Mean	10	42	50	218	356
Standard deviation	19	34	38	101	225
MAGNESIUM *(ppm.)*					
Formation	Pottsville	Mauch Chunk	Catskill	Chemung	Greenbrier
Soil	Dekalb	Teas	Calvin	Gilpin	Belmont
Mean	4	14	26	30	45
Standard deviation	1	4	10	13	9
MANGANESE *(ppm.)*					
Formation	Pottsville	Catskill	Chemung	Greenbrier	Mauch Chunk
Soil	Dekalb	Calvin	Gilpin	Belmont	Teas
Mean	19	37	39	51	79
Standard deviation	14	7	9	9	52

[1] Mean values are the average of 15 observations. Means not underscored by the same line are significantly different [Hartley test, 5-percent level (*10*, p. 253)]. Standard deviations calculated from means of the three samples obtained at each sampling location.

Figure 2.—Relative dispersion of nutrients in soil developed from different parent materials.



Ca and Mg levels were significantly lower than those associated with the fertile Belmonts.

Teas soils had significantly lower K concentrations than Gilpin, Calvin, or Belmont; but these levels were significantly higher than in the infertile Dekalb. P and Ca concentrations in Teas soils were comparable to those in the Belmont series, but Mg levels were significantly lower than in the Gilpin, Calvin, or Belmont series. Rather high Mn levels were also associated with Teas soils, but these levels were not statistically higher than concentrations in either the Gilpin, Calvin, or Belmont series.

Total N is not synonymous with available N, but has been used extensively as an indicator, along with other soil characteristics, of a soil's ability to provide N for plant growth.

Unlike the other nutrients, N was not significantly affected by soil series or parent materials, but indicated a strong positive trend with increasing elevation. Samples from high elevations consistently had higher total N values than samples from lower elevations. This trend may be the result of slower decomposition rates of organic matter caused by higher precipitation and cooler temperatures associated with rises in topography.

Significant differences in nutrient levels between these soils indicate the importance of parent material for delineating soil series in this vicinity. However, because these observations apply only to southern exposures and to soils supporting stands predominately of oak they should not, without confirming study, be used to estimate fertility levels on other exposures or for areas with different species compositions.

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ELIMINATION OF SCATTERED RESIDUAL SAPLINGS LEFT AFTER CLEARCUT HARVESTING OF APPALACHIAN HARDWOODS

Abstract.—Basal-spraying and power-saw felling were compared as methods for eliminating the 1- to 5-inch d.b.h. understory stems left after clearcutting. Felling leaves the area more esthetically acceptable, and costs are lower.

When mature Appalachian hardwoods are clearcut down to a 5-inch diameter (d.b.h.)—minimum for pulpwood-size stems—a number of living 1- to 5-inch stems are left standing. These stems are almost always too few, and many of them of too poor quality, to form a satisfactory new stand. And, scattered and exposed as they are, they are potential wolf trees with the inherent capacity to interfere with the development of the new reproduction. Whether to eliminate them—and if they are to be eliminated, how and when?—are questions of immediate concern to foresters.

Under the assumption that eliminating these small stems is worthwhile—and research has not as yet established under what conditions it is economically justified—we studied methodology and timing, based on operations in West Virginia. Two methods of elimination were compared: basal spraying and cutting with power saws. Timing and costs of these operations are discussed. We recognize that labor costs will vary from those shown here by time and location, but the user of this information can apply his own per-hour labor rates.

Study Results

Number of stems.—Tallies made on a number of 5- to 80-acre compartments in the Fernow Experimental Forest, near Parsons, West Virginia, showed that the number of 1-to 5-inch stems per acre in sawlog stands varies greatly, ranging from as few as 150 to over 700. More commonly, the numbers range between 300 and 600, and generally about half of them are in the 1- to 2-inch d.b.h. class.

When the stands are clearcut down to 5 inches d.b.h., about two-thirds of these small stems are broken off or knocked down in logging.

Basal-spraying understory stems.—We tested basal spraying of small stems on three clearcut areas totaling 98 acres (table 1). We used 2,4,5-T in fuel oil at a concentration of 14 pounds ahg., applied with a 2½-gallon hand-pump sprayer. Treatment costs, including labor and cost of materials, ranged from 2.3¢ to 3.4¢ per stem and from $6.05 to $9.59 per acre. With the data available, it was not possible to determine if time of treatment (before

Table 1.—Costs of basal spraying

Area No.	Acreage	Timing of operation	Size of stem treated	Stems treated /acre	Stems treated /hour	Man-hours /acre	Labor cost /acre at $2/hour	Spray cost /acre at $0.01/stem	Total costs Per acre	Total costs Per stem
	Acres		*Inches*	*No.*	*No.*	*Man-hours*	*$*	*$*	*$*	*$*
C. 38	13	After logging	1-5	265	152	1.70	3.40	2.65	6.05	0.023
C. 36	12	After logging	1-5	279	82	3.40	6.80	2.79	9.59	.034
WS #3	73	Before logging	2-5	212	90	2.40	4.80	2.12	6.92	.033

Table 2.—Costs of felling

Area No.	Acreage	Timing of operation	Size of stems treated	Stems treated /acre	Stems treated /hour	Man-hours /acre	Labor costs /acre at $2/hour	Cost of power saw /acre at $0.25/hr.	Total cost Per acre	Total cost Per stem
	Acres		*Inches*	*No.*	*No.*	*Man-hours*	*$*	*$*	*$*	*$*
C. 17B	2.0	Before logging	1-5	592	237	2.50	5.00	0.625	5.62	0.010
C. - Tier 3	2.0	Before logging	1-5	722	321	2.25	4.50	.562	5.06	.007
Cold Spring sale	4.0	After logging	1-5	107	122	.88	1.76	.220	1.98	.019

or after logging) affected costs. Spray materials cost about 1¢ per stem (with very little variation between areas), and labor costs were computed at $2 per hour. Only on-the-ground costs were considered; car travel and overhead costs were not included.

Mortality of treated stems varied. Based on previous mortality studies for this kind of treatment, we can expect a kill of 80 to 90 percent of treated stems.

Felling with power saw.—We tested power-saw cutting to eliminate the small stems on three areas totaling 8 acres (table 2). We used a small McCulloch saw with a 1-quart fuel tank (Mac 10-10 Automatic) and cut the stems about 6 inches above the ground.

On two of these areas, the stems were cut before logging (fig. 1); on one, they were cut

Figure 1.—Stems cut before logging. Left on the ground, they interfere with the logging operation.

a few months after clearcutting. Where the cutting was done before logging, costs per acre were $5.62 and $5.06; costs per stem were 1¢ and 0.7¢. On the area where cutting was done after logging, the job cost $1.98 per acre and 1.9¢ per stem. After-logging treatment was cheaper per acre because there were fewer stems per acre to treat, but it was more costly per stem because of more walking time between the wider-spaced stems.

Labor cost was computed at $2 per hour and power-saw costs at 25¢ per hour (maintenance, depreciation and fuel). As with the basal-spraying tests, only on-the-ground costs were considered.

Discussion and Recommendations

There are situations where the forester may wish to leave the 1- to 5-inch stems as a source of the next stand. These would be where the number of stems and the species composition are such that they promise a desirable potential new stand. Although such situations are probably rare, they should be recognized. For example, in northern hardwoods, where sugar maple is a desirable new crop, there may be enough 1- to 5-inch stems of this species to form the nucleus of a new forest.

Use of power saws to eliminate the small stems was considerably cheaper than basal spraying. Some of this difference may be due to the fact that the sample areas where power-saw cutting was used were easier to work in than areas where basal spraying was used. Moreover, the felling areas were smaller, necessitating less prolonged and tiring labor. In spite of this, indications are that cutting was actually cheaper. Moreover, use of power saws was 100 percent effective, and the best that can be hoped for in basal spraying is 80 to 90 percent effectiveness.

Cutting has another advantage over basal spraying. Since the stems are dropped on the ground in cutting, the looks of the area are improved tremendously; and this is a big consideration in pleasing an esthetically-minded public (figs. 2 and 3).

The best time to cut these stems is during the first year after logging. After that, the brush grows up so fast that the difficulty and hazard of carrying out this operation are both

Figure 2.—The 1- to 5-inch stems were cut a few months after logging. Laid on the ground, they present little adverse visual impact.

Figure 3.—Treated with a basal spray, unsightly dead stems like these remain standing for several years.

drastically increased. Although cutting is easier before logging, so many more stems must be cut per acre that per-acre costs are higher than for cutting after logging. In addition, if the stems are cut before logging, the costs of logging are probably increased because of the difficulty of working in the debris on the ground (fig. 1).

Many foresters think that 1- to 2-inch stems do not need to be eliminated. If decision is made to cut only the 2- to 5-inch stems (and leave the 1- to 2-inch stems standing), then on the average only about half as many per acre will require treatment.

In summation, we recommend that, where a decision has been made to eliminate the small stems, a power saw be used to do the job; that the operation be timed to follow logging as soon as possible; and that every effort be made to complete it before the second growing season. By all means, the job should be done before the third growing season.

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SPROUTING OF THINNED HYBRID POPLARS ON BITUMINOUS STRIP-MINE SPOILS IN PENNSYLVANIA

Abstract.—Various thinning techniques were applied to 5-year old hybrid poplar stands on bituminous strip-mine spoils. Basal and stump sprays of 2, 4, 5-T in diesel oil were effective for killing the trees. There was no evidence that chemical treatments affected adjacent trees. Where trees were cut and stumps were not chemically treated, all clones sprouted prolifically. Dominance in sprout clumps was asserted soon after thinning. Sprouting vigor was affected more by site quality than clonal parentage. Results indicate that hybrid poplar can be successfully regenerated under coppice management or can be easily removed for stand conversion.

Reclamation practices on strip-mine spoils have centered mainly about establishing a vegetative cover. We have now arrived at the point where it is necessary to consider management of the plantations that have been established.

This is especially true of the hybrid poplar plantings made on the more productive sites. In caring for these plantations, the land manager must decide what the objectives of management are to be. If successive crops of poplars are desired, then coppice management might be practical. If it is desirable to manage for sawlog-size hybrid poplars or to remove the poplars to favor some other tree species on the site, then a thinning or cleaning operation should be considered.

This note deals with the results of an experiment on two aspects of management—thinning techniques and coppice regeneration.

Only a few deciduous tree species have been found that will withstand the rigors of establishment on strip-mine spoil. This meager list is depleted even further by regional variation in spoil types and variation among spoils within a region.

Some hybrid poplar clones have shown promise on bituminous strip-mine spoils in Pennsylvania. The 10-year performance of one hybrid poplar clone reported by Hart and Byrnes *(1960)* prompted further testing of hybrid poplars for strip-mine reforestation. Screening tests of 60 hybrid poplar clones were started in 1961. In 1964 a report summarizing 2-year results of these tests was published *(Davis 1964)*. It indicated that early results were encouraging and that some of the clones showed promise for revegetating all but the most acid spoil banks.

The Experiment

The experimental plots were established in 1961 at six different field locations. At each location, plots were placed on graded and ungraded surfaces of both upper and lower portions of the spoil banks. The plots were replicated three times—a total of 12 plots on each bank. Sixty different clones were used, but not all clones were represented in each plot. The plots were six rows wide and varied in length according to the number of clones in the plot. Spacing within the plots was 6 x 6 feet, and two cuttings from each clone were planted in adjacent positions.

Soon after test plantings were established, it became obvious that some of the plots would have to be thinned. Rapid development of the hybrids indicated that competition would be detrimental to maximum growth. The objective of thinning was to have a final spacing of approximately 6 x 12 feet or 72 square feet of growing space per tree. Selection of trees to be removed was based on spacing and 5-year survival in each plot.

On two very acid sites (average pH 3.1 and 3.3) survival was so poor that thinning was not required. These sites were on spoils derived from mining the Kittanning coal seams. Two other plots on Clarion coal seam spoils were less acid (average pH 3.6 and 3.7) and had better survival. Thinning was light and was restricted to removing one ramet from a clone where both had survived if the average spacing indicated that thinning was required.

The last two sites were Freeport coal seam spoils (average pH 4.9 and 5.7). Survival on these sites approached 100 percent. The thinning removed one ramet from each clone. This left one ramet of each clone in each plot.

On the two areas having moderate survival, all the thinning was done by cutting the trees.

Three methods of thinning were used on the two areas having the best survival. The first was to cut the trees. The second was to cut the trees and spray the stumps with a mixture of 2,4,5-T in diesel oil. The third was to apply a basal spray of the same 2,4,5-T and diesel oil mixture to the standing trees. In the entire experiment, 256 trees were cut, 176 trees were cut and stump-sprayed, and 108 trees were basal-sprayed.

Data Collection

Two years after thinning, the study plots were examined and data were collected for evaluating the sprouting capacity of the hybrids and the effectiveness of the thinning methods. The following information was recorded for each treated tree: (1) total number of sprouts; (2) height of dominant sprout; (3) d.b.h. of dominant sprout; (4) form of dominant sprout; (5) number of stump sprouts strong enough to attain tree size; (6) number of root suckers; and (7) effectiveness of kill.

Number, height, and diameter of sprouts were measured directly. Form of dominant sprout was coded: 1 = straight; 2 = slight sweep; and 3 = severe sweep or crook. The number of stump sprouts strong enough to attain tree size was predetermined to include the dominant sprout plus all aggressive sprouts at least ¾ the height of the dominant.

All the aforementioned measurements and evaluations were made primarily for determining sprouting capacity of stems thinned by cutting. *No kill* was used to indicate stems that showed no effects of the treatment applied. *Partial kill* was used to indicate an injured main stem or a dead main stem with stump sprouts. *Complete* kill was recorded if the main stem was dead and no stump sprouts were present.

In many instances root suckers were present. The presence or absence of root suckers was not used as a criterion to determine effectiveness of kill because it was not always possible to ascertain the origin of the sprout.

Thinning Techniques

Chemical treatments. — Both treatments gave high percentages of complete kill. Cutting and stump-spraying resulted in a complete kill on 174 of the 176 treated stems (98.9 percent). In the basal spray treatment, 96 of the 108 treated stems (88.9 percent) were killed. In both treatments 14 stems were tallied as either *partial* or *no kill*. These were probably the result of insufficient chemical or misses in application of chemical at the time of treatment. Bridging was noted on some trees, and on others no effect of chemical treatment could be seen.

Root-suckering appeared to be more prevalent in the cutting and stump-spray treatment. Root suckers appeared to be associated with 68 percent of the 174 killed stumps. In contrast, only 40 percent of the 96 dead basal-sprayed trees appeared to have root suckers. It may be too soon to evaluate the root suckers because chemicals used in the thinning procedure may still have some effect on the vitality of the root suckers. There was no evidence that either of the chemical treatments affected adjacent trees.

Cutting.—526 trees on four different areas were treated by cutting the stems. Of these, 517 (98.3 percent) sprouted. One of the other 9 stumps had a single root sucker associated with it. All others showed no sign of life whatever.

Conclusions.—Hybrid poplars can be thinned effectively during the dormant season by using herbicides and standard thinning techniques. Our data show that over 95 percent of the stems basal-treated with herbicide or cut and stump-treated were killed. Cutting the stems, without herbicide application, was not an effective thinning technique. Less than 2 percent of the stumps were completely killed. Prolific sprouting followed this treatment.

If thinning is the management objective, and herbicides are not used, then better results could be obtained by doing the work during the summer. Although this experiment was conducted during the dormant season, past research has shown that sprouting is less vigorous from stems cut during the active growing season *(Ford and Snow 1954)*. Winter-cut stumps produce more sprouts per stump, and nearly all the stumps produce sprouts, while fewer than 60 percent of the summer-cut stumps produce sprouts.

Sprouting Capacity

Data on the sprouting capacity of the various clones does not lend itself to rigorous statistical analyses. However, by combining some statistical analyses with apparent trends in the data, conclusions can be drawn that provide the basis for both future experimental plantings and larger-scale field trials.

A vigor rating was assigned to each sprout clump to prepare the field data for analysis. These ratings were based on an evaluation of the measurements of height of dominant sprout, form of dominant sprout, and number

Table 1.—*Clones used in the study and analysis of vigor ratings, by parentage groups*

Clone number[1]	Parentage	Site[2]			
		C11	C12	LF	UF
NE-32 (A)	*P.* cv. Angulata X *P.* cv. Berolinensis	—	—	—	—
NE-245, -246, -247, -258 (B)	*P.* cv. Angulata X *P. deltoides*	—	—	x	x
NE-35 (C)	*P.* cv. Angulata X *P.* cv. Plantierensis	—	—	—	—
NE-249, -251, -252, -253, -254, -374 (D)	*P.* cv. Angulata X *P. trichocarpa*	x	x	x	x
NE-12, -302 (E)	*P.* cv. Betulifolia X *P. trichocarpa*	—	—	x	x
NE-327 (F)	*P.* cv. Candicans X *P.* cv. Berolinensis	x	—	—	x
NE-17, -313, -314 (G)	*P.* cv. Charkoviensis X *P.* cv. Caudina	x	—	x	x
NE-28, -29 (H)	*P.* cv. Charkoviensis X *P. trichocarpa*	—	—	x	x
NE-221, -223, -224, -228, -353, -359 (I)	*P. deltoides* X *P.* cv. Caudina	x	—	x	x
NE-241, -242 (J)	*P. deltoides* X *P.* cv. Plantierensis	—	—	x	x
NE-206, -207, -208, -211, -213, -214 -215, -216, -346, -350 (K)	*P. deltoides* X *P. trichocarpa*	x	x	x	x
NE-43, -44, -47, -48, -49, -50 (L)	*P. maximowiczii* X *P.* cv. Berolinensis	x	x	x	x
NE-53 (M)	*P. maximowiczii* X *P.* cv. Caudina	—	—	x	—
NE-52 (N)	*P. maximowiczii* X *P.* cv. Plantierensis	x	—	—	—
NE-41, -42, -388 (O)	*P. maximowiczii* X *P. trichocarpa*	x	—	x	x
NE-277 (P)	*P. nigra* X *P.* cv. Italica	—	—	—	—
NE-4, -5, -8, -279 (Q)	*P. nigra* X *P. laurifolia*	x	—	x	x
NE-11 (R)	*P. nigra* X *P. trichocarpa*	—	—	—	x
NE-40 (S)	*P.* cv. Petrovskiana X *P.* cv. Caudina	x	—	x	—
X (parentage uncertain) (X)	Either *P. maximowiczii* X *P. trichocarpa* or *P. maximowiczii* X *P.* cv. Berolinensis	x	—	—	—
	PLANTED AS 1-YEAR CUTTINGS				
M-86 or NY-3139 (86)	Populus robusta (robusta poplar)	x	—	—	—
M-87 or NY-3140 (87)	Populus species (Siouxland poplar)	x	—	—	—
M-88 or NY-3141 (88)	Populus species (Norway poplar)	x	—	—	—
NY-2555 (2555)	Populus canescens (Curly poplar)	—	—	—	—

[1]NE = Northeastern Forest Experiment Station; M = Michigan; NY = New York; Letter or number in parentheses refers to clone group designation as used in anaylsis.

[2]Site designations: C11 = Clarion, Clarion Co.; C12 = Clarion, Clearfield Co.; LF = Lower Freeport; UF = Upper Feeport. x indicates clone groups used in vigor analysis.

of sprouts strong enough to attain tree size. These broad ratings were assigned values of 1 for high vigor; 2 for moderate vigor; 3 for low vigor; and 4 for poor vigor. After the vigor ratings were assigned, the data were grouped for each planting site by clonal parentage. That is, all clones from parents of the same species or varieties were grouped together (table 1).

A contingency table was set up for each site for analyzing the vigor ratings. This type of analysis compares homogeneity within a group of data to homogeneity among all groups of data in the contingency table, using an approximation of the chi-square distribution. Only clonal groups represented by four or more sprout clumps were used in the analysis. A smaller number of representatives would have weakened the analysis. On the basis of this limitation, 13 groups each from the Upper and Lower Freeport sites, 14 groups from the Clarion (Clarion County) site, and 3 groups from the Clarion (Clearfield County) site were used in the analysis (table 2.).

The computed chi-square values were significant at the 5-percent level for the Lower Freeport site and at the 10-percent level for the Upper Freeport site. Chi-square for the Clarion (Clarion County) site was nearly significant at the 10-percent level and not significant for the Clarion (Clearfield County) site (table 3.). These low values of significance suggest that homogeneity within clone groups is nearly the same as homogeneity among groups.

This lack of homogeneity may be due to site characteristics rather than to clonal variation. This is illustrated by the fact that 46 percent of the sprout clumps on the Upper Freeport site were rated vigor class 1 or 2. On the Lower Freeport site 37 percent were 1 or 2; and on the Clarion (Clearfield County) and Clarion (Clarion County) sites 33 and 30 percent were rated 1 or 2. Unfortunately, the available data are not suitable for statistical analysis of site versus clonal variation.

Evaluation of the other measured variables also indicates that site plays an important role in the sprouting characteristics of the hybrid poplars. This is most evident in the height of the dominant sprouts. The average heights of the dominant sprouts on the four areas were 6.1 feet on the Clarion (Clearfield County) site, 7.0 feet on the Clarion (Clarion

Table 2.—Distribution of sprout clumps in each vigor class, by planting site and clone grouping

Clone group	Vigor class				Total
	I	II	III	IV	
LOWER FREEPORT SITE					
B	2	2	4	1	9
D	2	5	7	7	21
E	0	3	2	1	6
G	0	7	2	1	10
H	1	2	1	4	8
I	3	4	4	5	16
J	0	0	1	4	5
K	6	8	12	6	32
L	0	1	11	2	14
M	0	0	0	4	4
O	1	1	3	3	8
Q	3	6	5	1	15
S	1	1	1	1	4
Total	19	40	53	40	152
UPPER FREEPORT SITE					
B	0	1	3	2	6
D	1	7	9	4	21
E	0	1	4	1	6
F	1	2	1	0	4
G	1	2	4	1	8
H	0	2	3	1	6
I	2	7	2	5	16
J	0	0	6	0	6
K	5	14	7	3	29
L	0	5	10	4	19
O	4	3	3	0	10
Q	2	8	6	1	17
R	2	1	1	0	4
Total	18	53	59	22	152
CLARION (CLARION CO.) SITE					
D	4	6	4	5	19
F	0	1	1	2	4
G	0	1	2	1	4
I	0	0	3	1	4
K	4	4	11	5	24
L	0	2	6	13	21
N	0	1	3	1	5
O	1	3	9	2	15
Q	0	5	2	1	8
X	0	1	2	2	5
S	0	0	2	3	5
86	0	2	2	1	5
87	1	0	2	1	4
88	0	4	3	0	7
Total	10	30	52	38	130
CLARION (CLEARFIELD CO.) SITE					
D	0	1	3	2	6
K	1	1	4	3	9
L	0	1	3	2	6
Total	1	3	10	7	21

County) site, 7.3 feet on the Lower Freeport site, and 10.8 feet on the Upper Freeport site.

Average numbers of sprouts per clump increased as the height of the dominants increased. However, the average number of aggressive sprouts per clump was fairly constant; and the median number of aggressive sprouts per clump was the same for all sites. Table 4 lists these sprouting characteristics.

Conclusions

This study has shown that 5-year-old hybrid poplars will sprout prolifically when thinned by cutting during the dormant season. Analysis of sprouting vigor indicated that homogeneity among clonal groups was nearly the same as homogeneity between groups. However, there appeared to be a decrease in

Table 3.—*Chi-square values obtained from contingency tables of vigor ratings*

Planting site	Number of clone groups	df	x^2	Values of x^2 at 0.10 probability level
Clarion (Clarion Co.)	14	39	50.5	50.6
Clarion (Clearfield Co.)	3	6	1.5	10.6
Lower Freeport	13	36	[1]57.1	47.2
Upper Freeport	13	36	[2]49.8	47.2

[1]Significant at the 5-percent level.
[2]Significant at the 10-percent level.

Table 4.—*Sprouting characteristics of hybrid poplars on bituminous strip-mine spoils*

Planting site	Number of observations	Average	Range	Median
NUMBER OF SPROUTS PER CLUMP				
Clarion (Clarion Co.)	141	9.1	2-21	9
Clarion (Clearfield Co.)	33	9.3	3-25	8
Lower Freeport	175	11.1	1-32	11
Upper Freeport	177	13.7	1-35	13
NUMBER OF AGGRESSIVE SPROUTS PER CLUMP				
Clarion (Clarion Co.)	141	2.7	1-8	2
Clarion (Clearfield Co.)	33	3.2	1-10	2
Lower Freeport	175	2.3	1-7	2
Upper Freeport	177	2.4	1-7	2
HEIGHT OF DOMINANT SPROUT IN FEET				
Clarion (Clarion Co.)	141	7.0	0.9-13.6	7.4
Clarion (Clearfield Co.)	33	6.1	1.4-14.3	6.1
Lower Freeport	175	7.3	1.5-18.5	7.3
Upper Freeport	177	10.8	2.3-19.5	10.8

homogeneity between groups as site quality increased.

Although there was a great deal of variation in numbers of sprouts per clump, the number of aggressive sprouts per clump was relatively small and consistent, even between sites. The number of sprouts should not cause concern. Dominance seems to be asserted fairly soon, and reduction in growth rate due to competition from other sprouts in a clump seems to be minimal.

Thus, in managing hybrid poplars for successive crops on spoil banks, the best clones for the site can be selected with some assurance that they can be regenerated by the coppice method.

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THE EFFECT OF THE TARIFF ON THE MAPLE INDUSTRY

Abstract.—The U. S. maple tariff is a tax on maple syrup and sugar imports from Canada into the United States. An analysis of the maple tariff indicates that it was never very effective in protecting the domestic maple industry from foreign competition. The tariff has been especially ineffective since World War II. Its removal will not hurt the U. S. maple syrup industry.

A tariff is a tax on imported goods, levied by a national government and payable when the goods cross the nation's boundary. The U. S. maple tariff, levied in 1909, is paid on pure maple products imported from Canada into the United States. As a result of the Kennedy Rounds of tariff negotiations under the General Agreement on Tariffs and Trade (GATT) in 1964, the maple tariff (table 1) was abolished on 1 January 1972.

At the turn of the century, the tariff was an important means to achieve national and international policy goals. However, since the years of the Great Depression, and more noticeably since World War II, reliance on the tariff has steadily decreased. The demise of the tariff can be attributed to two major factors.

Table 1.—*The tariff on maple syrup and sugar imports from Canada*

Maple syrup		Maple sugar	
Year	Cents/pound	Year	Cents/pound
1925-1943	4.0	1925-1930	4.0
1944-1947	2.0	1931-1935	6.0
1948-1967	1.5	1936-1944	4.0
1968	1.2	1945-1947	3.0
1969	.9	1948-1967	2.0
1970	.6	1968	1.6
1971	.3	1969	1.2
—	—	1970	.8
—	—	1971	.4

First, imposition of a tariff yields a mixed bag of effects. If, for example, a tariff is imposed for the purpose of protecting a home industry from foreign competition, other results are automatically triggered. The ultimate result of the tariff may generally be more detrimental than the specific advantage gained in protecting the home industry.

More direct policy tools have evolved, which can be used to reach policy goals more fairly and without the inevitable side-effects of the tariff. Some of these tools are direct subsidies, taxes, transfers, and monetary and fiscal policies.

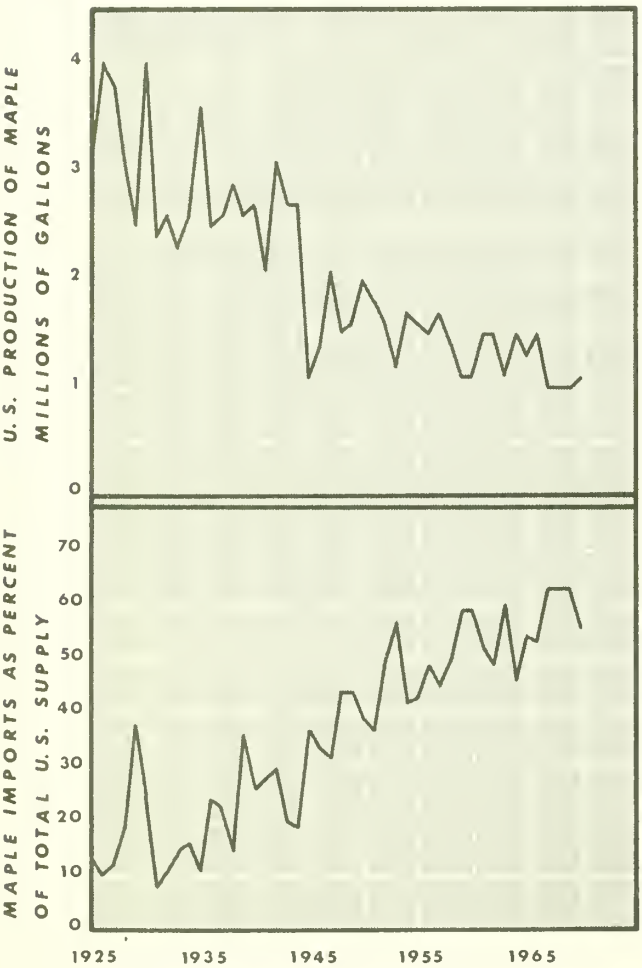
The second major factor concerns the rise in importance of capital to the American economy. Industries relying heavily on capital goods have gained prominence over industries still heavily dependent on labor and land. Capital has become an abundant resource relative to labor and land. Capital-intensive industries benefit from low tariffs on a worldwide basis because they can import raw materials at lower costs and can export finished goods to larger foreign markets. The United States has taken the lead in tariff reduction, and has generally encouraged world-wide tariff reduction.

Trends in Maple Production and Imports

Maple production in the United States has declined steadily since the peak production of 6.6 million gallons in 1860. Maple production since 1960 has averaged almost 1.3 million gallons per year compared to almost 2 million gallons per year since 1925 (fig. 1).

Maple imports from Canada have been recorded since 1916. Canadian maple has been a significant part of the total U. S. supply of maple products since 1925, when Canadian maple imports into the United States were 13 percent of the total U. S. supply. Today, Canadian maple imports account for over 56 percent of the total U. S. supply (fig. 1).

Figure 1.—Trends in maple production and imports in the United States from 1925 to 1970.



Imports Compete in the Bulk Market

Pure maple syrup is marketed in three ways: retail in consumer packages, wholesale in consumer packages, and wholesale in bulk to manufacturers *(Pasto and Taylor 1968)*. Most of the low-grade or commercial-grade syrup and surplus high- or table-grade syrup is sold in the bulk syrup market. Most of the table-grade syrup is sold in smaller packages to consumers.

It is believed that imported maple syrup competes mainly with drum or bulk syrup, most of which is blended with cane syrup to make the common maple-flavored table syrups. However, what happens to the imported bulk syrup is unknown, because information about grade and distribution of Canadian syrup in the United States has never been compiled. Although most imported Canadian maple is used in commercial processes, it is likely that some of it is packaged in consumer containers for competition with domestic syrup in the United States.

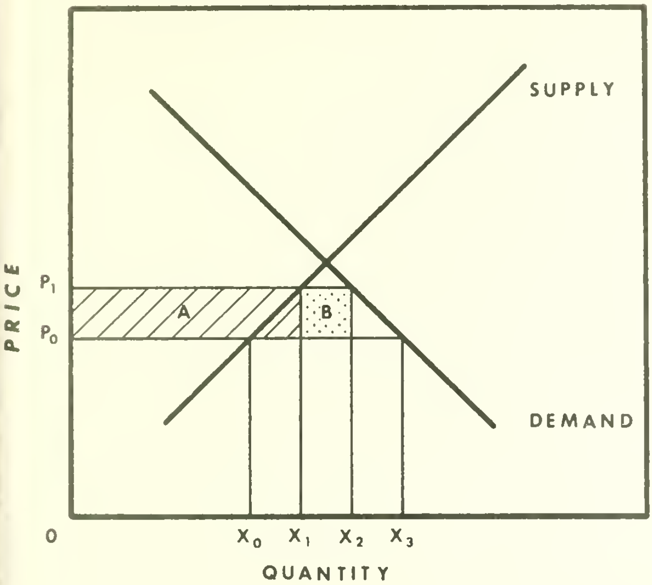
How the Tariff Worked

A tariff is probably best known for its protective effect. It is the most desired effect from a single industry perspective. But the protective effect is not independent of the other tariff effects, nor does it protect anything but the home industry manufacturing the product.

The total quantity of a product offered for sale in a home market is divided between the quantity supplied by domestic producers and the quantity supplied by foreign imports. If a tariff is levied on imports, and it is assumed that all other factors remain unchanged, the effects of the tariff can best be illustrated by partial equilibrium analysis. Figure 2 is an abstraction of this market *(Kindleberger 1968)*.

In the absence of a tariff, the market price is P_0, and the quantity on the market is the line segment $O - X_3$, made up of $O - X_0$, offered by domestic producers, and $X_0 - X_3$,

Figure 2.—The effects of a tariff. (A) redistribution effect; (B) revenue effect. $X_2-X_3=$ consumption effect; $X_0-X_1=$ protective effect.



offered by foreign producers. The line segment P_1-P_0 represents the tariff on imports.

The protective effect of the tariff is the increase in domestic production represented by the line segment X_0-X_1 at the new market price P_1. However, because of the higher price, total consumption of the product will decrease by X_2-X_3. This is the consumption effect.

Area A in figure 2 is the redistribution effect. This is the income directed away from consumers in favor of domestic producers, and it represents additional profits for domestic producers. Area B represents the revenue effect or the amount of money paid to the government on imports of the product.

The remaining effects have to do with the tariff as national policy. In brief, the tariff has an effect on the price the home country pays for its imports, the balance of trade, and total domestic employment. Any advantages gained in these three areas through tariff manipulation can be reduced or reversed if foreign countries are provoked into retaliatory tariff changes.

In summary, an industry supports a tariff for its protective effect. The home industry realizes a greater share of the market at a higher product price. However, the burden of protection is borne by the home consumer because of higher prices and reduced consumption.

Evaluating the Effect of the Tariff

Did the maple tariff ever work very well? A deductive approach can give some insight into the value of the maple tariff. Figure 3 represents supply curves for two different commodities: (A) an elastic supply curve and (B) an inelastic supply curve. Elasticity here refers to responsiveness of change in quantity supplied to changes in price. An elastic supply curve means that the change in quantity supplied is greater than the change in price. An inelastic supply curve means that the change in quantity supplied is smaller than the change in price.

Maple supply is tied to sap production. Sap production is roughly fixed each year by the number of trees tapped and the weather. Good weather sets supply at a high level: bad weather sets supply at a low level.

Once the short sap-gathering season is over, the maple supply is fixed for the year. The quantity of maple available cannot be increased no matter what the market price may be. If maple syrup is in short supply, thus increasing price, Canadian sellers might be encouraged to sell a little more in the domestic market.

P_0-P_1 represents the amount of the tariff in both graphs in figure 3; and X_1-X_2 is the protective effect or increase in home production. The more elastic the supply, the greater the protective effect or increase in home production. The more elastic the supply, the greater the protective effect with the same level of tariff.

Because the maple supply curve is inelastic (fig. 3, B), the potential protective effect of the maple tariff is small. It can be concluded that the maple tariff never had the potential to really work very well.

Apparent Effect of the Maple Tariff

The actual burden of the maple tariff is reflected in the tax expressed as a percentage of the value of the product (fig. 4). From 1925 to 1945 the tariff averaged 33 percent of the value of maple products. From 1946 to 1970 the tariff averaged less than 5½ percent

Figure 3.—The relationship of elasticity of supply to the size of the protective effect of the tariff. Maple supply is inelastic (B).

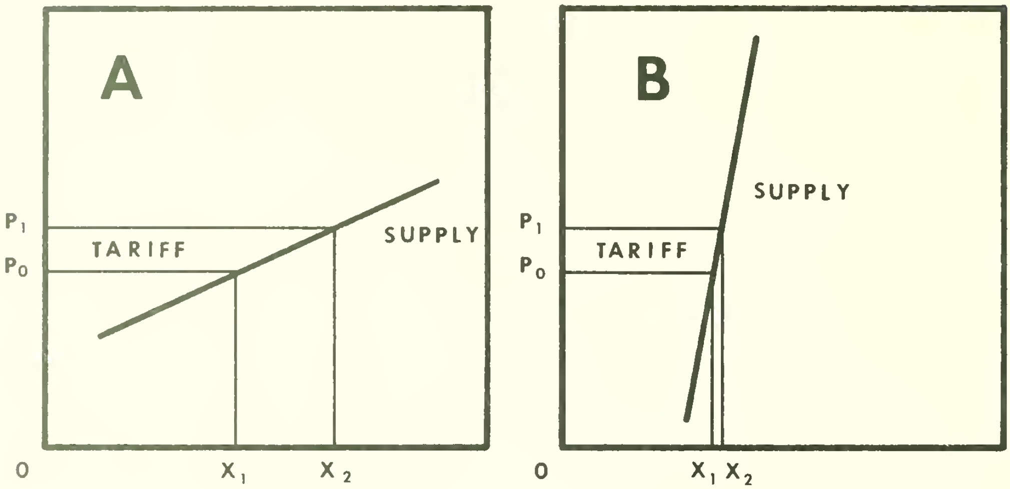
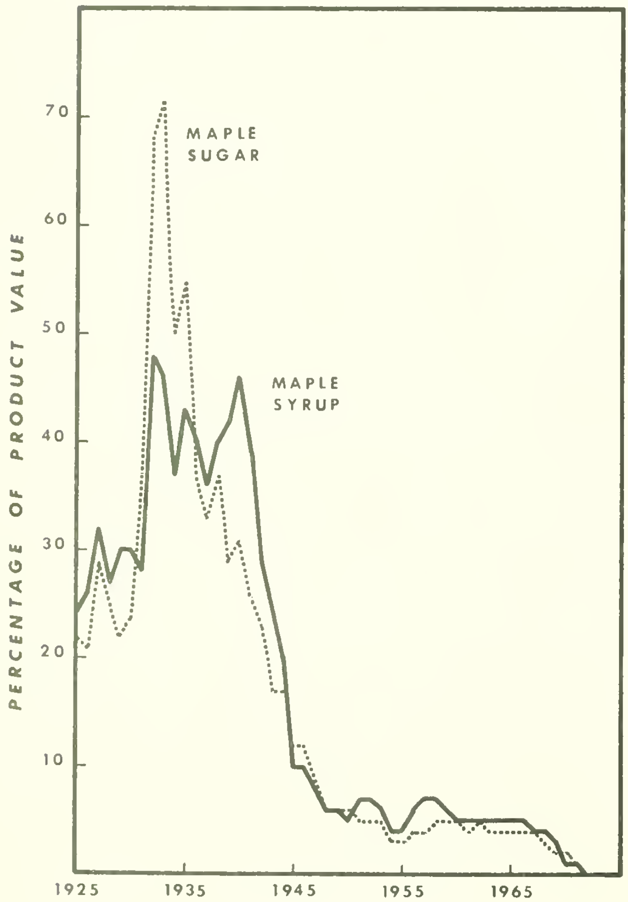


Figure 4.—Maple Syrup and Sugar Tariff expressed as a percentage of the value of the product.



of the value of syrup and less than 5 percent of the value of sugar. Value of imports from 1951 to 1970 was obtained from the U. S. Department of Commerce, Bureau of the Census; value of imports from 1925 to 1950 was assumed to be equal to the average annual Canadian value reported in Taylor et al. *(1967)*.

The actual burden of the tariff reached its highest level in the period 1931 to 1935. Annually it averaged 56 percent of the value of sugar and 41 percent of the value of syrup. Imports were very low during this period, averaging less than 0.4 million gallons per year compared to almost 1 million gallons annually from 1926 to 1930 and almost 1 million gallons annually from 1936 to 1940.

It is difficult to measure the direct effect of the tariff on maple imports. Changes in the supply and demand for maple products, in prices, and in the general price level confuse the picture. These other factors were equally important in influencing maple imports into the U. S. Maple prices in the U. S. were high and increasing from 1926 to 1930. They fell by as much as a third between 1931 to 1935, influenced by the Great Depression. Maple prices rose again to former levels from 1936 to 1940. This also may explain the change in imports.

In the Canadian market, maple prices were also very low in the period 1931 to 1935. However, the difference between Canadian price and U. S. price during that period was much smaller than in 1926-30 and 1936-40. After the depression, U. S. prices began to increase much faster than Canadian prices.

As an additional disturbance, maple buyers in the United States speculated that there would be a very large increase in the specific tariff in 1931. So they imported unusually large amounts of Canadian maple syrup in 1929 and 1930. However, the high tariff never fully materialized. The resulting large surplus of maple syrup undoubtedly contributed to the low level of imports from 1931 to 1935.

The aggregate effect of all these factors interacting resulted in the observed changes in imports. During this 15-year period, tariffs changed and imports changed. But more important, maple prices in the United States and Canada also changed, reflecting changes in demand and supply and causing changes in the actual burden of the tariff. Speculation in maple syrup based on expected tariff increases influenced imports, as did changes in the general price level during the Great Depression.

Considering the empirical evidence of the maple tariff, I concluded that the tariff has not had an observable protective effect on the U. S. industry, especially since World War II.

The Maple Industry Without a Tariff

Ordinarily a protected industry will be injured when a tariff is removed. But the protective effect of the maple tariff was insignificant; so, as the burden of the tariff is removed, injury to the United States maple syrup industry will be slight. The maple industry has been returned to an unprotected state with the least possible disorder.

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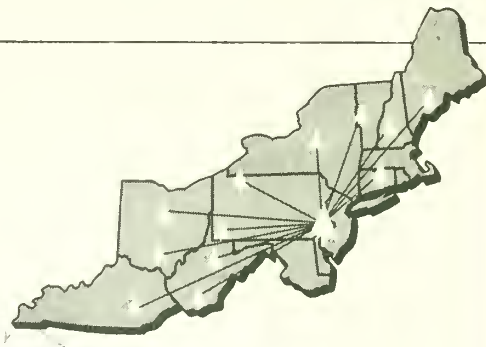

Northeastern Forest Experiment Station

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LONGEVITY OF BLACK CHERRY SEED IN THE FOREST FLOOR

Abstract.—Observations made on the Fernow Experimental Forest in West Virginia indicate that some black cherry seeds remain viable in the forest floor over three winters. On the average fewer than 10 percent of the seeds stored in the forest floor germinated the first spring, about 50 percent germinated the second spring, and 25 percent germinated the third spring.

The longevity of seeds stored in the forest floor—both of desirable hardwood species and of the principal competing species—is important in forest management. If viable seeds of the desired species accumulate in the forest floor, they may ensure good amounts of reproduction when favorable conditions are created—as through harvest cuttings. Furthermore, if viable seed is stored in the forest floor, managers need not rely on current seed crops nor on timing the cutting to take advantage of good seed crops.

Conversely, the presence of many viable seeds of *unwanted* species may mean that numerous seedlings of these will start and will compete with reproduction of desired species. To eliminate such competition, seed sources of undesirable species may have to be removed from the forest stand years before the harvest cutting.

In recent years information has been published about seed storage in the forest floor for several hardwood species. Sander and Clark *(1971)* determined that yellow-poplar (*Liriodendron tulipifera* L.) seeds remain viable for up to 8 years in the forest floor of the hardwood forests in the Central States. Clark *(1962)* found that white ash (*Fraxinus americana* L.) and hackberry (*Celtis occidentalis* L.) seeds remain viable after 3 winters of storage in the forest floor. Sassafras (*Sassafras albidum* (Nutt.) Nees) seed viability was found to be limited to one winter. Leak *(1963)* showed that white ash seeds also remain viable for 3 years in forest floors of the White Mountain area of New Hampshire.

Black cherry (*Prunus serotina* Ehrh.) is an important timber species in Pennsylvania and West Virginia. Delayed germination of this species in nursery seedbeds indicated that possibly in nature some of the seed might remain viable in the forest floor for more than 1 year. To determine this, tests were started on the Fernow Experimental Forest near Parsons, West Virginia, in the fall of 1968.

The Study

In the fall of 1968, mature black cherry fruits were collected in the vicinity of Parsons, West Virginia. Sixty lots of 200 fruits each were placed in field storage plots under a fully stocked hardwood stand. Thirty lots were broadcast-sown on the 1967 litter and 30 were placed on the litter in envelopes made of fiberglass screen cloth (fig. 1), similar to those used by Clark and Boyce *(1964)*. After the fruits were placed in storage, they were covered with a depth of litter equal to the current year's leaf fall. This procedure was repeated each autumn.

The field-storage plots were rectangular—16 by 24 inches—constructed of 12-inch-wide ¼-inch mesh hardware cloth, which was forced into a slit 6 inches deep around the perimeter of the plots to keep out burrowing animals (fig. 2).

The interior of each plot was divided into three subplots, each 8 by 16 inches—one to be used for broadcast storage, one for fiberglass envelope storage, and one to serve as a control.

The 30 field storage plots provided 90 subplots—enough to sample 6 envelope, 6 broadcast, and 6 control subplots annually for 5 years. However, in the late spring after the first winter, mice got into 15 of the plots and ate all the stored seeds. The experiment was revised so that 6 plots were sampled after the first winter, 3 plots were sampled after the second winter, and 2 plots were sampled after the third winter of storage.

Samples were removed from the storage plots in late April each year. Seeds that had germinated in the storage plots were removed from the samples and counted. Ungerminated seeds were placed on "Kimpak" paper, covered with a blotter, moistened, and put in a germinator where the temperature was main-

Figure 1.—A fiberglass screen envelope containing seed.

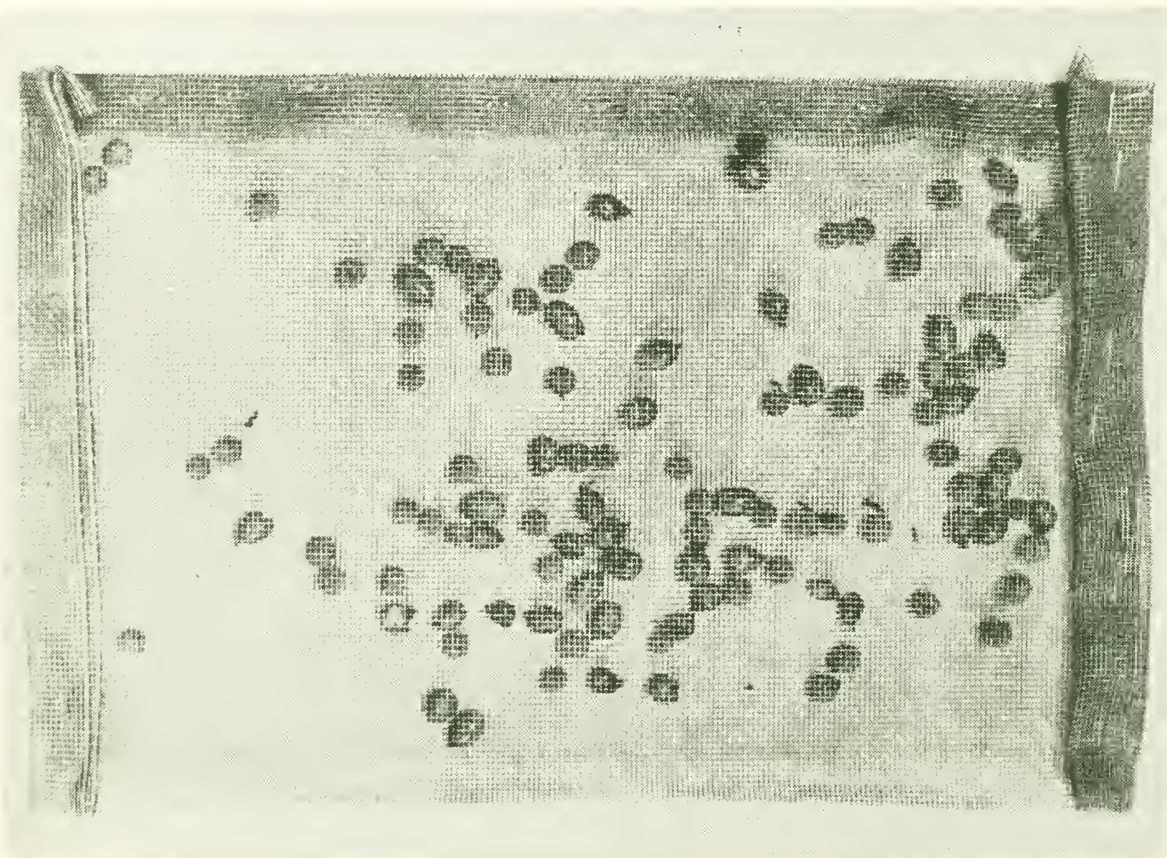

Figure 2.—Field storage plot.

tained at 78° F. Tests in the germinator were terminated after 3 weeks.

Results

Very few seeds germinated after the first winter—8.7 percent of the broadcast-stored seeds and 4.6 percent of the envelope-stored seed (table 1). In the samples collected after the second winter, 45.5 percent of the broadcast-stored and 54.7 percent of the envelope-stored seed germinated. After the third winter of storage, 23.5 percent of the broadcast-stored seeds and 26.5 percent of the envelope-stored black cherry seeds germinated.

More than 90 percent of the germination each year occurred in the field storage plots. This was recorded at the time the plots were sampled. The percent germination each year is the sum of field germination and tests in the germinator (table 1).

Since no natural black cherry seeds were found in the control plots during the first

Table 1.—*Percent germination of black cherry seeds*

Plot number	Type of storage	
	Broadcast	Envelope
AFTER FIRST WINTER		
	Percent	*Percent*
1	5.0	1.0
2	14.0	0
3	13.0	15.5
4	2.0	1.0
5	6.5	8.5
6	12.0	1.5
Average	8.7	4.6
AFTER SECOND WINTER		
7	51.5	46.0
8	42.5	53.5
9	42.5	64.5
Average	45.5	54.7
AFTER THIRD WINTER		
10	20.5	28.0
11	26.5	25.0
Average	23.5	26.5

year test, control plots were not sampled thereafter.

Accumulating the average percent germination for each year, we found that 78 percent of the broadcast-stored seeds and 86 percent of the envelope-stored seeds germinated during the first 3 years. Between 2 and 3 percent of the seed each year had rotted.

In general, more broadcast-stored seeds germinated after the first winter; but after the second and third winters, slightly more envelope-stored seed germinated (table 1).

Discussion

Under the conditions of the study, some of the black cherry seeds retained their viability over three winters. On the average, fewer than 10 percent of the seeds stored germinated after the first winter, 50 percent germinated after two winters, and 25 percent germinated after three winters.

We are repeating the study to find out if the longevity pattern is the same over a different span of years. In addition, we also have longevity tests under way with wild grape (*Vitis aestivalis* Michx.), pin cherry (*Prunus pensylvanica* L.f.), and sassafras.

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Northeastern Forest Experiment Station

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CAMPGROUND MARKETING — THE IMPULSE CAMPER

Abstract.—Impulse or unplanned campground visits may account for one-fourth to one-half of all camping activity. The concepts of impulse travel and impulse camping appear to be potentially useful extensions of the broader concept of impulse purchasing, which has become an important influence in retail marketing. Impulse campers may also be impulse buyers; they were found to spend more per day than other campers. Impulse campers visit more campgrounds, camp more often, and have somewhat different needs in camping facilities than do those campers who carefully plan all aspects of their camping trips.

Unplanned or impulse buying has been studied in a variety of retail settings. It is known to be an important factor in sales at gift shops, flower shops, book stores, and similar specialty shops. But it is also found in more unlikely settings like barber shops, auto supply stores, and retail lumber yards. One recent study indicated that unplanned purchasing accounts for up to 50 percent of the products purchased in food supermarkets *(2)*.

Because incomplete planning is an important characteristic of much leisure spending behavior, impulse purchasing may be as important to the travel and camping markets as it is to retailing. The 1970 National Advertising Company (NAC) study of automobile travelers at 21 popular vacation areas in the United States showed that vacationing Americans tend to have very flexible itineraries. More than three-fourths of their respondents indicated that they visited places and did things that they had not planned to do before they left home, and 12 percent did not have a trip plan at all upon leaving home. One out of six of these vacationers was a camper *(5)*.

Two studies conducted in 1967 and 1969 by the Northeastern Forest Experiment Station, though not aimed primarily at examining impulse camping, provided evidence that a large number of camping decisions are not planned in advance. The first of these studies dealt with visitors to state parks in New Hampshire and the role of fees in decisions of where and how much to camp *(3)*. The second study had, as one of its objectives, to determine how advertising influences campground visits along the coast of Maine.

The Decision Point

There are probably fewer impulse campers than there are impulse purchasers in a supermarket. In the supermarket, several types of unplanned purchases may occur: (1) *pure-impulse* purchases, which are totally unplanned and apparently frivolous; (2) *reminder-*

impulse purchases, in which the store shelves are deliberately used to remind shoppers or supplement a shopping list; (3) *suggestion-impulse*, in which the shopper sees a need for the item after being exposed to it; and (4) *planned-impulse*, in which the general decision is made in advance but the specific decision on item, brand, or size is reserved to take advantage of sales, discounts, and relative attractiveness of competing items *(2)*.

Most impulse camping is probably of the planned-impulse type, because the camper needs to have some minimal amount of camping equipment in advance. Tourist regions, containing several campgrounds, can be likened to a supermarket in which the final decision about which campground to patronize may be reserved until the tourist can personally compare camping alternatives. However, campgrounds offering rental equipment might also encourage suggestion-impulse camping in attracting tourists who would otherwise have stayed at a motel or hotel. And reminder-impulse camping decisions may be prompted by advertising that reaches the camper at home.

Since impulse camping is really a matter of a low level of pre-planning, the obvious question is: "At what point does the decision to visit a specific campground involve so little planning that it can realistically be considered an impulse decision?" In our survey of 736 campers on the Maine coast, a surprisingly high percentage made their final decision only hours before arriving at the campground:

Decision time:	*Percent*
Less than 6 hours	38
6 to 24 hours	8
2 to 4 days	6
5 to 7 days	6
1 to 2 weeks	4
2 to 4 weeks	8
1 to 3 months	10
Over 3 months	20

For comparison purposes, we labelled decisions occurring within 24 hours of arrival at the campground as impulse decisions; this accounted for 46 percent of the Maine coast campers and 21 percent of 699 New Hampshire state park campers. These campers differed significantly in many ways from their fellow campers who were more concerned with advance planning.

Accent on Flexibility and Variety

Flexibility and variety seem to have top priority in many people's vacation planning. Among the NAC sample of tourists, 39 percent visited commercial attractions that they did not know existed before they left home, and 38 percent visited a free attraction that they knew nothing about when they left home *(5)*.

In our studies we found that certain characteristics of impulse campers indicate that they incorporate more flexibility and variety in their camping trips than do non-impulse campers. For instance, we found that, though impulse and non-impulse campers averaged 16 days on the Maine coast, the non-impulse campers' average stay in a given coastal region or campground was nearly twice as long as that of the impulse campers (table 1). Impulse campers were also much more likely to be camping at the campground for the first time (table 2), and much less likely to have expectations of returning. Campers interviewed along the Maine coast were also asked if they planned to return to the campground in the future. Fifty-two percent of the non-impulse campers and 26 percent of the impulse campers planned to return.

The NAC study showed that auto vacationers were reluctant to reduce trip flexibility by making advance reservations *(5)*. The incidence of advance campground reservations among Maine coast campers varies greatly

Table 1.—*Trip length and length of stay in coastal regions and campgrounds; Maine coast campers, 1969*

[Mean number of days spent]

Type of camper	At campground	In region	Total trip
	Days	*Days*	*Days*
Impulse campers	5	6	16
Non-impulse campers	9	10	16

Table 2.—*Prior visits to the campground where interviewed*
[In percent]

Prior visits	N. H. state parks		Maine coast	
	Impulse campers	Non-impulse campers	Impulse campers	Non-impulse campers
Yes	28	58	9	43
No	72	42	91	57
	100	100	100	100

between impulse campers and other campers. Only 8 percent of the impulse campers attempted to make advance reservations, while 45 percent of the non-impulse campers either reserved or attempted to reserve a campsite.

When asked to rank the importance of several factors in choosing a campground, 32 percent of the impulse campers in New Hampshire state parks rated convenience to travel route as most important, while 12 percent ranked convenience to home as most important. Among the non-impulse campers, 20 percent rated convenience to home as most important and 6 percent rated convenience to travel route as most important.

The importance of campground convenience to the travel route, the low incidence of repeat visits and return-visit intentions, comparatively short visits in a given region or campground, and the low frequency of advance reservations, indicate that impulse campers like to visit new places and see new areas, making short stops at several campgrounds along their travel route.

Campground Management Implications

The impulse camper is incompletely prepared for a camping experience. Because he is unsure of where he may be camping, or even when he may go camping, he may have less camping equipment and supplies on hand than he needs. And, because he is willing to make camping decisions on an impulse basis, he may be an impulse purchaser of other items as well while on a camping trip. The average daily expenditure for impulse campers visiting New Hampshire state parks was $12.57 per family, while that for non-impulse campers was $10.34 *(4)*. A campground store, stocked with a variety of camping equipment and other convenience items, should be able to absorb a large portion of the additional $2.23 per day.

A good campground advertising and signing program should be helpful in attracting impulse campers. Maine coast campers who made impulse decisions were twice as likely to use guidebooks and directories as were all other campers (34 percent versus 15 percent). Impulse campers probably scan campground directories for campgrounds that are large enough to ensure having some vacancies at the last minute—31 percent of the Maine coast's impulse campers claimed to have a preference for large campgrounds as opposed to 23 percent of the non-impulse campers. Cautions in a camping directory about the desirability of making reservations may be a good way to discourage impulse campers.

Impulse-camping decisions, particularly those made on Friday for a weekend of camping, can result in more opportunities for camping trips. The impulse campers studied at New Hampshire state parks averaged 18, 21, and 26 days of camping in 1965, 1966, and 1967; non-impulse campers in those same years averaged 17, 17, and 22 days. Campgrounds situated near large population centers should be able to generate extra income by encouraging impulse camping with an advertising program aimed at the reminder and suggestion types of impulse spending behavior.

Impulse campers are not predominantly long-distance travelers, although they become a larger proportion of the total with increasing distance from the campground:

Travel time to coast (days)	*Impulse campers (percent)*
½	39
½ to 1	47
1+	55

The large proportion of impulse campers within ½-day's drive of the Maine coast may mean that suggestion-impulse camping behavior is as important as planned-impulse.

Impulse campers are not necessarily beginning campers. Among impulse campers in the Maine and New Hampshire studies, only 23 percent and 26 percent respectively had been camping for 1 year or less. For non-impulse campers the figures are 16 and 28 percent.

The frequent occurrence of impulse-camping behavior raises some potentially important questions in regard to Clawson's *(1)* well-accepted five-part model of a recreational experience: anticipation, travel, on-site recreation, return travel, and recollection. True-impulse, reminder-impulse, and suggestion-impulse types of camping behavior all suggest that a relatively low level of importance may be attached to the anticipation phase of a camping experience. According to Clawson, "pleasurable anticipation is almost a necessity" for a complete outdoor recreation experience. The absence of anticipation may indicate the lack of a strong and lasting interest in camping. Further, a high incidence of planned-impulse camping suggests that the campground industry has highly variable quality standards and that it is doing a less than adequate job of communicating what it has to offer campers.

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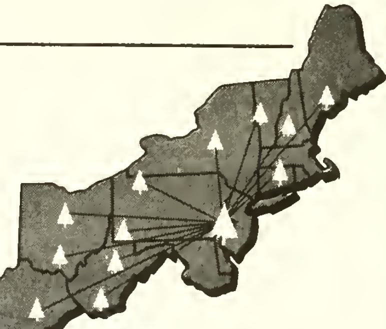

FOREST SERVICE, U.S. DEPT. OF AGRICULTURE, 6816 MARKET STREET, UPPER DARBY, PA. 19082

A PERFORMANCE TEST OF THE LOG and TREE GRADES for EASTERN WHITE PINE

Abstract. — The results of testing the Forest Service standard tree grades and sawlog grades for eastern white pine on an independent sample of 75 trees and 299 logs in southwestern Maine. The total predicted value of the 75 trees was 3 percent higher than the actual value. The total predicted value of the 299 logs was 2 percent higher than the actual value. The differences between the actual and predicted values are small enough to be of no practical importance.

Standard log and tree grades for eastern white pine, developed by the Northeastern Forest Experiment Station, have been approved by the USDA Forest Service for use in all Forest Service activities where tree and log grades are needed. They have been recommended for use by timber and log buyers, sellers, and processors throughout the commercial range of eastern white pine.

The log and tree grades (figs. 1 and 2) were developed from grade-yield studies conducted in New England, the southern Appalachians, and the Lake States. Reports describing the grading systems show the expected lumber-grade yields by log grade and diameter class. These grade yields are necessary for estimating the value of the graded trees and logs in terms of standard yard lumber.

This note is a report on the results of testing the adequacy of the grading systems and expected lumber grade yields on an independent sample of trees and logs in the New England area.

The Study

The 75 trees used in this study were selected from four different timber stands in southwestern Maine. They ranged from 60 to 120 years old. Diameter at breast height ranged from 12 to 28 inches. All the trees were measured and graded according to the standard tree grades. After felling, the trees were bucked into logs; and the logs were scaled and graded according to the standard sawlog grades. The 299 logs ranged from 6 to 24 inches in scaling diameter.

The logs were sawed into standard yard

EASTERN WHITE PINE SAWTIMBER TREE GRADE SPECIFICATIONS

GRADING FACTOR	*TREE GRADE 1*	*TREE GRADE 2*	*TREE GRADE 3*	*TREE GRADE 4*
(1) MINIMUM D.B.H. (inches)	10	10	10	10
(2) MAXIMUM WEEVIL INJURY IN BUTT 16 FOOT SECTION (number)	None	None	2 injuries	No limit
(3) MINIMUM FACE REQUIREMENTS ON BUTT 16 FOOT SECTION	Two full length or four 50% length good faces.[1] (In addition, knots on balance of faces shall not exceed size limitations of grade 2 sections).	No *GOOD* FACES REQUIRED. Maximum diameter of knots on three best faces: *SOUND RED KNOTS* not to exceed 1/6 scaling diameter and 3 inch maximum.[2] *DEAD OR BLACK KNOTS* including overgrown knots not to exceed 1/12 scaling diameter and 1½ inch maximum.[2]	*SOUND RED KNOTS* not to exceed 1/3 scaling diameter and 5 inch maximum.[2] *DEAD OR BLACK KNOTS* including overgrown knots not to exceed 1/6 scaling diameter and 2½ inch maximum.[2]	Includes all trees not qualifying for GRADE 3 or better and judged to have at least one-third of their gross volume in sound wood suitable for manufacture into standard lumber.
(4) MAXIMUM SWEEP OR CROOK IN BUTT 16 FOOT SECTION (percent)	20	30	40	No limit
(5) MAXIMUM TOTAL SCALING DEDUCTION IN BUTT 16 FOOT SECTION (percent)	50	50	50	No limit

After the tentative grade of the section is established from face examination, the section will be reduced in grade whenever the following defects are evident:

(6) *CONKS, PUNK KNOTS, AND PINE BORER DAMAGE ON BARK SURFACE OF SECTION*[3]

Degrade one grade if present on one face.
Degrade two grades if present on two faces.
Degrade three grades if present on three or four faces.

(7) If the final grade of the grading section is 1, 2, or 3, examine the tree for weevil injuries in the merchantable stem *above* 16 feet. If the total apparent weevil injuries exceed three, degrade the tree one grade below the section grade.[3] Otherwise the tree grade is the same as the final section grade.

[1] Trees under 16 inches d.b.h. require four full length good faces.
[2] Scaling diameter is estimated at the top of the 16 foot grading section.
[3] No tree will be degraded below GRADE 4 unless net tree scale is less than one-third of gross tree scale.

Figure 1. — Eastern white pine tree grade specifications.

[3] No tree will be degraded below GRADE 4 unless net tree scale ...

Figure 1. — Eastern white pine tree grade specifications.

EASTERN WHITE PINE SAWLOG GRADE SPECIFICATIONS

GRADING FACTOR	LOG GRADE 1	LOG GRADE 2	LOG GRADE 3	LOG GRADE 4
(1) MINIMUM SCALING DIAMETER (inches)	14[1]	6	6	6
(2) MINIMUM LOG LENGTH (feet)	10[2]	8	8	8
(3) MAXIMUM WEEVIL INJURY (number)	None	None	2 injuries[3]	No limit
(4) MINIMUM FACE REQUIREMENTS	Two full length or four 50% length good faces.[4] (In addition, log knots on balance of faces shall not exceed size limitations of grade 2 logs).	No *GOOD* FACES REQUIRED. Maximum diameter of log knots on three best faces: *SOUND RED KNOTS* not to exceed 1/6 scaling diameter and 3 inch maximum. *DEAD OR BLACK KNOTS* including overgrown knots not to exceed 1/12 scaling diameter and 1½ inch maximum.	*SOUND RED KNOTS* not to exceed 1/3 scaling diameter and 5 inch maximum. *DEAD OR BLACK KNOTS* including overgrown knots not to exceed 1/6 scaling diameter and 2½ inch maximum.	Includes all logs not qualifying for No. 3 or better and judged to have at least one-third of their gross volume in sound wood suitable for manufacture into standard lumber.
(5) MAXIMUM SWEEP OR CROOK ALLOWANCE (percent)	20	30	40	66-2/3
(6) MAXIMUM TOTAL SCALING DEDUCTION (percent)	50	50	50	66-2/3

After the tentative log grade is established from face examination, the log will be reduced in grade whenever the following defects are evident:

(7) *CONKS, PUNK KNOTS, AND PINE BORER DAMAGE ON BARK SURFACE*[5]
- Degrade one grade if present on one face.
- Degrade two grades if present on two faces.
- Degrade three grades if present on three or more faces.

(8) *LOG END DEFECTS: RED ROT, RING SHAKE, HEAVY STAIN AND PINE BORER DAMAGE OUTSIDE HEART CENTER OF LOG*[5]
Consider log as having a total of 8 quarters (4 on each end) and degrade as indicated below:
- Degrade one grade if present in 2 quarters of log ends.
- Degrade two grades if present in 3 or 4 quarters of log ends.
- Degrade three grades if present in 5 or more quarters of log ends.

[1] 12 and 13 inch logs with four full length good faces are acceptable.
[2] 8 foot logs with four full length good faces are acceptable.
[3] 8 foot No. 3 logs limited to one weevil injury.
[4] Minimum 50% length good face must be at least 6 feet.
[5] Factors 7 and 8 are not cumulative (total degrade based on more serious of the two).
No log to be degraded below grade 4 if net scale is at least one-third gross log scale.

Figure 2. — Eastern white pine sawlog grade specifications.

lumber at a circular sawmill in southwestern Maine. The lumber was graded by a certified grader, using the white pine lumber-grading rules of the Northeastern Lumber Manufacturer's Association. Length, width, thickness, and rough green grade of each board were recorded by log number. Of the 26,325 board feet of lumber produced, about 80 percent was 4/4; the remainder was 6/4 and 8/4.

Because the lumber-grade yield tables in the published reports are based on dressed-dry volumes, conversion of the rough green lumber-grade volumes to dressed-dry volumes was necessary. Conversion ratios developed from the original white pine grade-yield studies, were applied to the green volumes. The resulting volumes, hereafter called actual volumes, were then summed to obtain the actual dressed-dry lumber-tally volumes for each tree and log. Actual value of the lumber from each tree and log was computed by multiplying current lumber-grade prices by the actual lumber-grade volumes.

Predicted volumes and values, to be used for comparison with the actual volumes and values, were computed from the published lumber-grade yield percentages and the total lumber-tally volume of each tree and log. Lumber-tally volume was used instead of scaled volume so that the analysis would not be complicated by the introduction of overrun factors. The predicted value of each tree and log was obtained by multiplying the same current lumber-grade prices by the predicted lumber-grade volumes.

Results and Discussion

Tree grades. — The predicted and actual values of each tree were summed and converted to value per 1,000 board feet lumber tally for each tree grade. The predicted value of the entire 75-tree sample was about 3 percent higher than the actual value (table 1). The predicted value of the 9 grade-1 trees was about 5 percent higher than the actual. The relative differences between predicted and actual values for the other three tree grades ranged from 1.4 to 3.5 percent (table 1).

The 5-percent difference in value of the grade-1 trees was caused primarily by the overestimation of the volume of select lumber. There are two reasons why this happened. First, the sample size was small (9 trees). Second, although the 9 trees met the specifications for grade 1, the majority were, by chance, low-line grade-1 trees.

The average difference between total predicted value and total actual value of the trees in each tree grade was computed and tested for significance by use of the t-statistic based on paired observations (table 1). Results showed that the average differences for grades 2 and 3 were not significant. The differences for grades 1 and 4 were significant. However, the actual magnitude of these differences was small enough to be of no practical importance.

Another measure of the performance of a grading system is how well the grades segregate the sample of trees into distinct value

Table 1. — *Actual and predicted values for each tree grade*

Tree grade	Trees	Total tree value		Mean difference	Value/1,000 board feet		Percent difference
		Predicted	Actual		Predicted	Actual	
	No.	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Pct.*
1	9	427.94	407.78	2.24*	185.68	176.94	4.9
2	20	1,009.08	994.89	.71	162.89	160.60	1.4
3	22	1,276.29	1,243.21	1.50	144.33	140.59	2.7
4	24	1,198.37	1,157.71	1.69*	133.39	128.86	3.5
All grades	75	—	—	—	148.58	144.48	2.8

*Significant at 5-percent level.

Table 2. — *Actual and predicted values for each log grade*

Log grade	Logs	Total tree value		Mean difference	Value/1,000 board feet		Percent difference
		Predicted	Actual		Predicted	Actual	
	No.	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Pct.*
1	10	296.12	274.17	2.20	216.98	200.89	8.0
2	32	562.75	558.43	.14	175.14	173.80	.8
3	182	1,942.08	1,898.95	.24*	146.04	142.80	2.3
4	75	1,079.64	1,071.84	.10	127.78	126.85	.7
All logs	299	—	—	—	147.41	144.48	2.0

*Significant at 5-percent level.

classes with a minimum of overlapping values between grades. The average value per 1,000 board feet of the grade-2 trees was about 9 percent lower than the value of the grade-1 trees; the value of the grade-3 trees was about 14 percent lower than that of the grade-2 trees; and the value of the grade-4 trees was about 9 percent lower than that of the grade-3 trees. The variability around the average value for each grade (coefficient of variation) ranged from 5 to 7 percent.

Log grades. — The predicted value of the 299-log sample was 2 percent higher than the actual value (table 2). As was the case with the tree-grade comparisons, the grade-1 logs had the largest difference (8.0 percent) between the predicted and actual value. Again, this larger difference was caused primarily by the overestimation of the volume of select lumber produced from the grade-1 logs. The differences between predicted and actual value for the other log grades ranged from 0.7 percent to 2.3 percent (table 2).

The average differences between total predicted and actual value were non-significant except for log grade 3 (table 2). Even though the mean difference of grade-3 values was statistically significant, it was small enough to be of little practical importance.

The log-grade system segregated the sample logs into distinct value classes with a minimum of overlapping between grades. The average value per 1,000 board feet of the grade-2 logs was about 12 percent less than that of the grade-1 logs; the value of the grade-3 logs was about 19 percent less than that of the grade-2 logs; and the value of the grade-4 logs was about 10 percent less than that of the grade-3 logs. The coefficients of variation ranged from 9 percent to 12 percent within the four log grades.

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DECAY CAUSES LITTLE LOSS IN HICKORY

Abstract.—A study of 600 hickory trees indicated that heart-rot fungi cause little economic loss in species of the genus *Carya*. More than half of the decay volume for which a fungus could be identified was caused by *Poria spiculosa*, one of seven species of heart-rot fungi associated with decay in hickory that were isolated and identified. Basal fire scars, open branch stub scars, large unsound branch stubs, and mechanical injuries were important entry courts for decay fungi.

Hickory (*Carya* spp.) is widely distributed in the Eastern and Central United States. There is a net volume of 24 billion board feet of hickory in sawtimber-size trees—6 percent of the volume of all hardwoods in these states (2). Hickory is a valuable wood for many uses, such as furniture, implement handles, sporting goods, charcoal, and fuel. Increasing utilization of hickory has created a need for information about decay losses in the numerous species of the genus *Carya*.

Study Areas and Methods

From 1962 to 1968 we investigated decay in the principal species of deciduous trees in the oak-hickory forest type. One hundred fifty sample areas were selected in even-aged stands from 20 to more than 100 years old in Ohio, Kentucky, Indiana, Illinois, and Missouri. Data for this study were taken from hickory trees found on these sample areas. No attempt was made to separate the different species of hickory.

Each sample area consisted of concentric circular plots of 1/20-, 1/10-, and 1/5 acre. All living trees 3.6 inches d.b.h. (diameter at breast height) and larger were cut on the 1/20-acre plots; trees 5.6 inches d.b.h. and larger were cut on the 1/10-acre plots; and trees 11.6 inches d.b.h. and larger were cut on the 1/5-acre plots. Data collected from trees on the 1/20- and 1/10-acre plots were so weighted that all computations were based on 1/5 acre.

After felling, the trees were cut into 4-foot bolts up to a 4-inch top diameter inside bark and examined for decay. Where decay appeared, its extent and dimensions were determined by splitting the bolts longitudinally. Where external indicators of defects had been noted before the trees were cut into bolts, the indicators were examined, and any decay associated with them was recorded.

The gross volumes of the merchantable trunks and of decay were calculated for each age and size class. No reduction in gross volume was made for trim or breakage.

Cultures were prepared from samples of decayed wood to determine the fungi associated with decay. Sample blocks of decayed wood were split to expose a fresh face of infected wood. Six cores of infected wood, approximately 4 mm in diameter, were removed from each block with a sterilized increment hammer and placed in test tubes containing 2.5 percent Fleischman's diamalt with 2-percent agar. (Mention of a particular product should not be taken as endorsement by the Forest Service or the U.S. Department of Agriculture.) When the decay fungus was not isolated on the first attempt, re-isolations were attempted.

Decay vs. Tree Age and Diameter

The hickory industry frequently uses small, young trees. Age-decay and diameter-decay relationships indicate that heart-rot fungi cause little economic loss in hickory trees less than 100 years old or 11.6 inches in d.b.h. (tables 1 and 2). In fact, no decay was found in any of the 201 trees under 50 years old. Only 16.67 percent of the 600 trees in the study had measurable amounts of decay, and the overall loss was only 1.58 percent of the gross volume.

Table 1.—*Relationship between age and decay in living hickory trees*

Age class (years)	Trees	Gross Volume	Trees with decay	Decay volume as percent of gross
	No.	*Cu. ft.*	*Pct.*	*Pct.*
20 to 50	201	328.51	0.00	0.00
50 to 100	332	2,126.09	20.18	.96
100+	67	1,370.47	49.25	2.92

Table 2.—*Relationship between diameter and decay in living hickory trees*

Diameter class (inches)	Trees	Gross volume	Trees with decay	Decay volume as percent of gross
	No.	*Cu. ft.*	*Pct.*	*Pct.*
3.6-11.5	558	2,433.54	14.69	0.94
11.6-17.5	39	1,155.34	38.46	2.56
17.6-21.5	3	236.19	100.00	3.47

The Decay Fungi

Decay columns often become inactive after the entry point has healed (*3*). Almost 75 percent of the columns in the decayed hickories we examined were inactive, and we were unable to isolate any decay fungi from

Table 3.—*Fungi causing decay in living hickory trees, and portion of the trunk affected*

Fungus (species)	Number of infections			Decay volume (cu. ft.)		
	In butt[1]	In trunk	Total	In butt[1]	In trunk	Total
Poria spiculosa Campbell & Davidson	3	3	6	0.21	11.56	11.77
Poria andersonii (Ell. & Ev.) Neuman	5	8	13	3.43	.43	3.86
Pholiota aurivella (Batsch ex Fr.) Kumm.	1	—	1	2.64	—	2.64
Poria cocos (Schw.) Wolf	3	—	3	2.36	—	2.36
Corticium vellereum Ell. & Cragin	3	—	3	1.56	—	1.56
Polyporus adustus Willd. ex Fr.	2	—	2	1.10	—	1.10
Corticium galactinum (Fr.) Burt.	—	1	1	—	.05	.05
Unknown[2]	59	27	86	28.31	8.85	37.16
Total	76	39	115	39.61	20.89	60.50

[1]Decay originating at stump height or below.
[2]Decay columns from which we were unable to isolate any heart-rot fungi.

Figure 1.—Rot canker associated with *Poria spiculosa* on shagbark hickory.

them. Bacteria and non-decay fungi were recovered from some of the columns. These organisms have been shown to play an important part in the decay process (*4*).

Seven species of heart-rot fungi associated with decay in hickory were isolated and identified (table 3). *Poria spiculosa* Campbell & Davidson caused more than half of the decay volume in which the causative species was identified. This rot, which is accompanied by characteristic cankers (fig. 1), is probably the most widespread and damaging disease of hickory (*1*). Decay volume associated with the other fungus species identified was too small to support any conclusions as to their relative importance.

Decay originating at stump height or below is classified as butt rot; decay originating above stump height, as trunk rot. Two-thirds of the infections resulted in butt rot and accounted for two-thirds of the volume lost to decay.

How Fungi Gained Entry

Most heart-rot fungi enter the central core of living trees through wounds or dead tissue. Fire scars that expose a large area of wood provide an easy means of entry for these fungi (fig. 2). In hickory, more than 57 percent of the decay volume was associated with fire scars (table 4). Other wounds of significance

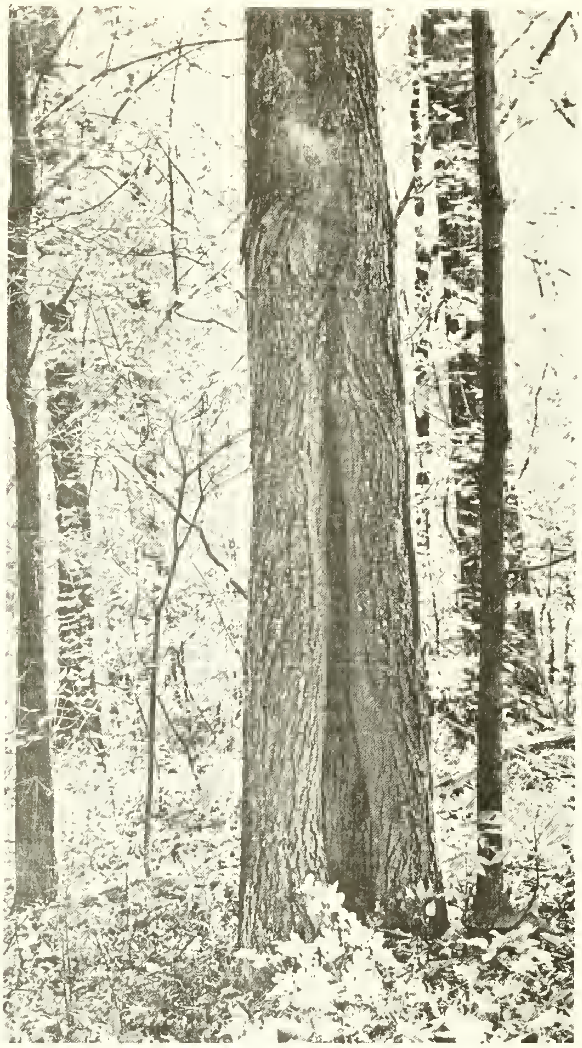

Figure 2.—An open fire scar on hickory.

Table 4.—*Relationship of entry courts to incidence of infection and volume of decay*

Entry court	Infections	Volume of decay	
	No.	*Cu. ft.*	*Pct.*
Fire scars	55	34.52	57.06
Open branch stub scars	9	12.00	19.83
Unsound branch stubs[1]	2	3.60	5.95
Mechanical injuries	6	3.21	5.31
Parent stumps	4	1.67	2.76
Unsound branch stubs[2]	2	1.13	1.87
Branch bumps[2]	2	.31	.51
Sound branch stubs[1]	3	.20	.33
Insect wounds	4	.17	.28
Sound branch stubs[2]	1	.14	.23
Woodpecker injuries	2	.07	.12
Unknown	25	3.48	5.75
Total	115	60.50	100.00

[1] 4 inches and more in diameter.
[2] Less than 4 inches in diameter.

in hickory included open branch-stub scars, large unsound branch stubs, and various mechanical injuries. About 33 percent of the total decay volume was associated with these other entry courts.

Conclusion

The hard, strong, durable wood of hickory makes it relatively resistant to decay fungi. Most decay fungi cause little, if any, decay in fairly small, young trees. Therefore, it seems that decay will not limit utilization of the hickory resource.

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THE RELATIONSHIP BETWEEN SAP-FLOW RATE AND SAP VOLUME IN DORMANT SUGAR MAPLES

Abstract.—Sap-flow rate is closely correlated with the sap volume produced by dormant sugar maple trees *(Acer saccharum* Marsh.) and could be used in making phenotypic selections of trees for superior sap production.

The selection of sugar maple trees for superior sap production is important in the development of superior sap-producing genotypes. Despite ample evidence of between-tree variability, there is no practical way of making the mass sap-volume measurements necessary for selection of superior phenotypes.

Researchers in sap-flow experiments use two methods for making sap-volume measurements. In one method the sap produced by trees during the sugaring season is collected in large drums. In the second — and more sophisticated way — the sap is collected and measured in tipping buckets. In this method, electricity must be available to operate mercury switches and recording instruments. But in either method, measurements can be made on only a few trees.

For a selection program to be effective, it is necessary to have measurements on large numbers of trees over a wide area. To carry out a project of this magnitude for selecting superior sap-producing phenotypes, we need a faster method for determining sap production. Such a method would depend on finding a character that could be measured rapidly and would satisfactorily reflect the total sap volume produced by the tree.

Sap-flow rate can be measured quickly and easily, and it is closely associated with the total volume of sap produced by sugar maple trees. We found this by studying the relationship between sap-flow rate and total sap volume produced by individual trees during the maple sugaring season.

Background

Sap flow in dormant sugar maples is a function of changes in temperature *(Jones et al. 1903)*. Warm days and freezing nights provide ideal sugaring conditions by creating a pumping action at the taphole of the tree. Cold nights induce a negative pressure within the tree, during which moisture is absorbed through the roots. Warm days provide a positive pressure, forcing the sap from the tree.

Twig temperatures have been reported to be more closely related to sap flow than temperatures in the xylem or inner bark *(Marvin and Erickson 1956)*. Sap production was found to be associated with the crown and stem size of trees *(Moore et al. 1951)*. Trask and Ward *(1967)* reported that 70 percent of the variation in sap yield between trees they studied could be assigned to height and diameter. Data from a sap-flow study by Jones et al. *(1903)* indicated that sap volumes of trees may fluctuate from year-to-year.

Our own observations, made over a 7-year period on 20 trees, have shown that trees with high sap-volume production are consistent in their performance rankings from year-to-year.

Materials and Methods

Sixty trees were selected for study in two relatively open sugar maple groves known as the Mitchell and Powell sugarbushes. These sugarbushes are located within 3 miles of each other on the eastern edge of Chittenden County, Vermont.

In general, the trees in both sugarbushes are widely spaced. Many of them have crowns that are open on two or more sides. The trees range from 13 to 39 inches in d.b.h. and from 57 to 90 feet in height.

All trees were tapped to a depth of 2½ inches. A 250-milligram paraformaldehyde pellet was placed in each taphole before inserting the spile and attaching the tubing, to retard bacterial growth that might lead to plugging of the taphole. Plastic spiles and tubing were used to conduct the sap from the trees to 20-gallon covered plastic containers (fig. 1). Graduated cylinders were used to collect sap for flow-rate measurements. Time intervals were determined by stopwatch.

Figure 1.—Left, sap-flow rate was measured with a stopwatch and graduated cylinder. Right, sap volume was measured to the nearest ½ liter.

Two groups of 20 trees each were selected for study in the Mitchell sugarbush. The trees in one group were tapped with only one hole, while the trees in the second group were multi-tapped, each tree receiving the number of taps recommended for its respective diameter, according to Willits *(1965)* as follows:

Tree d.b.h. (inches)	*Tapholes (number)*
Under 10	0
10-15	1
15-19	2
20-24	3
25 and over	4

Two groups of 10 trees each were selected in the Powell sugarbush and were tapped in the same manner as those in the Mitchell sugarbush.

All trees were tapped 4½ feet above the ground, during the latter part of February. Trees that were scheduled for only one taphole were tapped on the south face of the stem. On multi-tapped trees, the first taphole was made on the south face; other tapholes were drilled on the stem faces at the other cardinal points of the compass. All flow-rate measurements were made at the south-facing taphole of each tree on days when the sap was running freely.

Results

Sap flow rates of sugar maple trees showed a high degree of association among themselves and were highly correlated with the volume of sap produced.

Sap-flow rate.—One measure of the association of sap-flow rates may be expressed by W, the coefficient of concordance *(Kendall 1955, Segal 1956)*, in which W is computed from m rankings of n objects. Complete agreement among the rankings would result in $W = 1$; a complete lack of agreement would result in $W = 0$.

If the mean value of Spearman's rank correlation coefficient *(Spearman 1904)* is written as $\bar{r}_s$, then

$\bar{r}_s = (mW-1)/(m-1)$

Under the hypothesis that the m rankings are mutually independent, $X^2_r = m(n-1)W$ and has an X^2 distribution with (n—1) degrees of freedom. The values of W, r_s and X^2_r are shown in table 1. The X^2_r values for the single- and multi-tapped trees in both the Mitchell and Powell sugarbushes were found to be highly significant, and they indicate a high degree of agreement among flow rates.

The mean of the rank correlations (r_s), when compared with the mean of the product-moment correlations (r_p), measured on an interval scale, showed that the correlations are higher than those measured on an ordinal scale. The product-moment correlations were

Table 1.—*Coefficients of association among the sap-flow rates for single- and multi-tapped trees in the Mitchell and Powell sugarbushes*

Correlation measure	Mitchell sugarbush		Powell sugarbush	
	Single tap[1]	Multiple taps[1]	Single tap[2]	Multiple taps[2]
Coefficient of concordance (W)	0.68	0.67	0.90	0.66
$X^2_r = m\ (n-1)W$	103.6**	102.1**	40.3**	29.88**
Mean Spearman's rank correlation ($\bar{r}_s$)	.64	.63	.87	.58
Mean product-moment correlation ($\bar{r}_p$)	.69	.64	.88	.79

[1] m = 8 sap-flow measurements; n = 20 trees.
[2] m = 5 sap-flow measurements; n = 10 trees.
** Highly significant.

Table 2.—*Product-moment correlation (r_p) between sap-flow rate and sap volume for single- and multi-tapped trees in the Mitchell and Powell sugarbushes*

Date measured	Mitchell sugarbush		Powell sugarbush	
	Single tap[1]	Multiple taps[1]	Single tap[2]	Multiple taps[2]
March 28	0.64	0.71	—	—
29	.59	.82	—	—
31	.64	.15	0.73	0.78
April 1	.85	.46	.88	.88
5	.94	.42	.89	.87
6	.93	.48	.92	.80
9	.93	.52	.96	.43
11	.89	.67	—	—
Correlation of mean sap-flow rate and sap volume	0.93**	0.55*	0.92**	0.81**

[1] n = 20 trees.
[2] n = 10 trees.
* Significant.
** Highly significant.

lower for the Mitchell sugarbush than for the Powell sugarbush, but the lowest rank correlation was found in the multi-tapped trees in the Powell sugarbush (0.58, table 1). The product-moment correlation analysis confirmed the results of the rank analysis and verified the close agreement among flow-rate measurements taken on individual trees.

Sap volume and sap-flow rate.—A correlation analysis was run to determine the relationship between the sap volume produced and the rate of sap flow. In the analysis we calculated (1) the product-moment correlations (r_p) between individual flow rates and sap volumes, and (2) the correlations between mean flow rates and sap volumes (table 2).

Sap-flow rates and sap volumes were highly correlated for the single-tapped trees in the Mitchell sugarbush and the single- and multi-tapped trees in the Powell sugarbush. In general, there was a closer agreement between flow rates and sap volumes for single-tapped trees than for multi-tapped trees, particularly in the Mitchell sugarbush. Although there was a low correlation (0.15) in one set of measurements among the multi-tapped trees in the Mitchell bush, the correlation (0.55) between the mean sap-flow rate and the sap volume produced was significant. This showed that several measurements are necessary to identify trees with high sap-flow rates.

Conclusions

Our conclusions:

- There is a high degree of association between the sap flow rate and the total sap volume produced by individual dormant sugar maple trees during the maple sugaring season.
- Though it is possible to distinguish superior sap-producing phenotypes by one sap-flow-rate measurement, final selections should be based on at least three measurements because of occasional deviations.
- In the final screening, each selected tree should be single-tapped, and the taphole should be made on the south face of the tree.
- Sap-flow rate can be incorporated successfully into a practical method for the selection of sugar maple trees for superior sap production.

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Northeastern Forest Experiment Station

FOREST SERVICE, U.S. DEPT. OF AGRICULTURE, 6816 MARKET STREET, UPPER DARBY, PA. 19082

LIME RETENTION IN ANTHRACITE COAL-BREAKER REFUSE

Abstract.—Hydrated lime was applied to extremely acid anthracite coal-breaker refuse at rates of 2.5 and 5.0 tons per acre. The lime raised the pH to neutral range, and this range was still in evidence 7 years after treatment. The pH readings decreased with the depth of the refuse profile, and below 9 inches they approximated those of the control plots. The 2.5-tons-of-lime-per-acre treatment was almost as effective as the 5.0-ton treatment. Application of lime in establishing vegetation on coal-breaker refuse is recommended and encouraged.

Anthracite coal-breaker refuse is a pyrite-bearing material. It is extremely acid—too acid for plant survival. It is a continuing source of acid mine drainage, adversely affecting streams and rivers of the region. One way to minimize this acidity is to apply sufficient lime or lime materials.

Lime and lime materials are accepted soil amendments in agriculture, as well as in intensively managed forests; and their benefits have been well documented in the literature.

Lime has many functions in soil, but its primary function is to adjust the base saturation of soil colloids on the exchange complex by replacing the hydrogen ions with calcium ions. Thus it reduces acidity and may alleviate possible toxic levels of iron, manganese, aluminum, and other ions that are known to be phytotoxic at excessive levels.

In 1965 we applied lime to coal-breaker refuse in the Anthracite Region of Pennsylvania to establish crownvetch (*Coronilla varia* L.), Japanese larch (*Larix leptolepis* [Sieb. and Zucc.] Gord.), and red pine (*Pinus resinosa* Ait.). We found that lime was essential for establishing them.

But with the application of lime, two important questions arose: Will the lime effect be of short or long duration? To what depth in the refuse profile will this effect extend?

This is a report on the levels of reaction of (1) the 0- to 3-inch surface layer for 7 consecutive years after liming; and (2) the 15-inch profile 5½ years after lime application on graded refuse and 6½ years after application on ungraded refuse.

The Study

In the spring of 1965 we applied hydrated lime (125 percent $CaCO_3$ equivalent) on two anthracite coal-breaker refuse piles—at Tamaqua in the Southern Coal Field and at Shamokin in the Western-Middle Coal Field. At both locations the lime was applied to the surface, although some incorporation may have occurred during subsequent planting.

The coal-breaker refuse in Tamaqua was about 60 years old, graded to near level, and compacted; and it had a pH value of 3.9. Six plots, each measuring 20 by 30 feet, were limed at a rate of 2.5 tons per acre; a like number of plots were limed at 5.0 tons per acre. The liming rates were estimated on lime-requirement data, designed to raise the pH to about 6.0 and 7.0 respectively. The plots were planted to crownvetch.

The coal-breaker refuse pile in Shamokin was about 70 years old, ungraded, with about 45° slope and a southern aspect; it had a pH value of 3.3. Four plots, each measuring 60 by 60 feet, were limed at 5.0 tons per acre and were planted to Japanese larch and red pine seedlings. In 1969 the plots were interplanted with hybrid poplar (*Populus hybrid*) clone NE–388. At both locations the necessary control plots were established. The experimental design, site characteristics, treatment, and early performance of crownvetch and trees have already been reported (*Czapowskyj, et al. 1968; Czapowskyj, in press*).

Refuse samples from the 0- and 3-inch surface layer were taken in the spring or fall from 1965 to 1972. The pH values were determined, and means were computed from the limed and control plots.

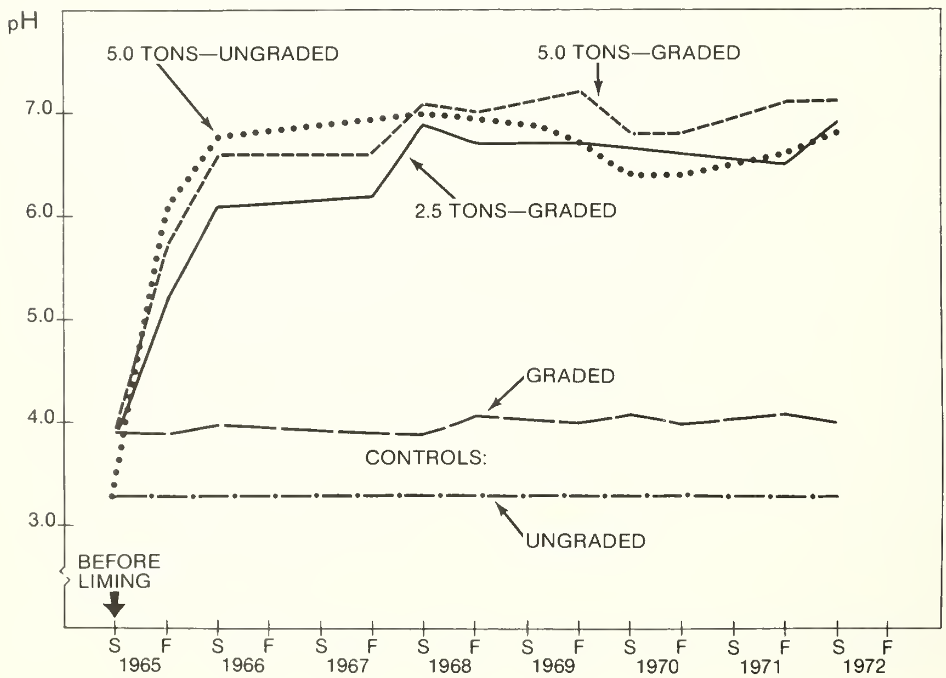
In the fall of 1970 we collected a series of samples at 3-inch intervals to the 15-inch depth from the refuse pile in Tamaqua and in the fall of 1971 from the Shamokin refuse pile. Limed and control plots were sampled. 144 samples were collected from the plots in Tamaqua and 120 from the plots in Shamokin.

All pH values were determined, using a Beckman Zeromatic pH meter in an aqueous solution of 1 to 1 spoil-water ratio and allowing a 30-minute equilibrium period. Mean pH values and ranges were computed and tabulated.

Results and Discussion

pH of the surface layer.—Before liming, the experimental plots were highly acid (fig. 1). As expected, lime gradually raised the pH of the surface layer of both the graded and un-

Figure 1.—Average pH values of graded and ungraded anthracite coal-breaker refuse related to liming rate and years after application. S = spring; F = fall.



graded coal-breaker refuse plots. Three years after liming, the neutral range was reached, and it remained in this range for the following 2 years. During the sixth year, the mean pH values decreased slightly and then increased slightly in the fall of 1971 and in the spring of 1972.

The mean pH values of the ungraded refuse at Shamokin, which was limed with 5.0 tons per acre, were slightly higher than the pH values of comparable graded refuse at Tamaqua for the first 3 years. Then pH values of the ungraded refuse decreased slightly during the following years. A slight increase was noted in the spring of 1972 (fig. 1).

pH of the profile.—The pH measurements of the refuse profile to 15 inches in the control plots at Tamaqua were 3.9 to 4.0 at all depths.

The effects of lime were evident for 5½ years. Refuse samples from the 0 to 1.0-inch upper surface layer were still near neutral. At 3.0 inches the refuse was slightly to medium acid, but the lowest pH value was within the range of pH values in the control plots. The pH values were somewhat higher for the 5.0-ton lime rate than for the 2.5-ton rate in the upper 3 inches. At 6.0 inches the mean pH values of plots limed at either rate were only slightly higher than those of the control plots, but the pH value of 6.7 in the 2.5-ton-per-acre treatment showed that some of the lime had reached this depth. At the depth of 9 to 15 inches the refuse was extremely acid, and no effect of lime was evident (table 1).

The ungraded refuse plots at Shamokin were more acid than the graded plots at Tamaqua. Here the pH values ranged from 3.0 to 3.5 near the surface and 2.8 to 3.1 at 9 inches in depth. The refuse was near neutral near the surface 6½ years after treatment with 5.0 tons of lime per acre. Below 3 inches in depth, the effect of lime decreased sharply. At 9 inches there was some evidence of lime, but at 12 inches the pH values were almost identical to those of the control plots. The range in pH values at 6 to 9 inches suggested that some lime had migrated downward. This may have been due to the slope steepness and the loose material in the plots or to some incorporation of lime into the refuse during liming, tree planting, and mulching activities.

Response of vegetation.—The effects of lime were also visible in vegetation growth (fig. 2). The planted crownvetch on limed plots in Tamaqua spread vigorously and after six growing seasons attained slightly over 85 percent ground cover on both liming treatments. There was no ground cover on the unlimed plots.

Red pine and Japanese larch on ungraded limed plots in Shamokin attained heights of 3.0 and 5.5 feet respectively. Survival was slightly over 31 percent. High mortality occurred during the first growing season, due mainly to rock slides and erosion from the steep slope. Hybrid poplar NE-388 had 80 percent survival and grew 3.9 feet after three growing seasons. No tree survived on the unlimed plots.

Table 1.—Average pH values (and ranges) of anthracite coal-breaker refuse

[Average of 8 replications]

Depth (inches)	Lime in tons per acre: 0	2.5	5.0
GRADED REFUSE—TAMAQUA[1]			
0.5	3.9 (3.5–4.2)	7.4 (6.6–8.0)	7.8 (7.6–8.0)
3.0	3.9 (3.5–4.2)	5.9 (4.0–7.8)	6.5 (4.3–7.6)
6.0	4.0 (3.7–4.1)	4.7 (3.8–6.7)	4.4 (3.4–5.4)
9.0	4.0 (3.6–4.4)	4.2 (3.4–5.0)	4.1 (3.9–4.6)
12.0	3.9 (3.8–4.2)	4.1 (3.6–4.6)	4.2 (3.5–4.9)
15.0	3.9 (3.1–4.5)	3.9 (2.4–4.6)	4.0 (3.5–4.5)
UNGRADED REFUSE—SHAMOKIN[2]			
0.5	3.3 (3.0–3.5)	--	6.9 (6.5–7.2)
3.0	3.3 (3.0–3.5)	—	5.7 (4.6–7.2)
6.0	3.2 (3.0–3.3)	—	4.2 (3.1–6.3)
9.0	3.0 (2.8–3.1)	—	3.5 (3.3–3.7)
12.0	3.4 (3.4–3.5)	—	3.5 (3.3–3.7)
15.0	3.4 (3.4–3.5)	—	3.4 (3.1–3.5)

[1] 5½ years after lime application.
[2] 6½ years after lime application.

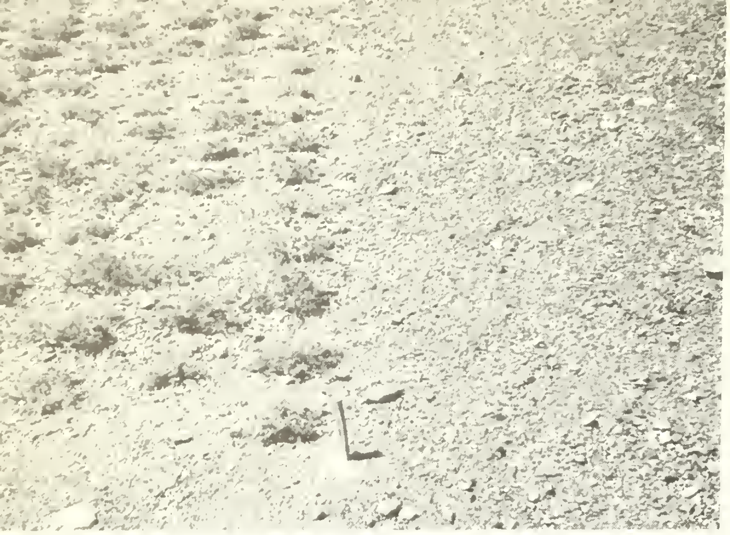


Figure 2.—The "lime line" is clearly visible on this graded coal-breaker refuse. The area on the left was limed; it produced a good cover of crownvetch. The area on the right was not limed; here no crownvetch survived.

Findings and Conclusions

From this study the following findings and conclusions were made:

- Hydrated lime was highly effective in neutralizing the surface layer of anthracite coal-breaker refuse.
- Lime brought the surface layer (0 to 3 inches) to near neutral pH within a year, and the surface layer was still neutral 7 years after liming.
- Lime effect, in terms of neutral pH ranges and establishment of vegetation, was still in evidence 7 years after treatment.
- The effects of lime were detectable to a depth of 9 to 12 inches only.
- The lower liming rate—2.5 tons per acre—was as beneficial as the higher rate—5.0 tons per acre. Evidently 2.5 tons was enough to neutralize the refuse and establish vegetation on the coal-breaker piles studied.
- Average pH values gradually decreased with depth, and at 9 inches in the graded refuse and at 12 inches in the ungraded refuse, pH values on the treated plots approached the values on the control plots.
- Since comparatively low rates of lime neutralized the refuse for at least 7 years, liming appears to be a practical method for establishing vegetation on anthracite coal-breaker refuse. Its use is recommended.

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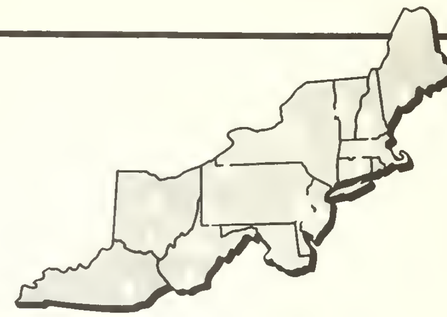


FOREST SERVICE, U.S. DEPT. OF AGRICULTURE, 6816 MARKET STREET, UPPER DARBY, PA. 19082

CAMBIAL DIEBACK AND TAPHOLE CLOSURE IN SUGAR MAPLE AFTER TAPPING

Abstract.—Dead cambial tissues adjacent to tapholes were found to be elliptical in shape and to average 1.6 inches in length and 0.2 inch in width. Chemical and physical treatments designed to stimulate the growth of callus tissues surrounding tapholes were not successful. Nearly all the tapholes, both treated and untreated, had closed after three growing seasons.

Maple sap producers annually drill one to four or more tapholes into their sugar maple trees. These holes are usually 7/16 inch in diameter and 2 to 4 inches deep. The damage caused to the tissues around the taphole is both internal and external. Internal damage results in discoloration of the wood in streaks about ½ inch wide, extending approximately 18 inches above and 18 inches below the taphole. External damage results in the dying of cambial tissues around the hole.

Both types of damage are important. However, the dieback of cambium may be of more concern to the syrup producer, because a tree cannot be tapped again at the same location until the hole has closed and is covered with a layer of wood equal to the taphole depth.

If a taphole closes rapidly, the same area can be tapped again sooner than if the taphole closed slowly. Also, the closing of the taphole tends to inhibit the advance of aerobic decay organisms. The more rapidly the taphole closes, the less chance there is for the decay organisms to gain a foothold in the tree tissues (*Shigo and Larson 1969*).

In an attempt to define and solve this problem, we made two studies at the same time: one to determine the amount of cambial dieback resulting from normal tapping procedures, and another to test several treatments designed to accelerate taphole closure. For both studies, the tapped trees were about 150 years old, averaging 26 inches d.b.h.; and the sugarbushes had a history of severe grazing.

We found that the pattern of dieback was elliptical in shape, averaging 1.6 inches in length and 0.2 inch in width. This dieback pattern was not influenced by spout materials —metal or plastic—or by the use of paraformaldehyde pellets. Chemical and physical treatments to the tissues around the tapholes failed to accelerate callus formation.

Damage to Cambial Tissue

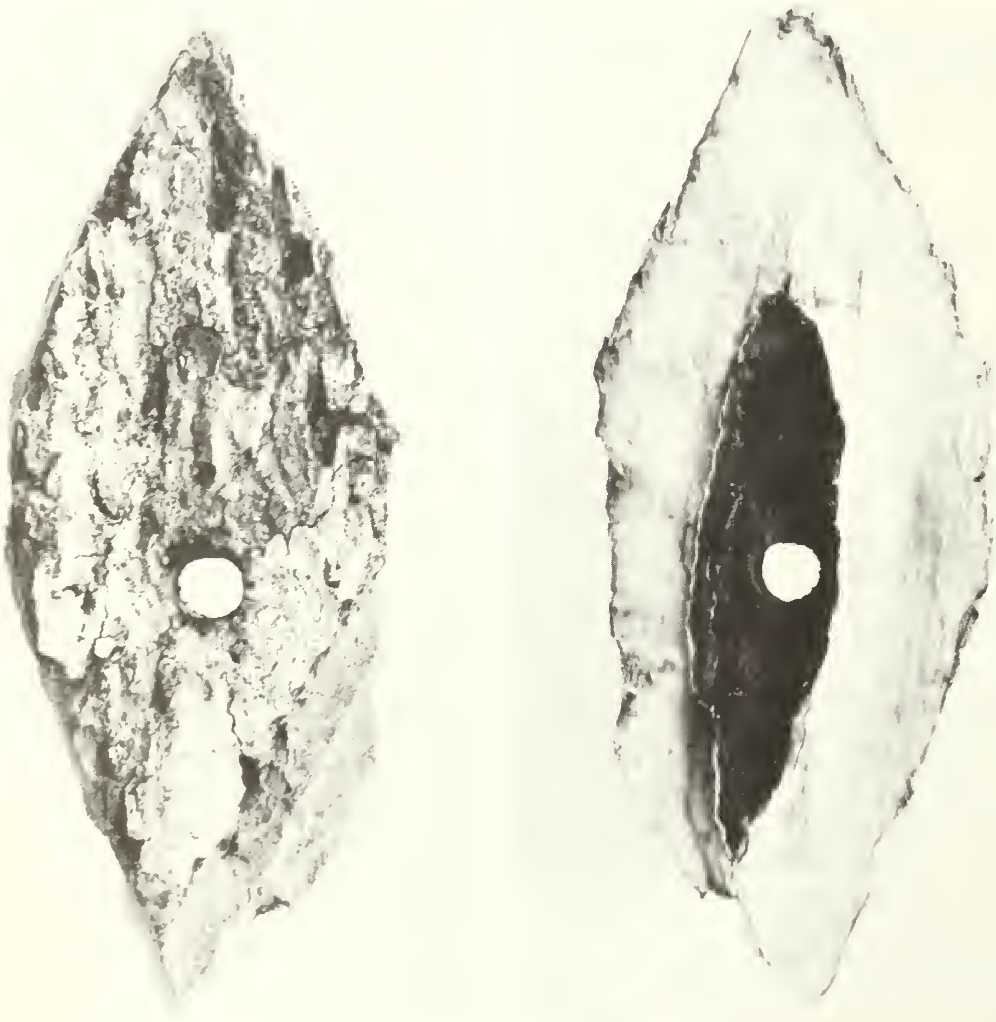
To evaluate the damage to cambial tissue surrounding the taphole, 4 tapholes were drilled in each of 10 trees. All tapholes were 7/16 inch in diameter, drilled to a wood depth of 3 inches. One of the following four treatments was assigned at random to one taphole on each tree.

1. Galvanized metal spout without 250-mg. paraformaldehyde pellet.
2. Galvanized metal spout with 250-mg. pellet.
3. Plastic spout without 250-mg. pellet.
4. Plastic spout with 250-mg. pellet.

The trees were tapped in late February, and the spouts were removed in mid-April. In early July, the bark around each taphole was removed, exposing all the dead cambial tissue beneath (fig. 1). The length and width of the affected area was measured to the nearest 0.01 inch. Taphole dimensions were excluded in these measurements.

The differences in width and length of cambial dieback around each taphole were ana-

Figure 1.—A section of bark and wood removed from a sugar maple tree to reveal the dieback of cambial tissue as a result of tapping. Left, the bark side; right, the under side.



lyzed, using an analysis of variance. The spout material, whether galvanized metal or plastic, and the use of paraformaldehyde pellets, did not significantly affect the amount of dieback:

Treatment	Average cambial dieback Length (inches)	Average cambial dieback Width (inches)
Metal spout without pellet	1.42	0.18
Metal spout with pellet	1.46	0.18
Plastic spout without pellet	1.34	0.14
Plastic spout with pellet	2.00	0.14
Average	1.56	0.16

The length of cambial dieback for the plastic spouts with a pellet—2.00 inches—was greater than that of the other three treatments. However, the difference was not statistically significant at the 5-percent level. Differences in width of dieback were very small. Similar results were reported by Nyland and Rudolph (*1969*).

Figure 2.—Growth of callus tissue is closing this taphole. Most tapholes close in about 3 years.

Taphole Closure

Taphole closure follows a pattern similar to that of healing in a pruning wound. Layers of callus tissue develop from live cambial tissue on each side of the taphole. With each successive layer, the callus converges toward the center of the taphole (fig. 2).

A total of 21 treatments were tried, including physical, chemical, and combinations of both physical and chemical. These treatments were as follows:

Physical.—At the end of the sugaring season in mid-April, tapholes were reamed with a ½-inch drill bit; pellets were washed from the taphole in mid-April.

Chemical.—Reamed tapholes were sprayed with traumatic acid at 300 and 1,200 p.p.m.; 2,4-D at 100 and 1,000 p.p.m.; indole-3-acetic acid at 300 and 1,200 p.p.m. Unreamed tapholes were sprayed with traumatic acid at 500, 1,000, and 2,000 p.p.m.; 2,4-D at 200, 800, and 1,600 p.p.m.; 2,4,5-T at 500, 1,000, and 2,000 p.p.m.; indole-3-acetic acid at 300, 500, and 1,800 p.p.m.

The 2,4-D and 2,4,5-T are synthetic auxins that can be growth stimulators when used in low concentrations (*Wells 1955*). All chemicals were mixed with distilled water.

For all treated tapholes we also had control or untreated tapholes for comparing data results.

We were unable to stimulate the formation of callus tissue around the tapholes; in fact 95 percent of the untreated tapholes healed after 3 years, and only 87 percent of the treated tapholes healed during the same period. One treatment—2,4,5-T at 2,000 p.p.m.—seemed to inhibit taphole healing, because 6 of the 10 treated tapholes showed no evidence of closure after 3 years.

Summary and Discussion

Results of our first study revealed that dead cambium associated with tapping was elliptical in shape and averaged 1.6 inches long and approximately 0.2 inch wide. The amount of cambium killed did not vary with any of the taphole treatments. The great difference between the length and width of damage may be due to the fact that there is little lateral translocation in tree tissues. Therefore, cambium on either side of the taphole was protected from any potentially harmful substances resulting from tapping. Also, and probably more important, driving spouts compresses tissues on the sides of the taphole, and spouts will often split the cambium tissues above and below the taphole.

In our second study, most of the tapholes closed in 3 years, regardless of chemical or physical treatments designed to promote the growth of callus tissue. The reason for failure of the treatments is not clear, but there are at least three possibilities. First, chemical treatments were not in contact with the living tissues long enough to be effective. The use of a carrier more persistent than water, such as lanolin, might have improved the effectiveness of the chemicals. Second, the treatments may not have reached the living tissue. We know that tissues around the taphole are killed very quickly (*Shigo and Laing 1970*), and the combination of heavy bark and dead cambium may have shielded the living tissues from both chemical and physical treatments. Third, the chemicals used in this study may not have been adequate growth stimulators for sugar maple cambial tissues.

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Northeastern Forest Experiment Station

FOREST SERVICE, U.S. DEPT. OF AGRICULTURE, 6816 MARKET STREET, UPPER DARBY, PA. 19082

A NEW KIND OF END-GLUED JOINT FOR THE HARDWOOD INDUSTRY

Abstract.—A method has been developed for end- and edge-gluing short pieces of high-value hardwood lumber into long panels, using a curved end joint we call SEM (Serpentine End Matching). Panels containing SEM end joints are aesthetically pleasing and are suited for exposed applications such as in finished furniture.

Furniture plants generate large quantities of short leftover pieces of wood. End-jointing these short pieces to make longer lengths allows greater utilization of raw materials. Some furniture companies use square butt joints or finger joints to do this. Almost all this material is being used in core stock and unexposed upholstered-furniture parts because these conventional types of joints are considered aesthetically unpleasing for exposed applications.

Researchers at the Forest Products Marketing Laboratory have developed curved end joints called SEM[1] (Serpentine End Matching) for exposed applications. Curved end joints follow the grain pattern of the wood better than the conventional butt or finger joints. The curved line of the SEM joint is less visible than the straight lines of the butt joint or finger joint (fig. 1).

Curved end joints cannot be made with conventional end-jointing equipment. However, use of tape-controlled or optical-head-controlled routers eliminates the machining obstacles.

Producing a Tight Curved End Joint

In end jointing, tightness of fit is essential. Though conventional finger joints or butt joints can be made easily with properly prepared cutterheads, curved end joints present another problem. The curved path of the cutterhead must be controlled precisely.

A curved end joint cannot be made by simply routing a curved path across a piece of wood and pushing the two resulting ends to-

[1] LUMBER PANELS WITH SERPENTINE JOINTS. Hugh W. Reynolds, Philip A. Araman, and Wesley R. Martin. Patent pending at the U. S. Department of Agriculture Office of the General Counsel, Washington, D. C.

ure 1.—An end- and edge-joined panel
r finishing (bleach, stain, and lacquer).

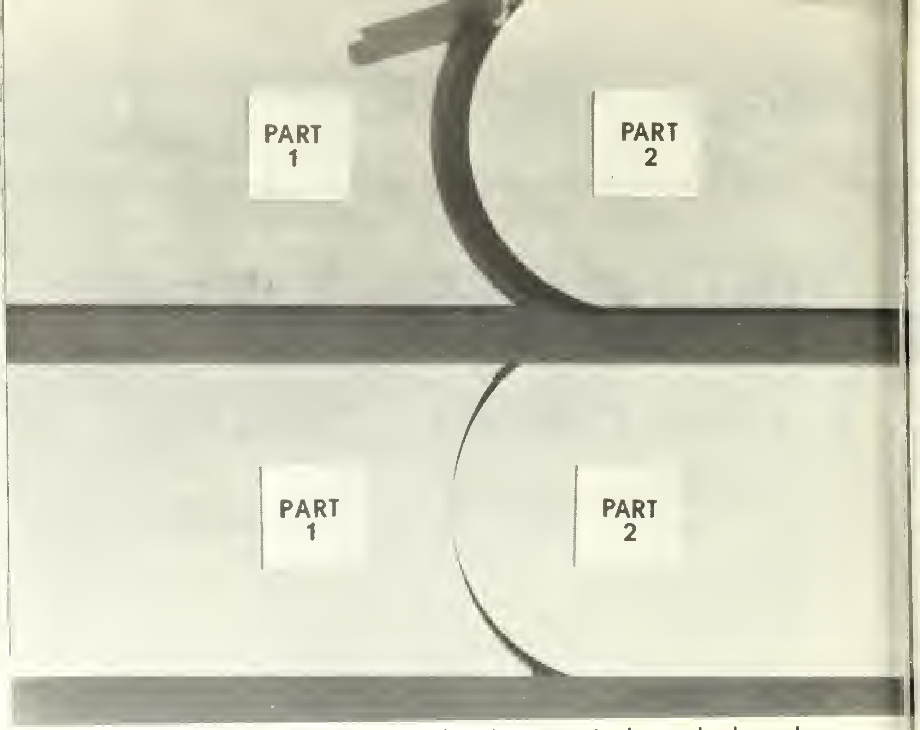

Figure 2.—A single cutterhead on a single path through a board results in two different curves.

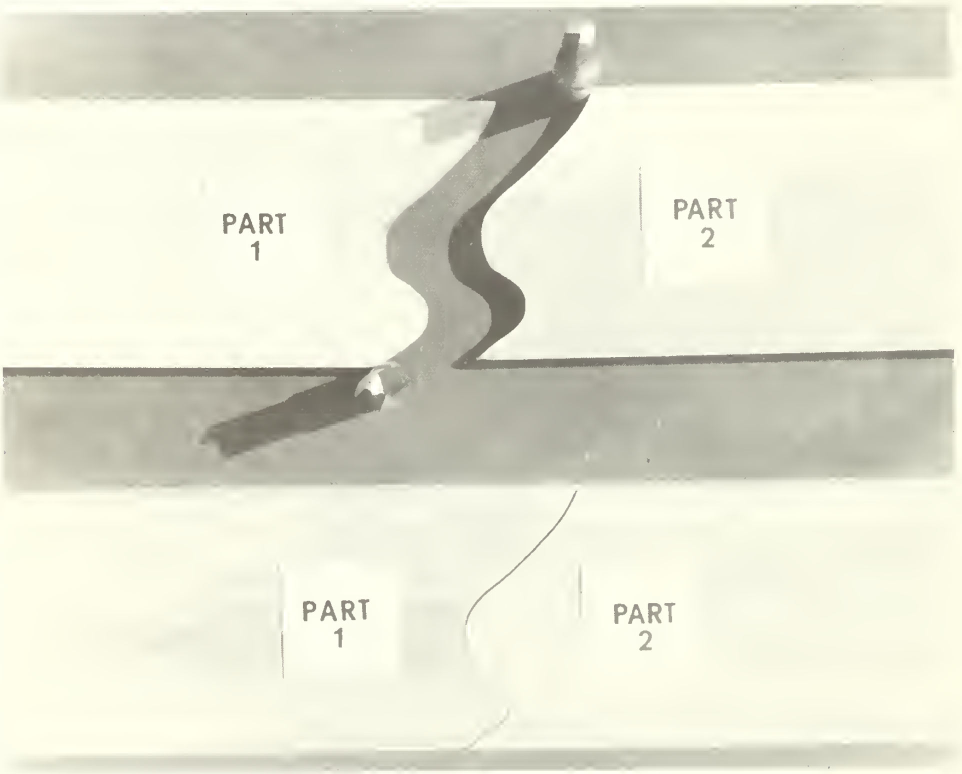

Figure 3.—Two operations, cutting opposite sides of the curve, produce a perfectly tight joint.

gether. A single cutterhead making a single cut through a board produces two different curves that do not fit (fig. 2). For making SEM joints, we used a single curve and a single cutterhead and machined opposite sides of the curve in two operations. The cutterhead follows the left side of the curve for the right part and the right side of the curve for the left part, producing a precisely fitting joint (fig. 3). Automatically controlled routers can produce these curved ends to the close tolerances required for tightness of fit.

Exploratory Study

To test the technical feasibility of the SEM joint, we conducted an exploratory study, using kiln-dried 4/4 No. 1 Common black walnut lumber to make end- and edge-glued panels. The lumber was ripped to eight different widths, from 1¼ to 3 inches, in ¼-inch increments, and was crosscut into random lengths to remove defects.

Several different 3-inch wide SEM curve patterns were used (fig. 4). With each pattern, any 3-inch wide cutting was cut to the full curve. Cuttings less than 3 inches wide used only part of the curve. The end joints were produced with an Ekstrom-Carlson tape-controlled router and a C. O. Porter automatic optical-head-controlled router. (The use of trade names is for information only and should not be considered an endorsement by the Forest Service or the U. S. Department of Agriculture.)

After machining the SEM joints, we end-glued the pieces into strips 6 and 10 feet long. After ripping to produce straight glue-line edges, these strips were then edge-glued into 12-inch-wide panels.

The end joints ranged from almost invisible (where color and grain were similar) to clearly distinct (where sap and heart pieces were joined). After surfacing, sanding, and finishing (bleach, stain, and lacquer, or stain only), most of the joints became very difficult to see and were aesthetically pleasing (fig. 5).

Making these 6- and 10-foot SEM panels with end- and edge-gluing, we utilized 64 percent of the original sample of No. 1 Common black walnut lumber. The yield of rough cuttings was 71 percent, and only 7 percent was lost in machining the end joints and ripping the glue-line edges.

One reason for this high yield was our use of random-length cuttings. Cutting strips into ¼-inch increment widths seemed to have no effect on the yield.

To produce the same kind of 6-foot panels

Figure 4.—Examples of SEM 3-inch patterns that could be used for producing end joints.

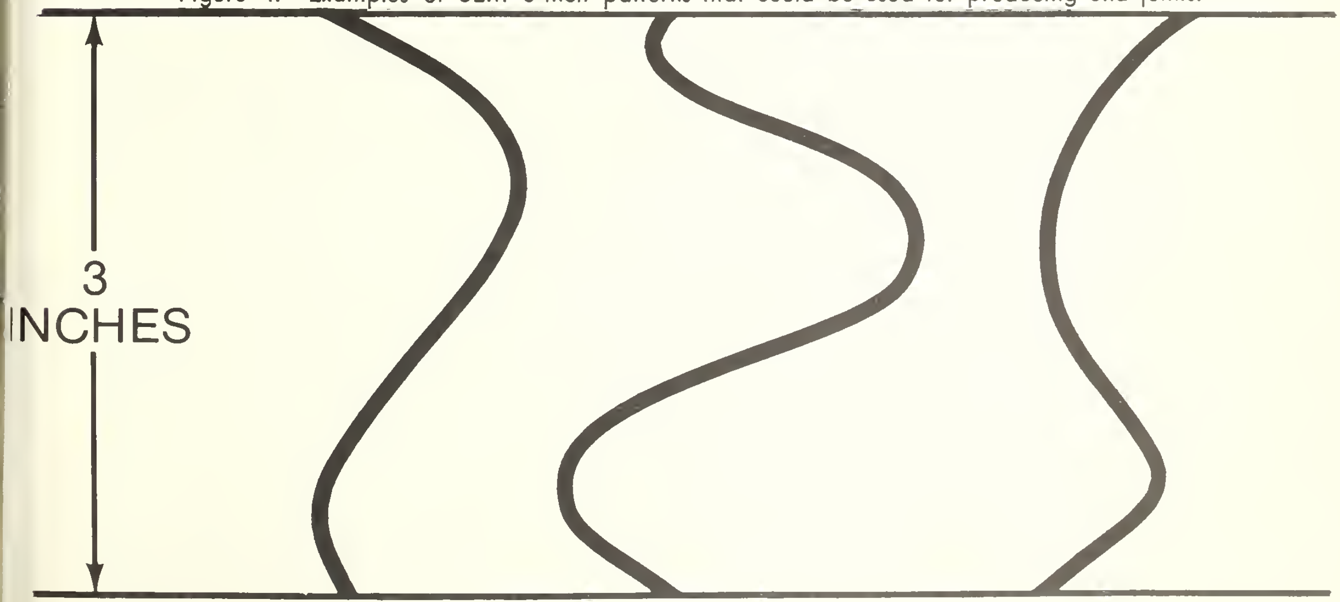

Figure 5.—A product made of SEM panels.

from random-width 6-foot-long strips of the same kind of lumber (No. 1 Common) would utilize only 13 percent of the raw material, according to walnut yield tables from the USDA Forest Products Laboratory (*1971*).

Moreover, SEM panels could be made in longer sizes without any reduction in yield, whereas the yield from making panels from edge-glued solid strips would decrease with any increase in length.

Comments

The SEM joint is technically feasible. Tightly fitted joints of different curvatures are easily made with automatically controlled routers. When wood grain and color are matched and a finish is applied, a well-hidden glue joint results.

SEM provides a method for using short lengths of high-value species for making aesthetically pleasing solid wood panels that can be processed for use in exposed wood products. Further research is under way to determine other methods of producing the joints, the effects of the joints in panels made of other species, and the economic potential of this process.

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Acknowledgments

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Northeastern Forest Experiment Station

FOREST SERVICE, U.S. DEPT. OF AGRICULTURE, 6816 MARKET STREET, UPPER DARBY, PA. 19082

RESPONSE OF PAPER BIRCH SEEDLINGS TO NITROGEN, PHOSPHORUS, AND POTASSIUM

Abstract.—The effects of N, P, and K on the growth of paper birch seedlings were tested in sand culture tests. Each element was tested singly at different supplies while holding constant the supply of all other elements. Seedling growth increased with increasing amounts of nitrogen. Three to 4 percent in the foliage indicated an adequate supply. Seedlings were relatively unaffected by different levels of phosphorus and potassium.

The nutrient requirements of paper birch (*Betula papyrifera* Marsh) have not been thoroughly investigated. Estimates have been made of the amount of various elements present in different portions of trees growing under natural conditions, but little work has been done in sand or solution culture studies where each element can be controlled. Such studies are needed to determine nutrient requirements of trees and to lay a foundation for forest fertilization studies.

In the study reported here, seedling growth improved with increasing amounts of nitrogen, but was relatively unaffected by different levels of phosphorus and potassium. Three to 4 percent nitrogen in the foliage seemed to be adequate for seedling growth.

Methods

The study was conducted in a growth room. Paper birch seeds were germinated, and the seedlings were grown in glazed containers (8 inches in diameter, 12 inches deep) filled with quartz sand and perlite. A combination of incandescent and fluorescent lamps provided about 3,000 foot candles at seedling height. Day length was 16 hours. Day and night temperatures were kept as close as possible to 85 and 65 degrees F, respectively.

The basic nutrient solution contained the required elements at the following concentrations:

	p.p.m.		p.p.m.
Nitrogen	140	Iron	3.000
Phosphorus	100	Manganese	.500
Potassium	175	Boron	.500
Calcium	120	Copper	.060
Magnesium	48	Zinc	.060
Sulfur	64	Molybdenum	.009

When nitrogen, phosphorus, or potassium was the tested element, the respective concentrations were:

Nitrogen	Phosphorus	Potassium
p.p.m.	*p.p.m.*	*p.p.m.*
3.5	1	3
35	5	30
70	50	100
140	100	300
280	200	600
560	400	900

The growing periods were 81 days for the nitrogen test, 91 days for the phosphorus test, and 69 days for the potassium test. During these periods, the seedlings were irrigated with solution about twice weekly. Fresh nutrient solutions, having pH values averaging 4.7, were prepared weekly.

Response was measured by seedling height and dry weight of foliage. In addition, the amount of each tested element in the foliage was determined. Nitrogen determinations were made by the semimicro-Kjeldahl method (*8*). Phosphorus determinations were made colorimetrically, using the vanadate-molybdate-yellow method (*1*). Potassium content was measured by atomic absorption spectrophotometry (*9*). Element content was expressed as percent dry weight and as milligrams per seedling.

Response to Nitrogen

As supplies of nitrogen increased, so did the average height of seedlings, and the average dry weight of foliage per seedling (table 1). However, treatment differences in average height were statistically significant only at 3.5 p.p.m. The dry weight relationships among treatments were similar to those of average height, but the weight data were not analyzed statistically. Optimum growth occurred when the nitrogen concentration was between 70 p.p.m and 140 p.p.m.

Nitrogen content also increased as the nitrogen supply increased (table 1). Treatment effects were statistically significant although the difference between any two treatments had to be relatively large to be significant.

Response to Phosphorus

When the supply of phosphorus was increased to a concentration of 200 p.p.m., average height increased. But at 400 p.p.m., height decreased slightly (table 2). Average dry weight of foliage followed the same trend, except that it was unaccountably high at the lowest concentration.

The phosphorus content of the foliage increased with increasing supplies of this element up to 200 p.p.m. (table 2). A de-

Table 1.—*Average height of seedlings, average dry weight of foliage per seedling, and foliar nitrogen content by treatment*

Nitrogen concentration	Seedlings	Average height	Average dry weight	Nitrogen content	
p.p.m.	*No.*	*mm.*	*mg.*	*Pct.*	*mg. per seedling*
3.5	33	42	63	[a]2.6 a	1.7 a
35	41	251	572	2.8 a	17.9 ab
70	47	370	1,253	3.3 ab	42.7 ab
140	31	341	1,201	3.8 bc	47.1 ab
280	29	373	1,421	4.6 c	69.8 bc
560	11	385	1,741	5.8 d	111.2 c

[a]In any column, treatment means having any letter in common are not significantly different from each other at the 5-percent level.

Table 2.—*Average height of seedlings, average dry weight of foliage per seedling, and foliar phosphorus content per seedling*

Phosphorus concentration	Seedlings	Average height	Average dry weight	Phosphorus content	
p.p.m.	*No.*	*mm.*	*mg.*	*Pct.*	*mg. per seedling*
1	2	244	2,131	1.0	20.0
5	11	302	1,002	.4	3.5
50	8	338	1,666	.7	12.9
100	3	347	2,929	.7	21.8
200	1	492	4,956	1.3	64.4
400	6	372	2,357	1.1	28.4

Table 3.—*Average height of seedlings, average dry weight of foliage per seedling, and foliar potassium content by treatment*

Potassium concentration	Seedlings	Average height	Average dry weight	Potassium content	
p.p.m.	*No.*	*mm.*	*mg.*	*Pct.*	*mg. per seedling*
3	20	206	434	[a]1.6 a	6.8 a
30	16	188	581	4.6 b	27.0 abc
100	30	245	448	5.6 bc	24.8 ab
300	11	155	517	7.8 bcd	40.1 abcd
600	6	101	438	11.0 d	48.3 bcd
900	0	0	0	0	0

[a]In any column, treatment means having any letter in common are not significantly different from each other at the 5-percent level.

crease in content occurred at the 400 p.p.m. level, which coincided with the decreases in height and weight.

Because seedlings were few in number and some treatment replications were not represented, no statistical analyses were made.

Response to Potassium

Neither average height nor dry weight of foliage per seedling appeared to be greatly affected by the amount of potassium supplied up to 600 p.p.m. (table 3). However, mortality occurred at a concentration of 900 p.p.m. There seemed to be a slight trend toward decreasing height and dry weight with an increasing supply, but a statistical analysis of the height data showed that differences due to treatment were not significant. The dry weight data were not analyzed, but the rather small differences by treatment suggested that dry weight response did not vary significantly.

The amount of potassium in the foliage increased rapidly with an increase in the potassium concentration (table 3). An analysis of these data showed that the effects of treatment were statistically significant although a relatively large change in potassium supply was needed to make a significant change in the potassium content.

Discussion

The results of this study indicated that a 3 to 4 percent nitrogen content in the foliage was adequate for satisfactory seedling growth. This amount of foliar nitrogen was slightly greater than that reported for seedling and sapling paper birch trees growing under natural conditions (*10*) but was within the range reported for other hardwood species (*2, 3, 4, 5*) and for many cultivated fruit trees (*7*).

Seedling response did not vary greatly among the different phosphorus levels. However, too few seedlings were harvested to make meaningful comparisons.

Average height and average dry weight did not vary greatly among the different potassium treatments. The foliar content in all but the lowest level of supply exceeded the amounts reported for other forest-grown tree species. However, they were within the range reported for cultivated fruit trees.

Although these results parallel those reported by Ingestad (*6*), they are only tentative. Further testing is required to more accurately define optimum levels of supply and to determine symptoms of deficiency and toxicity.

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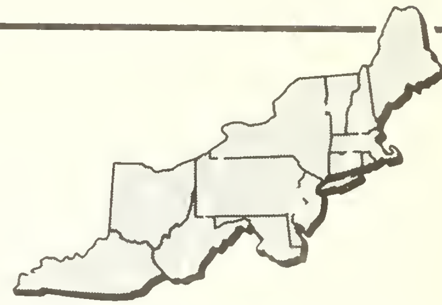


FOREST SERVICE, U.S. DEPT. OF AGRICULTURE, 6816 MARKET STREET, UPPER DARBY, PA. 19082

THE EFFECTS OF VARIOUS COMBINATIONS OF NITROGEN, PHOSPHORUS, AND POTASSIUM ON PAPER BIRCH SEEDLING GROWTH

Abstract.—The combined effects of various concentrations of N, P, and K on the growth of paper birch seedlings were tested in sand culture tests. All other elements were held constant. The best seedling growth and dry weight of foliage generally occurred at concentrations of 400 p.p.m. N, 50 p.p.m. P or 600 p.p.m. N, 75 p.p.m. P. The concentration of K had relatively little effect. The optimum combination was not found but the results suggested that the amount of K should be increased

The response of paper birch seedlings to varied supplies of a single element while holding constant the supply of all other elements was reported earlier (*1*). However, these results may differ when the supply of two or more elements is varied at the same time.

To gain some insight into these interactions, I tested the combined effect of different levels of nitrogen (N), phosphorus (P), and potassium (K) on the growth of paper birch (*Betula papyrifera* Marsh) seedlings. Also, I wanted to identify the combination of these elements that resulted in optimum response.

The results of this study showed that the greater average heights and the greater average dry weights followed treatments high in N and intermediate in P, with K making little if any contribution at the levels tested. However, the element concentrations for optimum growth were not found.

Methods

The study was conducted in a growth room. Seedlings were grown in 4-inch plastic pots filled with quartz sand and perlite. Fluorescent and incandescent lamps provided about 3,000 foot-candles of light at the top of the seedlings. Day length was 16 hours. Day and night temperatures were kept as close as possible to 85 and 65 degrees F, respectively.

Trials of combined N, P, and K were run, using a response surface design (*3, 4*) to determine treatment effects. After a number of trials, a promising treatment of 400 p.p.m.

(parts per million) N, 50 p.p.m. P, and 70 p.p.m. K was reached. Using this as the central treatment, the concentrations were calculated to be:

N	*P*	*K*
p.p.m.	*p.p.m.*	*p.p.m.*
64	8	11
200	25	35
400	50	70
600	75	105
736	92	129

The other elements were supplied in the following concentrations:

	p.p.m.		*p.p.m.*
Calcium	120	Manganese	0.500
Magnesium	48	Boron	.500
Sulfur	64	Copper	.060
Iron	3	Zinc	.060
		Molybdenum	.009

A total of 15 treatments were tested, and each treatment was replicated twice.

The treatment solutions were not applied until all seedlings had developed their first true leaves. During this period, all pots received periodic alternate applications of de-ionized distilled water and of nutrient solution. This solution (140 p.p.m. N, 100 p.p.m. P, and 175 p.p.m. K, and other elements as shown above) was applied at one-half strength.

The growth period was 70 days, from the time of the first application of the treatment solutions to seedling harvest. During this period, the treatment solutions were added twice weekly in 50 ml. amounts, alternating with 50 ml. amounts of de-ionized distilled water.

The seedling response was measured in terms of height growth and dry weight of foliage. In addition, the amount of each tested element in the foliage was determined. Nitrogen determinations were made by the semimicro-Kjeldahl method (*6*). Phosphorus determinations were made colorimetrically, using the vanadate-molybdate-yellow method (*2*). Potassium content was measured by atomic absorption spectrophotometry (*7*). Element content was expressed as a percent of the dry weight of foliage.

Height Growth

Because the average height of seedlings varied at the start of treatment, height growth was used to estimate the effect of treatment. On this basis, seedlings in the 600-75-35 (N-P-K) treatment responded best — their average height increased nearly 20 times to 339 mm. Seedlings in the 400-50-129 treatment did nearly as well. The average height of these seedlings increased about 18 times to reach 200 mm.

Ranking treatments in order of average height increase shows that the differences between successive treatments were generally small (table 1).

Table 1.—*Average height at start of treatment, at harvest, and height increase factor, by treatment*

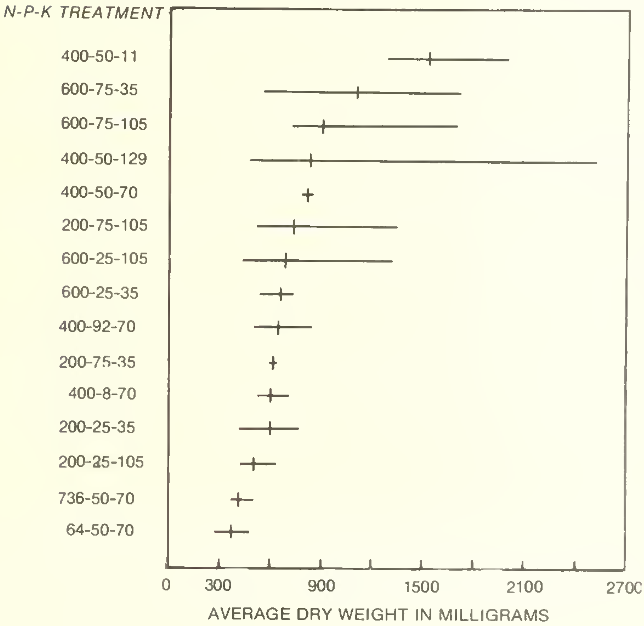
N-P-K treatment	Average height		Increase factor
	Start	Harvest	
	mm.	*mm.*	
600-75-35	17	339	20
400-50-129	11	200	18
400-50-11	17	234	14
400-8-70	14	176	12
400-50-70	15	185	12
200-75-105	15	177	12
600-75-105	17	190	11
200-25-35	14	155	11
736-50-70	17	188	11
600-25-35	15	151	10
400-92-70	19	174	9
200-75-35	14	126	9
600-25-105	20	178	9
200-25-105	16	132	8
64-50-70	18	115	6

Dry Weight of Foliage

The average dry weight of foliage per seedling varied by treatment, but no one level of nutrient supply was best consistently. In general, the treatments resulting in the greater dry weights tended to have both nitrogen and phosphorus in the middle range of concentrations while the concentration of potassium appeared to have little effect (fig. 1). In many cases, the variation in average dry weight of foliage per seedling was greater between replicates of the same treatment than it was between adjoining treatments.

Dry weight of foliage appeared to be a slightly more sensitive indicator of response to treatment than average height or height growth.

Figure 1.—Variation in foliage dry weight is often greater between treatment replications than between adjoining treatments. Here the horizontal lines show the range in dry weight with the mean indicated.



Element Content

As the supply of nitrogen increased, so did the percent nitrogen content in the foliage (table 2). Variations in the content of either phosphorus or potassium in the foliage were much less apparent although the content of these elements tended to increase slightly with increasing supplies.

Response Surface Analysis

A response surface analysis of both average height and of average dry weight indicated that the optimum level of potassium was not tested. However, within the range of concentrations tested, the optimum levels were:

	Nitrogen *p.p.m.*	*Phosphorus* *p.p.m.*	*Potassium* *p.p.m.*
Average height	500	78.3	88.4
Average dry weight	326	60.1	67.5

Discussion

The results of this study suggest that paper birch seedlings are more responsive to changes in nitrogen supply than they are to changes in phosphorus and potassium supplies. Within the conditions of the study, the better height growth and average dry weight of foliage were associated with 400 p.p.m. and 600 p.p.m. N, 50 and 75 p.p.m. P, and almost any concentration of K.

The effects of these elements were not greatly different, whether applied in combination or singly. However, the concentration of N giving the most favorable growth response was greater where N was supplied in combination with P and K than where N only was supplied. Nitrogen was the only element for which the foliar content appeared strongly related to supply.

The optimum combination of these elements was not defined by this study. Ingestad (*5*), working with *Betula verrucosa* Ehrh., reported that the optimum proportions of N., P, and K should be in the ratio of

Table 2.—*Percent content of nitrogen, phosphorus, and potassium in the foliage of paper birch seedlings, by treatment*

N-P-K treatment	Foliage content		
	N	P	K
	Pct.	*Pct.*	*Pct.*
64-50-70	1.4	1.6	1.8
200-25-35	2.8	1.4	1.2
200-25-105	2.8	1.7	1.7
200-75-35	2.8	2.0	1.3
200-75-105	3.0	1.8	2.2
400-8-70	3.8	1.6	1.4
400-50-11	4.0	1.7	.7
400-50-70	3.9	1.7	1.6
400-50-129	3.8	1.6	2.5
400-92-70	4.4	2.4	1.8
600-25-35	4.9	.9	.9
600-25-105	5.0	1.2	1.5
600-75-35	5.5	1.3	.9
600-75-105	5.1	1.5	1.6
736-50-70	5.3	1.4	1.2

100:13:65. On this basis, the relative amounts of N and P in the central treatment used here were satisfactory while the amount of K should have been 3 to 4 times greater. The response surface analysis of the study data, by indicating that the K supply was low, agrees with these general relationships. Thus, further testing is needed to determine the optimum levels of supply; and the results reported here should be considered as a first approximation only.

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FOREST SERVICE, U.S. DEPT. OF AGRICULTURE, 6816 MARKET STREET, UPPER DARBY, PA. 19082

A PREVIEW OF DELAWARE'S TIMBER RESOURCE

Abstract—The recently completed forest survey of Delaware indicated little change in the total forest area since the 1957 estimate. Softwood volume and the acreage of softwood types decreased considerably. Hardwoods now comprise two-thirds of the volume and three-fourths of the forest area. Total average annual growth exceeded removals, but softwood removals exceeded average annual growth by 50 percent.

A resurvey of the timber resources of Delaware was completed late in 1971. A statistical-analytical report containing data gathered on the inventory and an analysis of the trends and the current situation is being prepared for publication.

This interim release of some of the pertinent findings is intended to provide a glimpse at the forest-area and timber-volume totals and to point out some of the more important changes that have occurred since the initial forest survey was completed in 1956.

The total forest area has remained rather constant during this 15-year period. The 1972 total of 392,000 acres is almost the same as the 1957 figure.

However, there were several notable changes in the total acreage. The proportion of commercial forest land declined slightly. Thirty percent of the land area of Delaware is now classified as commercial forest. Major changes occurred in the forest types that comprise the commercial forest base. The softwood types occupy only one-half the area they did in 1957. Most of the area formerly classified as softwood is now in the oak-hickory and oak-pine forest types.

Timber-volume data reveal that the First State now has the highest average volume per acre of any state east of the Mississippi River. The average volumes are 1,530 cubic feet and 3,343 board feet per acre.

Notable changes have occurred in the species composition of this volume. Two-thirds of the 588 million cubic feet of growing stock are in hardwood species. In 1957 softwood species made up nearly one-half of the total growing-stock volume.

Remeasured plot data indicate that the ratio between average annual growth and average annual removals of all species is 3 to 2—18.3 million cubic feet of growth to 12.6 million cubic feet removed. But average annual removals of softwoods were 50 percent greater than the average annual growth, while average annual removals of hardwoods were less than 30 percent of the average annual hardwood growth.

Table 1.—*Land area of Delaware, by major classes of land and counties, 1972*

[In thousands of acres]

Land class	County			Total
	Kent	New Castle	Sussex	
Forest land:				
Commercial	93.1	55.7	235.6	384.4
Noncommercial	1.5	1.1	4.8	7.4
Total	94.6	56.8	240.4	391.8
Nonforest land	285.6	223.5	367.6	876.7
Total area	380.2	280.3	608.0	1,268.5

Table 2.—*Area of commercial forest land, by forest types, Delaware, 1972*

Forest type	Thousand acres	Percent
Loblolly-Virginia pine	99.2	25.8
Oak-pine	56.6	14.7
Oak-hickory	147.2	38.3
Oak-gum-red maple	69.8	18.2
Other types	11.6	3.0
Total	384.4	100.0

Table 3.—*Net volume of growing stock and sawtimber on commercial forest land, by species, Delaware, 1972*

Species	Growing-stock volume		Sawtimber volume	
	Million cubic feet	*Percent*	*Million board feet*	*Percent*
Loblolly pine	157.9	26.9	370.6	29.0
Virginia pine	25.6	4.4	46.1	3.6
Other softwoods	.8	.1	1.3	—
Total softwoods	184.3	31.4	418.0	32.6
White oaks	72.7	12.4	155.9	12.1
Red oaks	69.5	11.8	162.8	12.7
Hickory	22.0	3.7	48.0	3.7
Soft maples	72.9	12.4	138.8	10.8
Beech	15.8	2.7	48.9	3.8
Blackgum	17.2	2.9	42.0	3.3
Sweetgum	83.2	14.2	137.7	10.7
Yellow-poplar	32.3	5.5	100.2	7.8
Other hardwoods	17.7	3.0	31.4	2.5
Total hardwoods	403.3	68.6	865.7	67.4
Total, all species	587.6	100.0	1,283.7	100.0

Table 4.—*Average annual net growth and removals of growing stock, by species, Delaware, 1957-71*

[In thousand cubic feet]

Species	Average annual	
	Growth	Removals
Loblolly pine	4,293	6,941
Virginia pine	1,572	1,776
Other softwoods	35	183
Total softwoods	5,900	8,900
Select oaks [a]	2,132	477
Other oaks	4,573	1,672
Hickory	352	136
Soft maples	1,401	244
Blackgum	263	320
Sweetgum	2,389	391
Yellow-poplar	1,156	295
Other hardwoods	134	165
Total hardwoods	12,400	3.700
All species	18,300	12,600

[a] Includes white oak, swamp white oak, swamp chestnut oak, and northern red oak.

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Northeastern Forest Experiment Station

FOREST SERVICE, U.S. DEPT. OF AGRICULTURE, 6816 MARKET STREET, UPPER DARBY, PA. 19082

SAWLOG SIZES: A COMPARISON IN TWO APPALACHIAN AREAS

Abstract. Frequency distributions of log diameter and length were prepared for eight Appalachian hardwood species. Data obtained in Ohio, Kentucky, and Tennessee, were compared with information collected previously from West Virginia and New England. With the exception of red oak, significant regional differences were found.

The decision to replace a piece of logging or milling equipment, compete in a new market for timbers, or initiate an economic study of mill operations, involves many factors. One of the factors should be a knowledge of the characteristics of the basic input—logs. In some instances, an "eyeball" estimate is adequate; however, there are times when better information is needed.

Tables and graphs of the frequency distributions of the most commonly used Appalachian hardwood species have been published.[1] These data show the percentage of sawlogs of each diameter, length, and grade. Field reports indicate that these distributions are reliable when used where the data were collected: primarily West Virginia and New England (Region 1). To determine their applicability in other areas, we sampled log deliveries at six sawmills in Ohio, Kentucky, and Tennessee (Region 2). Mills in both regions were producing primarily grade lumber, although one mill in Region 2 also produced pallet material.

Log grade data from Region 2 were inadequate for a comparison of grade distribution with the original sample. However, sufficient information was available to make valid comparisons of diameter and length distribution.

Comparing Diameter Distributions

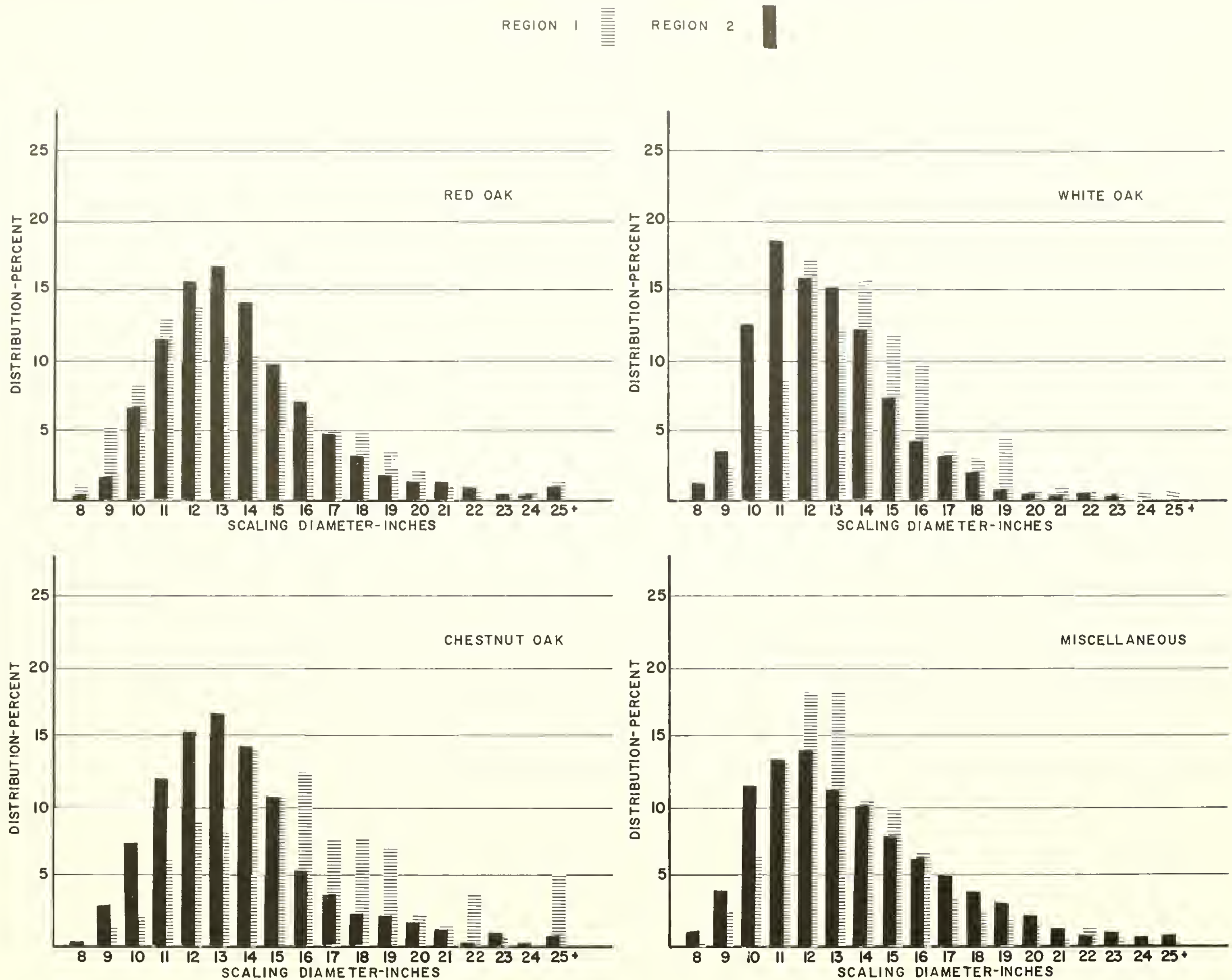
A plot of scaling diameters by frequency of occurrence shows both similarities and differences between the two regions (fig. 1). There are noticeable differences between regions in the curves for some species, particularly in individual diameter percentages. Tests showed that distributions for maple and red oak from Region 2 compared favorably with those from Region 1. Distributions for the other species showed considerably less agreement.[2]

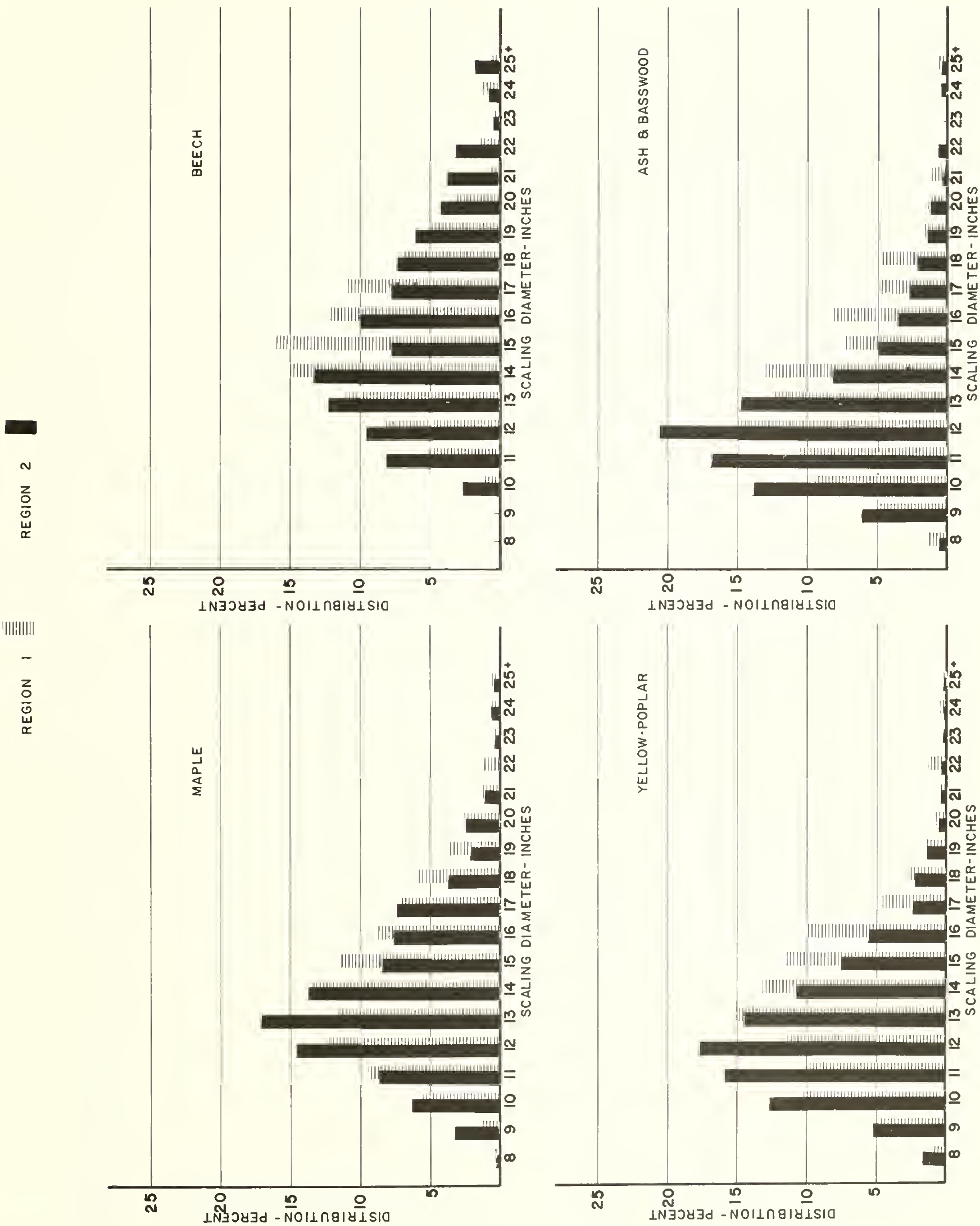
The diameter frequency distributions for both regions were concentrated heavily in the 11- through 15-inch diameter classes. The plotted frequencies for Region 1 rise abruptly, peak at 12 to 14 inches, and decline rapidly. Distributions for Region 2 follow a similar

[1] Goho, Curtis D., and Paul S. Wysor. 1970. CHARACTERISTICS OF FACTORY GRADE HARDWOOD LOGS DELIVERED TO APPALACHIAN SAWMILLS. USDA Forest Serv. Res Paper NE-166, 17 pp., illus., NE Forest Exp. Sta.

[2] Goodness-of-fit tests resulted in a Chi-square value for maple of 9.7, red oak—10.0, yellow-poplar and cucumber—14.3, miscellaneous species—16.7, ash and basswood—17.7, beech—24.7, white oak—33.5, and chestnut oak—51.4 (with 16 degrees of freedom).

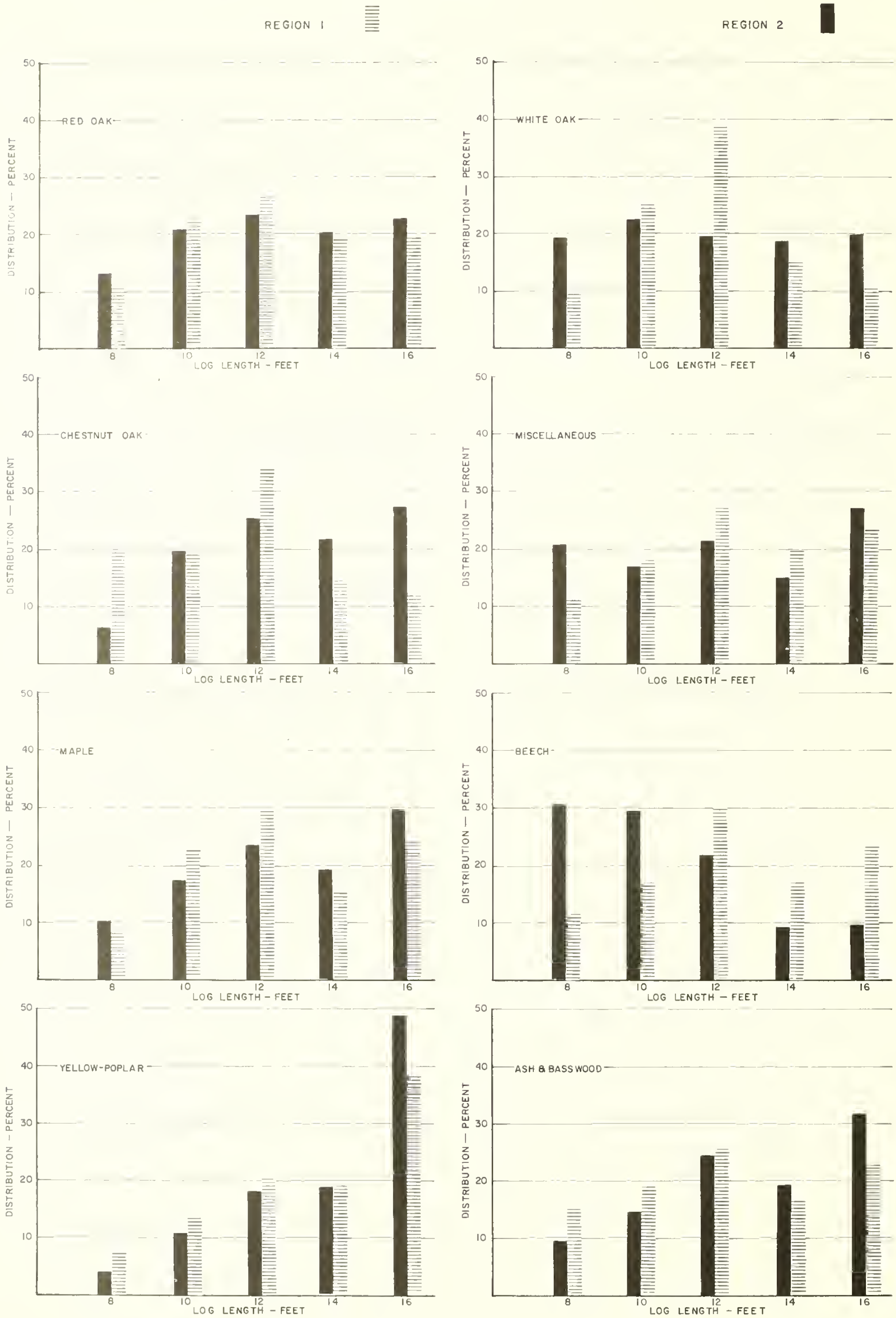
Figure 1. Comparison of distribution of log diameters between Regions 1 and 2.





REGION 1
REGION 2
MAPLE
BEECH
YELLOW-POPLAR
ASH & BASSWOOD
DISTRIBUTION - PERCENT
SCALING DIAMETER - INCHES

Figure 2. Comparison of distribution of log lengths between Regions 1 and 2.



pattern; however, they peak at 11 to 13 inches, or generally 1 inch less than those for Region 1.

Comparing Length Distributions

Log length distribution curves (fig. 2) for Region 1 show a steady increase from 8- to 12-foot logs, a decline in 14-foot logs, and a slight increase in the 16-foot category. The length distribution of red oak from Region 2 is very similar to that from Region 1.

However, not all length distributions exhibit such close agreement. Indeed, there is considerable variation between regions in length distributions for most species.[3] The greatest variations are in the distributions of beech, chestnut oak, and white oak. Percentages of some log lengths vary as much as 20 percent between the two regions. Elimination of data from the mill sawing pallet material had little or no effect on the distributions.

Discussion

In our opinion, only the red oak distributions (diameter and length) can be used reliably outside of Region 1. Of course, the data from Region 2 (shown on figs. 1 and 2) can be used in Ohio, Kentucky, and Tennessee. Log length distributions, however, can be modified to some extent by individual mill operators to meet their needs.

The analysis of diameter distributions from both regions shows that with the exception of chestnut oak and beech:

- At least 50 percent of all delivered logs are 13 inches or less in diameter.
- 75 percent are 15 inches or less.
- 90 percent are 19 inches or less.

This extremely high percentage of small diameter logs confirms the opinions of most mill operators. Increased efficiency in the processing of small logs may require changes in mill design, and these changes may be influenced by these distributions. Technological advances in logging techniques may also result from this information.

In conclusion, although some similarities have been uncovered between regions, in general there appear to be significant regional differences. This suggests that additional surveys are needed in other areas of the country; and that the geographical regions should probably be made smaller.

Perhaps the information from Regions 1 and 2 should be subdivided by state or some other area. It would also be desirable to have periodic surveys so that changes in log sizes could be observed over time.

[3] Goodness-of-fit tests resulted in a Chi-square value for red oak of 1.5, maple—5.1, yellow-poplar and cucumber—5.2, ash and basswood—7.4, miscellaneous species—11.1, white oak—27.8, chestnut oak—34.8, and beech—59.9 (with 3 degrees of freedom).

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WOODEN BEVERAGE CASES CAUSE LITTLE DAMAGE TO BOTTLE CAPS

Abstract.—Wooden beverage cases cause little damage to aluminum resealable caps during distribution. A study at bottling plants and distribution warehouses showed that an average of 1 bottle out of 4,000 has cap damage. Most of the damage was attributed to handling at the warehouse and in transit. Some recommendations are given for improvement of wooden beverage cases to prevent damage.

Wooden beverage cases used in distributing and storing soft drinks cause very little damage to aluminum bottle caps. This was revealed in a recent survey conducted by the U. S. Forest Service in cooperation with the Wooden Beverage Case Institute.

Soon after the introduction of aluminum screw-type bottle caps for use on returnable bottles, beverage-case manufacturers were told by bottlers that half-depth wooden beverage cases caused some damage to the bottle caps both when the cases were stacked upon one another in the bottler's warehouse and also during delivery. So our study was made to document the type and frequency of damage and to determine how seriously the damage affects the marketability of the soft-drink product. Half-depth wooden beverage cases and fiber and plastic cases were evaluated.

Four major soft drink syrup companies were surveyed, and data were taken from 15 of their franchised bottlers. Of the 15 bottlers, eight used half-depth wooden cases; five used half-depth fiberboard cases and one used full-depth fiberboard cases; and one used plastic cases.

In this study, we defined damage as that that required the removal of the bottle from the market. During our study, bottlers examined damaged bottles with us. They agreed that the seriously damaged bottles should not be placed on retail shelves for sale to the consumer.

Half-Depth Wooden Beverage Cases

We collected data from eight bottlers who used half-depth wooden beverage cases. Of these, five used corrugated paperboard slip sheets between case layers to stabilize pallet loads and prevent damage to the bottle caps. The other three used no slip sheets.

The general data collected at these bottling plants did not define the frequency of the damage problem. Therefore we collected more detailed data at one bottling plant and one distribution warehouse. The returned bottles whose caps were damaged during shipment were observed, recorded, and compared with total volume of shipments.

More than 430,000 bottles — about 18,000 cases — were observed at the one bottling plant and the distribution warehouse. Of these 430,000 bottles, we found 113 bottles damaged so that the product was not marketable. This figures out to 2.6 bottles out of 10,000 delivered to the retailer, or about one bottle per 160 cases. The damage was 0.0258 percent of the total number of bottles observed:

Source	Bottles observed	Damaged bottles	Type of damage observed: Punctured	Twisted loose	Dented	Scarred or scraped	Total
	No.	*No.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
Bottler	386,400	83	0.0114	0.0054	0.0039	0.00078	0.0215
Warehouse	52,224	30	.0096	.0306	.0096	.0077	.0575
All sources	438,624	113	0.0112	0.0084	0.0046	0.0016	0.0258

Puncture damage occurred at about the same frequency at both bottling plant and distribution warehouse. On the other hand, damage due to caps twisting loose was about 6 times greater at the distribution warehouse than at the bottling plant; damage due to denting was about 2½ times greater at the distribution warehouse than at the bottling plant; and damage due to scarring or scraping was 10 times greater at the distribution warehouse than at the bottling plant.

The four types of damage occurred with the following frequency:

Type of damage	*Frequency:* *Percent*	*No. of bottles*
Punctured	43	49
Cap twisted loose	33	37
Dented	18	20
Scarred or scraped	6	7

Punctures made up the largest portion of the damage we recorded. We considered a cap punctured when there was a complete perforation of the metal cap and its liner, resulting in a release of carbonation. The fact that a delivery-truck driver frequently has no alternative but to slide cases is a contributing factor to this type of damage. We attributed more than 90 percent of this type of damage to exposed nails on the bottom of the wooden case.

We considered a cap twisted loose when it had been flexed or moved enough to break the seal or to loosen it from the bottle threads, resulting in a release of carbonation.

The fact that the delivery-truck driver slides and twists the cases during delivery definitely contributes to caps twisting loose. More than 80 percent of this type of damage was attributed to driver handling. Damage of this type was discerned mostly by observing the loss of fluid from bottles.

We considered a cap dented when there was a severe deformation or depression in it, the liner being cut, allowing a release of carbonation from the soft drink. The dents were caused by a blow or pressure on the cap during handling. Although we attributed 50 percent of this type of damage to case strapping and 50 percent to irregularities of the case bottom, the human factor as a cause of this type of damage should not be overlooked.

We considered a cap scarred or scraped when the lithograph on it was defaced and considerable bare metal was exposed, resulting in a general unsightly appearance. Consumer acceptance of the product rather than loss of carbonation was the determining factor in this case. We attributed about 80 percent of this type of damage directly to friction from the bottom of the case during handling.

Fiber Cases

We also collected data from five bottling plants that used half-depth fiberboard cases and one plant that used full-depth fiberboard cases. Cap damage that would make the product unmarketable could not be attributed directly to the fiber cases. The only damages that could be related directly to the fiberboard cases were minor scratches and dents that would not make the product unmarketable.

Plastic Cases

Only one bottler who used plastic cases for handling returnable bottles was included in this study. Data from this bottler indicated that damage was not a problem.

Summary and Recommendations

An average of only five bottles out of 20,000 are damaged. However slight, the problem of damaged caps does exist. Many factors influence the degree of damage experienced by a bottler who uses half-depth wooden beverage cases:

1. Care used in handling the product.
2. Number of handlings the product receives before delivery.
3. Distance from the production point to the sales point.
4. Highway conditions encountered during the delivery process.
5. Case-stacking practices — use of corrugated paperboard slip sheets.
6. Case condition — old or new.

The care used in handling the soft-drink product may be important in cap damage. Because of the nature of the product, more damage is likely to occur now than before. The soft aluminum caps now used are more susceptible to damage than the hard steel caps formerly used. So are the flat, narrow, fragile rims on the glass bottles now used as opposed to the former rounded, thick, fire-hardened rims. Consequently, the care that plant and delivery personnel exercise in handling the product will have a direct effect on the amount of damage. Rough handling probably will lead to greater damage.

The number of handlings and the distance from the production point to the sales point are essentially the same for all bottlers.

Highway conditions encountered during the delivery process vary from one bottler to another. When a bottler ships to a distant distribution warehouse for final delivery, both the number of handlings and the distance are increased. Poor road conditions also increase the amount of damage. As much as ten times greater damage occurs when the product undergoes increased handlings and is shipped over greater distances.

Case-stacking practices in the bottlers' warehouse and on the delivery truck varied. Bottling plants using half-depth wooden beverage cases were divided on the practice of using slip sheets between case layers. More than half the plants used some interleaving to stabilize pallet loads and prevent cap damage. Although no cap damage was experienced by bottlers who use slip sheets, this practice is both time-consuming and expensive. Bottlers who did not use slip sheets either repaired or replaced cases as required. These bottlers in effect were substituting good case condition for use of slip sheets.

Case condition is important. Our survey showed that half-depth wooden cases that are new or in good repair are less likely to damage bottle caps. More than 60 percent of all observed damage was caused by poor case conditions: exposed nails; loose strapping, and split, warped, or broken sides and bottoms.

Case condition should not be considered the only cause of damage. For instance, twisting loose of the caps was the second most frequent type of damage. This damage was more likely caused by a twisting or shearing action either in the handling of the case or a shifting of the entire pallet load while in transit. On the other hand, punctures, dents, scars, and scrapes may be attributed directly to the beverage case.

To minimize the cap damage related directly to the use of half-depth wooden beverage cases, we recommend:

1. That nails that have greater withdrawal resistance be substituted for nails now

used. Annular-ring or helically-threaded nails should be considered because of their much greater withdrawal resistance.

2. That more tension be applied to bands before nailing to ensure that the band is flush at the corners.
3. That the bands be recessed to greater depths than at present.
4. That a one-piece bottom with recessed holes be considered for case design.
5. That bottlers place increased emphasis on care in handling by plant and delivery personnel.

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A BENOMYL-DERIVED FUNGITOXICANT FOR TREE WILT DISEASE CONTROL

Abstract.—Methyl 2-benzimidazolecarbamate (MBC) was derived from benomyl, a relatively new broad-spectrum systemic fungicide. MBC•HCl solutions have been found to be fungitoxic, stable, suitable for injection into trees, and effective in wilt disease control.

Prospects for control of vascular-wilt disease of trees have been greatly improved by the recent development of the broad-spectrum systemic fungicide methyl 1-(butylcarbamoyl)-2-benzimidazolecarbamate—common name, benomyl.

This fungicide has been applied experimentally as a soil drench and foliar spray, and by injection into the vascular system of the tree. Benomyl applied to the root zone of American elms by soil drenching gave some protection from Dutch elm disease, but relatively large amounts were required (*1, 15*); and uptake from some soils was unsatisfactory for control (*6*). Foliar sprays of benomyl have been reported as somewhat effective for control of Dutch elm disease (*5, 15*), but spraying is viewed with considerable apprehension because of possible contamination of the environment. Solubilized benomyl injected directly into the xylem of elm, oak, and maple trees becomes distributed in the branches and twigs (*3*); and this method seems to offer many advantages over other methods while possessing few disadvantages.

Benomyl is only sparingly soluble in water and has generally been applied as an aqueous suspension. However, Gregory *et al.* (*3*) reported that only small quantities of aqueous suspension of benomyl could be injected into elms and oaks, using a pressure-injection apparatus (*7*) that introduces the fluid into the vessels of the outer two or three annual growth rings. The suspended benomyl particles quickly plugged the xylem vessels. Hence a soluble form of benomyl or a fungitoxic derivative seemed to be essential for success with this injection method.

Important properties for a chemical to be suitable for injection into trees are:

- Solubility at high concentration.
- Capacity for infinite aqueous dilution.
- Low viscosity in the required solution concentration.
- Retention and persistence of fungitoxic activity.
- Minimum phytotoxicity in solution.
- Chemical stability.

This paper is a report about the preparation of a water-soluble benomyl-derived fungitoxicant, confirmation of its chemical identity, and determination of its fungitoxicity and suitability for injection into trees.

Method

Three hundred twenty grams of Benlate 50 WP (the available source of benomyl) were added in portions to 2 liters of de-ionized water at 90°C., and 200 ml. of 6 N HCl were concurrently added dropwise, with continuous stirring. Stirring and temperature were maintained for 20 to 30 minutes until gas evolution ceased. The solution was treated with decolorizing charcoal, and then was filtered. Two hundred eighty-four grams of solute (89 per cent yield) were obtained. The filtrate was stirred during dropwise addition of 160 ml. of 5 N NH_4OH, which produced a precipitate assumed to be methyl 2-benzimidazolecarbamate (MBC), which was collected and water-washed, yielding 132 g. (41.5 per cent MBC).

76 g./l. of fungitoxicant solution (stock solution) was obtained by nearly saturating 0.5 N HCl with the precipitate. Appropriate dilution of this solution with water provided low-viscosity solutions suitable for injection. pH ranged from 1.0 at 50 g./l. to 2.1 at 1 g./l. pH of these solutions can be increased somewhat without precipitation.

Confirmation of the benomyl-derived fungitoxicant as methyl 2-benzimidazolecarbamate (MBC) was made by elemental analysis of the prepared hydrochloride, picrate, and 3.5-dinitrosalicylate salts, as follows:

MBC•HCl was prepared by dissolving the assumed MBC prepared by the foregoing processes in an excess of 1 N HCl. Evaporation produced crystalline needles, which were put into solution, charcoaled, and dried, yielding a melting point of 163 to 167°C. Elemental analysis showed percentages of C, 47.21; H, 4.50; Cl, 15.46; and N, 18.21; compared to the theoretical percentages C, 47.50; H, 4.74; Cl, 15.58; and N, 18.46.

MBC picrate was prepared as follows. One gram of assumed MBC•HCl prepared as described was dissolved in 15 ml. of warm 95-percent EtOH, then 36 ml. (1.2 mol.) of 4-percent ethanolic picric acid were added. A yellow crystalline mass was obtained, which decomposed at 228 to 232°C. Elemental analysis showed percentages of C, 43.06; H, 2.77; and N, 20.19; whereas theoretical percentages are C, 42.89; H, 2.88; and N, 20.01.

MBC•3,5-dinitrosalicylate was prepared by dissolving 1 g. of the foregoing preparation of assumed MBC•HCl in 20 ml. of hot 95-percent EtOH and then adding 12 ml. of 10-percent ethanolic 3,5-dinitrosalicylate acid. A yellow crystalline mass was obtained, which gave an elemental analysis percentage of C, 46.00; H, 3.16; and N, 16.91; compared to the theoretical percentages of C, 45.82; H, 3.35; and N, 16.71.

Results and Discussion

Elemental analysis of hydrochloric, picric, and 3.5-dinitrosalicylic acid salts of the reaction product obtained by heating Benlate 50 WP with dilute hydrochloric acid and precipitating with ammonium hydroxide confirmed the assumption that this product is MBC.

MBC•HCl solutions varying from 0.5 to 50 g./l. were bioassayed for fungitoxicity, using *Penicillium*-seeded potato dextrose agar petri plates. Periodic tests during 7 months in the laboratory showed no loss of fungitoxic activity. Also, there was no visible evidence of chemical change such as precipitation or color change.

Solutions of MBC•HCl are capable of infinite dilution and have low viscosity. Furthermore, this MBC•HCl solution seems to have advantages over previous solutions (*13*), which contained excess acid, solubilized carrier, and contains reaction byproducts (benomyl hydrolyzes to give MBC, CO_2, and butylamine, which can be phytotoxic to injected trees).

McWain and Gregory (*10*) reported the ease with which aqueous acids convert benomyl into soluble fragments that can be measured to estimate the amount of benomyl (*11, 12*). Furthermore, hydrolysis of benomyl is known to produce relatively stable MBC (*2*), which apparently is the mobile species in plants (*12*). MBC is considered to be the benomyl-derived fungitoxic chemical in plants following application of benomyl to leaves or roots (*13,14*). Certain types of benzimidazolecarbamates were introduced as fungicides in patents by Klopping (*8*). Benomyl itself is covered by U. S. 3,541,213 (use claims) and by U. S. 3,631,176 (compound claims). Littler *et al.* (*9*) patented the use of MBC and some of its fungitoxic salts as foliar fungicides.

MBC·HCl has been tested for the control of vascular wilt diseases of red oak (*4*) and American elm. Excellent protection against oak wilt infection was obtained by injection of either 4 or 40 mg. of MBC·HCl into red oak seedlings (*4*). Similar treatment of diseased red oak seedlings resulted in symptom remission in some of the seedlings (*4*).

The requirement that a fungicide be in solution for efficient injection into trees for disease control was met for benomyl by forming the water-soluble derivative MBC·HCl. This salt appears to be chemically stable in solution in the laboratory for at least 7 months. Also, no loss in fungitoxicity was observed during 7 months. No foliar phytotoxicity was observed. MBC·HCl appears to have the chemical, fungitoxic, and injection characteristics desired.

Field trials for control of Dutch elm disease and oak wilt showed effective disease prevention and promising results for disease therapy. A report on this is being prepared.

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LAND CLEARING AND WOOD USE IN DELAWARE, 1972

Abstract.—Changing land use often results in removal of the existing forest cover. During a resurvey of Delaware's timber resources, a study was made to measure the losses of wood fiber that resulted from forest land clearing. It was estimated that nearly 33 million cubic feet of growing stock was destroyed on the 37,000 acres of commercial forest land that was cleared between 1954 and 1968.

The Boston-Washington megalopolis boasts one of the greatest concentration of cities on earth. Yet the states that make up this region are in the aggregate nearly 50 percent forested. As urbanization spreads into the outlying woodlands, most suburban residents see little evidence of planning for the orderly harvesting or utilization of trees from the woodlands. They are aware that trees are being removed, but have no knowledge of the actual quantity of wood removed nor the quantity recovered for use.

We made a study to (1) develop techniques that could be used for determining the rate of land clearing in rapidly urbanizing areas of other states in the Northeast, and (2) develop procedures for estimating the volume of growing-stock trees actually being destroyed.

(Growing-stock volume is defined as net volume, in cubic feet, of live growing-stock trees that are 5.0 inches d.b.h. and larger, from a 1-foot stump to a minimum 4.0-inch top diameter outside bark of the central stem or to the point where the central stem breaks into limbs. Net volume equals gross volume less deduction for rot.)

Delaware was chosen for the study because timber-resource statistics and complete aerial photographic coverage were available for two points in time, 14 years apart.

Delaware is made up of three counties (fig. 1); each has characteristics that are unique and that represent the conditions prevailing in other counties of the Northeastern States. New Castle County is urban, dominated by the city of Wilmington and its suburbs. The county population in 1970 was 386,000 residents, representing 70 percent of the state total. Kent County is mainly agricultural, having a low population density, a relatively poor transportation network, and is less than 25 percent forested. Sussex County is dominated by small industry—mainly poultry and forest products. It accounted for nearly 93 percent of the industrial roundwood harvest in the state in 1970.

Figure 1.—The three counties of Delaware.

Study Method

A set of aerial photographs taken in 1968 was used to divide Delaware into two major land classes—forest and nonforest. Four points systematically located on each aerial photograph were examined, and a land class was assigned to each. Of 4,120 points so classified, 2,633 fell into nonforested land classes. The locations of these nonforest points were transferred to a second set of aerial photographs that had been taken 14 years before, in 1954. When the locations on the two sets of aerial photographs were compared, we found that the classification of 135 points had changed from forested to nonforested. These 135 locations were the sample on which the field observations were based.

The office photo-interpretation was verified by checking on the ground. If it was correct (if the forest cover at the point on the ground in 1954 had been removed), the fieldman determined when the cover was removed, the forest type and size of trees removed, and whether all or a portion of the trees were used for forest products. This information and data from the current forest-inventory field plots were used to calculate acreages cleared.

Findings

Commercial forest area.—Nearly 37,000 acres of commercial forest land in Delaware were cleared between 1954 and 1968. The acreage cleared in each county, and the percentage this represented of the total commercial forest acreage reported in 1972 were:

County	*Commercial forest land cleared*	*Relation of area cleared to total commercial forest land*
	(thousand acres)	*(percent)*
Kent	3	3
New Castle	10	17
Sussex	24	10

The highest percentage of commercial forest land clearing was in mostly urban New Castle County. Although Sussex County had the most acreage cleared, 83 percent of the clearing was for agricultural uses rather than residential or industrial construction. The lowest percentage of commercial forest land clearing and least acreage cleared occurred in mostly agricultural Kent County.

Theoretically, at the current rate of clearing, New Castle County's entire commercial forest acreage could be cleared in 81 years, while it would take 466 years to clear the commercial forest land in Kent County. This is based on the assumption that no reforestation would occur during the period and that land clearing would proceed uninhibited.

Timber volume.—Nearly 33 million cubic feet of growing stock—including 54 million board feet of sawtimber—were burned, bur-

Figure 2.—In urban areas, trees are considered a hindrance to development, and few are used for industrial products.

Figure 3.—In rural areas, where markets for forest products are plentiful, considerable industrial wood is recovered during land clearing.

ied, or otherwise destroyed as a result of clearing the 37,000 acres of commercial forest land in Delaware between 1954 and 1968. This loss of wood fiber represents enough volume to satisfy the entire roundwood requirements of the forest-product industry in Delaware for a 3.5-year period at the 1970 operating levels.

Eighty percent of the growing-stock volume and 75 percent of the sawtimber volume that was destroyed was from hardwood trees. Forest land clearing in Sussex County alone accounted for 61 percent of the growing-stock volume and 53 percent of the sawtimber volume that was destroyed.

Forest product utilization.—During the 14 years between 1954 and 1968, the growing-stock volume on 70 percent of the forest acreage cleared in Sussex County was partially recovered and used for industrial products. In New Castle County, however, only 31 percent of the area cleared yielded some industrial products (fig. 2). In Kent County some products were recovered from 75 percent of the acreage cleared (fig. 3).

Complete recovery of products from merchantable sawtimber trees was small. For example, in Kent County recovery occurred on only 25 percent of the acreage. In the suburbs of New Castle County, some residents recovered firewood from land being cleared (fig. 4). Likewise, in Kent County complete

Figure 4.—Some urban residents, who otherwise would pay $30 to $40 a cord for fireplace wood, salvage wood when nearby building lots are cleared.

recovery occurred for such farm uses as fuelwood, fence posts, and agricultural poles.

Observations

Imbalance of demand between softwoods and hardwoods.—Forest-product industries have used most of the pine harvest in Sussex County and neighboring Kent County for many years. In the past 14 years, changes in the makeup of these wood-using industries have allowed even greater use of the available softwood growing stock. In 1956 two-thirds of the pine harvest went to sawmills, but in 1970 over 70 percent was being shipped to pulpmills. Much of the pine harvested today is transported tree-length to concentration points where it is segregated into poles and pilings, sawlogs, veneer logs, or pulpwood. Because of the many alternative products, little of the pine growing stock is left unused in the forests or destroyed during forest land clearing.

Demand for hardwood growing stock has been mixed. Although the large-diameter hardwood trees of good quality have been sought for veneer logs and sawlogs, the wood from poor-quality hardwood sawtimber trees and poletimber trees has had few commercial outlets. Between 1956 and 1970, hardwood sawlog production in Delaware decreased 42 percent, and veneer-log production decreased 43 percent as the demand for wooden baskets waned. The opportunity to channel hardwood material from land-clearing operations to industrial wood users has been very limited.

Pine types contain significant amounts of hardwoods.—Up to a quarter of the growing-stock volume in Delaware pine stands is in hardwood trees. During the 1960's, standard cutting practice in these stands was to harvest the pine for products and windrow and burn the hardwoods with the logging slash unless high quality hardwood sawtimber was present.

Availability of markets differed between counties.—Much of the forest land cleared in New Castle County was cleared in preparation for residential or commercial construction. Trees were often considered a hindrance to the sloping, grading, and landscaping operations. In those few instances when forest products were recovered, an intermediary was used who had a specific use for the wood and who was willing to conform to the building contractor's work schedule.

Forest land clearing in Sussex County afforded industry the greatest opportunity to recover forest products, because alternative markets were readily available. Residents recognized that timber had a value, and timber buyers were plentiful. In Kent County many residents were too far from forest-product plants to arrange for the one-time sale of relatively small quantities of timber.

Opportunities

As the Nation's population increases, the demand for wood fiber will also grow. Woodlands close to the urban consumer could be a cheap source of wood fiber if marketing channels are developed and improved techniques and equipment are designed to process it. A market for low-quality hardwood sawtimber and poletimber-size trees for pulpwood is developing in Delaware. Establishment of this new market should facilitate the complete utilization of the fiber produced from Delaware's urban woodlands.

Complete utilization is a desirable goal for everyone in our society, producing many fringe benefits. It affords the land manager and trained conservationist an opportunity to demonstrate renewable resource use to urban and suburban residents. Utilizing these urban trees also facilitates the removal of unwanted material—a solid-waste disposal problem—and turns it into an asset rather than a cost.

Table 1.—*Area of commercial forest land in Delaware in 1972, and area cleared between 1954 and 1968, by counties*

County	Area of commercial forest land, 1972	Area of commercial forest land cleared, 1954-1968		
		Total	Percent of 1972 area	Average annual clearing
	Thousand acres	*Thousand acres*	*Percent*	*Acres*
Kent	93.1	2.8	3.0	198
New Castle	55.8	9.6	17.2	683
Sussex	235.5	24.3	10.3	1,738
All counties	384.4	36.7	9.5	2,619

Table 2.—*Net volume of growing stock and sawtimber destroyed during land clearing in Delaware between 1954 and 1968, by species group*

County	Growing stock (million cubic feet)		Sawtimber (million board feet)[a]	
	Softwood	Hardwood	Softwood	Hardwood
Kent	0.3	2.4	0.4	4.0
New Castle	1.3	8.9	2.5	18.4
Sussex	5.0	15.7	10.5	18.5
All counties	6.6	27.0	13.4	40.9

[a]International ¼-inch rule.

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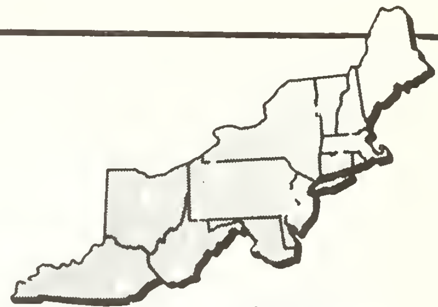


FOREST SERVICE, U.S. DEPT. OF AGRICULTURE, 6816 MARKET STREET, UPPER DARBY, PA. 19082

PREDICTORS OF JOB TENURE IN A LUMBER-PLYWOOD MILL

Abstract.—Multiple discriminant analysis was used to identify biographic and employment history variables associated with job tenure in a lumber-plywood mill. Several variables—friends and relatives, type of housing, commuting distance, and prior work experience in the wood industry—were found to be significant.

Recruiting workers and holding them on the job is a serious and persistent problem for many firms in the wood industry. Many new employees quit after working only a few weeks or months. This not only disrupts production but also results in higher operating and administrative costs.

Employee turnover involves the extra expense of recruiting, hiring, and training new workers and releasing those who have quit. It results in lost production, increased machinery maintenance, higher accident rates, and intangible problems such as poor employee morale, reduced supervisory efficiency, and loss of goodwill. The cost of turnover in production and maintenance jobs has been estimated to be as high as $1,072 per worker (*Merchants and Manufacturers Association 1970*).

The purpose of our pilot study was to determine if items commonly found on employment application forms can be used to predict the tenure of job applicants. Once identified, such items can be used by employers for screening applicants who are likely to quit within a short time after being hired. They can also help to indicate which applicants will have a reasonable chance of developing into long-term employees.

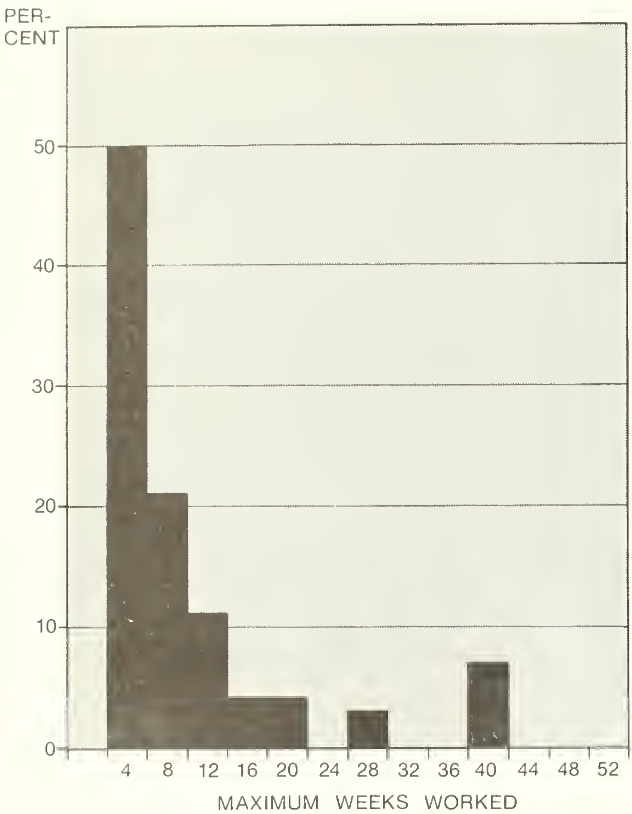
Methods

A lumber-plywood mill located in a rural section of the Southeast was selected for the study. The subjects were permanent full-time production and maintenance workers hired between July 1969 and July 1971. Most were employed to fill entry-level jobs in the firm's plywood plant and adjoining sawmill.

Two groups of these workers were selected for study. The first consisted of 34 employees who had worked 1 year or longer as of July 1971. The second included 62 employees who had quit before completing 1 year of service. Involuntary terminations such as lay-offs, discharges, and resignations due to poor health and military obligations were not considered.

One-half of those who quit during their first year of employment did so within 4 weeks of being hired (fig. 1). Reasons employees gave for quitting included marital problems, moving to another town, returning to farm

Figure 1.—Length of service for workers who quit during their first year of employment.



work, and accepting a job with another company.

The following biographic and employment items found on the company's job-application form were examined to test their effectiveness in predicting job tenure.

1. Age.
2. Education.
3. Marital status.
4. Race.
5. Housing accommodations.
6. Weight-height ratio.
7. Months of military service.
8. Telephone service.
9. Number of job references.
10. Number of friends and relatives employed by the company.
11. Number of times previously hired by the company.
12. Commuting distance.
13. Car ownership.
14. Length of service on last job.
15. Difference between starting wage and wage on last job.
16. Previous employment in the wood industry.

Analysis

Multiple discriminant analysis was used to distinguish between employees in the short-tenure group (less than 1 year) and long-tenure group (greater than 1 year) (*Tintner 1952; Williams 1959*). This technique is derived from the general linear model, with the criterion that the between-group sum of squares is maximized. It constructs a linear discriminant function of the form

$$Z = a_1x_1 + a_2x_2 \ldots a_nx_n$$

where $x_1, x_2 \ldots x_n$ are the independent variables measured, and $a_1, a_2 \ldots a_n$ are discriminant weights assigned so as to obtain a value of Z that will indicate group membership. In this study, long-tenure employees tended to have low values of Z and short-tenure employees high values.

The biomedical computer program for stepwise discriminant analysis (BMD07M) was used to answer two questions (*Dixion 1968*). First, which variables, when considered by themselves, best discriminate between the job-tenure groups? And second, which variables, when entered into the function in a stepwise fashion, will best separate the tenure groups?

The program provided the information for answering the first question by calculating an F statistic for each variable. The statistic serves to indicate the distance between groups. The program then identifies the best discriminant function by adding in successive steps those variables that result in the greatest increase in the between-group sum of squares.

Results

The following four variables, when taken individually, best discriminate between the job-tenure groups.

Variable	F ratio
1. Number of friends and relatives employed by the company	23.09
2. Housing accommodations	4.58
3. Commuting distance	3.06
4. Previous employment in the wood industry	3.01

A study by Rees (*1966*) suggested that friends and relatives are important because they provide information and advice about the fairness of supervision, working conditions, and other aspects of employment in a firm. This information enables the worker to better decide if the job will be to his liking. Once a new man is hired, friends and relatives help him to adjust to the job by explaining company policies, introducing him to other workers, and generally helping him to become better accustomed to the work environment.

Housing accommodations, the second most significant variable, may reflect an individual's social and economic ties to a particular town or labor market. Job applicants who either owned their own homes or lived with their parents tended to have longer tenure than those who rented.

The inverse relationship between commuting distance and tenure probably reflects increasing costs in both time and money of traveling to and from work.

The last variable—previous employment in the wood industry—may indicate an individual's prior knowledge of job requirements and his satisfaction with this type of work.

In addition to testing the significance of individual variables, a linear discriminant function was calculated in a stepwise manner. The first variable included in the discriminant function was number of friends and relatives (x_1). The F ratios for each of the remaining variables were recalculated and the variable with the largest F ratio—previous employment in the wood industry (x_2)—was added to the function. The F ratios were again recalculated, but none was sufficiently large to be entered, so the program was terminated.

Commuting distance and housing accommodations did not enter the discriminant function because their F ratios quickly decreased when the first two variables were included. This indicated that these variables were highly related to the number of friends and relatives. Consequently, adding them to the function would have done little to increase its ability to discriminate between the two groups.

The resulting function, which separated the short-tenure from long tenure workers, was:

$$Z = (-.01150)X_1 + (-.01268)X_2$$

An individual with a Z score of less than −.01982 was classified as a long-tenure worker and an individual with a Z score of greater than −.01982 was classified as a short-tenure worker. The function correctly classified 36 of the 62 short-tenure workers and 28 of the 34 long-tenure workers for an overall correct classification of 67 percent.

Conclusion

This analysis suggested that, to reduce employee turnover, the case-study firm should favor applicants who:

1. Have friends or relatives already employed by the firm.
2. Either own their own home or live with their parents.
3. Have previous work experience in the wood industry.
4. Live within a short commuting distance.

Age, marital status, length of service on last job, and other variables commonly used in making hiring decisions were *not* found to be useful in determining an applicant's tenure.

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THE VOLUME OF SELECTED HARDWOOD SPECIES SUITABLE FOR TURNERY BOLTS IN MAINE, 1970

Abstract.—During the last Forest Survey of Maine, data were collected about the four hardwood species—paper birch, yellow birch, sugar maple, and beech—that are used by turneries. Analysis of the data showed that only about 18 percent of the volume of growing stock in trees 8 inches d.b.h. and larger in these species is acceptable for turning bolts, according to the criteria used.

Maine has more wood-turning plants than any other state. In 1970 the wood-turning industry had 38 active plants in Maine. In 1958 the industry consumed 41.9 million board feet of wood; in 1970 it consumed 44.5 million board feet.

These plants produce a variety of products ranging from dowels, furniture parts, and brush handles to thread spools, textile bobbins, billiard cues, and ladies' shoe heels. The principal species used by the industry is yellow birch. But paper (white) birch, sugar (hard) maple, and beech are also utilized extensively. Aspen (popple), red (soft) maple, and white ash are also utilized, but not as extensively as the other species.

In recent years turners have encountered increasing difficulty in obtaining suitable bolts for turning. The bolts, from which are sawed the blanks to be turned, must be sound and relatively knot-free. Because such material is usually scattered in the forests, few logging operations are undertaken solely for the production of turnery bolts. More often material of turnery-bolt quality is harvested in sawlog and pulpwood operations. Often suitable material is not segregated but is sold as sawlogs or pulpwood, though it could provide a greater return as turnery bolts.

The recently completed resurvey of Maine's timber resources provides a wealth of information about the volume, growth, removal, and species composition of the State's timber resources. However, it does not provide these data in a form that can be related readily to the volume of wood that is suitable for turnery bolts. This note provides this information by combining the specifications for turnery bolts used by the wood-turning industry in Maine with data gathered as part of the forest survey.

The four species most commonly utilized for turnery bolts in Maine—paper birch, yellow birch, sugar maple, and beech—were analyzed to determine the volume of growing stock that is acceptable as turnery bolts. To do this, growing-stock trees 8 inches d.b.h. and larger were segregated according to two limiting criteria: (1) no external evidence of rot, and (2) a "surface defect code" of 4 or better.

The surface defect code is used in the forest survey as a measure of freedom of the bole from knots, scars, and other indicators of unclear or unsound wood. The code is the number of 2-foot clear cuttings in the first 16 feet of bole length. Thus a surface defect code of 4 means that there are 8 feet in clear cuttings, and a code of 8 means 16 feet in clear cuttings. The selection of these two external indicators of wood quality is based on procurement specifications supplied by several wood-turning companies in Maine.

Tables of growing stock, by species and diameter class, that meet or exceed the minimum specifications in the State and in each of the nine geographic sampling units used in the resurvey of Maine, are attached. A small portion of the volume shown may be in bolts that do not meet the minimum specifications for turnery bolts. However, we feel that this is offset by a similar volume of turnery-grade bolts in trees that do not meet the criteria established here.

The results of this analysis show that only a little more than 18 percent of the growing-stock volume in these four species is suitable for turnery bolts. By species, the percentages are: paper birch—18.7 percent; yellow birch—22.5 percent; sugar maple—19.9 percent; and beech—10.0 percent.

The most abundant species, statewide, is sugar maple—244 million cubic feet. Yellow birch totals 167 million cubic feet, paper birch 138 million cubic feet, and beech only 66 million cubic feet. In total there are 615.8 million cubic feet of growing stock in Maine's timber inventory that meet or exceed the specifications. Of this volume, 62 percent is in trees 12 inches d.b.h. and smaller.

All four of the important turnery species are being cut heavily in Maine. For yellow birch, growing-stock removals exceed growth. For sugar maple, growth and removals are about equal. Though removals of paper birch and beech do not exceed growth, they are rapidly approaching that point.

Given the small proportion of suitable material in these four species—and the precarious growth-to-removals situation—it appears that Maine turners face an even more difficult task in supplying their firms in future years than they have in the past.

There seem to be several ways to combat this situation. One is to institute an active, industry-sponsored, intensive forest-management program geared specifically to the production of top-quality trees of most desired species for turnery bolts. This would require active assistance to landowners because most turners do not own large tracts of timberland.

Another approach is to develop the technology for utilizing more of those species that are more abundant—such as red maple and aspen—and to develop the means to utilize the lower quality material that is not now considered suitable for turned products. Along these same lines, the development and employment of machines that would allow for more complete use of the existing raw material would effectively expand the usable resources. For instance, the use of band bolter mills and strippers would reduce losses from saw kerf.

Still another approach that would help to alleviate the scarcity of turnery bolts is closer cooperation between the turning industry and other users of roundwood to insure that raw material of turnery-bolt quality is not converted into lower-value products such as pulpwood or sawlogs. The failure to realize the highest possible return of harvested wood represents a loss to both industries. It is true that in some cases turnery bolt material is being segregated from sawlogs, but this practice is not nearly widespread enough. The recent trend toward integrated harvesting may be an added spur to this practice.

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Table 1.—*Volume of selected species suitable for turnery bolts, by species and geographic sampling unit, Maine, 1970*

[In thousands of cubic feet]

Geographic unit	Species				
	Paper birch	Yellow birch	Sugar maple	Beech	All species
Aroostook Co.	16,500	34,606	74,137	35,876	161,119
Capitol Region	6,965	6,394	10,402	843	24,604
Casco Bay	10,000	3,742	2,037	2,667	18,446
Hancock Co.	3,990	2,809	813	—	7,611
Penobscot Co.	3,122	12,463	24,428	3,293	43,307
Piscataquis Co.	22,735	41,308	52,688	13,368	130,099
Somerset Co.	18,738	26,502	35,200	3,314	83,754
Washington Co.	24,651	5,815	4,407	774	35,647
Western Maine	31,579	33,792	40,348	5,451	111,170
State total	138,280	167,431	244,460	65,586	615,757

Table 2.—*Volume of selected species suitable for turnery bolts, by species and diameter class, Maine, 1970*

[In thousands of cubic feet]

D.b.h. class (inches)	Species				
	Paper birch	Yellow birch	Sugar maple	Beech	All species
8	36,472	24,240	36,954	11,339	109,005
10	46,553	27,250	47,430	19,161	140,394
12	20,449	42,829	43,500	25,172	131,950
14	20,727	31,918	36,659	7,978	97,282
16	6,579	21,655	29,437	1,003	58,674
18	4,925	7,077	19,097	933	32,032
20+	2,575	12,462	31,383	—	46,420
Total	138,280	167,431	244,460	65,586	615,757

Table 3.—Volume of selected species suitable for turnery bolts, by species and diameter class, Maine, 1970

[In thousands of cubic feet]

D.b.h. class (inches)	Species				
	Paper birch	Yellow birch	Sugar maple	Beech	All species
			AROOSTOOK COUNTY		
8	1,451	4,795	9,098	3,788	19,132
10	3,990	4,736	17,111	9,045	34,882
12	1,468	6,230	11,223	18,992	37,913
14	6,333	8,364	11,953	3,118	29,768
16	1,590	5,110	13,241	—	19,941
18	794	2,966	2,196	933	6,889
20+	874	2,405	9,315	—	12,594
Total	16,500	34,606	74,137	35,876	161,119
			CAPITOL REGION (Kennebec, Knox, Lincoln, and Waldo Counties)		
8	1,671	—	7,080	843	9,594
10	3,451	2,718	1,190	—	7,359
12	925	914	1,045	—	2,884
14	918	—	—	—	918
16	—	2,762	1,087	—	3,849
18	—	—	—	—	—
20+	—	—	—	—	—
Total	6,965	6,394	10,402	843	24,604
			CASCO BAY REGION (Androscoggin, Cumberland, Sagadahoc, and York Counties)		
8	2,693	932	2,037	1,767	7,429
10	6,374	1,851	—	900	9,125
12	933	—	—	—	933
14	—	959	—	—	959
16	—	—	—	—	—
18	—	—	—	—	—
20+	—	—	—	—	—
Total	10,000	3,742	2,037	2,667	18,446
			HANCOCK COUNTY		
8	3,075	—	—	—	3,075
10	—	—	813	—	813
12	915	911	—	—	1,826
14	—	910	—	—	910
16	—	—	—	—	—
18	—	—	—	—	—
20+	—	988	—	—	988
Total	3,990	2,809	813	—	7,611
			PENOBSCOT COUNTY		
8	711	645	2,622	—	3,978
10	749	2,127	2,710	1,571	7,157
12	—	5,444	3,838	1,722	11,004
14	—	1,666	3,104	—	4,770
16	1,622	2,581	1,118	—	5,361
18	—	—	5,824	—	5,824
20+	—	—	5,212	—	5,212
Total	3,122	12,463	24,428	3,293	43,307
			PISCATAQUIS COUNTY		
8	4,482	6,792	3,561	3,381	18,216
10	6,873	3,790	8,219	4,226	23,108
12	3,908	11,918	8,810	940	25,576
14	2,367	5,558	12,227	3,818	23,970
16	2,527	4,962	6,470	1,003	14,962
18	1,699	1,647	3,291	—	6,637
20+	879	6,641	10,110	—	17,630
Total	22,735	41,308	52,688	13,368	130,099

CONTINUED

Table 3.—Continued

D.b.h. class (inches)	Species				
	Paper birch	Yellow birch	Sugar maple	Beech	All species
		SOMERSET COUNTY			
8	6,614	5,285	6,680	719	19,298
10	5,746	4,549	4,915	735	15,945
12	3,995	4,139	11,746	818	20,698
14	2,383	7,199	7,309	1,042	17,933
16	—	4,592	2,195	—	6,787
18	—	—	1,200	—	1,200
20+	—	738	1,155	—	1,893
Total	18,738	26,502	35,200	3,314	83,754
		WASHINGTON COUNTY			
8	6,118	1,356	729	—	8,203
10	10,329	1,429	1,630	—	13,388
12	5,154	1,463	928	774	8,319
14	2,256	769	—	—	3,025
16	—	—	—	—	—
18	794	798	—	—	1,592
20+	—	—	1,120	—	1,120
Total	24,651	5,815	4,407	774	35,647
		WESTERN MAINE REGION (Franklin and Oxford Counties)			
8	9,657	4,435	5,147	841	20,080
10	9,041	6,050	10,842	2,684	28,617
12	3,151	11,810	5,910	1,926	22,797
14	6,470	6,493	2,066	—	15,029
16	800	1,648	5,326	—	7,774
18	1,638	1,666	6,586	—	9,890
20+	822	1,690	4,471	—	6,983
Total	31,579	33,792	40,348	5,451	111,170

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FOREST SURVEY CUBIC-FOOT VOLUME EQUATIONS

Abstract.—The cubic-foot volume equations used in the regionwide Forest Survey are presented, and their development is discussed. An example of the use of an equation is given.

How does the Forest Survey estimate tree volume? This question is often asked by users of these data. Other people who make their own inventories often wish to calculate their tree volumes by using the same equations that are used in the regionwide forest survey. This note was prepared to provide this information.

Background

In the late 1940's, C. Allen Bickford (*1951*) worked on form-class and volume tables for tree species in the northeastern United States. This work was based on tree diagrams and average taper rates. He developed three volume tables.

One table gave the cubic-foot volume in the sawlog portion of the tree; one gave the volume in the upper-stem portion; and the third gave the volume in trees of less than minimum sawlog size. These tables segregated volume according to butt class and Girard form class (*Mesavage and Girard 1946*). Butt class is based on the ratio between stump diameter and d.b.h. Four butt classes were recognized:

1. Softwoods.
2. Hardwoods with a low ratio of stump diameter to d.b.h.
3. Hardwoods with a high ratio of stump diameter to d.b.h.
4. All other hardwoods.

To determine the total cubic-foot volume of a tree, volumes from several of these tables had to be combined.

In the early 1950's many trees in Connecticut, Maryland, New York, Vermont, and West Virginia were measured for Girard form class by forest-survey crews. The data were analyzed to test the hypothesis that, for each species, all Girard form-class measurements are from a single homogeneous population. The results showed no significant difference within a species due to location.

Some species within each of the four butt-log classes had the same average Girard form class. When these were combined, a total of 17 different species groups existed. The groups and the species in each are given in table 1.

Table 1.—*Seventeen species group cubic-foot volume equations*

General form of equation:
Gross cubic-foot volume = a + bX
where X = d.b.h.^{2} times height to 4-inch top in feet.

Species group	Species	Intercept (a)	Slope (b)
1	White, red pine	3.5142	0.00236
2	Red, white, black spruce	2.1998	.00257
3	Balsam fir	1.4793	.00272
4	Hemlock	2.4784	.00242
5	Hard pines, tamarack, Norway spruce	0.0496	.00303
6	Cedar species	1.5817	.00259
7	Sugar maple	1.6823	.00310
8	Soft maples, yellow-poplar	1.1763	.00310
9	Ash species, aspen species	1.0067	.00293
10	Black cherry	1.1809	.00292
11	Birch species	1.1339	.00281
12	Beech	1.2851	.00326
13	Basswood	.8976	.00349
14	Red oaks, sweet gum, black gum	1.2027	.00301
15	Chestnut oak	1.0009	.00300
16	Hickory	1.4438	.00316
17	Other hardwoods	.8591	.00309

Cubic-Foot Volume Equations

Several years later, cubic-foot volume estimates and other data for trees measured on forest-survey plots throughout the Northeast were available. The volumes had been determined by combining sawlog and upper-stem volume estimates based on the tables. The total volume of the tree was the volume in the main stem from a 1-foot stump to a flexible top diameter outside bark of either 4 inches or more when taper, knots, or other limits to merchantability occurred below the 4-inch point.

These volume, diameter, and height data were used to predict total volume. The best equation for predicting total volume was $Y = a + bX$, with X being d.b.h.^{2} times height. Table 1 gives the intercept (a) and slope (b) for each species group.

In a recent study at the University of Vermont (*Myers 1972*), these equations were tested along with several others. The volumes estimated by the various equations were compared with the volume of the felled tree as determined by a water-displacement technique. The forest-survey equations were found to give the estimate closest to that determined by displacement.

Here is an example of the use of these volume equations for calculating the volume of a tree:

Given:

A red spruce with d.b.h. of 18.6 inches, estimated height to a 4-inch top of 41 feet, and 21 percent cull material in the main stem.

What are the estimated gross and net cubic-foot volumes?

Red spruce is in species group 2. The intercept and slope are 2.1998 and 0.00257.

$$X = 18.6^2 \times 41 = 14184.36.$$

Gross cubic-foot volume = 38.6536 cubic feet.

Net volume in cubic feet = 30.53 cubic feet.

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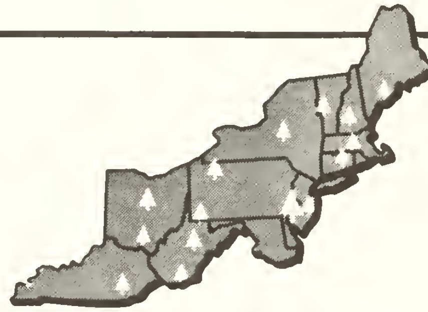


FOREST SERVICE, U.S. DEPT. OF AGRICULTURE, 6816 MARKET STREET, UPPER DARBY, PA. 19082

ANNUAL CYCLES OF SOIL AND WATER TEMPERATURES AT HUBBARD BROOK[1]

Abstract. Soil temperatures in the Hubbard Brook Experimental Forest in central New Hampshire decline very slowly from December to March and are restricted from falling below 0°C. by insulation of snow and organic matter. Soil in the hardwood forest on a moderate south slope warms rapidly in the spring leafless period after snowmelt and reaches a maximum temperature in early August that averages 17.5°C. near the surface and 12.5°C. at 91-cm. depth. The soil cools to nearly isothermal conditions at 11°C. in October. The mean annual cycle of soil temperature near the surface corresponds closely to that of air temperature under the canopy, except in winter. Stream temperatures are about the same as soil temperature at a depth of 31 cm. throughout the year. Windthrow mounds are cooler than uniform slopes in winter and warmer in summer. Simultaneous soil temperatures at different locations in the forest generally differ by no more than 2°C. at any given depth.

The Hubbard Brook Experimental Forest in central New Hampshire is the location of intensive investigations of the ecology of hardwood forest ecosystems and the effect of disturbance on them.

Soil and water temperatures in the undisturbed ecosystem are important baseline variables for many studies and have been measured routinely for more than 10 years. These temperatures affect the rates of many biological and geochemical processes in both the soil and stream parts of the ecosystem. Annual cycles of stream water temperature and of soil temperatures at several sites and depths for undisturbed forests are summarized in this paper.

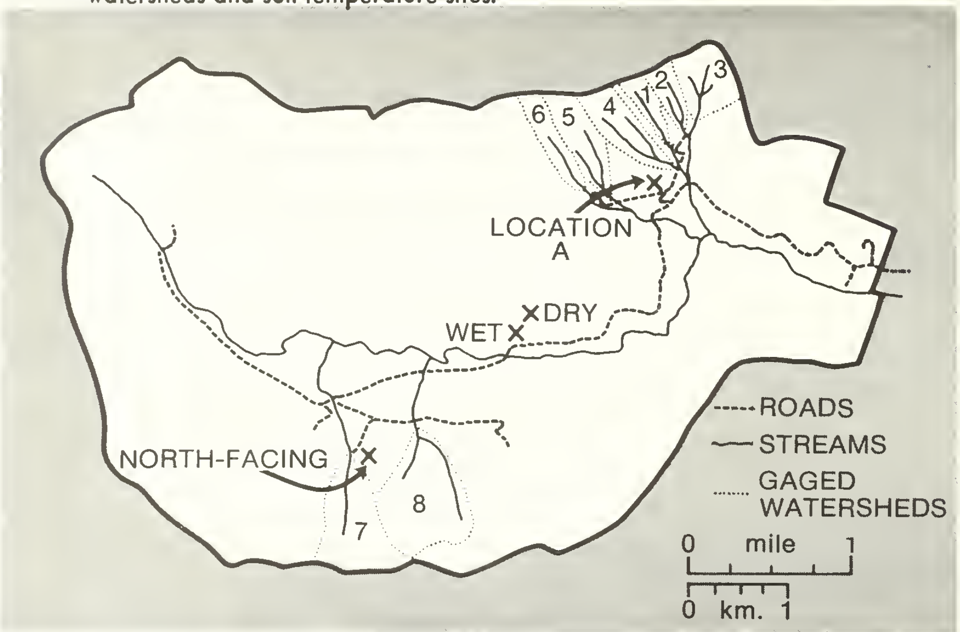
Soil Temperatures Vs. Depth and Time

Soil temperatures in this study were all measured by thermistors in Colman fiberglass soil-moisture units. These sensors, which are quite stable and are accurate to about ± 1°C., were calibrated before placement in the soil.

Eleven years of data (1960-1970) are available for a location about 300 m. southwest of weir 4 at Hubbard Brook. This site will hereafter be referred to as location A (fig. 1). Location A is on a southeast-facing slope of

[1] This is contribution No. 56 of the Hubbard Brook Ecosystem Study. John Eaton, Cornell University, compiled much of the water temperature data.

Figure 1.—Map of Hubbard Brook Experimental Forest showing gaged watersheds and soil temperature sites.



11° at an elevation of 450 m. in a typical northern hardwood forest, which consists primarily of beech (*Fagus grandifolia*), yellow birch (*Betula alleghaniensis*), and sugar maple (*Acer saccharum*) about 60 years old with scattered older trees. The soil at this location is Berkshire fine sandy loam, a member of the coarse loamy, mixed, frigid family of Typic Haplorthods.

Sensors at location A were placed vertically in two stacks or profiles 3 m. apart and at seven depths in each stack — 2.5, 7.5, 15, 30, 46, 61, and 91 cm. These depths were measured from the top of the F layer, which was just below the surface litter. The sensors at 2.5 cm. depth were in humus. Temperature data from the two sensors at each depth rarely differed by more than 1°C., so they were averaged for this study.

Measurements at location A were obtained at 1- or 2-week intervals, for a total of about 360 dates over the 11-year period. The time of day at which measurements were taken varied. All the data were plotted by depth and date, and all years were superimposed. A curve was fitted by eye through the points; I took this to be the annual cycle of mean daily soil temperature at that depth (fig. 2). Two other smoothed curves were drawn as envelopes around the data points for each depth (fig. 3). These included virtually all of the data points, so I have designated the difference between these curves on a given date as the range for that date.

Temperature at the soil surface in winter is normally held at the freezing point because of a continuous cover of snow from late December through early April. Heat flow out of the soil normally maintains a slow rate of melt, and thus the temperature is 0°C. at the soil-snow interface (*Federer 1965*).

At Hubbard Brook, soil frost occurs infrequently because it is limited to locations, such as the tops of windthrow mounds, where there is little organic cover. It occasionally spreads through much of the forest when snow cover is abnormally thin or late (*Hart, Leonard, and Pierce 1962; Sartz 1957*). Often this frost disappears by spring because of heat from greater depths in the soil.

Soil temperature in winter increases with increasing depth on any given date (fig. 2). The temperature at each depth declines gradually through the winter (fig. 2). At

Figure 2.—Annual cycle of mean daily soil temperature for 11 years of data at Hubbard Brook location A, a gentle south-facing slope at 450 m. elevation. Depths are measured from the top of the F horizon.

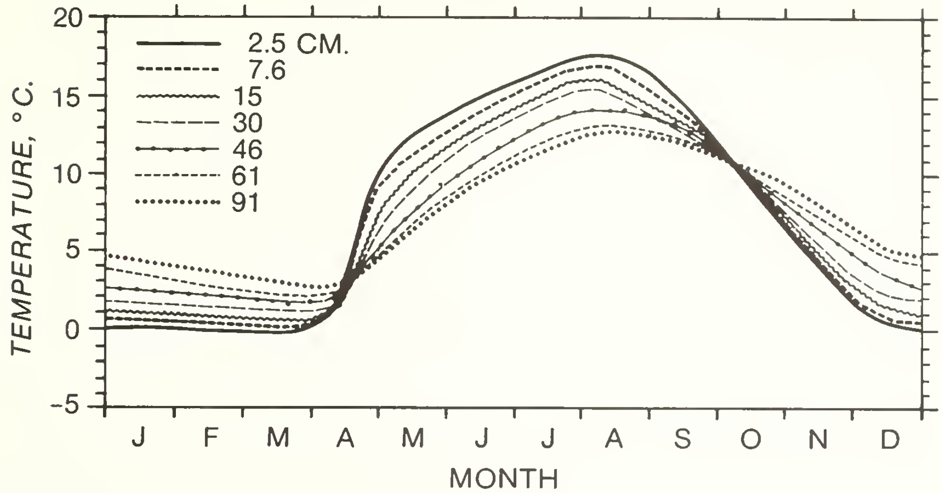
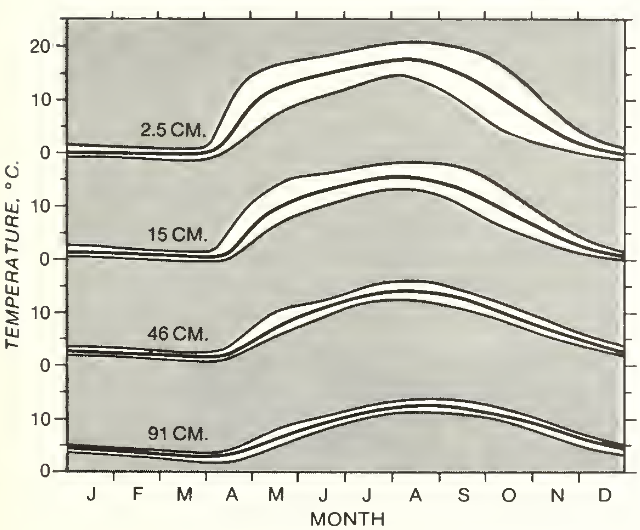


Figure 3. — Range of measured soil temperatures from 1960 to 1970 for 4 depths about the mean values shown in Figure 2.



91-cm. depth soil temperature is about 4.5°C. on January 1 and 3°C. on April 1. The winter temperatures are very consistent year after year, only deviating about 1°C. from the mean for a given date and depth (fig. 3).

As soon as the snow cover disappears in April, the soil warms rapidly but erratically at the surface and becomes nearly isothermal on the average in mid-April, but there is much year-to-year variablity. This variability shows up as a spring bulge in the range of temperatures for a given depth (fig. 3).

Soil temperature at 2.5 cm. may deviate as much as 5°C. from the long-term mean of 9°C. on May 1 (fig. 3). On clear days in April and May, the sun is quite high in the sky at midday; and solar radiation readily penetrates the leafless canopy, supplying large amounts of heat to the soil. On the other hand, cloudy days provide little heat; and the soil surface may temporarily be cooler than at greater depths. Thus the variability is caused primarily by variation in weather from day to day, but differences in seasonal warming from year to year and variability in the time of day at which the measurements were taken also play a role. The range declines in June as leaves develop in the canopy and a more uniform radiation regime is produced at the soil surface. It increases again in the autumn after leaf-fall (fig. 3).

By mid-May, soil temperature decreases with depth at least down to 91 cm. Soil temperatures continue to rise gradually until early August, reaching peak mean values of 17.5°C. at 2.5 cm., and 12.5°C. at 91 cm. (fig. 2). Thereafter, the surface cools most rapidly; and in about mid-October, the soil to a depth of 91 cm. is nearly isothermal at about 11°C. Further cooling then occurs until it is halted by snow accumulation in December.

Air Temperature and Soil Temperature

Air temperature was measured at location A from 1960 through 1970 with a thermograph in a standard instrument shelter (1.5 m. above the ground). Mean daily air temperature is defined here as the average of the daily maximum and minimum temperatures. An annual curve of mean daily temperature was drawn by eye through plotted air temperatures for the 10th, 20th, and last day of each month for the 11 years (fig. 4). Comparison of the mean daily air temperature and of soil temperature at 2.5 cm. clearly shows the insulating effort of the snow cover (fig. 4).

In January, the soil temperature is practically fixed at 0°C. although the mean daily air temperature drops to −12°C. From late March until late October, the soil temperature at 2.5 cm. is within 2°C. of the mean air temperature. In the spring, the soil surface warms more rapidly than the air; and in the fall, it cools less rapidly.

Water Temperature and Soil Temperature

The temperature of water in streams flowing through undisturbed hardwood forest was measured continually with 7-day Bourdon-tube recorders in some watersheds and weekly with thermometers in other watersheds. Recorder data from just above weir 1 for June 1965 through May 1968 (*Likens et al. 1970*), and just above weir 4 in 1969, and thermometer data from above weir 3 and weir 4 for June 1965 through May 1968 were analyzed for this study.

Water temperatures in the uppermost 50 m. of stream channel may be 5 to 7°C. higher than temperatures at the weirs in summer (*McConnochie and Likens 1969*). Diurnal cycles of water temperature are usually small (*Likens et al. 1970*), so the mean daily temperatures from the recorder and the instantaneous thermometer data were combined.

When all data points were plotted by day of the year, there were no evident differences

Figure 4.—Annual cycle of mean daily air temperature and range of daily values at 10-day intervals from 1960 to 1970 at 1.5 m. above the forest floor on a gentle south-facing slope at 450-m. elevation. Annual cycle of mean daily soil temperature at 2.5-cm. depth (dashed line) is superimposed.

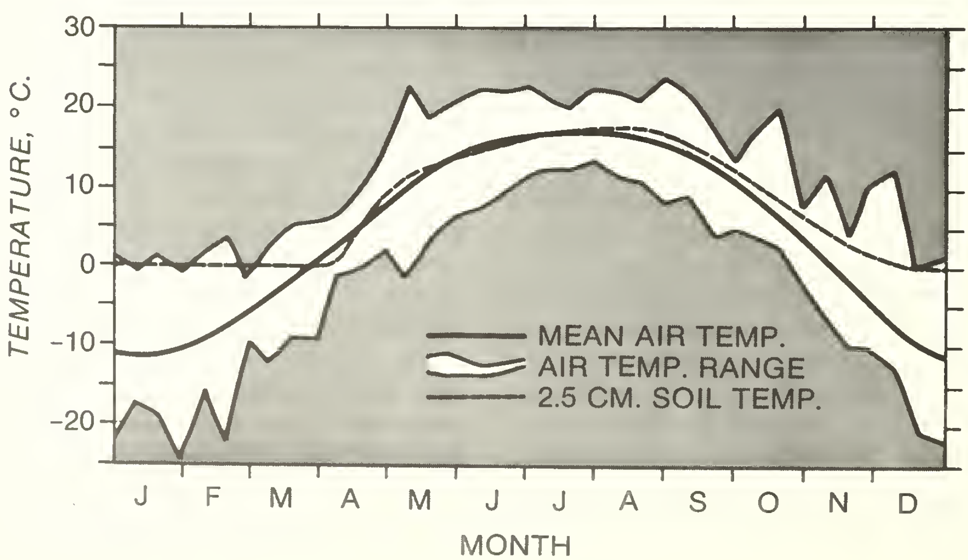
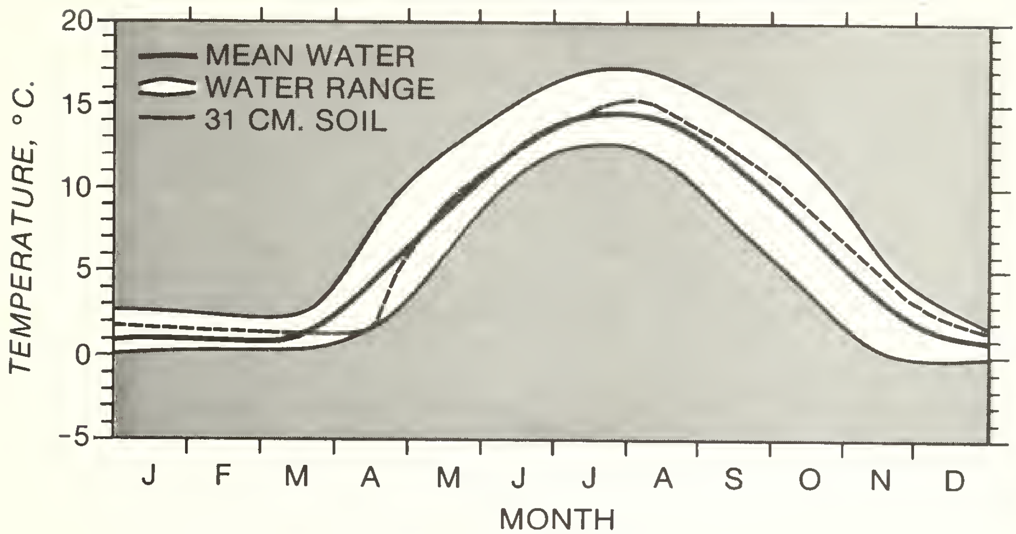


Figure 5.—Annual cycle and range of mean daily water temperature in several Hubbard Brook streams and range of temperatures. Annual cycle of soil temperature at 31 cm. (dashed line) is superimposed.



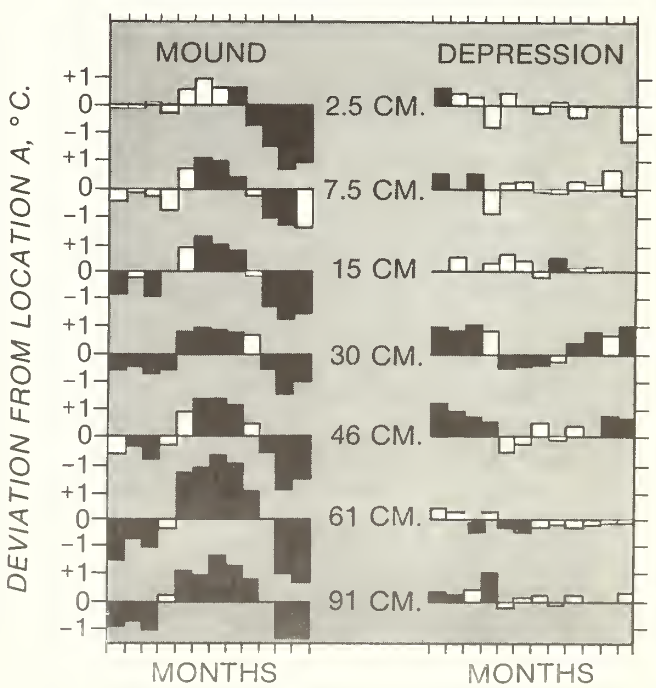
among the streams; thus data from all streams were combined. A curve of the annual cycle of mean daily temperature was drawn through the points, and envelope curves were drawn to show the range (fig. 5). Winter stream temperatures are normally 1°C., but range from 0 to 2.5°C. depending on snow cover over the stream channel — higher temperatures occur with more snow for insulation.

Throughout the year, mean stream temperature usually deviates less than 1°C. from the mean soil temperature at 31 cm. for location A. The stream seems to warm more rapidly in April, but the soil soon catches up. The stream warms to a peak of about 15°C. by the end of July. The range of water temperatures from May through November is about ± 3°C. from the mean and seems to increase slightly in the leafless periods as does the soil temperature range near the surface.

Microrelief and Soil Temperature

The ground surface at Hubbard Brook is very uneven; it is pock-marked by windthrow mounds and depressions and strewn with boulders. These factors alter the soil temperature regime from the uniform slope case of location A discussed so far. We have no

Figure 6.—Mean monthly deviation of soil temperatures in windthrow mounds and depressions from temperature at location A for the same depths and time. Solid bars indicate that the paired means are significantly different, based on a t-test at the 5 percent level.



specific information on the effect of rocks; but because their thermal conductivity is several times that of soil, they can be expected to make the temperature profile more isothermal.

We have measured temperature profiles in the top of two windthrow mounds (one profile each) and the bottom of an adjacent depression (two profiles) near location A. The two mound profiles were averaged, and the two depression profiles were averaged for this study; and the differences at each depth from the temperature at the same depth and time for location A were evaluated. Location A is on a uniform slope.

Three years of data (1960-62) clearly show that the mounds cool faster in the fall and are colder through the winter (fig. 6). This is due to a thinner organic layer and thinner snow cover and leads to a greater incidence of soil frost on the mounds (*Hart, Leonard and Pierce 1962*). The mounds also tend to be several degrees warmer in summer due to the thinness of their insulating organic cover. Depression temperatures deviate less than mounds from the uniform slope values (fig. 6). They may be about 1°C. warmer in winter at some depths because of thicker organic and snow layers. Summer temperatures in depressions are not consistently different from soil temperature at the same depth on a uniform slope.

Soil Temperatures at Other Sites

Soil temperatures have been measured with Colman units at three other sites on the Hubbard Brook Experimental Forest since 1969. One of these is near weir 7 on a 10° northwest-facing slope (here designated "north-facing") at 610 m. elevation (fig. 1). Two profiles were obtained at this location about 10 m. apart on uniform slopes, but data at the same depths were averaged for this analysis. The soil is a Becket fine sandy loam, a member of the coarse loamy, mixed, frigid family of Typic Fragiorthods.

The other two sites are close to each other near the center of the Experimental Forest at 470 m. elevation (fig. 1). The "wet" site is in a level area of poorly drained soil, a Peru slightly stony loam, a member of the coarse loamy, mixed, frigid family of Aquic Fragiorthods. A perched water table is near the surface much of the year. The nearby "dry" site is on a 15° south-facing slope and is Berkshire fine sandy loam. Only one profile was measured at each of these sites. Data for these sites was collected on the same date but not necessarily at the same time of day as at location A.

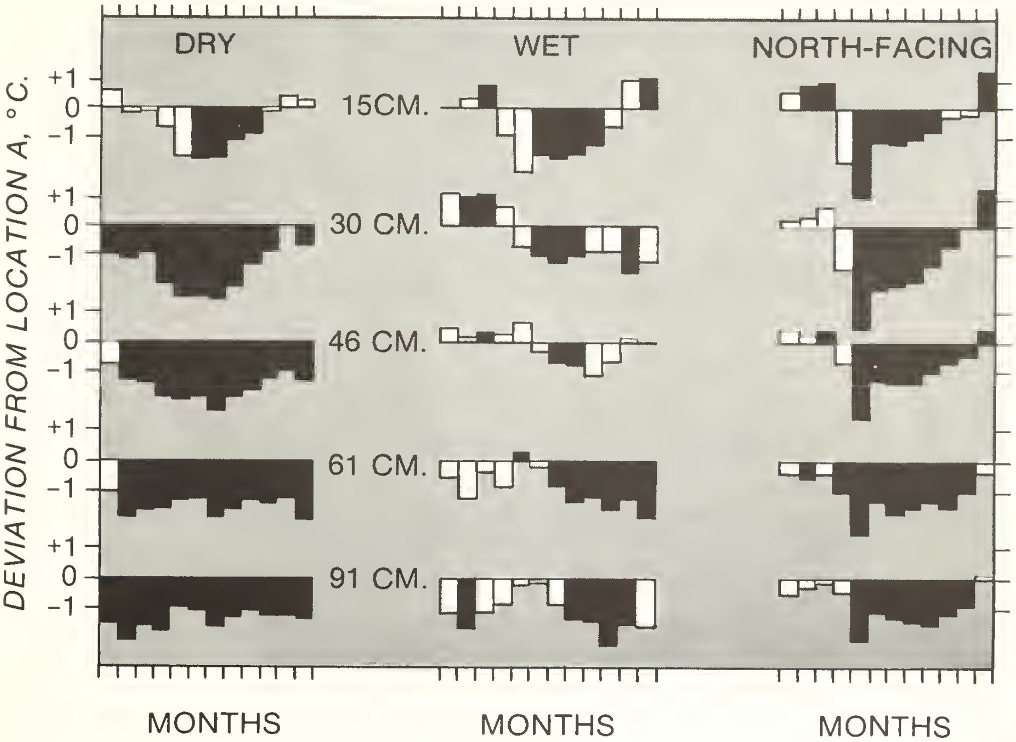
The best way to analyze these data was to average by months the differences in temperature from location A for the same depth and times (fig. 7). Although the depths had the same value as those for location A, they were not strictly comparable because depths were measured from the top of mineral soil for these sites rather than from the top of the F layer as at location A. This difference in the zero reference level may be about 6 cm.

The north-facing slope differs little from the south-facing location A in winter, but it warms more slowly in spring because of lower radiation and delayed snowmelt on the north-facing slope (fig. 7). Through the summer, this site is about 1.5°C. cooler than the south-facing slope. Figure 2 indicates that less than half of this difference can be attributed to the 6-cm. discrepancy in depths of measurement.

The dry site is 1 to 2°C. cooler than location A for all seasons and depths except 15 cm. (fig. 7). This is somewhat surprising because both sites have practically the same slope, elevation, and aspect. However the dry site is only 35 m. elevation above the Hubbard Brook valley floor, and it may be more subject to cold nocturnal drainage wind than is location A. The wet site is generally warmer than the dry site except in summer at 15 cm.; more detailed study of heat capacities and conductivities would be necessary to explain the differences. The wet site is cooler than location A in summer at all depths; and in fall, it is cooler at 61 and 91 cm.

None of the three sites differs on the average by more than 2.5°C. from location A except during snowmelt, which occurs in May on the north-facing slope. These differences, although small, are consistent and indicate that in some parts of the Hubbard Brook basin, soil temperature may average 1 to 2°C.

Figure 7.—Mean monthly deviation of soil temperatures at three sites from temperatures at location A for the same depths and date. Solid bars indicate that the paired means are significantly different based on a t-test at the 10 percent level.



cooler than at location A, especially in summer.

Soil temperatures for any date and depth on the south-facing watersheds of Hubbard Brook can be estimated from fig. 2, which provides long-term means by date and depth. Fig. 3 shows the possible deviations of the estimate from the actual temperature due to variation among days and years. Variation from site to site may contribute another 2 or 3°C. to the deviations of any estimate from the actual temperature.

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Northeastern Forest Experiment Station

FOREST SERVICE, U.S. DEPT. OF AGRICULTURE, 6816 MARKET STREET, UPPER DARBY, PA. 19082

A STOCKING GUIDE FOR EASTERN WHITE PINE

Abstract. — A stocking chart for eastern white pine is presented and described. The chart shows basal areas and numbers of trees by mean stand diameter, representing the upper limit in stocking for practical management (A curve) and minimum stocking for full site utilization (B curve).

Eastern white pine (*Pinus strobus* L.) is one of the most important timber species in New England—it accounts for about one-fifth of the board-foot volume. Although some studies on thinning have been made, foresters lack a practical guide for thinning white pine. The stocking guide for white pine presented in this paper is similar to those for hardwoods described by Gingrich (*1964*) and Leak, Solomon, and Filip (*1969*). Detailed techniques in developing the white pine guide were given by Philbrook (*1971*).

Description of Guide

The stocking guide (fig. 1) applies to nearly pure even-aged white pine stands. The guide shows an A curve, a B curve, basal area per acre, number of trees per acre, and mean d.b.h. for trees in the main crown canopy. The A curve represents 80 percent of full stocking, based on Frothingham's (*1914*) yield data. Because most natural stands contain openings and, therefore, trees are not as well spaced as in yield study data, the A curve was considered the upper limit in stocking for practical management. The B curve represents minimum stocking for full site utilization. Stands above the A curve are overstocked, stands between the A and B curves are adequately stocked, and stands below the B curve are understocked.

Under most conditions, stands are considered for thinning when stocking is more than halfway between the A and B curves. Stocking after thinning should be near the B curve. If the stand was originally near (or above) the A curve, it would be best to bring the stand down near the B curve in several successive thinnings. After thinning, the stand should consist of well-spaced, good quality trees with crowns large enough for vigorous tree growth.

An Example

Assume that we have a stand containing 110 square feet of basal area per acre and having a mean stand diameter of 8 inches. We plot a point for this stand in figure 2. Because the point is near the B curve, we allow the stand to grow toward the A curve. The stand grows until it reaches 165 square feet of basal area and a mean diameter of 10.0 inches (indicated by the solid line in figure 2). Then we decide to thin, and we

Figure 1.—Stocking guide for nearly pure even-aged white pine stands, showing basal area per acre, number of trees per acre, and mean d.b.h. for trees in the main crown canopy.

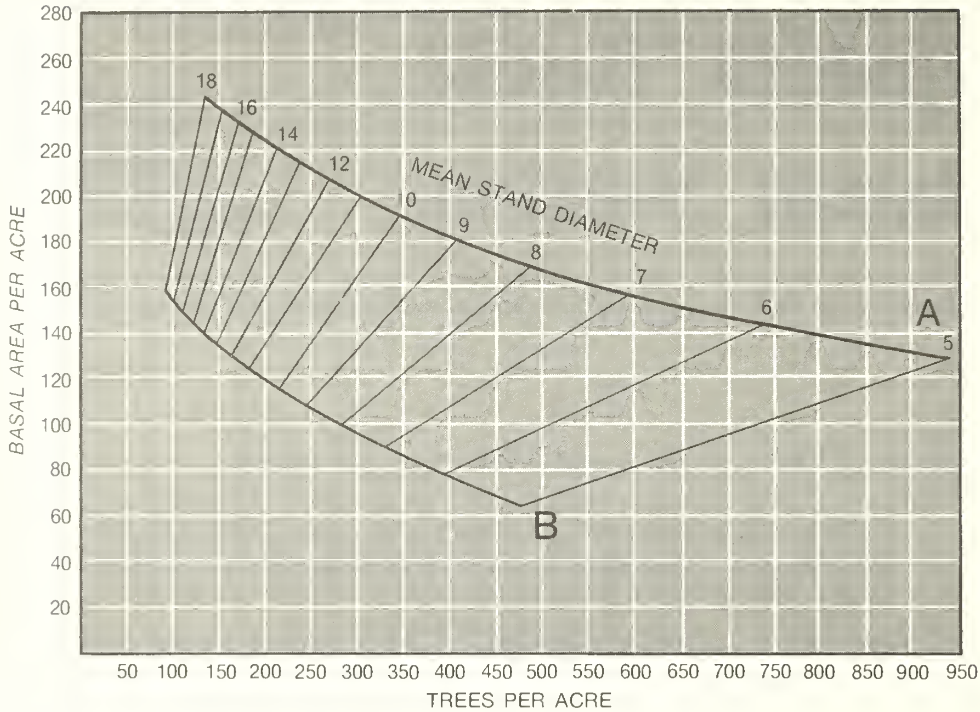
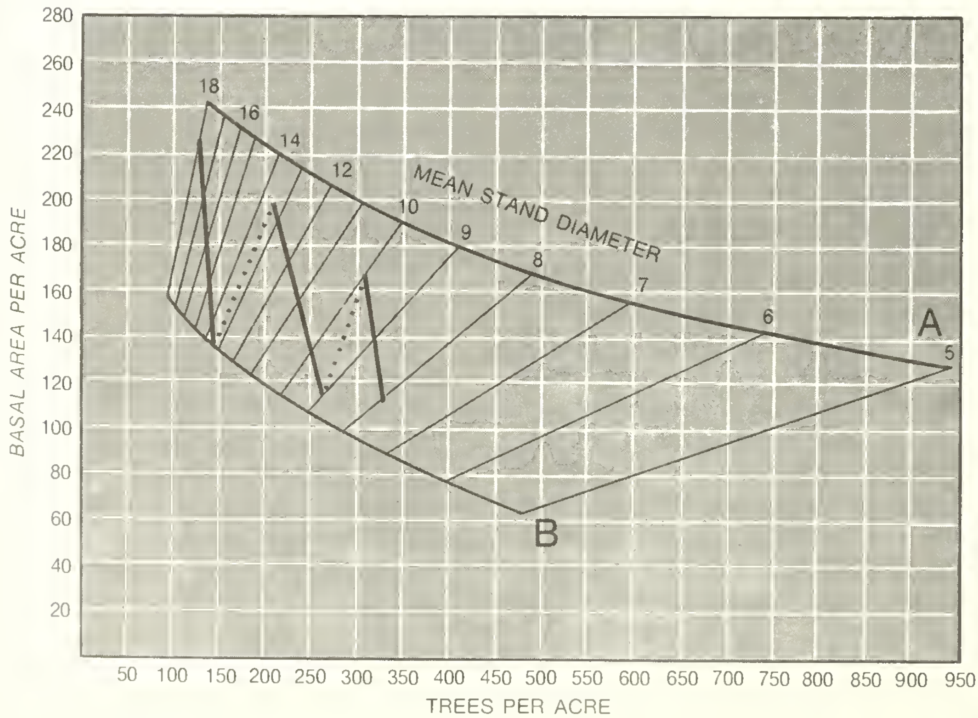


Figure 2.—An example of using the stocking guide in a hypothetical thinning schedule.



cut the stand back to a basal area of 116 square feet and a mean diameter of 9.2 inches (dotted line).

The mean stand diameter was reduced from 10.0 to 9.2 inches presumably because some large, poor quality trees were cut. The stand grows to 200 square feet of basal area per acre and a mean diameter of 13.4 inches (solid line). We thin a second time. After thinning, the stand contains 140 square feet of basal area per acre and has a mean diameter of 13.9 inches (dotted line). Then the stand grows to 222 square feet of basal area per acre and a mean stand diameter of 18.0 inches. At this time, we might consider a harvest cut.

Of course, the example given is hypothetical. A forester would have considerable flexibility in using the guide.

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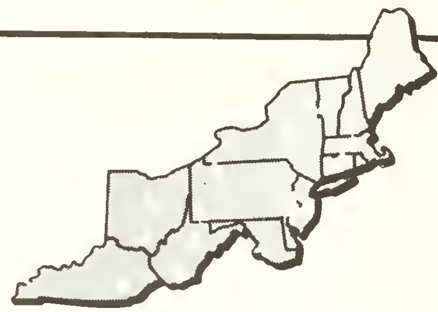

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SOME OBSERVATIONS ON AGE RELATIONSHIPS IN SPRUCE-FIR REGENERATION

Abstract. — Measurement of the ages of seedlings of balsam fir (*Abies balsamea* (L) Mill.), red spruce (*Picea rubens* Sarg.), and white spruce (*Picea glauca* (Moench) Voss) 15 years after the first harvest of a two-cut shelterwood operation revealed that very few potential crop-tree seedlings in the sample occurred as advance regeneration in the original stand. Relationships among total height, age, and current growth of the samples are reported, as well as the variation in seedling age encountered.

Knowledge of the development of spruce-fir regeneration under various silvicultural prescriptions can be extremely useful. The age, growth characteristics, and origin of regeneration in both time and space must be known in order to judge the success of a particular silvicultural prescription, and to predict the future performance of individual trees. In this study we determined the age variation in seedlings of crop-tree quality following a shelterwood cutting program and examined the relationships between total age, current leader growth, and total height.

The study area, on the Penobscot Experimental Forest in south-central Maine, was harvested by a two-cut shelterwood system. The original stand averaged 170.6 square feet of basal area with an average diameter of 7.1 inches for trees over 4.5 inches DBH. Fifty-seven percent of the basal area was spruce and fir. The first overstory removal in 1957 took 58.8 square feet or 34 percent of the original basal area. The final harvest in 1967 removed all but 31 square feet or about 18 percent of the basal area. The result was a very open area with a few scattered individual trees and islands of residual trees. Total stocking of regeneration of all species was 9,640 in 1965 (trees up to 2.1 feet in height or 0.49 inches DBH) and 18,160 seedlings in 1970. In both 1965 and 1970 the percentage of spruce and fir in the regeneration was 48 percent, and spruce alone made up 6 percent. This study was undertaken in the fall of 1971.

Sample trees were chosen at 15-foot intervals along two randomly-located line transects through a portion of the area. We tried to choose balsam fir (*Abies balsamea* (L) Mill.), red spruce (*Picea rubens* Sarg.), and white spruce (*Picea glauca* (Moench) Voss) at each location, although this was not always possible. The criteria for choosing individual trees was that each be the best potential crop tree of the species (a subjective judgment), under 1½ inches in diameter at breast height, within a 7½ foot radius of the sampling point.

Seventy-three trees were used for the correlation analysis; this sample was later enlarged to 121 trees for additional data on age variation.

Total height and current leader growth were measured in the field, as was leader growth for the prior two growing seasons. Age was determined from ring counts of cross sections made just above the root collar.

Age Variation

The sample trees ranged from 3 to 42 years old, the oldest being a balsam fir. The mean age of the 73 seedlings in the original sample was 10.96 years, with a standard deviation of ±5.96 and a coefficient of variation of 54 percent. A breakdown of these data by species was as follows:

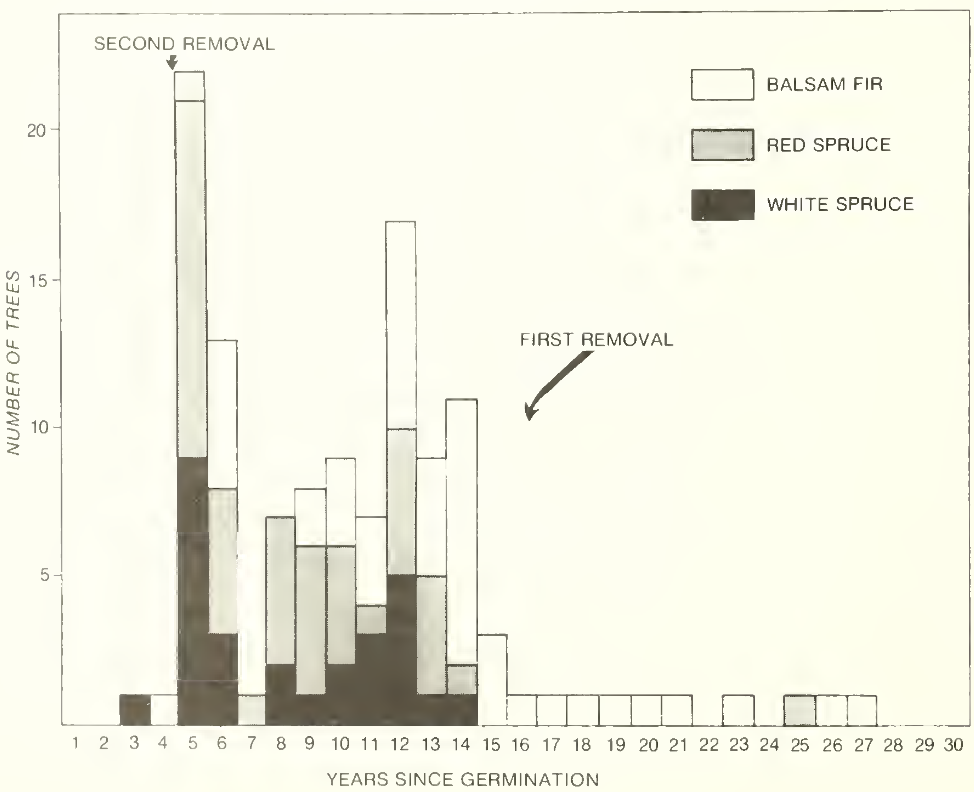
	Mean Age	*S*	*CV*
White spruce	8.00	±3.34	42%
Balsam fir	14.03	±7.08	50%
Red spruce	9.67	±4.22	44%

These statistics can be misleading, however, as a plot of the data (expanded to a sample of 121 seedlings) shows a definite bimodal trend that appears to be related to the two overstory removals (Figure 1).

The first overstory removal, which began in the spring of 1957 and continued into the fall, apparently created conditions favorable to the establishment of new seedlings through succeeding growing seasons. Approximately one-third of the crop-tree-quality seedlings were between 12 and 15 years old in 1971. Thus they were established during the four growing seasons after the first harvest; the largest number were established during the fourth growing season.

The second overstory removal took place in the late summer and fall of 1967. Apparently this removal released one- and two-year-old seedlings (5 and 6 years old in 1971) that made up another third of the crop trees in our sample. Any regeneration after this removal

Figure 1.—Numbers of potential crop trees, by age class and species. One balsam fir 37 years old and one 42 years old are not shown.



was probably too small in 1971 to be included in our sample of potential crop trees.

There were slight variations in this trend by species. The 1965 growing season was extremely dry, which may account for the lack of potential crop trees established during that year. Also, the almost total lack of spruces among the potential crop trees that originated before the first overstory removal is interesting. In fact, the number of potential crop trees of all species that were established in the stand before the first removal is relatively low, considering the importance often placed on advance reproduction in the management of spruce-fir stands (fig. 1). This may indicate that seedings established before cutting develop more slowly after release than newly established seedlings; it may also reflect a lack of adequate advance regeneration in the original stand, which was quite dense before harvest; or it may result from a combination of factors.

Growth Relationships

Correlations among total height, current leader growth, and age were evaluated.

Balsam fir, probably the most tolerant species of the three studied, had the lowest correlation among these factors, as illustrated by the following coefficients of determination (r^2):

	Total ht.	*Current growth*	*Age*
Total ht.	—	.282**	.334**
Current growth		—	.000(NS)
Age			—

** Highly significant (.01 percent level).
NS—Non-significant.

Relationships for red spruce, probably less tolerant than balsam fir, were somewhat better.

	Total ht.	*Current growth*	*Age*
Total ht.	—	.674**	.661**
Current growth		—	.559**
Age			—

For white spruce, the least tolerant of the three species, coefficients of determination (r^2) were:

	Total ht.	*Current growth*	*Age*
Total ht.	—	.845**	.608**
Current growth		—	.364**
Age			—

Balsam fir, the species often considered the most tolerant among those studied, demonstrated the weakest relationships among total height, current growth, and age because it has the ability to survive for relatively long periods in a suppressed position. The two spruces, particularly white spruce, are lower on the tolerance scale and those trees that survive are usually in positions more favorable for growth.

It was possible to identify and measure internodal growth on the sample crop trees for several prior growing seasons. To determine whether there were strong relationships between the amounts of annual leader growth in successive years, correlation coefficients for growth between years were determined.

	Annual Growth Correlations		
	71-70	*70-69*	*69-68*
Fir	.658**	.814**	.668**
Red spruce	.630**	.591**	.249NS
White spruce	.873**	.856**	.600**

The relationships were not considered consistent enough to be of value in choosing crop trees that would grow faster. Generally these young trees are just emerging from a host of competitive influences that affect growth. This, along with the myriad other variables that may limit leader growth, restricts the validity of past growth as a predictor of future growth. Once the seedlings reach a more stable competitive environment, it is reasonable to expect a more consistent relationship between the amounts of growth in successive years.

Conclusion

The need for information about the development of individual spruce and fir seedlings will increase with the advent of intensive silvicultural practices. We need to take a hard look at advance regeneration, and more particularly "well established" regeneration that can be relied on to reproduce the next stand.

Although the information in this case history is by no means conclusive because of sampling limitations, it does present some interesting conclusions and questions that warrant further investigation. For instance:

1. Most of the individual trees presently judged to be potential crop trees, particularly the spruces, were not present in the stand before it was first cut. It appears that seedlings established as a direct result of the two shelterwood removals, rather than advance reproduction present under the old stand, produced most of the potential crop trees on the area studied. This raises the question of whether adequate advanced regeneration, adequate in quantity or in quality, can be obtained in stands that have not been subjected to intermediate harvests or to modification of the crown canopy from natural causes.

2. There was considerable variation in the ages of trees we considered potential crop trees, and regeneration appears to be a continuing process related loosely to the overstory removals.

3. Internodal growth was not a consistent indicator of future growth in height.

4. Total height and current growth were significantly related in the two spruces, as were age and total height. These relationships were considerably weaker in the more tolerant balsam fir.

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TIMBER-HARVEST CLEARCUTTING AND NUTRIENTS IN THE NORTHEASTERN UNITED STATES

Abstract. The effect of ecosystem disturbance on nutrients in the system has been receiving widespread attention. An appraisal of research results in the Northeast indicates that timber-harvest clearcutting has not increased nutrient levels sufficiently to reduce water quality below drinking water standards. Losses of nutrients from clearcuttings in New Hampshire over a 2-year period were about 85 pounds per acre for nitrate-N and 80 pounds per acre for Ca. Losses in the central and southern Appalachians were far less. There is both need and opportunity for productive research on many aspects of nutrient flow in forested ecosystems.

For many years, it was believed that the only important effect of timber harvesting on water quality was the sedimentation of streams and reservoirs. This has been quite thoroughly investigated, and the effects of cutting on streamwater temperature have also been the subject of some study.

More recently, the effects of cutting on nutrient discharges in streamflow have attracted widespread attention. In 1965, a 39-acre watershed (Watershed No. 2) on the Hubbard Brook Experimental Forest in New Hampshire was completely deforested in an experiment designed primarily to determine the effect of vegetation elimination on water yield (*Hornbeck et al. 1970*). All trees and other woody vegetation were cut and left in place; herbicides were applied over the next 3 years to prevent regrowth. Along with the major objective, Forest Service researchers and cooperators studied the influence of this experimental treatment on the nutrient cycle (*Pierce et al. 1970*). After treatment, discharge of some nutrients in streamwater was surprisingly high, high enough that some expressed fears about the effects of forest cutting on streamwater quality and site productivity.

RESEARCH ON TIMBER-HARVEST CLEARCUTS

Because of these concerns, the Northeastern Forest Experiment Station initiated studies to determine nutrient losses from actual timber-harvest clearcuts. Several clearcuts on the White Mountain National Forest in New Hampshire were investigated and a timber-harvest clearcut was made on a gaged watershed at the Fernow Experimental Forest in West Virginia.

Two small clearcut watersheds in the Gale River drainage were included in the New Hampshire study. One of these areas had been cut the year before sampling, the other about 2 years before (*Pierce et al. 1972*). Nutrients discharged in streamflow following cutting were estimated, in pounds per acre, at:

	1st yr.	*2nd yr.*	*2-yr. total*
Nitrate-N	34	51	85
Ca	37	43	80

The effect on other nutrients was relatively small. Amounts of nutrients discharged from the other clearcut areas in the New Hampshire study were of the same general magnitude, though there was considerable variation. For comparative purposes, nutrient discharges from undisturbed watersheds can be considered negligible.

After these clearcuttings in the White Mountains, watershed averages for nitrate-N concentrations in the streamwater ranged from 1.3 to 4.5 parts per million (p.p.m.); the maximum recorded value was 6.4 p.p.m. Measurements made farther downstream illustrated the dilution provided by essentially nutrient-free water from areas not cut. As an example, on one sampling occasion, the nitrate-N concentration in streamwater draining 160 clearcut acres was about 4.3 p.p.m.; at a point downstream for which the total drainage area was 240 acres (160 cut, 80 uncut), the concentration was only about 2.3 p.p.m.

Nutrient discharges were far less following the timber-harvest clearcut studied in West Virginia (*Aubertin and Patric 1972*). In the first year after harvest, nitrate-N discharge was about 2.9 pounds per acre and Ca about 5.6 pounds.[1] Average nitrate-N concentration in streamwater was only 0.2 p.p.m. for the growing season and 0.5 p.p.m. for the dormant season; the maximum recorded was 1.4 p.p.m. Perhaps the per acre values should be increased somewhat to compensate for water lost to deep seepage and not measured at the weir, but such an adjustment would not change the general picture.

A beginning in studies on this subject has been made at the Coweeta Hydrologic Laboratory in the southern Appalachians. Researchers there report that "Contrary to findings at Hubbard Brook, the results of experimental treatments at Coweeta have not shown an accelerated loss of ions to the streams" (*Douglass and Swank 1972*).

A recent study by Marks and Bormann (*1972*) showed how forest regrowth tends to minimize nutrient losses from the ecosystem and thus promotes "a return to steady-state cycling characteristic of a mature forest". They sampled stands of pin cherry that followed clearcutting and found, among other things, that the standing crop at age 14 held about 180 pounds per acre of N and 160 pounds of Ca. They estimated that annual uptake of N in the 4- and 6-year-old stands was about 50 percent greater than in the more-or-less mature, undisturbed ecosystem at Hubbard Brook. Perhaps equally important is the shading of the forest floor by new vegetation and the resultant decreases in surface temperature and rate of organic matter decomposition.

DISCUSSION

Site Productivity

Our knowledge about nutrients in the forest ecosystem is still limited. But we are now in a far better position to evaluate the impacts of timber harvesting than we were just after the experimental deforestation of Hubbard Brook Watershed No. 2.

Nutrient losses at the Fernow in West Virginia and at Coweeta farther south in the Appalachians were only a small fraction of those in the White Mountains. Though much remains to be learned, the relatively high New Hampshire losses apparently occurred because of the podzol soils which have large accumulations of organic matter on the surface and mineral horizons that are generally low in available nutrients, and possibly low in ability to retain nutrients.

Exposure of the forest floor — at least on the New Hampshire study areas — resulted in greatly accelerated decomposition of organic matter and the release of stored nutrients. These nutrients are necessary for the rapid establishment and growth of a new stand, and to the extent that the nutrients are so used, the accelerated decomposition

[1] Aubertin, G. M. and J. H. Patric. Water quality after clearcutting a small watershed in West Virginia. Manuscript in preparation.

of the forest floor is desirable. But soluble nutrients are also subject to removal by drainage, and this effect is usually considered undesirable. On the other hand, some nutrient contribution to streams is necessary to maintain aquatic life.

The importance of nutrient loss after clearcutting cannot be evaluated without considering the nutrient capital of the ecosystem and the possible rate of replenishment of losses.

Loss of nitrate-N from the timber-harvest clearcuts studied in New Hampshire was an estimated 85 pounds per acre in two years. Probably an additional but lesser amount would be lost in subsequent years before regrowth reestablished near steady-state conditions. It has been estimated that there is about 4500 pounds per acre of N in the forest floor and upper 18 inches of soil at Hubbard Brook (*Pierce et al. 1972*). If loss after clearcutting is 100 pounds per acre, this would amount to 2.2 percent of the capital. But it must also be recognized that this N capital is in a variety of compounds, some extremely resistant to decomposition.

The Hubbard Brook studies indicate an annual input of nitrate-N in precipitation of about 3.6 pounds per acre; under nearly steady-state conditions, about half of this is discharged in streamflow. But precipitation input and streamflow output do not a nutrient budget make. There are other sources, especially fixation of atmospheric N by organisms, that are poorly understood and even less well measured. And there is some loss of N from the ecosystem to the atmosphere and some loss of nutrients in harvested forest products.

We cannot say with any precision how much Ca is in the nutrient capital of the Hubbard Brook ecosystem. However, according to one estimate there is about 2700 pounds per acre in the organic matter and as available nutrient in the soil (and perhaps 25,000 pounds per acre incorporated in the soil and rock minerals) (*Bormann and Likens 1970*). A loss of 100 pounds per acre would amount to a little less than 4 percent of the organic-available component. Some replenishment may come from the mineral component, but at very slow rates. The precipitation input for Ca is a little less, and the near steady-state discharge in streamflow a little more, than in the case of N.

Some express concern about the impact of repeated clearcutting upon site productivity. Fortunately, decision makers now are not required to decide what to do at the end of the rotation period, 60 to 100 years from now. Decisions then can be based upon conditions at that time and certainly on a fund of knowledge about ecosystems that will be vastly superior to ours. But we must assess now the consequence of the practices applied now. Thus the question raised for stands and soils like these in New Hampshire may be something like this: Can we afford to lose through clearcutting something in the neighborhood of 100 pounds per acre of nitrate N and a similar amount of Ca (perhaps 2 percent of the available capital for N and almost 4 percent for Ca)? And this with the understanding that the rate of replenishment through the next rotation is uncertain, and that some portions of the area will lose more, some less than the average.

A timber harvest by strip cutting, a method favored by many silviculturists for use in northern hardwoods, is now being studied on a gaged watershed at Hubbard Brook. Trees are being cut in a series of three successive strips at 2-year intervals in this modification of clearcutting, and nutrient outflows are being measured. When results are available, they should show the extent to which the trees left on the site slow decomposition by shading the forest floor and utilize nutrients made available by the cutting.

For soils like those at the Fernow and Coweeta — and in a general way this *may* turn out to include most non-podzols in the East — losses of nutrients appear to be negligible.

One way to meet the problem presented by the different results at different locations is to monitor streamflow from areas harvested in the near future, to get a better idea of the situation in each locality. The consistency of nutrient concentrations that has been demonstrated at any sampling site from week to week should make such monitoring relatively easy. Probably as few as three samples collected during the year after cutting and analyzed for N and Ca would have demonstrated the big difference in reaction to cutting of the Gale River and Fernow watersheds.

My discussion so far, and much that has appeared recently in the literature, has dealt only with the cutting of trees. A review of both older and more recent literature still impresses me with the fact that in timber harvest the soil disturbance associated with logging has a greater impact on the site than tree cutting by itself. Thus when harvesting timber — whether by clearcutting or some other method — care in logging is of great importance. Much has been written about how to log with a minimum impact on soil and water and I won't go into it here.

Water Quality

None of the measurements of streamwater from timber-harvest clearcut areas indicated nutrient concentrations higher than public health standards for drinking water. Barring almost simultaneous clearcutting of all the area in major drainages, that problem will not even be approached. Not even the strongest advocates of clearcutting are advocating that kind of application.

Minor localized and probably transient eutrophication of small streams may follow clearcutting (*Pierce et al. 1972*). Because this effect is temporary, it does not appear to pose any serious problem.

RESEARCH NEEDED

We can now paint with a broad brush the impact of timber harvest on nutrients. But more knowledge is needed on many aspects to round out the picture.

We need continued study to determine effects over a longer period of years. And we need to find out what soil and other factors contributed to the great differences in nutrient discharge obtained at different locations.

We need quantitative information on nutrient input from sources other than precipitation, especially the fixation of atmospheric N. And at what rates do the N and Ca in the organic matter and in the soil become available to plants under both steady-state and disturbed conditions?

We can now readily measure the discharge of nutrients in streamflow and thus determine the average loss over the watershed. But it is safe to assume that different parts of the watershed are affected differently, and we must learn more about this as a guide to more intensive management.

A far-reaching appraisal of the general well-being of a variety of stands on sites subjected to various severe disturbances should improve our ability to make value judgments. Included might be European stands regularly clearcut over a period of several hundred years, stands established on abandoned depleted farmland, stands of near-rotation age on surface-mined sites, and stands on sites logged and burned in years past. The capacity of forest cover to survive and often prosper under difficult conditions should be documented.

Application of fertilizer to compensate for nutrient losses is a possible option in future management. We need to investigate the feasibility of this practice, including considering side effects on the ecosystem.

We need to learn more about how much nutrient increase it takes to cause eutrophication of specific water bodies, and the damage and benefits resulting from this eutrophication.

And perhaps most important, we must learn how to put it all together to better understand, manage, and protect the ecosystem.

SUMMARY AND CONCLUSIONS

Recent research on the impact of timber-harvest clearcutting on soil nutrients may be summarized thus:

In 2 years following clearcutting in New Hampshire, about 85 pounds per acre of nitrate-N and 80 pounds of Ca were discharged in streamflow. Losses after cutting may amount to about 2 percent of the N capital available in the ecosystem and 4 percent of the Ca. These are only approximations and are average figures; losses in particular situations, such as in very shallow soil, may be greater relative to nutrient capital on the site.

Nutrient losses following clearcutting in the central and southern Appalachians appear to be negligible. The differences between the

New Hampshire and other results seems to be associated with the nature of podzol soils.

Timber-harvest clearcutting did not result in reducing water quality below drinking water standards in any of the studies made. Slight, local, and temporary eutrophication of streamflow was noted in the New Hampshire studies.

There are many opportunities for productive research on various aspects of nutrient flow in forest ecosystems.

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PRESSURE INJECTION OF SOLUBILIZED BENOMYL FOR PREVENTION AND CURE OF OAK WILT

Abstract—A preliminary evaluation of the effectiveness of injecting solubilized benomyl into oaks for prevention or cure of oak wilt disease is presented. Symptom development was greatly reduced or prevented in trees injected with fungicide before inoculation. Symptom development was markedly arrested in diseased trees by fungicide injected before more than 10 percent of the crown was wilted, but treatment of trees with more advanced disease symptoms was not effective.

Benomyl (methyl 1-(butylcarbamoyl)-2-benzimidazole carbamate), a broad-spectrum systemic fungicide, is being widely investigated as a control agent for Dutch elm disease. We are also studying the effectiveness of this fungicide for control of oak wilt, a similar vascular wilt disease.

Various workers (*1, 6, 12, 13*) have applied benomyl to the soil around healthy elms to provide protection from Dutch elm disease. Results have ranged from good protection to no protection. Smalley (*12*) and Hart (*5*) have reported success with spray application of benomyl to American elm for protection from natural infection. Solubilized benomyl injected into the xylem of oaks, elms, and maples becomes distributed in the branches and twigs (*3*); and Gregory *et al* (*4*) reported the effectiveness of solubilized benomyl injected into red oak seedlings as a protectant and therapeutant for oak wilt disease.

This is a report of preliminary results of studies to determine the value of pressure injection of methyl 2-benzimidazole carbamate hydrochloride (MBC·HCl) solutions into the xylem of large red oaks for prevention and therapy of oak wilt.

Benomyl hydrolyzes to methyl 2-benzimidazole carbamate, butylamine, and carbon dioxide. Of these hydrolysis products, methyl 2-benzimidazole carbamate (MBC) is considered to be the active fungicidal material in plants treated with benomyl (*11*). Buchenaur and Erwin (*2*) applied a spray containing MBC to cotton plants for control of *Verticillum* wilt. The fungicidal properties of certain benzimidazole carbamates were reported in patents by Klopping (*8*). Littler *et al.* (*9*) patented the use of MBC and some of its fungitoxic salts as foliar fungicides. McWain and Gregory (*10*) reported a process for converting benomyl to water-soluble MBC·HCl, and this was the solution used in these tests.

Pressure injection of fungicide directly into the xylem of trees was selected as the application method for these studies because it seems to offer many advantages over other methods. With injection, the fungicide is confined within the tree, so the environmental contamination hazard is minimal. Less fungicide is required with this method, and there is almost no delay between treatment and establishment of an effective dosage at desired sites.

METHODS

Methods for the prophylactic study and the therapeutic study were similar. The studies were made in an even-aged oak-hickory stand in southern Ohio. Study trees were northern red oak, *Quercus rubra* L., black oak, *Q. velutina* Lam., and scarlet oak, *Q. coccinea* Muench., 7 to 21 inches d.b.h. Species was ignored in assigning treatments. Study trees were divided into five size classes. Each treatment of the two studies was randomly assigned to one tree in each size class so each treatment was repeated five times.

Prophylactic Study

Study trees were injected during the last week in May, using the pressure injection apparatus and method described by Jones and Gregory (*7*). Injected solutions were of solubized benomyl (MBC·HCl) at concentrations of 0.67, 4.0, and 24.0 g./l. Injection volumes were approximately proportional to the d.b.h. of the tree (2,280 ml. for 7-inch trees to 7,015 ml. for 21-inch trees). The number of injection sites per tree was 2, 3, or 4 for 7-9, 10-13, or 14-21 inch d.b.h. trees, respectively. The injection sites were evenly spaced around the tree trunk 1 to 3 feet above the ground. Injection pressure was 80 p.s.i.

During the first week of June (1 week after injection), the trees were inoculated in one of two ways; through 1/2-inch wood-chisel cuts into the xylem at 4-inch intervals around the bole of the tree at breast height or through one 1/2-inch wood-chisel cut into the xylem of a branch located about midway between the top and bottom of the crown at a point on that branch about 8 feet from the bole of the tree. About 5 million conida of *Ceratocystis fagacearum* (Bretz) Hunt, suspended in water, were applied to each chisel cut.

These particularly severe inoculation procedures were used to rigorously test the value of the MBC·HCl injection treatments.

Treatment checks consisted of trees that were injected but not inoculated, and inoculation checks consisted of trees that were inoculated but not injected.

Observations of symptom development were made at approximately weekly intervals throughout the growing season.

Therapeutic Study

Study trees were inoculated in the crown during the first week in June as described for the preceding study. When trace, 25 percent, or 50 percent crown symptoms were apparent, the trees were injected, as previously described, with either 4 or 24 g./l. MBC·HCl solution. Injection pressure was 80 p.s.i.

Inoculation checks consisted of trees that were inoculated but not treated. Treatment checks from the prophylactic study were considered to be applicable also to this study. Oak wilt infection in trees of both studies was confirmed by isolation of the pathogen from branch samples.

RESULTS AND DISCUSSION

In the prophylactic study, symptom development in bole-inoculated trees decreased as concentration of injected MBC·HCl increased (table 1) and was limited to an average of only 12 percent of the crown in trees treated with the highest concentration. In crown-inoculated trees, symptom development was not prevented by the low concentration of solution, but virtually no symptoms developed in trees treated with the medium and high concentrations.

In the therapeutic study, a marked reduction in symptom expression occurred in trees injected at trace (5 to 10 percent) symptom development with either concentration of MBC·HCl (table 2). But treatment of trees with 25 and 50 percent crown symptoms was not effective.

No evidence of chemical phytotoxicity or mechanical damage from the pressure injection was observed in the crowns of any treated trees. However, there was some tissue damage in the boles of some trees treated with the high-concentration solution. In these trees, the cambium was killed in a narrow strip extending from a few inches to a few feet above and below the injection site. By the end of the growing season, healthy callus tissue was evident

Table 1.—Prophylactic study: average percent of oak wilt crown symptom development at end of 1972 growing season in inoculated trees previously injected with solubilized MBC·HCl

Treatment	Noninoculated	Bole inoculated	Crown inoculated
No injection	0	84	28
Water injection	0	76	44
MBC·HCl injection			
Low concentration (0.67 g./l.)	0	32	45
Medium concentration (4.0 g./l.)	0	21	1
High concentration (24.0 g./l.)	0	12	0

Table 2.—Therapeutic study: average percent of oak wilt crown symptom development at the end of the 1972 growing season in crown inoculated trees injected with solubilized MBC·HCl

Treatment	No injection (checks)	Treatment at trace symptoms	Treatment at 25% symptoms	Treatment at 50% symptoms
No injection	85	—	—	—
MBC·HCl injection				
Medium concentration (4 g./l.)	—	22	79	71
High concentration (24 g./l.)	—	37	74	85

around the margin of these wounds, and they appeared to be healing satisfactorily. Injection wounds, where no chemical injury was apparent, were two-thirds callused over by the end of the growing season.

Time required for solution injection was quite variable, but for healthy trees in the prophylactic study averaged 22 minutes per tree. Injection time for diseased trees in the therapeutic study averaged 52, 89, and 93 minutes per tree for trees treated with trace, 25, and 50 percent symptom development, respectively.

CONCLUSIONS

The preliminary results of these studies suggest that injecting solubilized benomyl into red oaks can be effective for prevention of oak wilt disease. But this conclusion is based on the condition of study trees at the end of only one growing season after treatment. Of much greater significance will be the condition of these trees next summer when we can better judge the duration of the protection afforded by the injection treatment. Conclusions about the curative value of the injection treatment must be deferred until we determine whether arrestment of symptom progression in diseased trees is permanent or temporary.

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THE SIGNIFICANCE OF SWEEP IN APPALACHIAN HARDWOOD SAWLOGS

Abstract. Sweep is one of the major stem-form defects in hardwood sawtimber. Some sweep is removed during bucking. But we found sweep of 2 inches or more on 17 percent of the 4,510 logs measured at Appalachian sawmills. Volume deductions for sweep scaled at least 10 percent in 1 of every 7 sample logs and at least 15 percent in 1 of every 9 sample logs. Reduction in the severity of sweep might be obtained by applying the simple rules outlined for buckers.

Many hardwood trees do not grow into perfectly straight stems. Sharp deviations in stem alignment are called crooks. More gradual stem curvatures are called sweep.

The sharp crooks usually are removed and left in the woods when buckers cut the misshapen trees into usable sawlogs. But loggers find it difficult to remove most sawlog sweep without wasting much of the valuable timber resource. So sweepy logs are sent to the sawmills.

Just how prevalent and severe is the sweep in Appalachian hardwood sawlogs? Measurement of 4,510 logs at five mills in three states revealed the following:

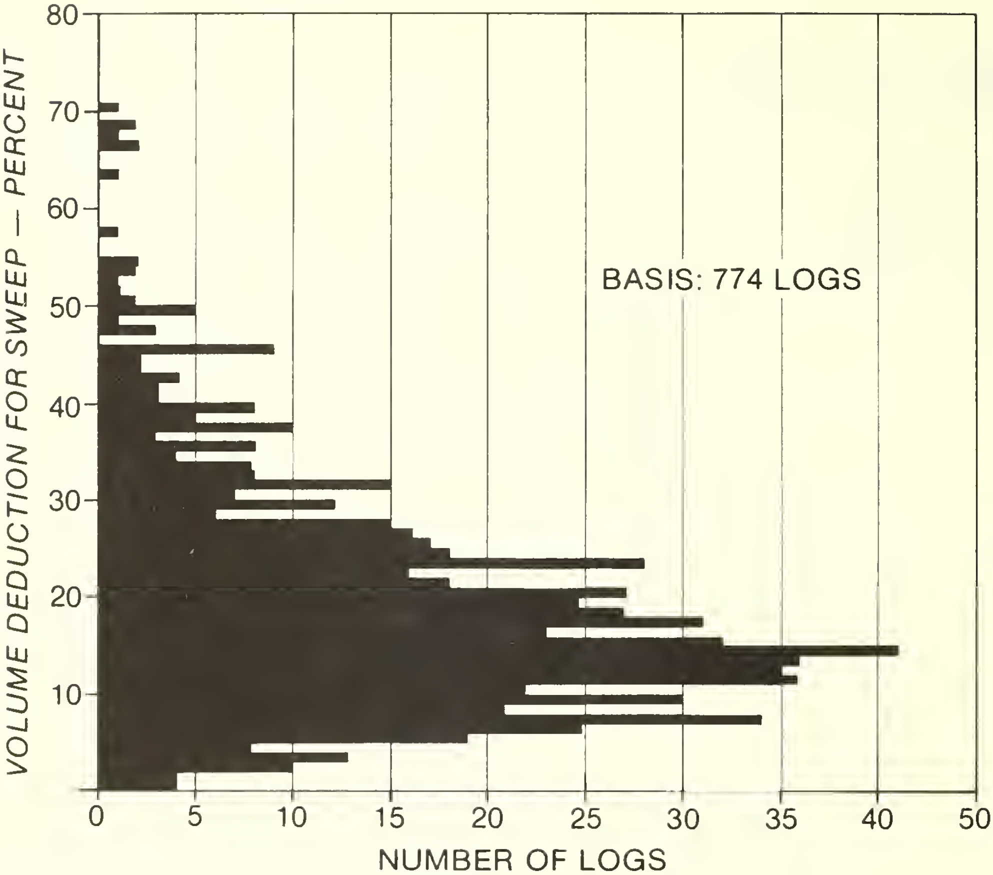
1. Most logs (83 percent) were straight or had only 1 inch of sweep. Sweep was measured in inches of maximum perpendicular deviation from a straight tape stretched from the center of one end to the center of the other end. Sweep of less than 2 inches was not recorded because the formula for computing sweep volume loss gives a zero or negative value when misalignment is only 1 inch in logs 8 feet long and longer.

2. About 17 percent of the logs had sweep of 2 inches or more. Eleven percent of the logs had sweep of 4 inches or more:

Sweep (inches)	*Logs (number)*	*Logs (percent)*
0 to 1	3,725	82.6
2	69	1.5
3	205	4.6
4	231	5.1
5	113	2.5
6	88	2.0
7	40	.9
8	24	.5
9	10	.2
10 or more	5	.1
	4,510	100.0

3. In those logs in which sweep caused a calculated volume loss, deductions for sweep ranged from 1 to 70 percent of gross log volume (fig. 1). The median deduction was 17 percent. Sweep deductions were com-

Figure 1.—Distribution of volume losses due to sweep in Appalachian hardwood logs.



puted from the modified Forest Service formula: percent volume deduction = [(maximum sweep deviation in inches) — (log length in feet ÷ 8)] ÷ [small end diameter inside bark].

4. In 1 out of every 7 sample logs, sweep deductions amounted to 10 percent or more. For 1 out of every 9 sample logs, sweep deductions were 15 percent or more.

Effect on Production and Economics

The fact that only 17 percent of the logs had enough sweep to influence log scale may tend to obscure the importance of this defect. So let me illustrate sweep effects in other terms.

Suppose one of the sample mills saws about 5 million board feet per year. Suppose further that the frequency and severity of sweep resembles the conditions we found. If allowances for sweep were disregarded, the overestimate of annual volume could reach 150,000 board feet. And overpayment for this extra log volume could easily amount to $12,000.

Most sawmills reduce the detrimental impact of sweep by deducting a portion of the gross volume when scaling. If either stumpage price or logging costs are based on correctly scaled net volume, then the sawmill does not pay for undeveloped lumber from logs with heavy sweep. But if sweep deductions are inaccurate, someone in the marketing chain (seller, producer, or buyer) gains or loses money to the benefit or detriment of the others.

Effect on Grade

We did not grade the logs used in this sample. Therefore we cannot describe the influence that sweep had upon either log grade or lumber grade. But we can logically theorize that sweep adversely affected grade.

Our observations showed that more than half the logs with sweep had volume deductions greater than 15 percent. So, any potential grade 1 logs in this category would have automatically been reduced to grade 2. They exceeded the maximum grade 1 sweep limitation of 15 percent imposed by the Forest Service grading system. About one-sixth of the logs had sweep volume deductions greater than 30 percent. Thus any potential grade 1 or grade 2 logs in this category would have been reduced to grade 3 because of grading system sweep limitations.

Of course, even small amounts of sweep will reduce the yield of better grade lumber from a log. Grade losses are due to heavier trimming, edging, and shorter boards than would have been produced from straight logs with similar size, taper, and grade characteristics. Also, when a saw bites into a sweepy log, grade defects in the heart show up sooner on faces perpendicular to the direction of sweep.

Potential Remedies

To reduce sweep, loggers often cut short logs. They do this to reduce scaling penalties and to achieve better utilization of the curved tree stems. But short logs obviously yield short lumber.

Short logs are objectionable because many sawmills have customers who prefer long lumber and pay premium prices for it. Furthermore, short logs require more handling and processing time per unit of lumber produced. So the trade-offs between short and long logs with regard to sweep must be carefully considered by company managers.

We know that once a tree has been bucked, a major decision affecting grade and volume yields has already been made. Of course, log conversion practices in the sawmill naturally influence the lumber grade and volume recovered. But the condition of the logs is a primary determinant of lumber recovery. So, perhaps a simple guideline would help to reduce the detrimental effects of sweep and still allow the manufacture of longer logs and lumber.

We recommend the following rule-of-thumb for bucking trees with sweep. Our calculations show that, if such a rule had been used in developing the logs we measured, volume deductions for sweep would have been cut in half:

Tree section	*Maximum sweep allowance (inches)*
Butt log	3
Upper log	4

Commonsense exceptions should be allowed to obtain logs at least 8 feet long and to more fully utilize stem sections in trees with unusual form characteristics.

Why do we suggest a greater allowance for sweep in upper logs especially when the larger butt logs could tolerate more sweep with a lower percentage scaling deduction? First, the mid- and upper-stem portions are usually more curved than the lower stem. Thus acceptance of greater sweep in upper logs would permit the manufacture of longer logs and lumber even though some volume would be lost. Second, grade declines with increasing height above the butt. So, significant losses in lumber quality are less likely to occur in upper logs with greater sweep.

How could this rule-of-thumb be applied in the woods? First, it could be done by ocular inspection. Remember that only 1 out of 6 logs had sweep critical enough to cause scale deductions. So, loggers are doing a fairly good job already. Ocular inspection might be enough to change the bucking location on tree sections with moderate to heavy sweep.

Second, loggers could use a self-retracting tautline or tape with a hook on one end. The line could be stretched along the side of the curved bole section perpendicular to the direction of major sweep. If the line deviated more than 3 or 4 inches from the center of the bole at any point, the proposed log length could be reduced to meet the sweep standards.

Application of this rule-of-thumb to sweepy timber should allow production of the longest possible logs, yet hold volume deductions from sweep to acceptable levels. The standards are stringent enough to nearly eliminate grade deductions due to sweep. Of course, cutters must realize that final bucking decisions must be based on other important factors such as stem defects, log diameter and length, and unusual form or grade characteristics.

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SAMPLING PLANTATIONS TO DETERMINE WHITE-PINE WEEVIL INJURY

Abstract. — Use of 1/10-acre square plots to obtain estimates of the proportion of never-weeviled trees necessary for evaluating and scheduling white-pine weevil control is described. The optimum number of trees to observe per plot is estimated from data obtained from sample plantations in the Northeast and a table is given of sample size required to achieve a standard error of the proportion of trees never weeviled of ± 0.05, a value that can be obtained at a reasonable cost for the purpose intended.

Methods for evaluating and scheduling white-pine weevil control have been developed (*Marty and Mott 1964*) and field-tested (*Ford et al. 1965*). To use the evaluation scheme, an estimate of weevil intensity is needed. This paper is a report on the use of 1/10-acre plots to obtain estimates of the proportion of never-weeviled trees in plantations.

Methods and Results

Five 1/10-acre square plots were established in each of 32 white pine plantations from Maine to Virginia. The plots were widely distributed in each plantation so all weevil conditions would be represented in the sample. In each plot, every live tree was observed for evidence of weeviling, past or present; the total number of weeviled and never-weeviled trees was recorded for the plot.

Variance.—In sampling for proportions (p) with plots (cluster sampling), the mean and variance between plots do not have the simple binomial relationship expected from simple random sampling; but for a given size and shape of plot there is sometimes a common multiplier or clustering factor (k) by which the between-plot variance can be approximated from the binomial variance.

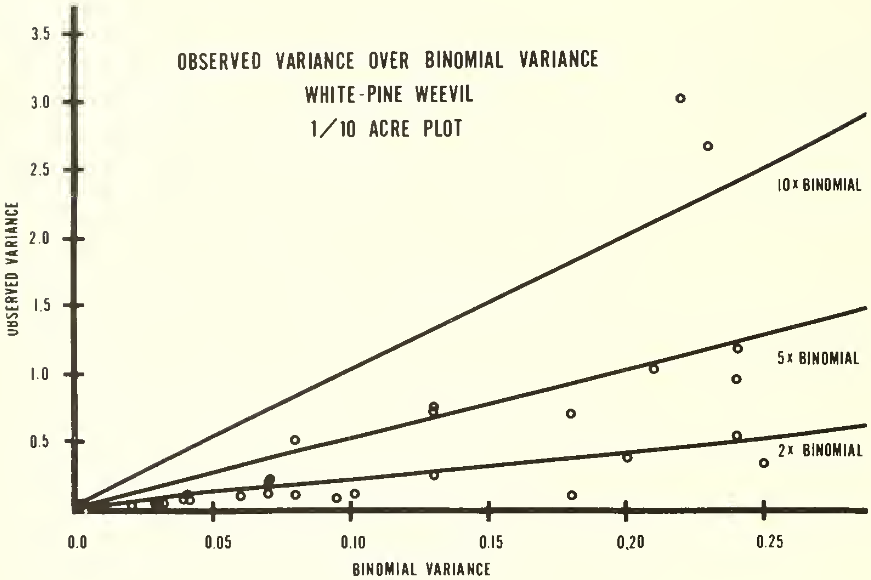
To investigate this possibility, mean squares between and within plots for each plantation were estimated by analysis of variance. The within-plot mean squares approximate the binomial variance ($\bar{p}[1-\bar{p}]$) very closely. The between-plot mean squares, like the binomial variances, are smallest for both small and large values of $\bar{p}$ and are largest in the mid-range of $\bar{p}$, but they exhibit an erratic pattern and are, in general, larger than the binomial variances.

When the between-plot mean squares are plotted over the binomial variances (fig. 1), it is clear that a common clustering factor will not represent all of the plantations. But, except for two aberrant values (which we cannot explain), the factors do have a relatively narrow range. In fact, 28 of the 32 plantation values have a factor of 5 or less; and for 21 plantations the factor was 2 or less. In the absence of other information about variances,

Figure 1.—Observed variance,

$$MS_b = M \sum_{i=1}^{n} (\bar{p}_i - \bar{\bar{p}}.)^2/(n-1),$$

of never-weeviled trees compared with binomial variance, $\bar{p}(1-\bar{p})$. The lines indicate various values of the clustering factor, k.



we suggest that the binomial variance and a clustering factor of 4 will usually be satisfactory for the design of cluster sampling plans using square 0.1-acre plots.

Cost relationships.—Efficient sample design also depends upon cost relationships among the component parts of the sampling process; in this case, upon the ratio of the cost (c_c) of locating and laying out a cluster (plot) to the cost (c_e) of locating and observing an element (tree) within the cluster.

Given the total man-hours for cluster sampling (C), the number of clusters in the sample (n), and the average number of elements observed per cluster (m) from each of about 10 plantations of varying densities (trees per acre), the component costs can be estimated by simple linear regression:

$$C/n = c_c + c_e(m)$$

The crude cost data at our disposal are not adequate for estimating c_c and c_e, but they do give evidence that the ratio c_c/c_e may have an average value between 50 and 100.

Application to Sampling Design

Sub-sampling fraction. — Though it is a common practice in cluster sampling to observe all the elements in a cluster, it is not necessarily an optimal practice. The optimum sub-sampling fraction (f_e) depends upon cluster size or number of elements per cluster (M), the clustering factor (k), and the cost ratio (c_c/c_e) in the following way:

$$f_e = m_{opt}/M = \frac{1}{M}\sqrt{\frac{M}{k-1}}\sqrt{\frac{c_c}{c_e}}$$

in which m_{opt} is the optimum *number* of elements to be observed in a cluster. This was modified from Sampford (*1962, p. 176, equation 8.40*), assuming that $S^2_w = p(1-p)$ and $S^2_b = kS^2_w/M$.

Optimum sub-sampling fractions were computed throughout the parameter space for the ranges of values we can reasonably expect will be encountered in practice: cluster size from 40 to 160 trees, clustering factor from 3 to 5, and cost ratio from 50 to 100. Sub-sampling fractions between ⅓ and ⅔ encompassed almost the whole space, with fractions near ½ occupying the central portion of the space. Because moderate departures from the optimum have only a small effect on sampling efficiency and because of its simplicity in practice, we suggest that the sub-sampling fraction of ½ be used as standard. For each cluster, choose to examine either the first or the second tree encountered by a flip of a coin, and then examine every second tree thereafter in a systematic manner.

Cluster sampling fraction. — The fraction (f_c) of the total population of clusters (0.1-acre plots) to be included in the sample for an estimate of the proportion of trees never-weeviled to a predetermined level of precision may now be computed:

$$f_c = n/N = \frac{p(1.0\text{-}p)\ [k/M + (1.0\text{-}f_e)/m]}{p(1.0\text{-}p)k/M + N(SE)^2}$$

in which

n = The number of clusters in the sample.
N = The number of clusters in the population; in this case, the number of acres in the plantation multiplied by 10.
p = The anticipated proportion of never-weeviled trees.
k = 4 = The clustering factor assumed.
f_e = ½ = The near-optimal sub-sampling fraction.
SE = The desired standard error of the estimated proportion of never-weeviled trees.

This was modified from Sampford (1962, p. 176, equation 8.39), assuming that $S^2_w = p(1\text{-}p)$ and $S^2_b = kS^2_w/M$.

We have tabulated (table 1) the sample sizes required to achieve a standard error of the proportion of trees never-weeviled of ± 0.05, a value which can be obtained at reasonable cost and is suitable for the purpose intended.

Table 1.—*The number of 0.1-acre plots required for estimating the proportion of trees never-weeviled at specified values for plantation of 1 to 5 acres and 5 to 20 acres*

[SE = 0.05, k = 4, fe = ½]

M	P								
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
			10<N<50 0.1-ACRE PLOTS						
121	2	3	4	4	4	4	4	3	2
89	2	4	4	5	5	5	4	4	2
68	3	4	5	6	6	6	5	4	3
54	3	5	6	7	7	7	6	5	3
			50<N<200 0.1-ACRE PLOTS						
121	2	3	4	4	5	4	4	3	2
89	2	4	5	6	6	6	5	4	2
68	3	5	6	7	7	7	6	5	3
54	4	6	8	9	9	9	8	6	4

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GRAY SQUIRRELS REPRODUCE IN A 2-ACRE ENCLOSURE

Abstract. — A 2-acre enclosure was built in a 40-year-old hardwood stand, and 5 to 19 gray squirrels (*Sciurus carolinensis*) were confined in it during 3 years. Reproductive behavior of the squirrels was the same at all population densities, but densities above 12 may have reduced productivity. For 10 to 12 squirrels, behavior was about normal and productivity was high. At population levels above 12, antagonistic behavior and fence-running increased. The enclosure was modified until escapes were reduced to less than 10 percent per year. Disease and predation were not a problem. Fence costs were $2,000 for materials and about 125 man-days of labor. The enclosure proved practical for squirrel research.

The gray squirrel (*Sciurus carolinensis*) can be accommodated in a small area, has known food habits, and will accept commercially prepared food. He is tolerant of man and can be trapped, handled, and tamed fairly easily. But there is one difficulty: the gray squirrel does not reproduce readily in confinement (*Shorten 1951-1952*). We thought a large outdoor enclosure might allow normal reproduction; and, on the basis of work in Ohio (*Donohoe 1965*) and Florida (*Moore 1957*), we selected 2 acres as a likely size.

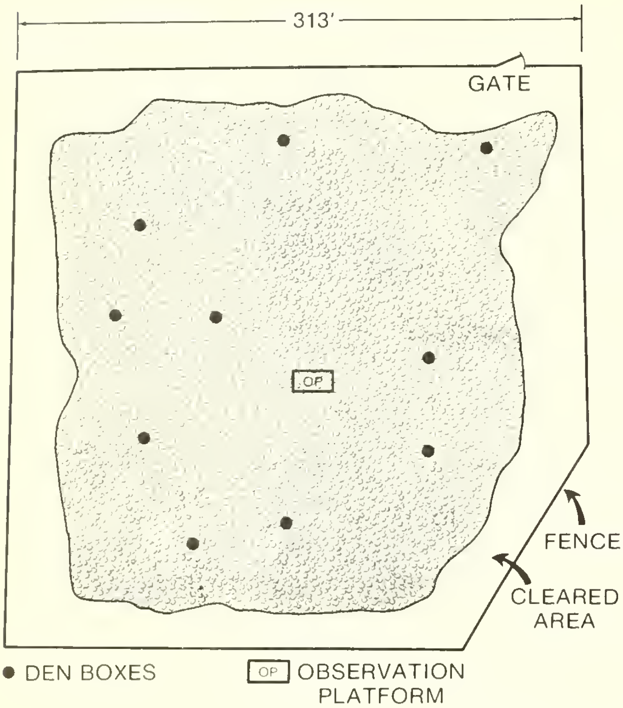
Our initial objectives were to design and test an escape-proof enclosure, to determine how many squirrels could be maintained without producing manifestations of overpopulation, and to determine if reproduction would occur.

This is a report on design and use of the enclosure and includes only limited data on squirrel behavior.

ENCLOSURE AND METHODS

An area of immature but potentially good squirrel habitat was selected in the West Virginia University Forest, 11 miles east of Morgantown. The stand is mixed hardwoods about 40 years old, with low mast production and few den sites. A relatively flat site was chosen — to give maximum effectiveness to the height of the fence. To prevent squirrels from crossing the fence via tree canopies, we cut and removed all trees with canopies above a 30-foot-wide strip centered on the fence line. The total area enclosed was 2.1 acres, including 1.5 acres of tree canopy (fig. 1).

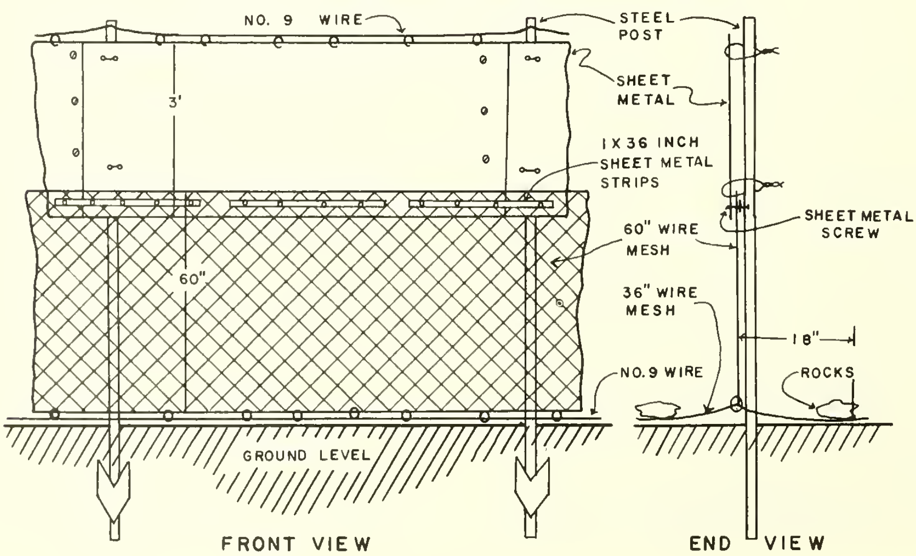
Figure 1.—Diagram of the 2-acre squirrel enclosure.



The squirrel-proof fence was about 7.5 feet high with a 3-foot strip of sheet metal attached above a 5-foot high base course of 1-inch mesh wire (fig. 2). It was not practical to bury the bottom of the fence, because the soil was very rocky. Therefore 3-foot-wide 1-inch mesh wire was laid on the ground and attached to the bottom of the fence to prevent animals from going underneath (fig. 2). Materials cost approximately $2,000, and about 125 man-days were used in building the fence. Construction details and recommendations can be obtained by writing to the USDA Forest Service, Forestry Sciences Laboratory, 180 Canfield Street, Morgantown, W. Va. 26505.

We plugged the natural dens and installed den boxes (*Barkalow and Soots 1965*), because it would be easier to check litters and capture squirrels in the boxes than in natural tree-dens. Six den boxes were placed 20 to 25 feet up in trees scattered throughout the enclosure. More boxes were added when needed to provide one more den box than the squirrels were regularly using. All den-box entrances were visible from an observation platform constructed about 10 feet up in a tree near the enclosure center (fig. 1). We did not interfere with leaf nest construction and maintenance.

Figure 2.—Detail sketch of the squirrel-proof fence.



Natural foods were supplemented with corn and laboratory rat chow as needed. Drinking water was supplied, and the squirrels used snow or ice during freezing weather.

Squirrels were marked with numbered, self-piercing, monel fingerling tags in each ear, and with colored plastic-impregnated nylon collars ½ inch wide. Some collars were chewed off and some caused neck infections. Consequently, collars were abandoned in favor of marking the fur with Nyanzol D dye from Nyanza, Inc., Lawrence, Mass. (The use of a trade name is for the information and convenience of the reader, and is not an official endorsement or approval by the U. S. Department of Agriculture.)

Observations of behavior were made to evaluate the effects of the enclosure on the introduced populations. The squirrels were periodically recaptured in box traps and den boxes for examination and re-dying.

External parasites were controlled by dusting the boxes and squirrels with rotenone. Coccidiosis was the only disease problem; this was controlled by adding a sodium sulfamethazine coccidiostat to the drinking water at the manufacturer's recommended dosage for poultry.

No losses to predation were observed or suspected; however, we saw a red-tailed hawk swoop unsuccessfully at a squirrel, and two rattlesnakes were removed from the enclosure.

The introduced squirrels were trapped in Maryland, West Virginia, and Pennsylvania. Age estimates were made, using the techniques of Uhlig (*1955*) and Barrier and Barkalow (*1967*). Adults were defined as those capable of breeding. Females generally breed at about 12 months and males at 17 months (*Horwich 1967*).

SQUIRREL BEHAVIOR AND REPRODUCTION

The evaluation was divided into three time periods: (1) November 1969 to August 1970 — low population, (2) September 1970 to August 1971 — high population, and (3) September 1971 to July 1972 — medium population.

November 1969 to August 1970 — Low Population

Three adults — two males and one female — were introduced in November. A subadult pair was introduced in February, and an adult pair was introduced in March. Of the six den boxes available, only three were used. The squirrels denned together by release groups, except for two loners.

Some fence-running occurred immediately after each introduction, but it was not excessive and soon ceased except for occasional exploration of the fence. Three squirrels that had been captured in the immediate vicinity did more fence-running than the others. Perhaps their familiarity with the surrounding area stimulated extra effort to escape from the pen.

By May two squirrels were missing. One female was recaptured outside the enclosure and was returned four times without our discovering her escape route. The other squirrel was never accounted for. Later in the summer, another squirrel escaped and was recaptured. We assumed that the squirrels had escaped over sections of the fence that had wooden cross braces. Therefore we moved the braces from below to above the sheet metal. But the problem was not completely solved until a sheet-metal shield was installed under the braces in July 1972 (fig. 3).

Pre-mating behavior began in April, and mating chases were observed in May and June. The first known litter, born in July, was successfully reared and remained in the enclosure until the following summer. The mother was probably the only breeding-age female in the pen. The key event was the birth and survival of a litter.

September 1970 to August 1971 — High Population

The next objective was to determine how many squirrels could be maintained satisfactorily in the enclosure. The residual group of 7 (5 adults and 2 juveniles) was increased to 19 by introducing 2 groups of 4 subadults (2 males, 2 females) in December and March, respectively. A group of 4 squirrels — 3 adults (1 male, 2 females) and a subadult male —

Figure 3. — Completed corner of squirrel-proof fence. Note the metal shields under the wooden braces and the wire cross bracing below the 3-foot-wide sheet metal.

was introduced in July. The maximum density attained was probably 17.

No squirrels were added until those of the previous introduction had integrated with the earlier residents.

We judged the effect of each new introduction on the residents by looking for behavioral changes, such as an increase in aggression, fence-running, and re-establishment of a social hierarchy. Reproductive behavior was also noted.

Mating chases began in mid-May, and the first litter was born in early July, by the same female that had borne a litter the previous year. When the young were 4 weeks old, they were ear-punched for identification, but the marks disappeared by age 8 weeks. Then the ears were large enough for tagging. Three more litters were born in late July. When the young were less than 10 days old, they were toe-clipped, since their ears were too small to punch. The late-July litters were subsequently destroyed, probably by the mothers. Two other females behaved as though they had litters, but we never found the young.

After the second group of squirrels was introduced, in March, we saw some behavioral signs of overpopulation. The number of squirrels running along the fence increased. The fur on a few squirrels appeared dull and rough, versus smooth and glossy coats on healthy squirrels; and several squirrels had indications of diarrhea — a symptom of coccidiosis. Squirrels started to escape through holes in the rusted 20-gage wire net in May; and despite repairs, 12 were lost by September 1. These escapes prevented a full evaluation of the July introduction. However we hypothesized that this introduction of 4 squirrels, raising the total number to 17, may have contributed to the litter destruction.

We concluded that 10 to 12 squirrels would be a reasonable density in our 2-acre enclosure.

September 1971 to July 1972 — Medium Population

The rusted wire net (20-gage 1 x 1 inch) was replaced with a heavier material (14-gage

1-inch wire mesh), and the enclosure was readied for restocking. There were 7 squirrels remaining in the enclosure, and we brought the population up to 12 (5 males and 7 females) by March 1.

Two litters were born in early May—earlier than previous litters born in the enclosure. By mid-July a third litter was born and a fourth female was pregnant (determined by palpation).

The three litters were checked when less than 10 days old; one squirrel from each litter was removed for age determination and then returned. The two early-May litters were not disturbed again until age 6 to 7 weeks, when they were examined, weighed, and ear-tagged on June 7. In mid-July they were removed from the enclosure to reduce the population. All had been weaned by then and were healthy and active.

CONCLUSIONS

Gray squirrel reproduction was not inhibited by the 2-acre enclosure, but litter survival was reduced at the highest population levels.

Toe-clipping the young squirrels may have triggered their destruction by the mothers. Although toe-clipping has been successfully used to mark unconfined nestling gray and fox squirrels (*Sciurus niger*) (*Bakken 1952; Baumgartner 1940; Barkalow et al. 1970*), one confined litter of fox squirrels was killed by their mother immediately after they were handled and toe-slipped (*Charles Nixon, personal communication*). In our study, the addition of the last group of squirrels may have produced sufficient population stress to provoke this behavior. Litter survival was excellent the following year, but only 12 adult squirrels were present in the enclosure then, and no toe-clipping was done.

A population of 10 to 12 squirrels appears to approach optimum density for this 2-acre enclosure.

We believe escape problems have been reduced to the minimum possible with our enclosure design and that it is suitable for many kinds of squirrel research.

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THE PROBLEM OF EXTREME EVENTS IN PAIRED-WATERSHED STUDIES

Abstract.—In paired-watershed studies, the occurrence of an extreme event during the after-treatment period presents a problem: the effects of treatment must be determined by using greatly extrapolated regression statistics. Several steps are presented to help insure careful handling of extreme events during analysis and reporting of research results.

Much of our present knowledge of forest hydrology is the result of experiments on paired gaged watersheds. The statistical method most commonly used in these studies is relatively straightforward and was first proposed by Wilm (*1949*). Data from a calibration period are used to develop regression equations between streamflow from a control watershed (additional variables may be included if necessary) and streamflow from a nearby similar watershed on which a forest treatment will be performed. After treatment, deviations of the treated watershed values from the calibration regression are considered to represent treatment effects if the deviations fall outside specified confidence intervals placed about the regression line. Illustrations of this technique can be found in papers by Hibbert (*1969*), Reinhart *et al.* (*1963*), and Goodell (*1958*).

A problem in paired-watershed studies is the occurrence of an extreme event—a streamflow total or other variable that falls well away from the expected span of measured values. Causes of extreme events are overabundant precipitation, unusually rapid snow-water contribution (frequently combined with rainfall), or prolonged drought. Because they are rare, extreme events are often of particular interest in studying the effects of forests and forest treatments on streamflow. However, the current statistical methods used in paired-watershed studies are not well adapted to handling the extreme event, particularly if it occurs in the after-treatment period. Calibration statistics must be extrapolated to accommodate the extreme event, thus providing a potential source of error in determining treatment effects on streamflow.

The best protection against the extreme event is an all-encompassing calibration. Such a calibration is usually obtained by a lengthy period of measurement (*Wilm 1949*). Longer calibrations, in addition to providing more precise regressions and confidence intervals, increase the chances of including a full range of weather events for a particular time period (both wet Augusts and dry Augusts, for example). However, costs and the desire to obtain quick research results frequently dictate that calibration be ended after the shortest practicable period.

In the East, treatment is usually performed after a calibration of 5 to 8 years. The exact length of calibration is generally arrived at with the aid of a graphical solution developed by Kovner and Evans (*1954*), which takes into account the variation and range of the measured data. In addition, long-term precipitation records are usually studied to further insure that the calibration period has encompassed a nearly full range of weather events. Despite these precautions, experience has shown that some streamflow values from the control watershed during the after-treatment period can be expected to fall outside the range encountered during calibration.

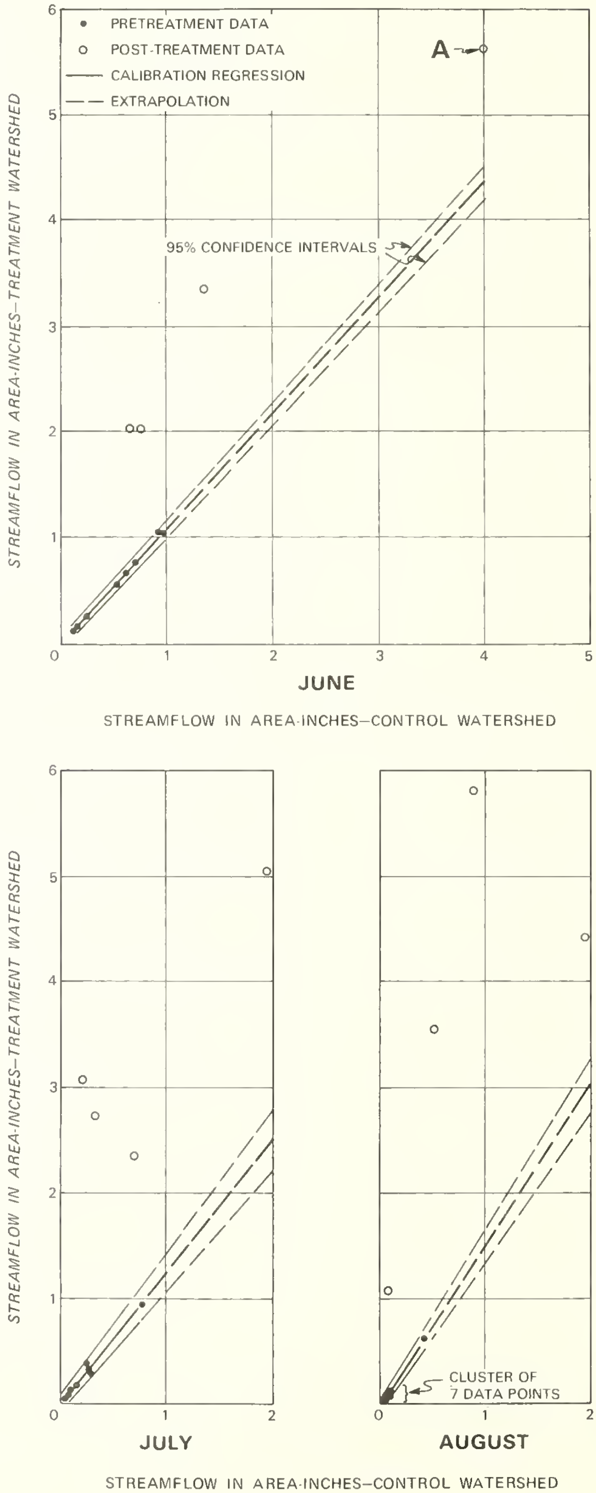
A case in point is a study now in progress at the Hubbard Brook Experimental Forest in central New Hampshire. After an 8-year calibration, a 39-acre watershed was cleared of its forest cover and sprayed with herbicides for three successive summers in an attempt to obtain a measure of maximum increases in water yield (*Hornbeck et al. 1970*). During the first 44 months after treatment, 12 monthly streamflow values for the control watershed fell outside the ranges encountered during calibration. At least three of the monthly flows were large enough to be classed as extreme events.

The extreme event problem is not unique to Hubbard Brook. It has also been experienced at other hydrologic research stations in the East, including the Fernow Experimental Forest in West Virginia and the Coweeta Hydrologic Laboratory in North Carolina. The extreme event problem may also be familiar to researchers in other disciplines, who use regression to determine effects of a treatment.

Problem Illustration

When the after-treatment values for the control watershed fall outside the range of flows encountered during calibration, determination of treatment effects must be based on extrapolated regression statistics (fig. 1). In the case of an extreme event, the extrapo-

Figure 1. — Streamflow and regression data for Hubbard Brook paired-watershed experiment. Streamflow of the control watershed was the only independent variable used in calibrating this watershed.



lation may have to be several times the range covered during calibration. Because the researcher cannot be certain that the regression model is valid over a wider range than the calibration sample, the extrapolation procedure is risky. Watershed differences in soil depth, area, precipitation distribution, or vegetation could conceivably cause pronounced change in slope of the regression line, beginning at some point beyond the range sampled during calibration.

Streamflow totals from the Hubbard Brook paired watersheds for June, July, and August illustrate the problem that arises when after-treatment values fall outside the range of flows measured during the calibration. For each of these 3 months, at least one after-treatment streamflow value from the control was more than double the maximum value measured during calibration (fig. 1). The highest June after-treatment value (point A in fig. 1) clearly falls into the extreme event class.

Intuitively, watershed researchers using extrapolated regression statistics probably would not be concerned about determining treatment effects on the July and August points. The highest control watershed values for these months exceed the maximum calibration values by only about 1 inch, which is not likely to greatly change the slope of the regression line. But less confidence could be placed in a test of the highest June after-treatment value (point A in fig. 1), which exceeds the maximum control watershed calibration value by more than 3 inches.

The real peril of the extreme event problem lies in the reporting of gaged watershed results. The effect of a particular forest treatment is usually given quantitatively as the difference between the regression line and the actual measured streamflow. For example, point A in figure 1 would be reported as a 1.2-inch increase in streamflow for June 1968. If, in reality, the regression line were not linear, but changed slope and became less steep at around 2.0 inches, the effect of treatment would actually be an increase greater than 1.2 inches. On the other hand, if the regression line swung more sharply upward, there may not have been any significant change in streamflow for the month. The area in which it becomes unsafe to use an extrapolated regression depends on many factors and must be determined by a researcher who is thoroughly familiar with the watersheds and the statistics being studied.

Analyzing the Extreme Event

When an extreme event occurs, the first step should be to assure the validity of the measurement. Simple comparisons among a group of gaged watersheds will usually point out gross errors. Comparable precipitation for the watersheds can also be checked to determine that amounts are radically higher or lower than those obtained in the calibration period.

If the extreme event proves valid, the next step should be to check the calibration regression for any signs of non-linearity. In most cases, the calibration data will fit well, particularly because paired watersheds are selected so that they will be as similar as possible. But if the calibration fit is poor or the standard error is large, it may be necessary to exclude analysis of the extreme event or at least be fully aware that any conclusions based on extrapolation will be weak.

When the calibration fit is satisfactory, a final step is to look for reasons why the watersheds might react differently for an extreme event than they did for the range of calibration measurements. Where such reasons are not readily apparent, some idea of reaction for extreme events may be obtained if a spare untreated watershed is available. Calibration statistics can be determined and post-treatment streamflow values for the spare untreated watershed can be estimated in the same manner as for the treated watershed. In the case of an extreme event, if the estimated flow is close to actual streamflow for the spare untreated watershed, more confidence can be placed in determinations of streamflow changes on the treated watershed.

This procedure was tried for the June streamflow values presented earlier (fig. 1). For the extreme event, a predicted streamflow of 3.9 inches was obtained for a nearby untreated watershed. Actual flow from the watershed was 4.1 inches. The difference in the two values is not statistically significant, illustrating that the prediction equation holds up well for the extreme event. Thus more confidence can be placed in the extrapolated estimate of flow for the treated watershed.

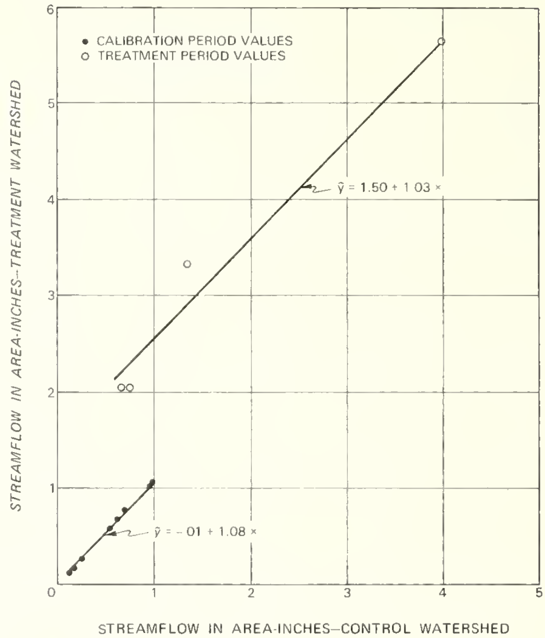
As an alternate approach to analyzing the extreme event, paired regressions can be used (*Freese 1967, pp. 68-70*). This method tests before- and after-treatment regressions for significant differences, but it is adaptable only to experiments in which the before and after vegetative cover is relatively constant. Figure 2 shows the paired regressions for the Hubbard Brook watersheds for the month of June. F-tests show no significant change in slope, but show a highly significant change in regression level or intercept. Thus the effect of treatment would be reported as an increase of 1.5 inches in June streamflow (differences in intercept for the two regression lines).

A conceivable advantage of paired regression analysis is that this technique tests the after-treatment observations as a group instead of individually. Also, the plotted regressions give a clearer illustration of how the extreme event is related to the remainder of the data. However, the extreme event problem remains because there is still no indication of how the before-treatment regression might change over a greater range of data.

The above discussion has been concerned with the extreme event occurring in the after-treatment period. Occurrence in the calibration period can also be troublesome. A monthly streamflow of several area-inches during the calibration period of the months shown in figure 1 would obviously carry heavy weight and could make important changes in the slope and intercept of the regression. In such cases, a minimum precaution should be the use of a second-order polynomial model for the calibration regression.

In summary, extreme events are an inherent problem in paired watershed studies. The only real solution is to greatly lengthen the calibrated period. Because this solution is generally impractical, I suggest some approaches to help insure that extreme events are treated carefully during analysis and reporting of research results.

Figure 2. — Paired regressions for determining effect of treatment on June streamflow totals.



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PRESSURE INJECTION OF METHYL 2-BENZIMIDAZOLE CARBAMATE HYDROCHLORIDE SOLUTION AS A CONTROL FOR DUTCH ELM DISEASE

Abstract. A preliminary evaluation of the effectiveness of injecting methyl 2-benzimidazole carbamate hydrochloride solution into elms for prevention or cure of Dutch elm disease is reported. Symptom development was diminished or prevented in elms injected with fungicide before inoculation. Symptom development was arrested in all crown-inoculated diseased trees injected with the high and medium concentration of the fungicide and in bole-inoculated diseased trees injected with the high concentration of the fungicide when not more than about 50 percent of the crown was symptomatic.

Benomyl (1-(butylcarbamoyl)-2-benzimidazole carbamic acid, methyl ester) is a broad-range systemic fungicide that has been widely investigated during the last few years as a possible control agent for various plant diseases.

Benomyl has been used experimentally in attempts to control Dutch elm disease (DED). Various workers have used soil drenches (1,5,11,12) and spray application to the crown (4,11) in an effort to protect elms from DED, with results ranging from none to apparently good protection.

Soil drenches and fungicide sprays are objectionable in several respects. Application by soil drench results in variable uptake of benomyl, dependent on soil type and probably on soil moisture. This method requires large amounts of fungicide and allows little control over its subsequent fate. We have little understanding of its effect on soil microbiology. Similarly, spray application requires relatively large amounts of the chemical, much of which eventually is deposited in the soil. Drift of spray onto or into houses, cars, etc., is also undesirable.

On the other hand, pressurized injection of fungicide directly into the xylem of the tree seems to offer many advantages over the other two methods. Solubilized benomyl injected into the xylem of elms, oaks, and maples becomes distributed in the branches and twigs (3). With injection the fungicide is confined within the tree, so the environmental contamination hazard appears to be minimal. The time between treatment and establishment of an effective dosage at desired sites is appreciable for soil applications but short for injections.

Benomyl hydrolyzes to methyl 2-benzimidazolecarbamate (MBC), butylamine, and carbon dioxide. MBC is considered to be the active fungicidal material in plants that receive applications of benomyl (10). Buchenauer and Erwin (2) applied a spray containing MBC to cotton plants for the control of *Verticillium* wilt. Certain types of benzimidazolecarbamates were introduced as fungicides in patents by Klopping (7). Littler et al. (8) patented the use of MBC and some of its fungitoxic salts as foliar fungicides. McWain and Gregory (9) devised a laboratory-scale procedure for conversion of benomyl to water-soluble hydrochloride salt of MBC (MBC·HCl) that was used in these tests.

This is a report of the preliminary results of studies to determine the value of pressure injection of the MBC·HCl solution into the xylem of American elms for prevention and therapy of Dutch elm disease.

Methods

The methods were similar for the two studies, benomyl prophylaxis and benomyl therapy of Dutch elm disease in *Ulmus americana*, American elm.

Study trees were divided into four size classes. Each treatment of the two studies was randomly assigned to one tree in each size class so each treatment was repeated four times. Four replications of each treatment were in nursery trees of 5 to 11 inches d.b.h.

Prophylactic Study

Trees were injected using the pressure injection apparatus and method described by Jones and Gregory (6). Injected solutions were 0.00, 0.67, 4.0, and 24 g./l. MBC·HCl. Injected volumes were approximately proportional to the d.b.h. of the trees (about 325 ml./inch d.b.h.). The number of injection sites per tree was two for 5- to 9-inch trees or three for 10- to 13-inch trees. The injection sites were evenly spaced around the tree trunk, 1 to 3 feet above the ground. Injection pressure was 40 p.s.i. Injection wounds were covered immediately after injection with tree wound dressing.

One week after injection, the trees were inoculated in one of two ways: through 1/2-inch wood chisel cuts into the xylem at 4-inch intervals around the bole of the tree at breast height, or through one 1/2-inch wood chisel cut into the xylem of a branch located about midway between the top and bottom of the crown and where that branch was about 1 inch in diameter. Twenty-five million conidia of an aqueous suspension of a mixture of five isolates of *Ceratocystis ulmi*, were applied to each chisel cut. These particularly severe inoculation procedures were used to test the value of the MBC·HCl injection treatments rigorously.

Treatment checks consisted of trees that were treated but not inoculated and inoculation checks consisted of trees that were inoculated but not injected.

Detection of fungitoxicant in the branches of treated trees was attempted 2 weeks after injection and then at monthly intervals throughout the remainder of the growing season. Branch tip samples were collected from the north, east, south, and west sides of each tree at about midcrown height. Samples were refrigerated until processed in the laboratory. A 1/4-inch-long section from each sample was placed in the center of 10-cm.-diameter petri plates containing 30 ml. of potato dextrose agar, in which 450,000 conidia of *Penicillium* sp. were dispersed. Zones of *Penicillium* growth inhibition were measured after 48 hours' incubation at room temperature.

Observations of foliar symptoms were recorded at approximately weekly intervals throughout the growing season. Near the end of the season injection sites were examined for injury, and the extent of the dead tissue, if any, was recorded.

Therapeutic Study

Trees were inoculated as described for the prophylactic study. Injections, as previously described, were made at 70 p.s.i. with either 4 or 24 g./l. of MBC·HCl when trace, 25 percent, or 50 percent crown symptoms were apparent.

Inoculation checks consisted of trees that were inoculated but not treated. Treatment checks in the prophylactic study were considered applicable to this study, as well.

C. ulmi infection in trees of both studies was confirmed by pathogen isolation from branch samples.

Results and Discussion

Bole-inoculated trees of the prophylactic study showed less symptom development with greater concentrations of injected MBC·HCl (table 1). Symptom development was limited to an average of 8 percent of the crown in trees treated with the highest concentration. This is especially impressive in view of the extreme severity of the inoculation. Furthermore, only 50 percent of the trees treated with the medium and high concentrations developed any symptoms.

The crown-inoculated trees showed markedly less symptom development at all concentrations of the fungicide, and, at the highest concentration, no symptom development at all.

In the bole-inoculated trees of the therapeutic study there was little difference in symptom development between noninjected check trees and those injected with 4 g./l. of MBC·HCl at trace, 25, and 50 percent crown symptom development (table 2). There were markedly fewer symptoms in those injected with 24 g./l. at trace and possibly at 25 percent symptom development. It is important to recognize that in bole-inoculated trees, very rapid disease development occurred almost at the same time throughout the crown. This, in practice, meant that disease development was actually much more advanced at the time of treatment than is indicated by the assigned value of trace, 25, or 50 percent symptoms (table 2).

Symptom development was curtailed and some remission of symptoms occurred in crown-inoculated trees injected with either 4 or 24 g./l. of fungicide at trace, 25, and 50 percent symptoms (table 2). Trees injected at 25 percent symptom development with 4 g./l. MBC·HCl are possible exceptions to this conclusion.

Table 1.--Prophylactic study: development of DED crown symptoms at the end of the 1972 growing season in inoculated trees previously injected with MBC·HCl solution

Treatment	Average percentage of crown symptomatic[a]			Percentage of trees symptomatic[a]	
	Noninoculated checks	Bole inoculated	Crown inoculated	Bole inoculated	Crown inoculated
No injection	0	100	50	100	100
Water injection	0	88	73	100	100
Benomyl injection					
0.67 g./l. conc.	0	63	6	100	50
4.0 g./l. conc.	0	24	28	50	50
24.0 g./l. conc.	0	8	0	50	0

[a] Average of four replicates.

Table 2.--Therapeutic study: average[a] percentage of DED leaf symptoms at time of injection and at end of 1972 growing season in inoculated trees injected with MBC·HCl solution

MBC·HCl concentration	Inoculation site	Percent symptoms-- At time of injection	At end of growing season
Trees designated to be injected at trace symptoms[b]			
4 g./l.	Bole	60	85
4 g./l.	Crown	3	5
24 g./l.	Bole	53	55
24 g./l.	Crown	3	14
Trees designated to be injected at 25% symptoms[b]			
4 g./l.	Bole	70	78
4 g./l.	Crown	37	53
24 g./l.	Bole	50	68
24 g./l.	Crown	26	18
Trees designated to be injected at 50% symptoms[b]			
4 g./l.	Bole	55	88
4 g./l.	Crown	57	53
24 g./l.	Bole	73	96
24 g./l.	Crown	58	58
Controls			
No injection	Bole		85
	Crown		80

[a] Average of four replicates.

[b] Trees frequently developed symptoms rapidly and consequently could not be injected at the designated percent symptoms. This is particularly true for the bole-inoculated trees.

In both studies, the time required for solution injection varied with the health of the tree and with the volume and concentration of the solution. However, most of the trees required less than 30 minutes.

No apparent injury to the foliage resulted from injection of any of the MBC·HCl solutions. Injury to the tissue for variable but usually short distances above and sometimes below the injection sites was observed at about 70 percent of the injection sites on trees treated with 24 g./l. of MBC·HCl. The injection sites on trees treated with 4 g./l. MBC·HCl or less showed little or no injury. Larger trees had less injury than the smaller ones. Active callus tissue was present around most injection sites and some were nearly healed over by the end of the season. Most of the trees injected with 4 and 24 g./l. MBC·HCl yielded some positive bioassays. However, few of the trees that received 0.67 g./l. MBC·HCl had positive bioassays.

In conclusion, it appears that injection of 24 g./l. MBC·HCl provided nearly complete protection from Dutch elm disease in American elms under conditions of this study, and either the high or medium concentration generally checked symptom progression in infected trees. However, it should be emphasized that these are preliminary results and it remains for observations in the spring and summer of 1973 to determine the permanence of the disease control.

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A PREVIEW OF NEW JERSEY'S FOREST RESOURCE

Abstract. — The recently completed forest survey of New Jersey indicates that 54 percent of the land area has tree cover on it. Thirty-eight percent of the state is classified as commercial forest land. Total growing-stock volume has increased, although the softwood component of the resource has decreased in both cubic-foot volume and area occupied by the softwood types. Average annual growth for all species combined exceeded timber removals; however, softwood removals exceeded growth by 22 percent.

New Jersey, the Nation's most densely populated state, also possesses considerable forest cover. The recently completed resurvey of the State's timber resources[1] reveals that 54 percent of the land area — 2,613,400 acres — has tree cover on it. The area of commercial forest land is 1,856,800 acres. Productive-reserved (state parks) and uproductive forest land comprise 71,600 acres. The remaining 685,000 acres consist primarily of urban and suburban areas on which tree cover enhances the primary land use.

Some 40 percent of the commercial forest land is in the oak-hickory forest type. The next most prevalent forest type, pitch and shortleaf pine, accounts for 26 percent of the forest area. Several other types account for the remaining 34 percent. These include the white pine-hemlock, Atlantic white-cedar, oak-pine, ash-elm-red maple, and maple-beech-birch types.

[1]A resurvey of the timber resources of New Jersey was completed in 1972. A statistical-analytical report containing data gathered on the inventory and an analysis of the trends and current situation is being prepared for publication.

When the first Forest Survey of the state's timber resources was made in 1955, Hudson County was classified as an urban county. Since then the trend toward urbanization in northern New Jersey has continued. In the 1972 inventory, Bergen, Essex, Union, and eastern Passaic counties were included with Hudson in the urban category. The reclassification of forest land from these counties accounted for one-quarter of the total decrease of 263 thousand acres of forest land. Even outside these counties, urbanization such as new road construction, land clearing for housing, etc., was the major cause of forest land area change.

Timber volume increased during the 16-year period between surveys. The cubic-foot volume of growing stock increased 11 percent and the sawtimber portion of growing stock had a 6 percent increase in board-foot volume. The current totals of 1,470 million cubic feet and 3,070 million board feet represent an average of 792 cubic feet and 1,653 board feet per acre of forest land.

Land clearing, timber harvest, and species succession over the past 16 years have resulted in a change in the species composition of the forest. Softwoods declined from 21 percent of the growing-stock volume in 1956 to 18 percent of the 1972 volume. Among the hardwoods the oaks maintained approximately the same proportion as in 1956 — about 49 percent of total growing-stock volume. The other hardwood species increased from 30 percent of the 1956 total to 33 percent of the 1972 total volume. Soft maples and yellow-poplar were the species that made significant gains in cubic-foot volume.

Data from permanent sample plots remeasured in 1972 indicate that the ratio between average annual net growth and average annual removals during the 16-year period is 3 to 2 — 23.2 million cubic feet of growth to 14.4 million cubic feet of removals. However, these averages do not tell the full story. Softwood average annual removals, 6.6 million cubic feet, are 22 percent more than the average growth of 5.4 million cubic feet. Hardwoods, on the other hand, are growing at twice the rate of removals — 17.8 million cubic feet of growth to 7.8 million cubic feet of removals.

Table 1.—*Area by land classes, New Jersey, 1972*

Land class	Area	
	Thousand acres	*Percent*
Forest land:		
Commercial	1,856.8	38
Productive-reserved	34.0	1
Unproductive	37.6	1
Total forest land	1,928.4	40
Urban and other:		
Land with tree cover[a]	685.0	14
Land without tree cover[b]	1,556.6	32
Cropland[c]	573.0	12
Pasture	77.5	2
Total area[d]	4,820.5	100

[a] These are lands where the principal use for the immediate future precludes planning or management for future timber production but which are partially in tree cover. In New Jersey 75 percent of the land in this category is devoted to urban and suburban uses.

[b] Includes swampland, industrial and urban areas, other nonforest land, and 48,600 acres, classed as water by Forest Survey standards, but defined by the Bureau of the Census as land.

[c] Squrce: 1969 Census of Agriculture. Data extrapolated to 1972.

[d] Source: United States Bureau of the Census, Areas of New Jersey: 1960 (Jan. 1967).

Table 2.—*Area of commercial forest land, by forest types, New Jersey, 1972*

Forest type	Thousand acres	Percent
White pine-hemlock	20.2	1.1
Pitch-shortleaf pine	478.4	25.8
Oak-pine	172.1	9.3
Oak-hickory	754.0	40.6
Oak-gum[a]	60.3	3.2
Ash-elm-red maple	267.6	14.4
Maple-beech-birch	104.2	5.6
All types	1,856.8	100.0

[a] Includes 50,000 acres of Atlantic white-cedar.

Table 3.—*Net volume of growing stock and sawtimber on commercial forest land, by species, New Jersey, 1972*

Species	Growing-stock volume		Sawtimber volume	
	Million cubic feet	*Percent*	*Million board feet*	*Percent*
Pitch pine	167.4	11.4	332.6	10.8
Shortleaf pine	22.8	1.6	65.4	2.1
Virginia pine	10.6	.7	25.1	.8
Other pines	7.9	.5	24.2	.8
Atlantic white-cedar	26.1	1.8	53.7	1.8
Other softwoods	23.2	1.6	71.0	2.3
Total softwoods	258.0	17.6	572.0	18.6
White oaks	317.9	21.6	686.6	22.4
Red oaks	402.7	27.4	998.3	32.5
Hickories	63.8	4.3	104.6	3.4
Sugar maple	22.3	1.5	53.7	1.7
Soft maples	106.8	7.3	124.7	4.1
Beech	15.1	1.0	33.6	1.1
Blackgum	38.5	2.6	48.9	1.6
Sweetgum	75.2	5.1	153.0	5.0
Yellow-poplar	29.3	2.0	101.7	3.3
Other hardwoods	140.7	9.6	193.1	6.3
Total hardwoods	1,212.3	82.4	2,498.2	81.4
Total, all species	1,470.3	100.0	3,070.2	100.0

Table 4.—*Average annual net growth and removals of growing stock, by species, New Jersey, 1951-71*

(In thousands of cubic feet)

Species	Average annual	
	Net growth	Removals
Pitch pine	4,196	3,051
Other softwoods	1,204	3,549
Total softwoods	5,400	6,600
White oaks	3,017	1,333
Red oaks	7,984	4,393
Hickories	487	12
Soft maples	2,404	281
Blackgum	446	35
Sweetgum	613	1,001
Yellow-poplar	1,038	332
Other hardwoods	1,811	413
Total hardwoods	17,800	7,800
All species	23,200	14,400

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A TWO-CELL CHAMBER FOR MEASURING GAS EXCHANGE IN TREE SEEDLINGS

Abstract.—A two-celled chamber for measuring gas exchange in tree seedlings is described. Temperature is controlled within ± 0.5° C by means of a copper coil. The two cells are independent of one another, and one cell can be used as a preconditioning cell while gas exchange measurements are being made in the second cell.

We constructed a chamber to measure gas exchange in forest tree seedlings. Even though several chambers have been described in the literature (*Broerman et al. 1967*; *Ronco 1969*; and *Bate and Canvin 1971)*, none was found that met our specifications and budget limitations. Our chamber has two independent cells for measurement of gas exchange, good temperature control, a wide temperature range, and variable light control; and it is reasonably inexpensive.

Description of Chamber

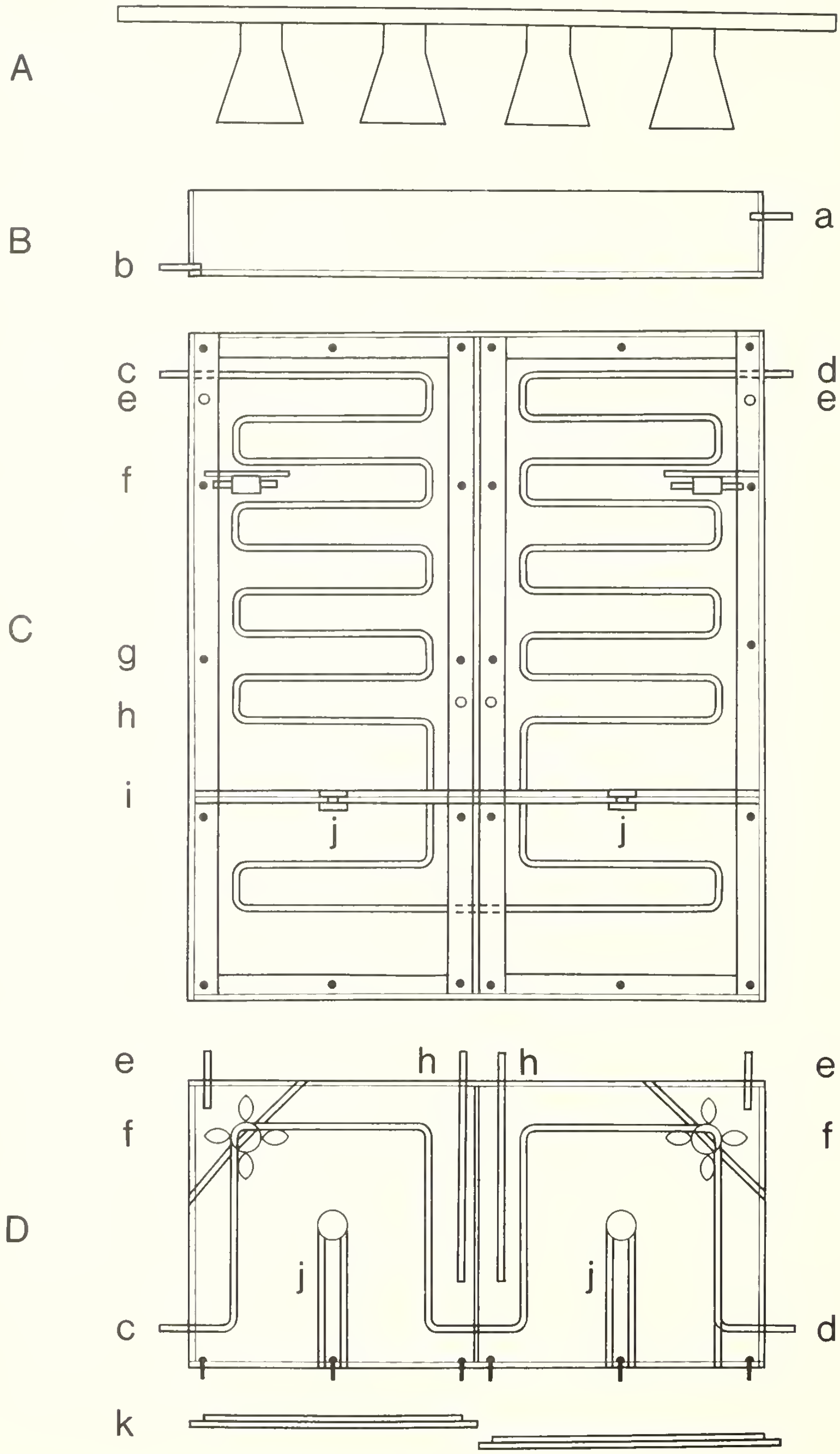
The chamber, constructed of ¼-inch plexiglas, consists of two cells, each 12 inches square and 28 inches high (fig. 1). A shelf made of two layers of ¼-inch plexiglas is placed 9 inches above the floor of each cell. An opening, consisting of a 1-inch slot in the top layer of plexiglas and a ⅝-inch slot in the bottom layer of plexiglas, leads to a 1-inch hole in the center of the shelf. A slide to fill the slot in the shelf is constructed of two 1-inch pieces of ¼-inch plexiglas glued to either side of a ¼-inch piece of plexiglas ⅝ inches wide. The slide reaches from the front edge of the shelf to the edge of the center hole.

A 1-inch strip of ¼-inch plexiglas is glued around the front edge of each cell. Bolts are glued to the strip at approximately 6-inch intervals to fasten the door to the cell. Each door consists of a flat piece of ¼-inch plexiglas with holes to match the bolts on each cell. Quarter-inch tygon tubing is glued to the back of each door to press against the strips on the front of the cell and prevent air exchange around the door. Two glass tubes are connected into the top and bottom of each cell as an inlet and outlet for gas sampling. A muffin fan in each cell is used for air circulation.

The heat filter on top of the chamber is also constructed of ¼-inch plexiglas. It is 12 x 24 x 3 inches with an inlet and outlet that maintain the water level at about 2 inches.

A system of ⅜-inch rigid copper pipe forms a cooling coil on three sides of each cell. The continuous system has nine loops above the shelf and two loops below the shelf in each cell. The flow of water through the coil is con-

Figure 1.—The two-cell chamber. A, light bank. B, heat filter: a, outlet; b, inlet. C, front view of chamber: c, inlet for cooling system; d, outlet for cooling system; e, air inlet; f, muffin fans; g, bolt; h, air outlet; i, shelf; j, slide in shelf. D, top view of chamber: k, door with tygon tubing seal.



trolled with a Fenwal-type thermoregulator in one cell. The light bank consists of eight 300-watt floodlights.

Operational Procedure

To use the chamber, connect the heat filter with a water supply. Allow the filter to fill with water and to overflow continuously at a slow rate. This will remove most of the heat from the lights.

Depending on its height, the seedling can be placed either on the shelf or below the shelf. If the pot and seedling are less than 19 inches tall, place the pot in a plastic bag and seal it around the stem. Then place the pot on top of the shelf in which the center hole has been plugged. If the pot and plant are over 19 inches tall, place the pot below the shelf with the stem up through the center hole. Seal the hole around the stem with a stopper to prevent gas exchange through the shelf area. Place the door on the cell and tighten the wing nuts to prevent gas exchange around the door.

After the fan and lights are turned on, the solenoid on the cooling coil connected to the thermoregulator is activated and opens or closes depending on the desired temperature. The solenoid may be placed either on a cold water line to maintain temperatures between water temperature and ambient temperature or on a constant temperature bath to maintain temperatures between 0 and 40° C. Temperature can be maintained within ± 0.5 C.

A second plant can be placed in the second cell concurrently with the first plant or at a later time without any interference to the first cell. If the second cell is not going to be used, the door should be closed to maintain the desired temperature.

The light bank can be wired to a powerstat to vary light intensities. The maximum light intensity is 4,500 foot-candles.

The chamber is versatile and can be used for different types of gas exchange measurements. We have attached it to an MSA infrared gas analyzer for carbon dioxide measurements. One cell is used as a preconditioning chamber while gas exchange is measured in the second cell. Many types of photosynthesis and respiration measurements can be made by using an array of connections or airflow systems.

We constructed the chamber from materials costing about $125.00, excluding the thermoregulator, solenoid, and powerstat.

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EFFECT OF DEFOLIATION ON CARBOHYDRATE CONTENT OF YELLOW-POPLAR SEEDLINGS

Abstract. — Sixty yellow-poplar seedlings were divided into two groups. One group was defoliated twice, and the second group served as the control. Three months after the second defoliation there was no difference in carbohydrate content between the defoliated and undefoliated seedlings in either the stems or roots.

Fusarium solani (Mart.) App. & Wr. emend Synd. & Hans. is a pathogen on hosts weakened by stress factors such as drought (*Dochinger and Seliskar 1962; Skelly and Wood 1966; True and Tryon 1956*). Recently, it has been suggested that, when trees are placed in a stress condition, a change in the carbohydrate composition of the tree may occur, making it more susceptible to fungal attack (*Parker 1970*). Our study was conducted to determine whether or not defoliation would alter the carbohydrate composition of yellow-poplar (*Liriodendron tulipifera* L.) seedlings. If a change in the carbohydrate composition is found, this study will serve as a guide for further pathogenicity studies of *F. solani.*

Materials and Methods

Sixty vigorous 1-year-old yellow-poplar seedlings were selected and placed on a greenhouse bench in a completely randomized design. Half of the seedlings were assigned to the defoliation treatment, and half were assigned to the nondefoliation treatment. The defoliation treatment, which was applied on June 1 and July 6, consisted of removing all leaves from the seedlings except the terminal leaves.

The plants were harvested in October. The stems or roots in each group were divided into six groups, dried overnight at 80° C., ground in a Wiley mill to pass through a 20-mesh screen, and stored at room temperature in sealed bottles.

To analyze the samples, 0.5 g. of ground material was placed in an extraction thimble and extracted with 100 ml. of 80 percent ethyl alcohol for 4 hours. The extract was concentrated and clarified according to the procedure of Siminovitch, Wilson, and Briggs (*1953*). The reducing sugars were determined by Nelson's test, and the sucrose concentration was determined by Noggle's procedure (*1953*). The starch content of the residue was measured by the procedure of Smith, Paulsen, and Raguse (*1964*).

Table 1.—*Carbohydrate content in stems and roots of defoliated and nondefoliated yellow-poplar seedlings*

Treatment	Reducing sugars[a]		Sucrose[a]		Starch[a]	
	Stem	Root	Stem	Root	Stem	Root
Nondefoliated	6.5	5.9	3.7	7.0	28.8	45.9
Defoliated	6.6	7.3	3.5	4.2	26.0	42.5
Average	6.6	6.6	3.6	5.6	27.4	44.2

[a] mg./0.5 g. sample.

Results and Discussion

The results of the carbohydrate analyses are given in table 1. Analyses of variances were completed on all the stem and root carbohydrate fractions. No significant differences were found between the defoliated and nondefoliated seedlings. However, the starch content was severalfold higher than either the reducing sugar content or the sucrose content. The starch and sucrose content in the roots was higher than it was in the stem.

Although Parker (*1970*) reported that two defoliations caused a reduction in food reserves in sugar maple seedlings, and Parker and Houston (*1971*) observed that defoliated sugar maple trees had lower root extractives than nondefoliated trees, our defoliation treatments did not reduce the carbohydrate content in the yellow-poplar seedlings.

These differences may be due to the different lengths of time between the final defoliation and the harvesting of the seedlings. Parker harvested his seedlings 1 month after the final defoliation, whereas the seedlings in our study were harvested 3 months after the final defoliation. Parker and Houston harvested their seedlings 2 to 6 weeks after defoliation. Parker found no significant reduction between his control treatment and seedlings harvested 2 months after one defoliation.

The stress treatment, defoliation, did not cause a change in the carbohydrate content in yellow-poplar seedlings under the conditions in this investigation. Additional investigations are needed with more severe treatments and different sampling times before a correlation between defoliation and change in carbohydrate content can be made. After this relationship is defined, studies between stress conditions and fungal attack can be made to determine whether or not any relationship exists between carbohydrate content of the host and fungal attack by *F. solani.*

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REQUIREMENTS FOR ADVANCE REPRODUCTION IN ALLEGHENY HARDWOODS — AN INTERIM GUIDE

Abstract.—Reproduction tallies on 65 areas planned for clearcutting were compared with reproduction 2 to 4 years after cutting. As a result, we recommend that 70 percent of the area be stocked with at least 5,000 black cherry seedlings or 30,000 seedlings per acre of desirable species before cutting. If this requirement had been used on these 65 areas, the proportion of regeneration successes would have been raised from 54 to 92 percent.

The Problem

When mature stands in most hardwood regions of the East are clearcut for regeneration under even-aged management, some kind of more or less complete tree cover is normally re-established in a short time. This does not always occur in the Allegheny hardwood region of northern Pennsylvania, however. Numerous clearcut areas in this region have failed to regenerate adequately to tree seedlings and are now stocked mainly with ferns and grasses, with or without some beech or striped maple.

Fencing studies have shown that browsing by the large population of white-tailed deer on the Allegheny Plateau is a major cause of these regeneration failures (*Grisez 1957 and Huntzinger 1967*). Ground cover competition, poor seed sources, site, and other factors may also be important — alone, or in combination with browsing damage.

Of course, prompt regeneration after clearcutting is vital to even-aged management. Without it, regeneration cuttings must be deferred or large costs must be borne to assure adequate restocking. The longer the interval between cutting and restocking, the more difficult the process becomes, due to the build-up of competing herbaceous vegetation.

It is generally agreed that adequate advance reproduction is necessary for securing prompt and satisfactory regeneration (*Pa. Forest. Assoc. 1970*). Observations indicate that good regeneration usually follows clearcutting in spite of heavy deer browsing where advance seedlings were abundant. Conversely, regeneration failures are likely where advance seedlings were scarce before cutting.

But how many advance seedlings are needed to insure successful regeneration? This is a report on results of correlations between the stocking of advance seedlings present before cutting and the success of regeneration 2 to 4 years after cutting. It provides an interim guide to the selection of stands for clearcutting.

Methods

Advance reproduction tallies were made in late summer each year in 65 areas scheduled for clearcutting over the period 1967-69. Seedlings were counted on a cluster of 9 milacre plots in each area. Tallies included — at the minimum — estimates of the number of black cherry seedlings and the total number of seedlings of all desirable species. On about half of the plots — which are part of a more detailed research study — tallies included numbers by species, two age classes of seedlings, and numerous other variables.

In December 1971, all clearcuts where counts of advance reproduction had been made were reexamined. Ocular estimates were made of the size and density of reproduction on the clearcuts. Each clearcut was judged as being *apparently successful* or *apparently unsuccessful*. All areas were classified, even though several were questionable. Successful or satisfactory regeneration was defined as having at least 70 percent of the area stocked with desirable species (all commercial species except birch, beech, hemlock, and aspen). Desirability is based on value for timber production only.

The success ratings were then compared to seedling tallies made before cutting. This was done by assuming a variety of different minimum stocking levels and then examining the data to find out how many of the 65 areas would have qualified for clearcutting under each of the assumed levels. Seedling tallies were used in two different kinds of stocking requirements: (1) in terms of the average number of seedlings on all 9 plots, and (2) in terms of the minimum number of seedlings on 6 of the 9 plots (table 1). The former is the same as thousands of seedlings per acre, because these were milacre plots. The latter was used because it is close to the 70-percent requirement for a successfully regenerated clearcut.

If the stocking requirement had been set extremely low, say only 2,000 seedlings per acre of desirable species, all of the 65 stands would have qualified for cutting; and the results would have been just as actually happened — 35, or 54 percent, are apparently successful. If the requirement had been set higher than the stocking of seedlings found on any of the areas, none of the areas would have qualified; and the 35 stands that could have been regenerated would not have been cut.

As table 1 illustrates, when the stocking requirements are more stringent, the number of stands that qualify decreases and the prediction accuracy or percentage of success increases among those that qualify. At the same time, the number of stands that are not qualified, but would be successful if cut, increases. What we were looking for was a stocking-level requirement that provides high success among the stands that qualify for cutting without disqualifying too many stands that would actually regenerate successfully.

Many different stocking-level requirements were tried, in terms of both the average number of seedlings on all 9 plots and a minimum number on 6 of the 9 plots. These included various numbers of black cherry alone, various numbers of desirable species, various numbers of black cherry *or* desirable species, and various numbers of black cherry *and* desirable species (table 1). Stocking-level requirements were also tried that involved only first-year seedlings, and only second-year and older seedlings of each of the following: black cherry, desirable species, and all tree species. These data were available only on the 31 research-plot clusters.

Results

Stocking requirements based on the age-class groups from the research-plot data either had low value for predicting success or disqualified too many stands. However, these plots did show that first-year black cherry seedlings were equally as good predictors as older ones.

For all 65 areas, requirements based on only 5 or 10 black cherry seedlings of both age classes on 6 out of 9 plots had remarkably high predictive value — 95 to 100 percent of the stands that qualified under such require-

Table 1.—*Outcome of stand regeneration on 65 areas under various advance regeneration stocking requirements*

Stocking required (number of seedlings)	Stands qualified for cutting	Stands apparently regenerated successfully		Stands not qualified but apparently regenerated successfully
	No.	*No.*	*Pct.*	*No.*
IN TERMS OF AVERAGE NUMBER ON ALL NINE PLOTS				
5 black cherry	33	27	82	8
10 black cherry	24	20	83	15
15 black cherry	19	18	95	17
20 desirable species	39	29	74	6
25 desirable species	34	27	79	8
30 desirable species	30	24	80	11
40 desirable species	27	22	81	13
50 desirable species	16	15	94	20
5 black cherry or 25 desirable species	40	31	78	4
5 black cherry or 35 desirable species	37	29	78	6
5 black cherry or 45 desirable species	33	27	82	8
10 black cherry or 25 desirable species	34	27	79	8
10 black cherry or 35 desirable species	31	25	81	10
10 black cherry or 45 desirable species	27	23	85	12
10 black cherry or 55 desirable species	26	22	85	13
15 black cherry or 25 desirable species	33	27	82	8
15 black cherry or 35 desirable species	30	25	83	10
15 black cherry or 45 desirable species	25	23	92	12
15 black cherry or 55 desirable species	22	20	91	15
5 black cherry and 20 desirable species	28	24	86	11
5 black cherry and 25 desirable species	26	23	88	12
10 black cherry and 20 desirable species	23	20	87	15
10 black cherry and 30 desirable species	22	19	86	16
IN TERMS OF MINIMUM NUMBER ON SIX OUT OF NINE PLOTS				
5 black cherry	19	18	95	17
10 black cherry	12	12	100	23
15 black cherry	10	10	100	25
10 desirable species	39	29	74	6
20 desirable species	25	19	76	16
25 desirable species	20	17	85	18
30 desirable species	17	15	88	20
35 desirable species	14	12	86	23
5 black cherry or 20 desirable species	30	24	80	11
5 black cherry or 25 desirable species	27	24	89	11
5 black cherry or 30 desirable species	25	23	92	12
5 black cherry or 35 desirable species	22	20	91	15
10 black cherry or 20 desirable species	27	21	78	14
10 black cherry or 25 desirable species	23	20	87	15
10 black cherry or 30 desirable species	20	18	90	17
10 black cherry or 35 desirable species	18	16	89	19
15 black cherry or 20 desirable species	25	19	76	16
15 black cherry or 25 desirable species	21	18	86	17
15 black cherry or 30 desirable species	19	17	89	18
15 black cherry or 35 desirable species	16	14	88	21
5 black cherry and 15 desirable species	17	15	88	20
5 black cherry and 20 desirable species	15	14	93	21
5 black cherry and 25 desirable species	13	12	92	23

ments are successfully regenerating. But these criteria excluded from cutting 17 to 23 stands that are also regenerating successfully. The stocking of seedlings of desirable species was generally not as good in predicting success as black cherry alone; or where it was (at high levels of stocking), it disqualified more successful stands.

The criterion that seems to offer the best compromise is the requirement that 70 percent of the milacres examined contain at least 5 black cherry seedlings *or* 30 seedlings of desirable species (table 1). This combination gives a good prediction without disqualifying too many potentially successful cases.

Had this criterion been used prior to cutting these 65 stands, only 25 would actually have been cut. Twenty-three (92 percent) of these are apparently regenerating successfully. Only 12 of the other 40 stands that did not qualify for cutting under this criterion are apparently regenerating.

The same results would have been obtained on these 65 areas if the required stocking had been an average of 15 black cherry seedlings or 45 of desirable species on the 9 plots. We prefer to use the minimum stocking on 6 out of 9 plots because it requires that the seedlings be well distributed. The 25 stands that qualified under one method are not the same 25 that qualified under the other; 3 of them are different.

There are probably several reasons why relatively small numbers of black cherry seedlings indicate a good chance of regeneration success. Even small first-year black cherry seedlings apparently have a high rate of survival when the overstory is removed. And these seedlings grow rapidly when released, particularly in the absence of dense ground cover.

Areas with advance black cherry seedlings are also likely to have ungerminated seeds in the litter and humus from the most recent seed crop, thus increasing chances that successful reproduction will be obtained. More definite information about this should result from studies now under way.

And finally, regeneration assessed only 2 to 4 years after cutting, as was done here, may be more apt to be rated good if it is mainly black cherry than if it were a slower growing species that would be smaller and more difficult to see at the time of the assessment.

Application of Results — an Interim Guide

In the examination of stands for cutting or other silvicultural treatment, many factors of stand condition and site should be taken into account (stocking, maturity, proportion of acceptable growing stock, etc.). The stocking of advance seedlings is another factor that should be considered before any harvest cutting is prescribed in Allegheny hardwoods. As a basis for evaluating advance regeneration, we suggest the following:

- Advance reproduction must be sampled to estimate amount and distribution. Twenty to 30 sample points in each stand are desirable; more may be required if the area is large or diverse; fewer may suffice if the area is small and uniform; but 10 should be an absolute minimum. These points should be selected by some random procedure, and they may be the same points used for examination of other stand characteristics such as volume.

- Each sample point is rated as being either stocked or not stocked, on the following criteria:

  Stocked: Contains at least 15 advance seedlings of black cherry *or* at least 80 advance seedlings of any desirable species within a 6-foot radius of the sample-point center. The values of 15 and 80 seedlings per 6-foot-radius plot correspond to 5,000 and 30,000 seedlings per acre (5 and 30 per milacre). Estimates rather than actual seedling counts are adequate, once some experience has been gained. (The 6-foot plot radius was selected because of a tie-in to standard stocking guides for stands of northern hardwoods that have an average d.b.h. of 5 inches.)

  Not stocked: Contains less than above.

- When all sample points have been rated, the percentage of plots stocked by the above criteria is determined. If 70 percent or more are stocked, the stand can be expected to regenerate after clearcutting. If fewer than 70 percent are stocked, chances of regeneration failure after clearcutting are high; and final cutting should usually be postponed.

This stocking guide is considered an interim guide because it should be possible to improve it with further research and experience. A study to determine the size, age, or vigor of advance seedlings that survive and develop into the succeeding stand is under way. Use of such information should improve the reliability of the guide. The results that other users of this guide might have in regenerating Allegheny hardwoods will also be useful in checking its reliability or in modifying it, and we welcome such information.

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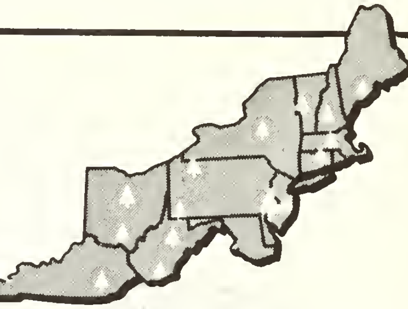


FOREST SERVICE, U.S. DEPT. OF AGRICULTURE, 6816 MARKET STREET, UPPER DARBY, PA. 19082

SPECIES AND STRUCTURE OF A VIRGIN NORTHERN HARDWOOD STAND IN NEW HAMPSHIRE

Abstract.—Virgin northern hardwoods in the Bowl, a natural area in the White Mountain National Forest in New Hampshire, exhibit a limited number of species, large sizes in all key species except beech, a full understory, and a well-developed diameter distribution.

Nearly all forest stands in the Northeast have been cut over at least once in the past. However, during the last few years, groups interested in natural resources have been trying to locate and permanently protect the few remaining virgin stands—mature forest stands that have never been logged nor heavily disturbed by natural catastrophe. This effort is in recognition of the scientific and esthetic value of these areas. Virgin stands provide a basis for evaluating innate species characteristics, tracing successional trends, and weighing the influence of management or disturbance.

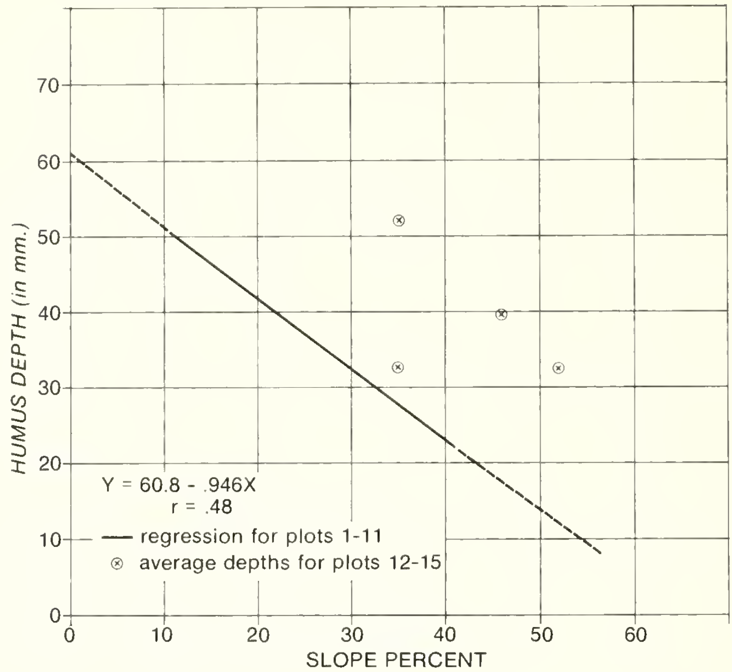
One important virgin forest area is the Bowl, a 206-hectare (510-acre) natural area in the White Mountain National Forest (*Lyon and Bormann 1962*). The Bowl contains virgin stands of both spruce-fir and northern hardwoods or beech-birch-maple. In the summer of 1972, I inventoried one of the northern hardwood stands. The record provides a description of the unique character of the vegetation as compared to that of cutover stands.

The stand is an 18-hectare (44-acre) tract of northern hardwoods in the southeast corner of the Bowl. The aspect is east to northeast. Elevation ranges from 580 to 640 meters above sea level. The soil is Berkshire, a well-drained, fine, sandy loam.

Fifteen plot locations were systematically established in the stand. Eleven of these plot locations fell in typical northern hardwoods well within the stand borders. Four plots fell near the transition between hardwoods and spruce-fir at the upper elevations of the study area. At each plot location, the diameter above the root collar (above root swell) and the species were recorded for all trees 100 mm and larger on a 1/10-hectare plot, all woody stems 10 to 99 mm on a 1/100-hectare plot, and all woody stems of 1 year old to 9 mm on four 1/10,000-hectare plots. Ten humus-depth measurements (H layer, excluding L and F layers) were made per plot location, using a sharp tube sampler. Slope percent was estimated at each plot location with a clinometer.

Slope percent varied in the stand from 11 to 52 percent and averaged 34 percent. Humus depth on the 11 plots well within the stand was negatively related to slope percent with a fair degree of accuracy (r = .48). However, average humus depths on the four plots near

Figure 1.—Regression of humus depth over slope percent for typical hardwood (plots 1-11) and average humus depths for hardwood-softwood transition plots (12-15).



the hardwood-softwood transition were considerably above the regression line (fig. 1), possibly because of the influence of the slightly higher softwood component.

A stand table for the Bowl was compared with a table based on two plots in compartment 26 on the Bartlett Experimental Forest, New Hampshire (table 1). Compartment 26 has been reserved as a natural area of old-growth northern hardwoods — a stand that was high-graded for the best softwoods and hardwoods in the late 1800s and has remained uncut since that time. Elevation is about 335 meters; aspect and soils are similar to those of the Bowl.

The Bowl stand contains a relatively small number of species: beech, yellow birch, sugar maple, red spruce, balsam fir, striped maple, mountain maple, and hobblebush are well represented. Red maple, paper birch, white ash, hemlock, and yew are noticeably absent as compared with the compartment 26 stand. An analysis of age distribution indicates that spruce, fir, and yellow birch also are decreasing in the typical hardwood portion of the Bowl stand.

This limited number of species is further emphasized by comparison with the species composition (based on basal area) of a range of stands on the Bartlett Experimental Forest, representing both old-growth and second-growth (stands clearcut in the late 1800s) (table 2).

Table 1 reveals the fairly large sizes attained by yellow birch, sugar maple, spruce, striped maple, and mountain maple in the virgin Bowl stand. Beech, on the other hand, does not grow very large in the Bowl even though it is an abundant, stable, and long-lived (250 years) resident.

All species considered together, the diameter distributions of the Bowl stand and the compartment 26 stand are similar. If we ignore the very small stems (0 to 9 mm), the understory in the Bowl is at least as dense as that of compartment 26 — a departure from the parklike conditions sometimes associated with virgin stands.

Table 1.—*Stand tables (numbers per hectare) for virgin northern hardwoods (The Bowl) and old-growth northern hardwoods (Compartment 26, Bartlett Experimental Forest)*

Diameter (mm)	Beech	Yellow birch	Sugar maple	Red maple	Paper birch	White ash	Red spruce	Eastern hemlock	Balsam fir	Striped maple	Mountain maple	Hobble-bush	Scarlet elder	Yew	Service berry	Total
							THE BOWL (15 PLOTS)									
0-9	5,167	—	37,667	—	—	—	167	—	167	4,667	2,833	9,667	0	—	—	60,335
10-99	3,333	20	886	—	—	—	254	—	20	993	453	2,120	7	—	—	8,086
100-199	188	9	24	1	—	—	7	—	2	76	3	—	—	—	—	310
200-299	61	17	11	—	—	—	5	—	2	8	—	—	—	—	—	104
300-399	24	17	15	—	—	—	5	—	—	—	—	—	—	—	—	61
400-499	9	10	23	—	—	—	3	—	—	—	—	—	—	—	—	45
500-599	3	11	15	—	—	—	1	—	—	—	—	—	—	—	—	30
600-699	—	3	4	—	—	—	1	—	—	—	—	—	—	—	—	8
700-799	—	3	1	—	—	—	—	—	—	—	—	—	—	—	—	4
800-899	—	2	1	—	—	—	—	—	—	—	—	—	—	—	—	3
900-949	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	1
							COMPARTMENT 26 (2 PLOTS)									
0-9	8,568	2,499	27,489	34,272	—	17,493	714	714	—	9,282	—	92,963	—	3,213	357	197,564
10-99	4,195	—	122	0	—	—	169	248	83	730	—	679	—	—	—	6,316
100-199	130	20	15	15	5	5	5	90	—	5	—	—	—	—	—	290
200-299	20	5	15	35	—	10	0	15	—	—	—	—	—	—	—	100
300-399	35	10	—	30	—	5	5	—	—	—	—	—	—	—	—	85
400-499	10	5	—	20	5	10	0	5	—	—	—	—	—	—	—	55
500-599	10	10	5	—	10	5	—	—	—	—	—	—	—	—	—	40
600-699	5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	5
700-799	—	—	—	—	—	5	—	—	—	—	—	—	—	—	—	5
800-899	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
900-949	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

Table 2.—Species composition of old-growth and second-growth northern hardwoods in percent of basal area, trees over 114 mm (4.5 inches) d.b.h. (Filip et al 1960; Leak 1961)

Stand condition	Beech	Yellow birch	Sugar maple	Red maple	Paper birch	White ash	Red spruce	Eastern hemlock	Others
Well-stocked second-growth	21	11	7	30	11	8	1	11	—
Old-growth	41	13	12	13	4	2	3	12	—

In summary, the virgin northern hardwoods in the Bowl are characterized by a limited number of species, fairly large sizes in all key species except beech, a full understory, and a well-developed diameter distribution similar to that found in old-growth northern hardwoods. This information may prove useful as a basis for comparison with managed or disturbed northern hardwood stands and as a base line for future observations on the development of virgin stands in the Bowl.

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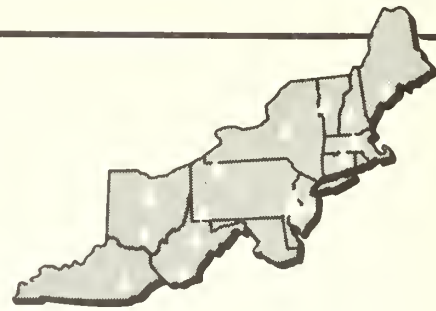

FOREST SERVICE, U.S. DEPT. OF AGRICULTURE, 6816 MARKET STREET, UPPER DARBY, PA. 19082

FERTILIZATION INCREASES DIAMETER GROWTH OF BIRCH-BEECH-MAPLE TREES IN NEW HAMPSHIRE

Abstract. — In a 60-year-old northern hardwood stand treated with lime plus NPK fertilizer, the following increases in average basal area growth rate over untreated trees were observed: sugar maple 128 percent, paper birch 69 percent, yellow birch 51 percent, and beech 20 percent. Magnitude of response was inversely related to relative growth rate of the species. Growth rate before treatment was used as a covariate to adjust treatment means for differences in vigor of the trees.

Fertility of forest soils in New England is generally low. Nutritional limitations on growth are common on many sites in this region. Mitchell and Chandler (*2*) showed that there is a strong relationship between nitrogen supply and radial increment of several deciduous trees of the Northeast and estimated that only 15 percent of the soils supporting hardwood species had an optimum nitrogen status. Hoyle and Bjorkbom (*1*) emphasized that not only N but also, P, Ca, and Mg in mineral soils in New Hampshire were deficient for growth of yellow birch. Yet there have been few field trials of fertilizers in northern hardwood forests to test the effects of fertilizers on tree growth response.

This note is a report on increased diameter growth of four northern hardwood species after combined application of dolomitic limestone and NPK fertilizer.

Study Area

This trial was established as a timber-stand-improvement project in the Bartlett Experimental Forest in the White Mountain National Forest in New Hampshire. The site is at about 300 m (1,000 ft) elevation on gentle 5-10 percent slope with northerly aspect. The soil is a coarse loam, classified as a Typic Fragiorthod in the Becket series.

This stand contained 30 m^2 per ha (130 ft^2 per A) of basal area, with the following species distribution: American beech (*Fagus grandifolia* Ehrl.) 36 percent; red maple (*Acer rubrum* L.) 21 percent; sugar maple (*A. sac-*

charum Marsh.) 13 percent; yellow birch (*Betula alleghaniensis* Britton) 12 percent; paper birch (*B. papyrifera* Marsh.) 12 percent; and other species 5 percent. Average height of dominant and co-dominant trees was 20 m (65 ft); age was 90 years.

A block of 10 contiguous .4-ha (1-acre) plots was established, and 1,120 kg/ha (1,000 lb/A) of dolomitic limestone (30% CaO, 20% MgO) were broadcast by hand over the entire area in the fall of 1963. One of the .4-ha plots received 3,360 kg/ha (3,000 lb/A) of 15-10-10 NPK fertilizer in a broadcast application in April 1964 and a second application of NPK (same amount) in June 1969. This was equivalent to 240 kg/ha (214 lb/A) Ca and 120 kg/ha (107 lb/A) of Mg for the entire block, plus 1,008 kg/ha (900 lb/A) N, 369 kg/ha (330 lb/A) P, and 558 kg/ha (500 lb/A) K on the lime + NPK plot.

Growth Measurements and Analysis

After the 1971 growing season, increment cores were taken from 10 trees each of yellow birch, paper birch, sugar maple, and beech on the limed area, the lime + NPK plot, and the surrounding untreated stand. Only healthy dominant or co-dominant trees 5 m or more from plot boundaries were chosen. Mean and range of 1971 dbh for measured trees were as follows: sugar maple 25 cm (15-50), yellow birch 26 cm (15-37), paper birch 30 cm (21-43), and beech 25 cm (18-35). The ranges in tree sizes were about the same for the three treatments.

Radial growth for the period after treatment (1964-71) and for the corresponding 8-year period before treatment (1956-63) was measured on each of the 120 increment cores. Measuremnets were to the nearest 0.25 mm. Initial diameters were calculated by subtracting 2 times radial increment from present dbh outside bark. Thus bark thickness was assumed to be a constant and unaffected by treatment. Relative basal-area growth — cm^2 per 100 cm^2 initial basal area per tree — was calculated.

Analysis of covariance (3) was performed on relative basal-area increase since treatment (1964-71), using relative basal-area increase before treatment (1956-63) as the covariate. A preliminary analysis suggested that for each species the regression coefficients were the same for the three treatments. Therefore the growth model used in the study assumes a common regression coefficient for the covariate.

Results

For each species, mean relative basal-area growth of trees from the lime + NPK plot was greater than that of untreated trees. In addition all species from the lime-only treatment — especially paper birch and sugar maple trees — had greater basal-area increment than trees from the control area (table 1). Untreated sugar maple trees were the slowest growing and made the greatest response to treatment. Untreated beech trees were the fastest growing and showed the least response to treatment.

The pattern of differences among growth rates of untreated and treated trees before treatment (table 2) was similar to that after treatment. The only difference in this pattern

Table 1. — *Average relative basal-area growth per tree after fertilizer treatment (1964-71)*

[cm^2 per 100 cm^2 per tree]

Species	Treatment		
	Control	Lime	Lime + NPK
Yellow birch	3.7	4.2	9.5
Paper birch	3.3	3.9	4.9
Sugar maple	2.8	4.9	8.8
Beech	7.1	7.4	9.4

Table 2. — *Average relative basal-area growth per tree before fertilizer treatment (1956-63)*

[cm^2 per 100 cm^2 per tree]

Species	Treatment		
	Control	Lime	Lime + NPK
Yellow birch	4.2	4.4	7.8
Paper birch	4.6	5.3	3.8
Sugar maple	4.2	8.1	7.3
Beech	8.8	9.0	10.2

was with paper birch: where lime only was used, trees had the highest basal-area increment; and where lime + NPK were used, the lowest. These pretreatment growth patterns cloud the response to treatment referred to in table 1. Were the differences reported in table 1 caused by the treatments, or by an influence of the pretreatment growth rate shown in table 2?

To answer this question, mean basal-area growth after treatment was adjusted for basal-area growth before treatment by a covariance technique (table 3). The pattern of mean values was similar to the uncorrected growth rates in table 1. Effect of treatment was significant at the 1-percent level for paper birch and sugar maple, and at the 10-percent level for yellow birch. Treatment effects on beech were not significant.

Table 3. — *Average relative basal-area growth per tree after fertilizer treatment (1964-71) corrected by covariance for growth rate before treatment (1956-63)*

[cm^2 per 100 cm^2 per tree]

Species	Treatment		
	Control	Lime	Lime + NPK
Yellow birch[a]	4.9	5.2 (6)[b]	7.4 (51)
Paper birch[c]	3.2	3.5 (9)	5.4 (69)
Sugar maple[c]	3.7	4.4 (19)	8.5 (128)
Beech[d]	7.4	7.5 (1)	8.9 (20)

[a]Treatment effects significant at 10% level by analysis of covariance.
[b]Figures in parentheses show percent increase over control.
[c]Treatment effects significant at 1% level by analysis of covariance.
[d]Treatment effects not significant.

In the lime-only treatment, the greater growth of paper birch and sugar maple shown in table 1 was evidently attributable to growth rate before treatment, because the adjusted treatment means (table 3) are only slightly greater than that of untreated trees.

Sugar maple growth was more than doubled by the lime + NPK treatment. Paper and yellow birch growth was increased by more than 50 percent. Beech showed a 20-percent increase—though not statistically significant.

Discussion

The results of this small study indicated that species of advanced age growing together in mixed stands may respond differentially to fertilizer treatment. Paper birch, an intolerant pioneer species, approaching overmaturity at 90 years, showed a substantial response to fertilizer. Beech, a tolerant climax species and the fastest growing species in the untreated stand, was only slightly stimulated. These results suggest that research into the possible use of nutrient manipulation as a means of influencing species dominance in mixed northern hardwood stands is needed.

Trees in this study apparently were already in a period of declining growth from natural causes. (Compare control and lime-only values in table 1 and table 2 for each species.) Effect of lime + NPK treatment was to reverse this trend and increase increment of treated trees. This raises a question about magnitude of response. Had the trees been growing normally — at a rate equal to the before-treatment rate — would the response to treatment have been greater or less than that observed? Intuitively one would answer greater. More vigorous trees should show a greater response. However, the data for beech, the fastest-growing but least responding species, tend to support the opposite hypothesis.

The important consideration here is that rate of growth before treatment, and trend of control-tree growth after treatment, have an important bearing on the evaluation and interpretation of treatment response. Design of future research studies should incorporate the vigor of the trees being treated as a variable. Growth measurements must cover a sufficient period of time for assessing the interaction of treatment response with uncontrolled sources of growth variation.

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A SIMPLE AND INEXPENSIVE PULSING DEVICE FOR DATA-RECORDING CAMERAS

Abstract.—In some areas of forestry and wood utilization research, use of automatic data recording equipment has become commonplace. This research note describes the basic electronic components needed to modify an existing intervalometer into a simplified pulsing device for controlling an automatic data recording camera. The pulsing device is easily assembled and inexpensive, when compared to similar proprietary units.

Pong et al. (1970) have developed an automatic photoelectric triggering mechanism for a pulse-operated data-recording 35 mm camera. The primary use of their camera system is to record information about individual pieces of lumber as they are produced in a sawmill. Incorporated in the system is a pulse generator, designed and built by the Pacific Northwest Forest and Range Experiment Station. The pulse generator is the "brain" of the camera system, and is quite expensive to build. This research note describes an inexpensive pulsing device built at the Northeastern Forest Experiment Station, for a similar use. The camera, remote triggering mechanism, and basic ideas all originated from the PNW Station. The only difference in our camera system is the pulsing device.

Definition

An intervalometer is an electrical device used for controlling various types of pulse-operated electronic camera equipment. It is a critical component in an electronic camera system since the operation of the system is initiated by the pulse it generates through the closure of remote switches. Most data-recording cameras are operated by an electrical pulse of a given duration; a device that produces a pulse of the required duration may be extremely expensive to develop or purchase commercially.

Researchers at the Northeastern Forest Experiment Station have developed an inexpensive pulsing device using modified surplus equipment and available standard electronic components. This pulsing device will operate an Automax G-3, 35 mm Data-Recording Camera,[1] meeting the specific pulse and power requirements of the camera.

B-8B Intervalometer

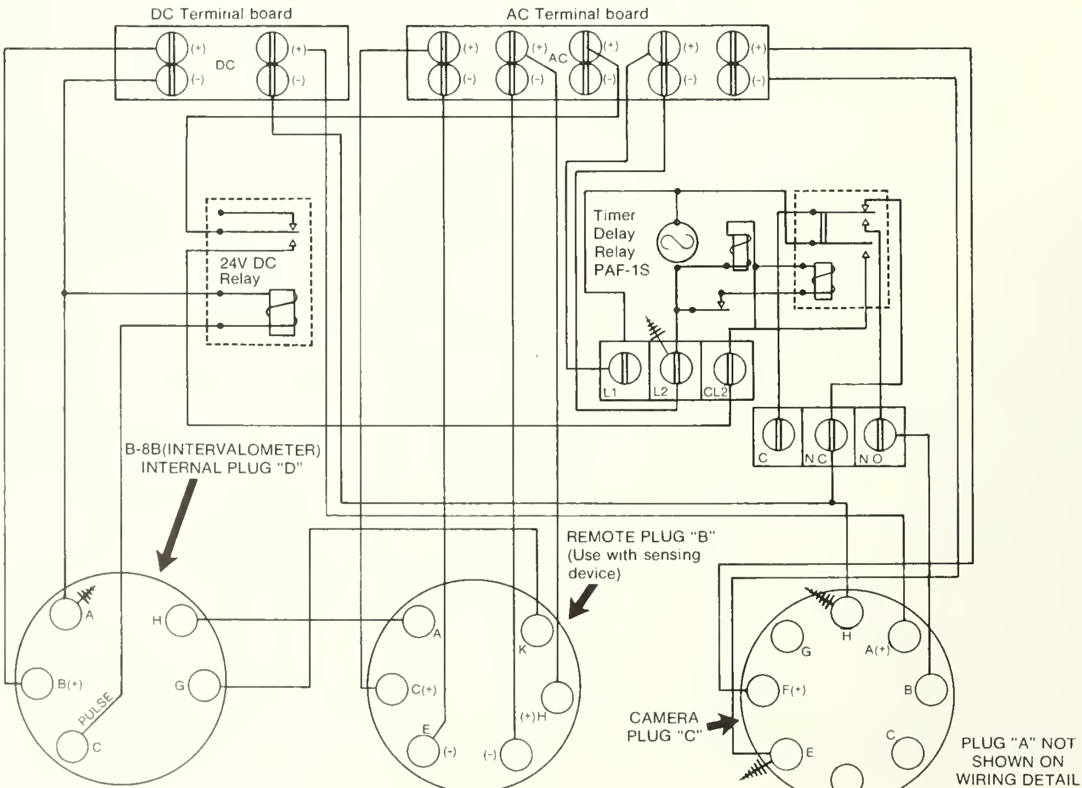
The basis of this pulsing device is an Abrams B-8B intervalometer (fig. 1) used by the Air Force and readily available on federal

[1]Trade names are used for the convenience of the reader and do not imply endorsement by the U.S. Department of Agriculture.

Figure 1.—Type B-8B intervalometer, overall view.

surplus supply lists. The B-8B intervalometer, built by the Abrams Instrument Corporation, is designed to control aerial photographic cameras in bombardment aircraft. It is powered by a small external 24VDC power source wired to the B-8B intervalometer through amphenol plugs. The intervalometer has an initial delay time of 1 to 60 seconds and interval rates of 1 to 60 seconds. Other equipment visible on the face panel of the intervalometer are ready and operation lights, manual initiation and camera trip buttons, pulse counter, fuse, exposure limiter, and off switch. The unit produces a 1- to 2-second pulse at 24VDC for any delay and interval desired. Because the pulse generated by the B-8B intervalometer is not of proper duration to operate the data-recording camera directly, a series of relays were added to modify this pulse.

Figure 2.—Wiring detail of pulsing device showing terminal boards, relays, and plugs.



General Purpose 24VDC Relay

The initial relay used in the pulsing device is a Potter-Brumfield, KA type, general-purpose 24VDC relay (fig. 2). It is SPDT, using the 24VDC pulse from the B-8B to operate the relay coil, with 110 VAC power across the relay points. It operates in an "open" configuration, with the 24VDC pulse from the B-8B activating the coil, closing the contacts and allowing 110 VAC power (1- to 2-seconds duration) to pass to the next relay.

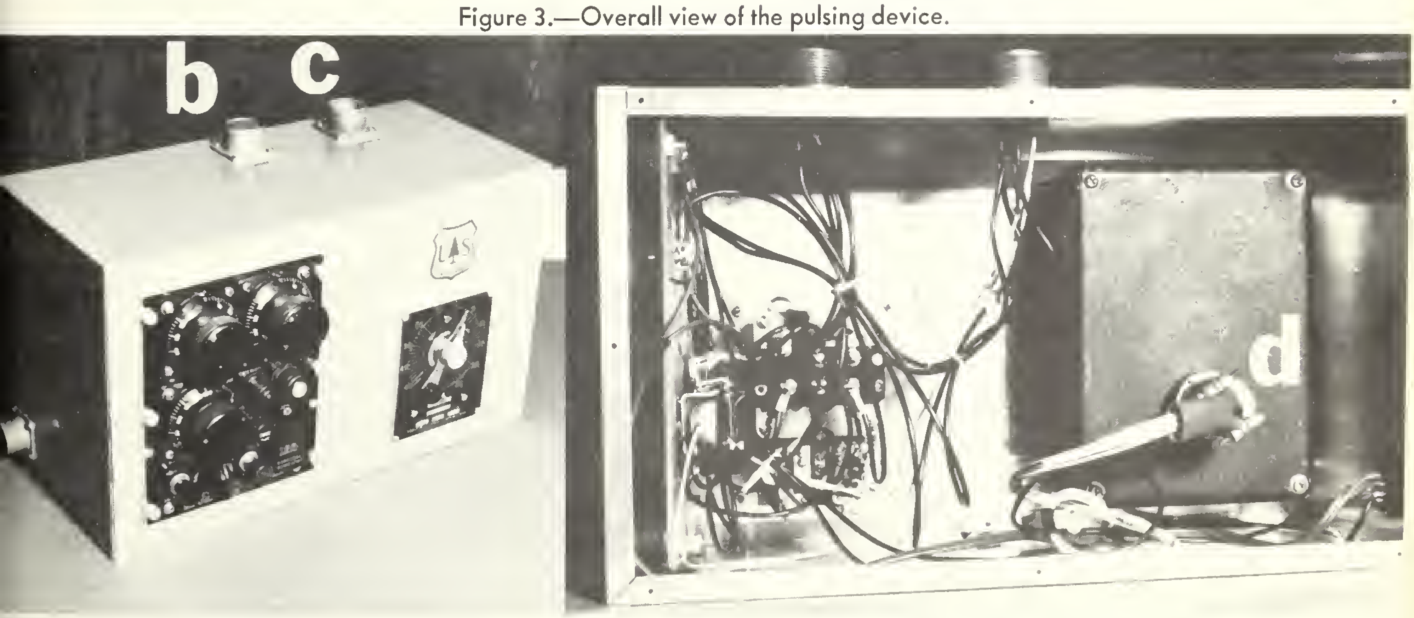
Automatic Reset Time Delay Relay

The second relay is an Industrial Timer, Series PAF-1S, panel-mounted interval timer (fig. 2). This particular model is a clutch-operated, automatic-reset timer relay operating on 110 VAC, 60 cycles, with a maximum time cycle of 1 second in 1/60 second increments. Since the 1- to 2-second (110 VAC) pulse from the previous general purpose relay is not of the proper duration or voltage to operate the data recording camera directly, the automatic reset timer relay is used to generate an electrical pulse output of the proper voltage (24VDC) and duration (30-50 milliseconds) to operate the camera shutter and take-up motor of the data camera. The entire pulsing device is contained in a 15 x 9 x 7 aluminum box (fig. 3) with amphenol plugs for the external connections.

Amphenol Plugs

Plug "A" (fig. 3) connects the 24VDC power pack and 110 VAC power line to the pulsing device. For automatic use of the unit, plug "B" (fig. 3) is used with any remote sensing device, such as photoelectric cells or micro switches. A manual switch may also be used for individual pulsing of the unit. Plug "C" (fig. 3) is the camera pulse plug which carries the 30-50 millisecond pulse to the camera. Plug "D" is the B-8B intervalometer plug (fig. 3, bottom) which connects the B-8B to the series of relays. It is internal and not accessible from outside the pulsing device. All connecting wires are 16 gage, shielded, stranded and covered with heat-shrinkable tubing.

Figure 3.—Overall view of the pulsing device.



FRONT

REAR (with cover removed)

Camera

The data-recording camera used is an Automax G-3, 35 mm, single frame format (.738 x .970), using a Mitchell Magazine with a capacity of 500 feet of film. The large roll gives a maximum of 7800 individual pictures with one load of the camera and magazine. The camera has a speed of 10 frames per second or 600 frames per minute.

Use

The pulsing device and camera system were developed for use as a mechanical tally system to "back up" the hand tally of lumber. Grade marks, sawing order numbers, length, width and thickness of each board are photographed by the camera. The photographic data can then be used to check the hand tally.

The pulsing device and camera may have additional uses other than the particular one it was developed for. Because of its versatility and dependability, the camera system can be used for time lapse photography as well as high speed photography.

Cost

The cost of purchasing or having constructed a commercial pulsing device that will satisfy all the camera system requirements is $800.00 to $1,600.00. The overall cost of the pulsing device described in this paper is $120.00, not including the cost of the surplus B-8B intervalometer and labor. Construction time is approximately 8 to 10 hours from start to finish.

The following list shows the individual components and cost of each:

B-8B Intervalometer (Surplus) . .	$ —
Industrial Timer (Time-Delay Relay)	$ 47.50
24 VDC Power Pack	59.50
Potter-Brumfiield 24VDC Relay	3.60
Metal (Alum.) Box	6.90
Shielded Wire (Conductor)	1.60
Tubing (Shrinkable)	1.77
3 Cannon Plugs (Surplus)	—
Total Cost	$120.87

For additional information contact the Northeastern Forest Experiment Station, 6816 Market Street, Upper Darby, Pa.

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Northeastern Forest Experiment Station

FOREST SERVICE, U.S. DEPT. OF AGRICULTURE, 6816 MARKET STREET, UPPER DARBY, PA. 19082

SHOOT SIZE SIGNIFICANTLY AFFECTS ROOTING RESPONSE OF SUGAR MAPLE SOFTWOOD CUTTINGS

Abstract. Three hundred softwood cuttings were collected from each of three mature sugar maple trees to test the effect of shoot size on adventitious root formation. One of the trees was a good rooter (61 percent rooted); one was a poor rooter (19 percent rooted); and the third was a non-rooter (1 percent rooted). There was an insufficient number of rooted cuttings from the third tree to permit meaningful comparisons. For the other two trees, long cuttings rooted better than short cuttings. Also, thick cuttings tended to root better than thin ones for one study tree; for the other tree, relative shoot thickness within a particular length class had no effect on rooting.

As one step in formulating workable procedures for propagating superior sugar maple trees vegetatively, we studied the possibility of a relationship between shoot size and rooting response. Results of this study provide propagators with a criterion for selecting cuttings when they are attempting to reproduce this species vegetatively.

Materials and Methods

Approximately 300 softwood cuttings were collected from each of 3 mature sugar maple trees in mid-June 1968. The term *softwood cutting* refers to the current year's total shoot growth. The length and basal diameter of each cutting were recorded to the nearest 0.1 inch and 0.001 inch, respectively. An approximately 2-inch minimum length limit was established to insure that all cuttings would be large enough to be treated equally in the rooting bed; no maximum length nor minimum or maximum diameter limits were set.

The cuttings were lined out randomly (with regard to size) by tree source in a 20- x 60-foot plastic-covered greenhouse. Daily maximum air temperature in the greenhouse was approximately 80°F; daily minimum air temperature was approximately 60°F. The rooting medium, a 50-percent-by-volume mixture of coarse perlite and shredded sphagnum moss, was heated with electric cables; and its temperature was thermostatically maintained at 80°F. Cuttings were watered with intermitten mist; applications were regulated with a MacPenny electronic leaf. Because long days tend to stimulate rooting *(Hartman and Kester 1968)*, supplemental lighting (150-watt incandescent lamps placed approximately 4 feet above the rooting beds) provided a 20-hour day length.

A sufficient number of lower leaves were removed from the cuttings to facilitate sticking; this generally required removing one or two pairs of leaves. Before being inserted into the rooting medium, cuttings were wounded and dipped into Jiffy Grow (*Donnelly 1971*).

(Mention of a particular product is for information only and should not be considered a recommendation or endorsement by the U. S. Department of Agriculture or Forest Service.)

Cuttings were checked for the presence of roots in mid-September, approximately 3 months after they had been collected. A cutting was considered to have rooted if it had at least one recognizable root.

Results

Relationship between shoot length and shoot diameter.—As might be expected, shoot length is correlated with shoot diameter: long cuttings tend to be thicker than short cuttings. Because shoot length and diameter are positively correlated, either of these two variables could perhaps be used to test for a possible relationship between shoot size and rooting response. However, it would be expected that, when propagators select cuttings from mature trees, it would generally be easier to select them on the basis of length rather than diameter; therefore, subsequent major analyses were based on shoot length.

Effect of shoot size on rooting.—Cuttings from one tree (tree C) rooted very poorly, regardless of size. Only four cuttings from this tree, approximately 1 percent, developed adventitious roots. Cause of this almost complete failure is unknown. It appears unlikely that failure was due to improper treatment or environmental conditions within the rooting greenhouse. In mid-September the foliage of the tree from which these cuttings were collected had a rather reddish-brown cast, indicating a possible nutrient deficiency or some other physiological problem. This may have caused the almost complete lack of rooting. Because rooting was insufficient for meaningful comparisons, results from this tree were omitted from subsequent analyses of the effect shoot size has on rooting response.

Approximately 40 percent of the almost 600 cuttings from the other two trees developed adventitious roots. Of these 600 cuttings, 23 became desiccated in the rooting beds before they were checked for the presence of roots; they were omitted from subsequent calculations. In general, tree A was a relatively poor rooter (19 percent of all cuttings rooted), and tree B was a good rooter (61 percent of all cuttings rooted).

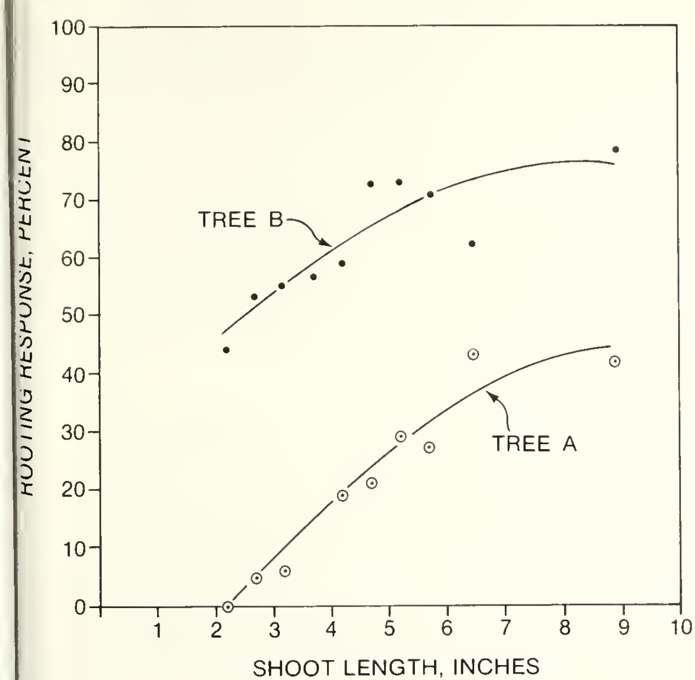
The effect of shoot size on rooting was tested by assigning all cuttings from each tree to one of 10 size classes, calculating the rooting response for each class (table 1) and determining the probability that observed differences in rooting could be due to chance. The length classes were: I.—2.0 to 2.4 inches; II.—2.5 to 2.9 inches; III.—3.0 to 3.4 inches; etc. Because there were relatively few cuttings longer than 6 inches, class IX included cuttings 6.0 to 6.9 inches; and class X included cuttings that were 7.0 inches and longer.

A general increase in rooting response with increase in shoot length was noted for both tree (fig. 1); but cuttings of a particular size class rooted much better for tree B than for tree A. The lowest rooting response obtained from tree B (44 percent for cuttings less than 2.5 inches long) was higher than the highest

Table 1.—*Rooting response of sugar maple cuttings of various length classes*

Class	Length	Tree A		Tree B		Total	
		Cuttings	Cuttings rooted	Cuttings	Cuttings rooted	Cuttings	Cuttings rooted
	Inches	*No.*	*Percent*	*No.*	*Percent*	*No.*	*Percent*
I	2.0 - 2.4	29	0	36	44	65	25
II	2.5 - 2.9	48	4	47	53	95	28
III	3.0 - 3.4	33	6	29	55	62	29
IV	3.5 - 3.9	30	17	28	57	58	36
V	4.0 - 4.4	26	19	29	59	55	40
VI	4.5 - 4.9	23	21	22	73	50	44
VII	5.0 - 5.4	17	29	15	73	32	50
VIII	5.5 - 5.9	26	27	14	71	40	42
IX	6.0 - 6.9	21	43	26	62	47	53
X	7.0+	31	42	42	79	73	63

Figure 1.—Relationship between shoot length and rooting response for stem cuttings from two mature sugar maple trees.



response obtained from tree A (43 percent of cuttings between 6 and 7 inches long).

The probability (chi-square test) that observed size-class differences could be due to chance was less than 0.01 for tree A. For tree B, the probability was approximately 0.10. Thus cuttings from tree B rooted much better than those from tree A did, but response from tree A was more closely correlated with shoot length.

As previously stated, long cuttings tended to be thicker than short cuttings; however, considerable variation in diameter existed for shoots within any length class. Therefore we tested to see if, within each length class, relatively thick cuttings rooted better than relatively thin ones did. Tree-to-tree variations were apparent. For tree A, thick cuttings rooted better than thin ones did (30 percent vs. 9 percent rooting). The probability that this difference could be due to chance is less than 0.01 (chi-square test). For tree B, the average rooting response for relatively thick cuttings (60 percent) was approximately equal to that for relatively thin cuttings (62 percent). The probability that this difference could be due to chance was approximately 0.68.

Discussion

Several researchers have previously reported a relationship between shoot size and the potential for these shoots to be propagated vegetatively *(Snow 1941; Smith et al. 1956; Sardina 1958; Amihan 1959; Chiang 1963; Schwarz and Weide 1963; Suszka 1963; and Morsink 1971)*. Although there have been exceptions *(Snow 1941; Chiang 1963)*, researchers have generally reported that large cuttings propagate better than small ones. Morsink *(1971)* recently tested the effect that shoot size has on length and diameter of juvenile softwood sugar maple cuttings. Cuttings 35 to 55 cm long rooted better than either shorter or longer ones. Also, thick cuttings tended to root somewhat better than thin ones.

Our data support the general assumption that large cuttings root better than small ones. But we have observed tremendous tree-to-tree variability in response. Based on our results, cuttings from some trees (tree B) apparently root relatively well regardless of size (although long cuttings root somewhat better than short ones). For other trees (tree A), rooting response was very closely correlated with cutting size (none of the very short cuttings rooted); and for some trees (tree C) cuttings of all sizes rooted poorly. Tree differences were also apparent in the effect of relative shoot thickness within a particular length class. For tree A (the tree in which rooting response was closely correlated with shoot length) thick cuttings rooted significantly better than thin ones. For tree B (the tree that rooted relatively well regardless of shoot length), shoot thickness had no significant effect on rooting response.

Because of tremendous tree-to-tree variability in rooting response, we cannot meaningfully predict the response a propagator could expect by selecting cuttings of a particular size. Consideration of shoot size is certainly not a panacea for solving the problem of vegetatively propagating selected sugar maples. However, this tree-to-tree variability should not obscure the fact that a positive correlation tends to exist between cutting size and rooting response. Propagators attempting to reproduce this species vegetatively should take advantage of this relationship to increase their chances of success.

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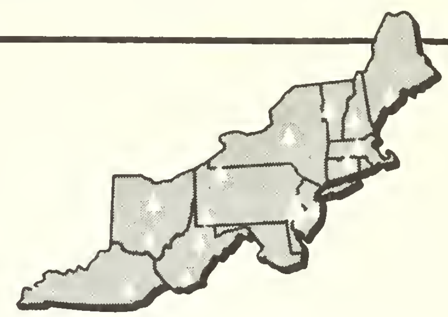

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LOCAL SOURCES OF BLACK WALNUT RECOMMENDED FOR PLANTING IN MARYLAND

Abstract.—After 5 years, local black walnut seedlings were taller than those of 12 out-of-state sources in a Maryland planting. Seedlings from south-of-local sources outgrew trees from northern sources. Genetic influence on height was expressed early—with little change in ranking of sources after the third year.

Black walnut (*Juglans nigra* L.) trees are being planted in many parts of Maryland and adjoining states. The question has been: what are the best seed sources for plantings in this area? Results of this study indicate that stock from local seed sources is best for planting in Maryland, and that, if local seed supplies are insufficient, seed should be obtained from areas south of Maryland.

Methods

Seedlings were raised in two different nurseries: those of the local Maryland source were raised in the nursery of the Maryland Forest Service; those of the other 12 sources were raised in the Union Tree Nursery in southern Illinois. For the seedlings of each source, seed was collected from about eight parent trees.

When planted in Maryland, the 1-0 seedlings from the Illinois nursery were about 18 inches tall (average height by stocks varied from 10 to 25 inches) and had strong taproots with few lateral roots. They were planted in auger holes (11 inches in diameter) on 15 April 1968. In contrast, seedlings from the Maryland nursery were about 11 inches tall and had many lateral roots; they were planted in holes dug with shovels on 16 April 1968.

For this study, 24 seedlings of each source were planted: a four-tree plot in each of six blocks. Sources were arranged randomly within blocks. Spacing of trees was 12 x 12 feet. Around most of the study area, an isolation strip was planted to black walnut seedlings from the Maryland nursery.

The planting is in a former field in the Gunpowder State Park (latitude 39°29′ N, longitude 76°25′ W) at an elevation of 220 feet. The site is about 10 feet above the nearby stream. Two floodplain soils occur in the area: Codorus (formerly Chewacla) and Hatboro (formerly Wehadkee) silt loams. Natural drainage of the Codorus is better than that of the Hatboro soil.

Before planting, the ground was prepared by rototilling in 6-foot strips. Weeds were controlled annually with atrazine, simazine, rototilling, and hoeing in various combinations.

The degree of weed control varied from fair during the first 2 years to excellent in the last 3 years.

Corrective pruning (Krajicek and Bey 1969), a technique for developing straight central stems, was performed annually. Only a small amount of pruning was done each year, except in 1971. Because of late frosts in 1968 and 1970, many stems had severe crooks in 1971. If a crook deviated more than 10 inches from the central stem axis, the tree was coppiced at 1 inch above ground. About 25 percent of the trees (by sources 9 to 38 percent) were coppiced in 1971.

Results

Survival was good for all sources throughout the 5-year period (table 1). Ninety-six percent of the trees were alive at the end of the third year. Then, heavy rains during the next 2 years and a clogged drainage ditch produced excess water on part of the site; and survival was reduced to 78 percent. After 5 years, survival by source ranged from 62 to 88 percent; and there was no apparent geographic trend.

After 5 years, trees from southern sources were generally taller than trees from northern sources (table 1). The correlation between 1972 height of all trees (including coppiced stems) and latitude of origin was significant. Fifty-eight percent of the height variation among sources was accounted for by latitude of source. In contrast, the effect of longitude on variation among sources was negligible.

Coppicing had little effect on average height and relative ranking among sources (table 1). As might be expected, sprouts grew so rapidly that in three of the sources with relatively short trees, average height of all trees (including coppiced stems) was the same or more than the average height of stems excluding sprouts.

The Maryland source trees, grown in a separate nursery, were next to the shortest at planting time. In the first 2 years, they advanced from 12th to 8th in ranking for total height, in the third year to 4th, and in the fourth year to 1st. Even though there were differences in nursery and methods of digging planting holes, their effect in favoring the Maryland source trees is questionable.

The steady advancement in rank of the locally grown stock from local seed apparently indicates that it is genetically better adapted to Maryland conditions than trees from out-of-state sources. Because Maryland trees were tallest after 5 years, use of local seed sources for plantings within the State is encouraged.

Table 1.—*Location, average height, and survival by seed source*

Source number	Location			Average height[1] at end of—			Survival in fifth year[2]
	State	Latitude; North	Longitude; West	First year	Third year	Fifth year	
		Degrees	*Degrees*	*Ft.*	*Ft.*	*Ft.*	*%*
—	Md.	[3]39°18′	[3]76-77°	1.1	4.6	[4]8.9 (9.4)	83
5,891	Va.	36°50′	78°45′	2.2	5.0	8.7 (9.1)	83
5,893	Ill.	37°50′	89°30′	1.9	5.2	8.5 (9.4)	88
5,872	Mo.	37°09′	93°49′	2.2	4.7	8.1 (8.3)	83
5,873	Mo.	37°37′	91°25′	1.3	4.3	8.0 (8.3)	67
5,876	W. Va.	37°56′	80°16′	1.7	4.3	7.9 (8.9)	75
5,868	Ohio	40°45′	81°55′	1.8	4.2	7.6 (7.8)	79
5,877	Mo.	39°45′	94°35′	1.9	4.2	7.5 (7.2)	88
5,875	Mich.	42°14′	85°14′	1.6	4.2	7.1 (7.4)	67
5,879	Mich.	42°33′	84°31′	1.2	3.9	7.1 (7.1)	67
5,966	Neb.	40°46′	95°48′	1.0	4.1	7.0 (7.0)	88
5,895	Pa.	40°52′	77°18′	1.4	3.9	6.5 (7.0)	62
5,896	Ohio	41°10′	80°45′	1.3	3.8	6.4 (6.9)	83

[1]Of living trees in year shown.
[2]Including coppiced trees.
[3]Estimated; actual values are unknown for the Maryland stock.
[4]Values in parentheses exclude coppiced trees. Differences greater than 1.6 (1.8) feet are statistically significant.

Source influence on relative height at 5 years was evident by age 3. Correlation coefficients for heights at age 5 versus ages 1, 2, 3, and 4 were 0.46, 0.66, 0.87, and 0.89 respectively. The Maryland source was included in this analysis. In such analysis, correlation values naturally increase as the period decreases. Even so, both the correlation analysis and the data (table 1) indicate that the tallest and shortest third of the sources at 5 years could have been selected with high reliability after two or three growing seasons in the field.

These early results suggest that if Maryland seed supplies are inadequate, the needed seed should be obtained in areas *south* of Maryland. The southernmost source in this test was at a distance of almost 200 miles. This and other tests indicate that winter hardiness is not usually a problem within a 200-mile zone. However, in case of variability in hardiness, we suggest that: (1) in the absence of enough local seed, obtain seed only from within a 200-mile zone; and (2) mix seed so that seedlings varying in winter hardiness or rate of growth are mixed in all lots. Sources of seed from north of the state, or appreciably north of the planting site, should be avoided.

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SOME EFFECTS OF FOREST PRESERVATION

Abstract.—Long-term preservation (no cutting) of a deciduous forest stand in New Hampshire is leading toward stable populations of beech, sugar maple, striped maple, mountain maple, and hobblebush, coupled with a decline or complete disappearance of other woody species. The humus has stabilized at a depth no greater than that of cut stands. Nitrate discharge in the streams is higher than what is normally found in uncut stands, possibly because of stability in standing crop and humus.

The acceleration in nutrient losses from a small watershed in New Hampshire that was devegetated and then chemically treated to prevent regrowth has been described by Bormann et al. *(1968)*. Pierce et al. *(1970)* suggested that such losses can degrade the soil so that tree growth will be impaired or that only nondemanding species will grow. Recent work *(Pierce et al. 1972)* indicates that a moderate acceleration in nutrient discharge occurs after normal clearcutting operations in forest stands in the mountains of New England.

Because of these results, as well as aesthetic and recreational considerations, the clearcutting of timber stands has become a national issue. Opponents of clearcutting demand some alternative method of managing timber stands in certain locations. Basically, only two other approaches exist: (1) partial cutting in one form or another, and (2) no cutting (forest preservation). Both alternatives are being proposed for certain areas. However, before any alternative is accepted, information should be obtained about long-term effects on vegetation, soil, and water.

Our way to gain an insight into the possible effects of a no-cutting policy is to examine the characteristics of the few remaining so-called virgin forests—forests that have followed natural successional trends because they have seldom, if ever, been heavily damaged by logging or natural catastrophe.

The Study

In the summer of 1972, I studied a portion of The Bowl, a 206-ha Research Natural Area in the White Mountains of New Hampshire. The Bowl lies about 17 miles (27 km) due east of the Hubbard Brook Experimental Forest. The study was limited to an 18-ha stand typed as typical beech-birch-maple. This stand, to our knowledge, has never been logged and thus has developed naturally for many decades. The aspect is east to northeast. Elevation ranges from about 580 to 640 m above sea level. The soil is Berkshire, a podzol, a well-drained fine sandy loam.

Eleven plot locations were established well within the stand borders. (Other plots, not reported on here, were established near the transition between hardwoods and spruce-fir at the upper elevations of the study area.) At each location, the species and the diameter above the root collar (above root swell) were recorded for all trees 100 mm and larger on a 1/10-ha plot, all woody stems 10 to 99 mm on a 1/100-ha plot, and all woody stems of 1-year-old and up to 9 mm on four 1/10,000-ha plots.

One stem per species on the smaller plots and two stems per species on the large plot were aged (above root collar) either by counting terminal bud scars in the field (small stems) or by ring-counting a section or increment boring in the laboratory. Ten humus-depth measurements (H layer, excluding L and F layers) were made per plot location, using a sharp tube sampler.

Water samples were taken every 2 weeks during the growing season for NO_3^- analysis by an Orion NO_3^- probe (operated by Wayne C. Martin at the Hubbard Brook Experimental Forest). Samples were taken in three small permanent brooks that drain through the study area. A few samples also were taken in the Wonalancet River, which drains both the Natural Area and the eastern portion of the geologic bowl, which contains nonvirgin forest.

For each species, a linear or second-degree regression of age over diameter was run. Standard errors of the mean for the major species were less than 8 years; R^2 values were about 0.8, except for a 0.5 for sugar maple. From these relationships, all measured trees were classified into 20-year age groups and all shrubs were classified into 5-year age groups.

Results and Discussion

Survival curves for tree species in New England follow a steeply descending (negative exponential) form (*Marquis 1967*, *Leak 1969*, and *Leak et al. 1969*); mortality of small or young stems is high. Only four tree species

Figure 1.—Number of trees/ha (common logarithms) over midpoints of age classes for species with stationary age distributions.

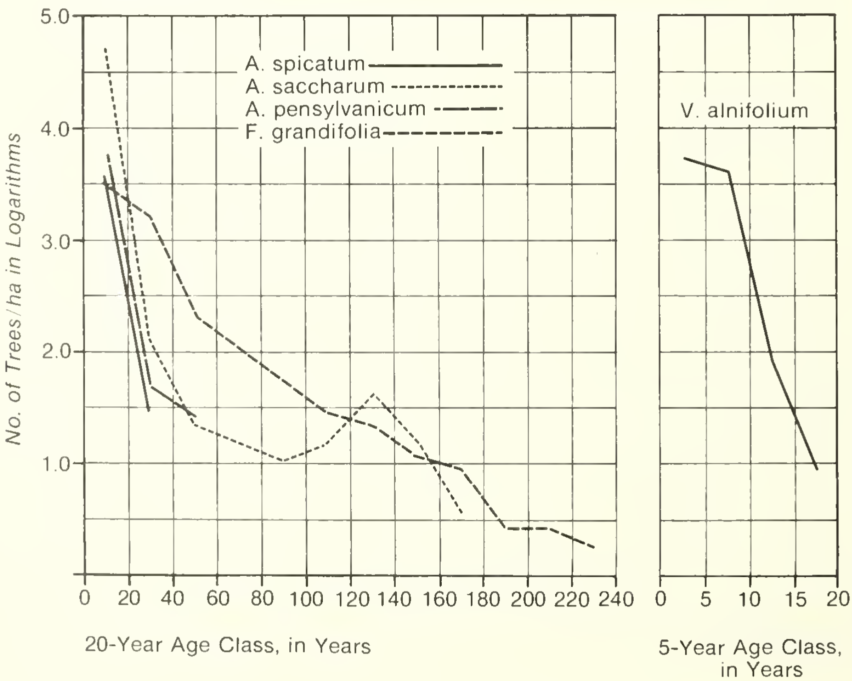
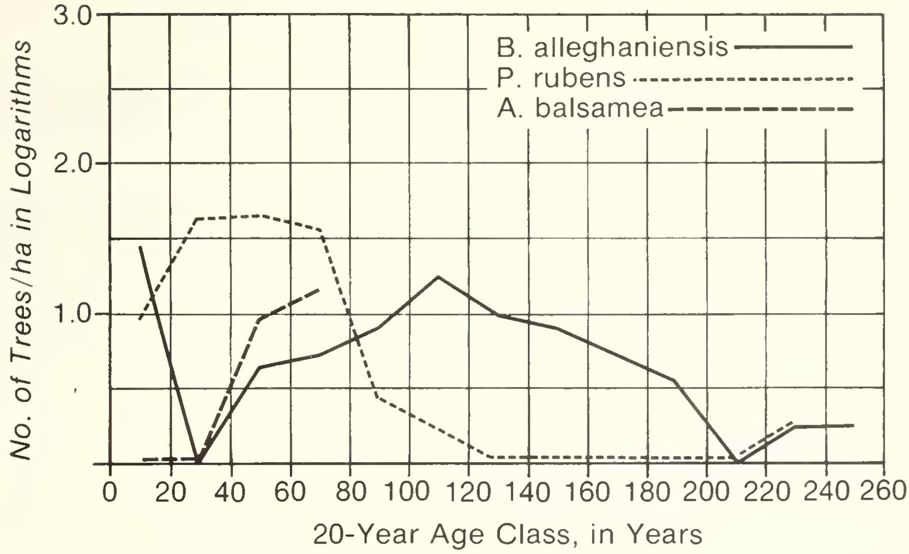


Figure 2.—Number of trees/ha (common logarithms) over midpoints of age classes for species with nonstationary (declining) distributions.



and one shrub found in The Bowl had the steeply descending age distributions characteristic of reasonably stationary populations: beech (*Fagus grandifolia* Ehrh.), sugar maple (*Acer saccharum* Marsh.), striped maple (*A. pensylvanicum* L.), mountain maple (*A. spicatum* Lam.), and hobblebush (*Viburnum alnifolium* Marsh.) (fig. 1). These species seem to be permanent and abundant residents of the study area.

Three species had somewhat bell-shaped age structures typical of declining populations: yellow birch (*Betula alleghaniensis* Britton), red spruce (*Picea rubens* Sarg.), and balsam fir (*Abies balsamea* (L.) Mill.) (fig. 2). Although these species—especially yellow birch —were abundant in certain age classes, the age structure indicates that all must decline appreciably in the future, unless regeneration rates markedly increase—an unlikely possibility.

Three tree species and one shrub were present in very limited numbers: red maple (*Acer rubrum* L.), one tree tallied on a plot near the transition between hardwoods and spruce-fir; eastern hemlock (*Tsuga canadensis* (L.) Carr.), an occasional large tree observed off the plots; pin cherry (*Prunus pensylvanica* L.), three to four trees along the trail at the upper edge of the study area, apparently the result of the 1938 hurricane; and red elder (*Sambucus pubens Michx.*), one stem tallied on a transition plot.

Two local tree species were not found: paper birch (*Betula papyrifera* Marsh.) and white ash (*Fraxinus americana* L.). Several white ash can be seen along the trail into The Bowl. Paper birch is very common in disturbed areas near the study area and at about the same elevation. A number of large dead paper birch were found in the spruce-fir zone just above the study area. Either these two species were prevented from entering the study area by the heavy stand of vegetation present, or—a more likely explanation —these species were present at some time in the past but could not survive because of their high requirement for sunlight.

Humus depths averaged between about 20 and 50 mm, depending upon the slope of the land (Humus depth (mm) $= 60.8 - .946 \times$ slope %). The maximum single measurement was 101 mm. The average depths are less than those reported for several cut stands on comparable well-drained soils on the Bartlett Experimental Forest, New Hampshire *(Hart 1961)*. Apparently, humus in The Bowl study area has reached its maximum depth.

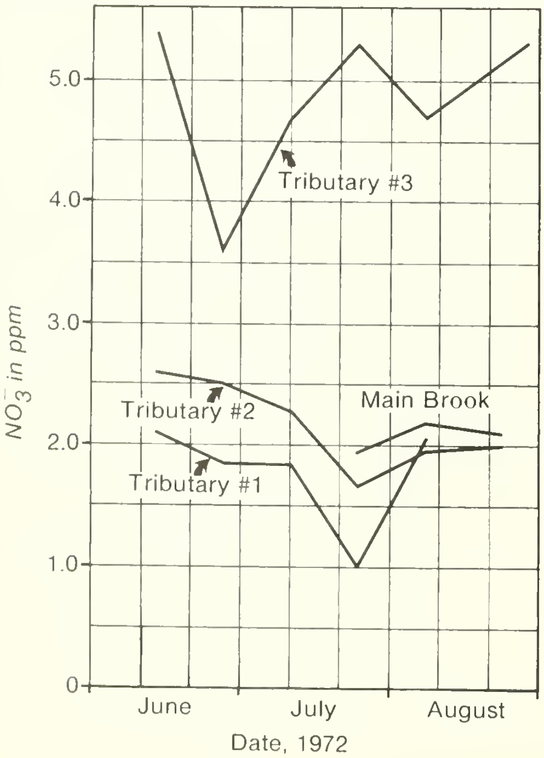
Conclusions

As in most virgin forests, it can be assumed that the standing crop remains about constant—the total biomass produced is offset by the large quantity that dies in the form of dead leaves, twigs, stems, and roots. Because the humus depth apparently is not increasing, I hypothesized that nutrient discharge into the stream must be higher in The Bowl stand than in younger stands that are either increasing in standing crop or humus depth. NO_3^- content in the water samples was high (fig. 3), between 1 and 5 ppm, depending upon sampling date and location.

Uncut controls at Hubbard Brook and elsewhere in the White Mountains usually produce less than 1 ppm of NO_3^- during the summer—often they produce only a trace *(Bormann et al. 1968)*. The highest discharge for an uncut sampling site that I know of is one (Dartmouth Outing Club), reported by Pierce et al. *(1972)*, which produced between 1 and 3 ppm during the summer; we do not know anything about stand and humus conditions on this site.

Preservation of beech-birch-maple stands leads toward a very restricted species composition that could work either for or against the use objective for the stand. It is well known that disturbance of such stands broadens the species composition to include both early- and late-successional species. Contrary to common belief, the humus, which is the major nutrient capital in podzol soils, is no deeper in the virgin beech-birch-maple study area than in disturbed stands. Stability in both humus and biomass may help explain the accelerated nitrate discharge observed in this virgin stand as compared to younger, more vigorous stands. This aspect of nutrient budgeting should be examined in depth by those with the necessary facilities.

Figure 3.—NO_3^- (ppm) in three tributaries and the main stream of The Bowl during the 1972 growing season.



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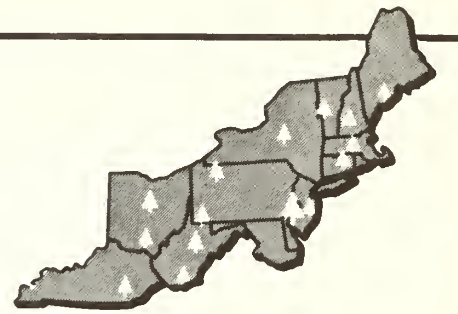

FOREST SERVICE, U.S. DEPT. OF AGRICULTURE, 6816 MARKET STREET, UPPER DARBY, PA. 19082

A HANDY GUIDE TO RATE OF INCREASE INTERPRETATIONS

Abstract. Compound interest tables are reduced to a single 3x5 card for field use. Examples are given to illustrate the table's use.

Introduction

How many years will it take a stand's volume to triple if its volume growth rate is 3 percent? If you said 37 years you're right. Probably you would have to look in a compound interest table for 3 percent, search out a $(1+p)^n$ value of 3 and read off the number of years.

What would you expect a stand to be worth in 10 years if it's worth $100 now and grows at a rate of 4 percent per year, and if stumpage values increase at 3 percent per year? If you responded $200, you're right. Probably you would have to look in a compound interest table for 10 years and 7 (3+4) percent to discover that V_o (beginning value) would be multiplied by $(1+p)^n$ of 2 yielding V_n (ending value) of $200.

If you want to be able to give on the spot answers to questions like this quickly and easily then the table that follows is for you. In 1911, Howard Krinbill[1] constructed a table to answer just such questions. Here his table has been modernized; minor inconsistencies have been ironed out, limits for the table's use have been determined and it has been put on a small card which can be carried in your pocket.

How the Guide was Constructed

Compound interest relationships are expressed in a formula

$$V_n/V_o = (1+p)^n$$

[1]Krinbill, Howard R. 1911. Biltmore Timber Tables. 13 pp. Biltmore Forest School.

where V_n = Quantity or value at year n

V_o = Quantity or value at year o, the beginning of the period

p = Compound interest rate

n = The number of years in the period

Compound interest tables display the value V_n/V_o for different combinations of p and n. A given V_n/V_o ratio may be produced by many combinations of p and n. The product pxn is always the same for a given V_n/V_o ratio and it is this product that is called a compound interest factor.

For example, if we had a value for V_o of $150 and a value for V_n of $300 then the ratio V_n/V_o = 2.0. Other combinations of p and n may also produce this ratio but pxn (compound interest factor) is always the same.

V_n/V_o *ratio*	*p*	*n*	*pxn*
2.0	1	70	70
2.0	2	35	70
2.0	5	14	70
2.0	7	10	70
2.0	10	7	70

These principles are used to formulate the table of compound interest factors on the attached card.

The numbers down the left side and across the top are units and tenths of the V_n/V_o ratio: the ratio of the final value to the initial value of the quantity in which the user is interested. For example, a tree containing 100 fbm grows to 260 fbm in a period of n years. The ratio is $V_n/V_o = \frac{260}{100} = 2.6$. Reading across from 2 on the left side and down from 0.6 at the top, we would find a value of 96 at the intersection. The table value is the product of p, (the rate of increase) times n (the number of years). To determine p we divide the table value by n. To find n we divide the table value by p. If our example tree had shown this increase in 30 years the rate of increase would be 96/30 = 3.2 percent. If, on the other hand, a tree of this character would be expected to increase in volume at a rate of 4 percent, then we would expect to achieve an increase of 2.6 times or 260 fbm in 96/4 or 24 years.

How to Use the Guide to Solve Some Typical Problems

Nature of Problem	*Given*	*Wanted*	*Solution*
1. Estimate the rate of value increase of a stand worth $100 ten years ago which is now worth $150 (Other quantities such as volume or basal area could be used.)	V_o = $100 V_n = $150 n = 10	p	Find the factor for $\frac{150}{100} = 1.5$ in the table (ans. 41). Divide 41/10 = 4.1 percent rate of value increase.
2. If a stand measure (e.g. volume) increases at the rate of 3 percent, how long will it take for this measure to double?	p = 3 percent $\frac{V_n}{V_o} = 2.0$	n	Find the factor $\frac{V_n}{V_o} = 2$ (ans. 70). Divide 70/3 percent = 23 years.
3. If a timbered tract has a land value of $100 which is expected to increase at 7 percent per year and has $75 of standing timber expected to increase at 4.7 percent per year (a) what is the estimated value of the whole investment in 10 years and (b) what rate is earned on the total investment?	V_{o1} = $100 V_{o2} = $ 75 p_1 = 7.0 percent p_2 = 4.7 percent n = 10	a) V_{n3} (the end of period value for V_{o1} and V_{o2} combined. b) p_3 (the rate of interest earned by the combined land and timber investment).	7 percent x 10 years = 70, a factor for $V_{n1}/V_{o1} = 2$ ∴ value of land. V_{n1} = 2 x $100 = $200. 4.7 percent x 10 years = 47, a factor for $V_{n2}/V_{o2} = 1.6$ ∴ value of timber V_{n2} = 1.6 x $75 = $120. a) value V_{n3} = $200 + $120 = $320. b) rate of total investment p_3. Determine $\frac{V_{n3}}{V_{o3}} = \frac{320}{175} = 1.8$. Look up factor (ans. 59). Divide by 10 and p_3 = 5.9 percent.

Accuracy

The table has some accuracy limitations with which the user should be acquainted. It must be recognized that this estimating table is the result of considerable rounding off so answers obtained by using it lack precision. Tests of the table reveal that estimates of n (number of years) are correct within 1 year. An answer of 47 years then may be as high as 48 or as low as 46 years. Answers in terms of p are not uniformly precise. Their limits are shown below.

If answer is between	*It may be off as much as*
0—5%	0.1%
6—10%	0.5%
10—15%	1.0%
15—20%	2.0%
20% and over	4.0%

Since most answers in the forestry field are in the 0 to 10 percent bracket these limitations are not considered serious. The accuracy of V_o and V_n determinations can be estimated by rerunning the usual procedure to estimate the limits. For example, to estimate the range of V_n at a p of 25 percent, we would estimate for 25 percent plus and minus 4 percent, or 21 percent and 29 percent. This would give the possible range of V_n values.

Extrapolation

This is a factoring type table so the user is not limited to the V_n/V_o ratios shown. He can extend these data by using V_n/V_o multiples and adding the factors. For example: What is the factor for a V_n/V_o ratio of 20? V_n/V_o ratios of 2 and 10 equal 20 when multiplied and their factors add up to the factor for 20.

Ratios: V_n/V_o of 10 x V_n/V_o of 2 = 20

Factors: for 10 = 234
+ for 2 = 70
for 20 = 304

Had we factored 20 using 4x5 for the ratios our factor for 20 would have been 139 + 163 = 302. The differences are due to rounding off as mentioned earlier. The accuracy limits given earlier still hold for these extrapolated values.

Conclusions

If you take a couple of hours to become familiar with this table, you can estimate rate relationships with incredible speed and understanding. But resist the temptation to solve the complex compound interest problems that are theoretically possible with this table. Rounding off errors will propagate in complex situations and give you misleading answers.

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Compound interest factors (pxn) for given rates of increase (V_n/V_o)

Rate of increase	Tenths									
	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
Units										
1		10	19	26	34	41	47	53	59	65
2	70	75	79	84	88	92	96	100	104	107
3	110	114	117	120	123	126	129	131	135	137
4	139	142	144	147	149	152	154	157	159	161
5	163	165	168	170	172	174	176	178	179	180
6	182	183	185	186	187	189	191	193	195	197
7	199	200	202	203	205	206	207	208	209	210
8	211	213	214	215	216	217	218	219	220	221
9	222	223	224	226	227	228	229	231	232	233
10	234									

Conceived by Howard R. Krinbill, 1911; modernized by David P. Worley, 1974.

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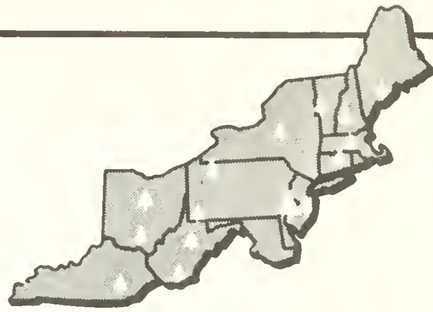


FOREST SERVICE, U.S. DEPT. OF AGRICULTURE, 6816 MARKET STREET, UPPER DARBY, PA. 19082

A GUIDE TO COLLECTING AND PRESERVING PLANTS

Abstract—In this paper, we discuss how to collect and preserve plant specimens. Plant pressing, mounting, and labeling techniques are also outlined.

This is a guide to collecting and preserving plant specimens. Specific information is presented to assist forest botanists and others who want to know "how to do it." This guide covers three major areas: (1) collecting plant specimens, (2) pressing and drying plant specimens, and (3) mounting and preserving plant specimens. General techniques are discussed in each area, and illustrations are used to clarify specific points.

COLLECTING PLANT SPECIMENS

When collecting plants, get all plant parts in as many stages of development as possible. Buds, leaves, flower parts and fruits will aid in identification. If a plant has a unique characteristic that distinguishes it from other species of the same genus, be certain to include this feature with the collected specimen.

Field Materials

A good plant identification manual is essential. Manuals such as those by Matthews (*1927*), Gray (*1950*), Cobb (*1956*), Petrides (*1958*), Peterson and McKenny (*1968*), and Seymour (*1969*) are available for given locales. For information as to what source reference to use in a particular area, contact the botany department of a nearby college or university.

In addition to having a plant identification manual, it is highly desirable to have certain basic tools and materials for collecting plants in the field (fig. 1). These include the following: field notebook, 100-foot tape, compass, topographic map, pencil, hand lens (10X), geologist's hammer, screwdriver, pruning shears—small knife, plant press, plastic collection bags or vasculum; and camera.

Figure 1.—Some essential tools for collecting and pressing plant specimens.

DOCUMENTING PLANT COLLECTION DATA

A general description of the area in which a plant is collected provides valuable information on the plant's habitat. Record this information in the field at the time the collection is made.

When making entries in the field notebook, include the information outlined below:

1. Species name, scientific and common. (If a plant identification is not possible in the field, then code the information recorded for the collected specimen so that the data can be related to the plant after it has been identified.)
2. Date of collection
3. Name of collector
4. Specific location where collected
5. Average plant size
6. Other distinguishable characteristics, such as color and fragrance of fruit and flowers
7. Soil characteristics including soil type, soil texture, drainage, slope aspect, site exposure. Use a soil map (Soil Conservation Service) to acquire this information.
8. Associated plant species
9. Additional environmental or plant descriptive information that may be pertinent to a particular plant specimen

Make a sketch of the plant's location, using permanent points for references, and put it in the field notebook. This will assist you in returning to the area. In certain instances, a photograph of the plant growing in its habitat may be of interest and could be attached to the herbarium mounting sheet.

REMOVING PLANT SPECIMENS FROM THE SOIL

A plant specimen must be removed from the soil carefully. Try to remove all the roots and upper stems without disfiguring the plant. A small geologist's hammer, a pick, or a long screwdriver can be used. Once the specimen has been uprooted, remove all foreign matter from the plant by washing, shaking, and, in certain instances, using hand pruning shears to remove dead plant parts.

After the plant has been removed from the soil and cleaned, place it in a portable press. If a press is not used in the field, then place the plant in a sealed plastic bag or a vasculum. When the plant is temporarily stored in this manner, place wet moss around it to prevent or minimize wilting.

Be aware that in most states a collector must have permission from the landowner to remove plant specimens. Respect the rights of the owner, and ask before removing any plants.

PRESSING AND PRESERVING SPECIMENS

Pressing

After the plant specimens have been collected, press them. Some collectors use portable presses similar to the one shown in figure 1. They place specimens in the presses while they are out in the field. This practice prevents wilting and insures preservation of the plant's shape and color. Most presses consist of a series of ventilator sheets (corrugated material) to absorb moisture and to allow air to circulate between the layers of plant material. As it may be difficult to carry ventilators to the field when collecting, specimens can be pressed between newspapers in the field. However, the specimens will become discolored or spoil if ventilators are not inserted between them within 12 hours after collection.

To press, first place the specimen inside a pressing sheet—a standard sheet of newspaper that is folded in half. Using a small pencil or wire, arrange the plant so that all the leaves, stems, roots, and the other plant parts are not needlessly folded or bent to give a misleading or unnatural appearance. Then insert the pressing sheet containing the specimen between two blotters. If the specimens are small and have thin leaves that retain little moisture, three to five pressing sheets can be placed between two blotters. However, for the best results, place blotters and ventilators between each pressed specimen and the next. When pressing thick-stemmed woody plants (larger than ¼-inch in diameter), use a polyurethane foam mat as illustrated in figure 2.

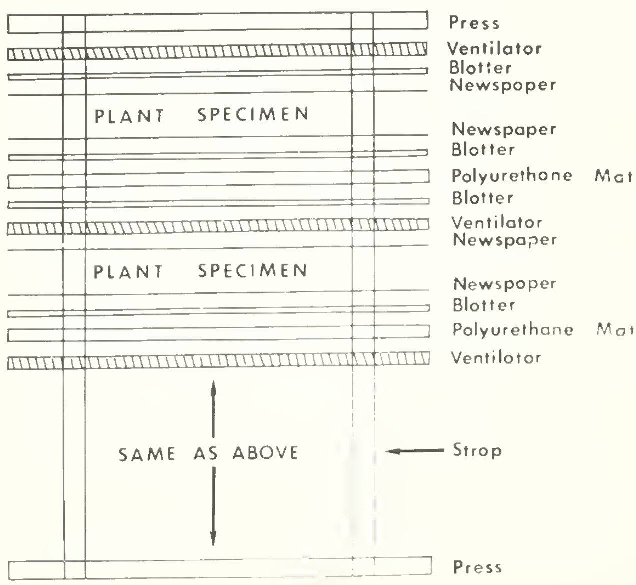
A specimen identification card can also be attached inside the pressing sheet using information from the field notebook. However, because the cards are often misplaced during plant pressing, some collectors prefer to write a number on the newspaper and put the complete information in the field notebook.

Next, place the press in an oven at a temperature of 120°F, until the spceimens are dry. Plants usually dry in 24 to 72 hours, but larger woody or thick-stemmed plants may take longer. Generally, a plant's natural colors are better preserved with fast drying than they are with slow drying. Also, for the best results, change the blotters daily.

When a portable field press is used, recheck the plants for proper arrangement and identification before placing the press into the drying oven.

For those interested in collecting and preserving small water plants such as algae, float the plant on rice paper and then put into a newspaper to dry. Then attach the rice paper and plant to a mounting sheet. Sass (*1958*)

Figure 2.—An illustration of a cross-sectional view of a plant press.



gives further details on mounting and preserving such small plant materials.

Other plant parts such as nuts, cones, seeds, etc., which are not normally pressed, can be placed in a box or plastic bag with an identification tag. After drying, these plant parts can be attached to the mounting sheet along with the plant.

FUMIGATION

Fumigate plants to kill all living organisms that could damage the specimens. Do this after the specimens have been dried. Place the pressing sheets containing the specimens in a fumigation box (fig. 3), which is slightly larger than the pressing sheets. Several specimens can be fumigated at one time, depending on plant thickness. Cover the bottom of the fumigation box with fumigant and sprinkle the fumigant on the outside upper surface of the paper for each specimen. Place an open dish with the fumigant material on top.

Close the fumigation box and make it airtight by using masking tape. Leave the specimens in the box for 7 days. Then remove the specimens from the fumigation box, and mount them permanently. Insert them in a genus cover folder and store them in a permanent steel or wooden cabinet. Several commonly used fumigants are paradichlorobenzene, carboxide, or mystax. Fumigation should be done in a well-ventilated room. Manufacturer's recommendations for fumigants vary; read directions carefully.

Figure 3.—A mounted sugar maple specimen being fumigated.

MOUNTING SPECIMENS

Mounting Procedure

After pressing, drying, and fumigating, the specimens are ready for mounting. The following procedure has been used with excellent results: Brush the surface of a plastic or glass plate (20″ × 15″ × ¼″) with an adhesive. Then remove the specimen from the pressing sheet with forceps and place it on the plate. Use the tips of the forceps to carefully press the plant into the adhesive. After the undersurface of the plant has been coated with the adhesive, lift the specimen and transfer it to a permanent mounting sheet. It is desirable *not* to place the thickest part of the plant in the center of the mounting paper because a bulge will develop when you place several mounted specimens in a stack. After mounting, allow the specimens to dry for 48 to 72 hours.

A very thick stem or woody plant will need additional bonding to hold it on the mounting sheet. Plastic adhesive applied from a tube or a squirt oilcan to form a ribbon across the thick parts of stems, seeds, or flowers has proven very satisfactory.

The stickiness of the adhesive is very important. In a dry atmosphere, the adhesive may tend to become thick. If it is too thick, the specimen will be difficult to transfer; and if it is too thin, the specimen will not adhere properly to the mounting sheet.

To be certain that the specimen sticks to the mounting sheet, place a piece of wax paper on top of the mounted specimen. Then put a sheet of polyurethane foam over the wax paper and add weights. A board is often used, and weights are placed on top of the board. You can put about four mounted specimens, separated by wax paper, into a stack before using a sheet of polyurethane material.

The importance of a well-mounted herbarium specimen cannot be overemphasized. Additional information on collecting, identifying, pressing, and mounting techniques is presented by Lawrence (*1955*), and Smith (*1971*).

IDENTIFICATION LABELS

Another step in the mounting process is to make an identification label for each specimen. Normally, a gummed label about $3\frac{1}{2} \times 2\frac{1}{2}$ inches or a 3×5 card is placed in the lower right-hand corner of the mounting sheet. It should include the following typed information:

1. Scientific name
2. Common name
3. Precise location where collected
4. Associate plants
5. Soil characteristics
6. Date of collection
7. Authority identifying specimen
8. Name of collector
9. Name and address of herbarium (if plant used for herbarium purposes)

If 3×5 cards are to be used, attaching them to the mounting sheet can be a prolem. Normally, glue is applied to the card with a brush; but if it is applied to the entire underside of the card, the glue may cause the card to curl. To prevent curling, apply glue only along the card margins.

OTHER INFORMATION

If you cannot identify a plant specimen, contact a local university or college botany department, private herbarium, or the U.S. Forest Service Herbarium, USDA, Washington, D.C. Often the complete specimen and all available data will have to be presented or sent in an uncrushable container to the identifier. In some instances, plant collectors have been able to identify specimens from photographs of mounted plants (fig. 4), and these photographs can be sent in place of the actual specimen. In many cases, a picture of the plant in its natural habitat will be sufficient for identification; and only a minimum number of plants need to be collected. Thus living plants can be preserved for future use.

Figure 4.—A mounted plant specimen that can be identified from the photograph.

Occasionally, data from collected plants are used in electronic data processing machines (*Beschel and Soper 1972*). This electronic processing is particularly useful in larger herbariums.

For those desiring to preserve the color and shape of the plants in a three-dimensional effect, plastics can be very useful. A specimen can be mounted between plastic sheets, or it can be embedded in a plastic mold or casting, giving a very lifelike portrayal of the plant (*Specht 1950*).

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ROOTING COMMON AND CAT GREENBRIER

Abstract.—Because reliable methods for propagating greenbriers are needed for wildlife-habitat purposes, we tested stem and rhizome cuttings of common and cat greenbrier and tubers of the latter species. Common greenbrier is the better species for most wildlife habitat uses. It proved fairly easy to propagate from either stem or rhizome cuttings. Similar cuttings from cat greenbrier failed, but tubers rooted well and can be collected at moderate cost. We comment on the kinds of cuttings to collect, when to collect them, nursery procedures, and relative costs.

Common and cat greenbrier (*Smilax rotundifolia* L. and S. *glauca* Walt.) are among the native vines most valuable for wildlife in much of the southern and eastern United States. Greenbriers provide food and cover for grouse, turkey, pheasant, quail, wood duck, rabbit, deer, bear, opposum, raccoon, gray fox, and many songbirds (*Bailey and Rinell 1968, Blair 1936, Gilfillan and Bezdek 1944, Goodrum 1961, McAtee 1936, Martin et al. 1951, Nelson et al. 1938*). Greenbriers are highly nutritious; they produce fruit nearly every year, and the fruit often hangs on the vine until spring. Because greenbriers are aggressive and adapt well to poor sites, they could be grown on sites such as strip-mine spoils, cut banks, and old fields to improve wildlife habitat.

Little propagation research has been conducted. Sheat (*1953*) recommended lifting and dividing stock plants in the spring. Goodrum (*1961*) and Everett (*1967*) stated that greenbriers can be grown by division of the rhizomes in spring, but that canes may not appear until the second year after planting. Halls and Alcaniz (*1965*) tested stem cuttings under mist in a greenhouse and obtained 55 percent rooting from common greenbrier and 1 percent from cat greenbrier, after 13 weeks.

Materials and Methods

Greenbrier cuttings were collected at several locations near Morgantown, West Virginia. To compare differences among growth stages, stems of both species were collected in April (dormant), June (fast growth), and September (hardened off). In May and October, rhizomes of both species and tubers of cat greenbrier were collected—common greenbrier does not produce tubers. All samples were from vigorous plants growing in full or nearly-full sunlight.

To diversify the samples, only one or two stems or rhizomes were taken from a plant; and only one to three cuttings were made from a stem or rhizome. Because greenbriers root mostly at the nodes, each cutting was made long enough to include three to five healthy nodes, each with a live bud. Lengths ranged from 2.5 to 13 inches; and many were longer than was necessary.

Stem cuttings were of two kinds, which we called juvenile and mature. Juvenile cuttings were taken from main stems only and were of the preceding year's growth (April) or current growth (June and September). Mature cuttings were taken from older growth on a main stem or from any portion of a lateral stem.

Rhizome cuttings were taken from all parts of the rhizomes except from the distal ends. These cuttings were of two kinds: without and with sprouts. Sprouts were pruned back, if necessary, so that each one had only three to five nodes. Few of the rhizomes with sprouts had more than one sprout.

Each collection was mixed; and samples of 25 stem cuttings, 20 rhizome cuttings, and 20 tubers were drawn. All leaves but one or two were removed from each stem cutting or sprout. Each sample then was used as 1 of 4 replicates among 49 treatments.

For the stem cuttings, all 20 treatments of common greenbrier are shown in table 2. Indolebutyric acid (IBA) mixed in talc was applied to bases of the stem cuttings, except for two samples collected in September. The 18 treatments of cat greenbrier were practically the same, but none worked. The 11 treatments of rhizomes of both species and tubers of cat greenbrier are shown in table 3.

Planting depth for all cuttings was about 2 inches. Stem cuttings were planted upright, with one to three nodes below the surface of the medium. Rhizomes were planted horizontally, and all nodes (three to five) were within the medium. In rhizomes with sprouts, nearly all the upright sprouts had at least one node within the medium.

The rooting medium was sphagnum peat and perlite 1:1, plus a complete fertilizer at the rate of 22 ounces per 1/10 cubic yard. (Dolomitic limestone 16 oz., 46 percent superphosphate 1.5 oz., Ca $(NO_3)_2$ 2.5 oz., $MgSO_4$ 1.5 oz., iron chelate 1 tablespoon, and fritted trace elements 1 tablespoon.) Because this fertilizer leached quickly, we later added a slow-release feritlizer that lasted 3 to 4 months (Osmocote 14-14-14 at 8 pounds/100 square feet.) (Mention of a brand name is given for identification only and is not to be considered as an endorsement by the USDA Forest Service.) Our reason for fertilizing was to simulate treatment of the cuttings as if they were part of a hydroseeding mix.

Table 1.—Costs of greenbrier propagation treatments

Cutting	Month collected	Labor for collecting and planting		Greenhouse equipment, supplies, operation	Total per treatment
		Hours	*Dollars*	*Dollars*	*Dollars*
	COMMON GREENBRIER				
Stem[1]	Apr	4.7	7.08	20.21	27.29
Stem[1]	Jun	5.1	7.71	21.65	29.36
Stem, juvenile	Sep	5.3	7.96	25.49	33.45
Stem, mature	Sep	5.8	8.71	25.49	34.20
Rhizome[1]	May	5.6	8.46	20.53	28.99
Rhizome w/sprout	Oct	9.4	14.08	25.81	39.89
Rhizome w/o sprout	Oct	6.9	10.33	25.81	36.14
	CAT GREENBRIER				
Rhizome[1]	May	8.9	13.32	20.53	33.85
Rhizome w/sprout	Oct	10.9	16.32	25.81	42.13
Rhizome w/o sprout	Oct	7.4	11.08	25.81	36.89
Tuber	May	8.9	13.32	20.53	33.85
Tuber	Oct	5.4	8.08	25.81	33.89
Tuber, stored 41°F	Oct	5.4	8.08	22.74	30.82

[1]Two kinds were collected, but their costs were not recorded separately.

Table 2.—Common greenbrier stem cuttings (100 per treatment) after 6 months under mist in a greenhouse

Cutting[1]	IBA concentration in talc	Alive	Rooted	Sprouted: Within medium	Sprouted: Above medium	Rootlets/ rooted cutting
	Pct.	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Ave. No.*
Dormant (April): Stem, juvenile	0.1	76	56	54	0	82
	.3	92	60	57	3	92
	.8	95	67	66	4	59
Stem, mature	.1	88	59	54	2	59
	.3	89	64	59	3	66
	.8	80	72	71	2	74
All stems	—	87	63	60	2	—
Growing (June): Stem, juvenile	0.1	4	4	3	0	—
	.3	2	2	1	0	—
	.8	6	6	4	0	—
Stem, mature	.1	1	1	1	0	—
	.3	1	1	0	0	—
	.8	2	2	1	0	—
All stems	—	3	3	2	0	—
Hardened (Sep): Stem, juvenile	0.0	36	22	12	0	10
	.1	80	65	49	1	13
	.3	54	38	28	0	9
	.8	56	46	25	0	9
Stem, mature	.0	71	54	30	0	12
	.1	66	45	35	0	7
	.3	60	52	25	0	12
	.8	68	59	33	0	6
All stems	—	61	48	30	0	—

[1]Juvenile cuttings were from main stems only and from the preceding year's growth in April cuttings or current-season growth in June and September cuttings. Mature cuttings were from older growth on main stems or from any portion of lateral stems.

Table 3.—Greenbrier rhizomes and tubers (80 per treatment) after 6 months under mist in a greenhouse

Cutting	Month collected	Alive	Rooted	Sprouted: Within medium	Sprouted: Above medium	Rootlets per rooted cutting
		Pct.	*Pct.*	*Pct.*	*Pct.*	*Ave. No.*
COMMON GREENBRIER						
Rhizome w/sprout	May	75	74	62	51	146
	Oct	95	86	55	1	39
Rhizome w/o sprout	May	44	40	44	0	52
	Oct	88	42	65	0	9
CAT GREENBRIER						
Rhizome w/sprout	May	34	31	24	4	245
	Oct	51	26	6	0	10
Rhizome w/o sprout	May	15	15	12	0	142
	Oct	71	12	39	0	2
Tuber, fresh	May	99	69	68	0	238
	Oct	100	50	61	0	21
Tuber, stored[1]	Oct	90	30	35	18	249

[1]Stored for 3 months at 41°F before planting.

Cuttings and tubers were planted in flats; and the flats were kept in a small gothic-type greenhouse similar to the one developed by Marshall et al. (*1966*). The highest daytime temperatures were 70 to 95°F, and the nighttime lows were 60 to 65°F. From 7 a.m. to 9 p.m. the flats were kept moist by automatic, intermittent mist sprayed for 6 seconds at 6-minute intervals.

After 6 months in the greenhouse, cuttings and tubers were examined for survival, rooting, number and length of roots, rootlets, sprouts, and number of new tubers.

Work time and other costs were recorded or estimated for each set of activities so that efficiencies of the treatments could be compared. The following expenses were prorated among treatments: labor $1.50/hour, flats $27.90, mist system $90.40, refrigeration $0.15/month, greenhouse cost $1.32/square foot/year (*Bartok 1971*), greenhouse operation $0.06 to $0.10/square foot/week (*Ball 1972*), and miscellaneous equipment and supplies $55.58. From these amounts, we estimated the relative costs per treatment (table 1). Our costs were higher than they would be in larger-scale production, but differences among them are repesentative of the different treatments.

Results

Common greenbrier responded better than cat greenbrier to each treatment applied to both species. This species difference confirms findings by Halls and Alcaniz (*1965*) and holds for seed germination as well. Cat greenbrier seems better adapted to propagation from tubers, which common greenbrier lacks, than from any of the other vegetative or seed methods.

Common Greenbrier.—Among stem cuttings, those collected in April from dormant stems and rolled in an 0.8-percent IBA mixture (talc) did best. About 70 percent of them rooted, and nearly all rooting took place at the base of a sprout that formed within the rooting medium. The number of rootlets per rooted cutting was also substantially higher in April-collected cuttings than in the others; but the relationship, if any, between rootlet numbers and IBA concentration was not clear. Also, there was no clear difference between juvenile and mature stem cuttings (table 2).

Almost all the stems collected in June died. The September stems did fairly well—38 to 65 percent rooting among cuttings treated with IBA. But rooting locations, number of rootlets, and propagation costs were all less favorable than those for the April collections (tables 1 and 2).

In the rhizome cuttings, those with sprouts had about double the rooting percentage and a propagation cost that was 15 percent higher than that of rhizomes without sprouts. The extra cost (table 1) was well justified. The season of collection was less important than the presence of sprouts, but the rhizomes-with-sprouts collected in May were the best overall. Their rooting percentage (74) was lower than that of the October collection, but the May collection produced 3.7 times more rootlets per rooted cutting than the October collection (table 3).

Cat Greenbrier.—None of the stem cuttings rooted well enough to be of practical interest: 95 percent of the cuttings died within 6 months, and no treatment gave more than 10 percent rooting.

The rhizomes rooted better than the stems, and rhizomes-with-sprouts collected in May were the most promising—31 percent rooted. Similar rhizomes collected in October showed about the same rooting, 26 percent, but had substantially fewer rootlets per cutting. As in common greenbrier, the rhizomes with sprouts cost more to collect but produced rooted cuttings much more economically than did rhizomes without sprouts (tables 1 and 3).

Tubers collected in May rooted best—69 percent—and the rooting was vigorous. Tubers collected in September and planted while fresh all survived and half of them rooted, but they produced few rootlets. Cold storing the fall-collected tubers for 3 months before planting apparently restored rooting vigor to about the same level as in the May collection, but reduced the rooting percentage. Clearly, the May-collection tubers were the most economical of all cat greenbrier propagation sources (tables 1 and 3).

Discussion

Our results favor common greenbrier over cat greenbrier and suggest at least three options in propagating both species: (1) start in the greenhouse in spring, (2) in the greenhouse in fall, or (3) outdoors in the spring.

1. High rooting percentages and vigor favor starting in the greenhouse in spring using either:

- Common greenbrier rhizomes-with-sprouts collected in May.
- Common greenbrier stems collected in April.
- Cat greenbrier tubers collected in May.

The disadvantage in a spring start is that the stock should be held in the greenhouse nearly a full year before transplanting.

2. Fall-started cuttings probably can be transplanted in the following spring, particularly if they are hardened-off before transplanting. We did not test this thoroughly, but it was successful in a few trials that did not include a hardening-off period before planting. Although this option requires less time in the greenhouse, it would require more stock and bench space. Rooting percentages and vigor were generally lower in our fall-collected cuttings than in our spring collections.

3. Starting the cuttings outdoors in the spring may be more effective than a start in the greenhouse in the fall. We did not test this alternative, but the spring-collected cuttings and tubers seem adaptable to rooting outdoors if they are adequately watered and protected from heat. This option may allow more flexibility in selecting the outplanting time, and rooting percentages over the course of a full year might be higher than those we observed at 6 months after planting.

Because stem cuttings from the youngest growth rooted about the same as those from older growth, many cuttings can be taken from a single stem. Similarly, one rhizome can provide many cuttings. Length of a cutting should be about 6 inches or less as needed to include at least three nodes with live buds. Because greenbriers root mainly at nodes that are underground, planting should be done so that one to three nodes on stem cuttings, and three or more nodes on rhizomes, are buried in the rooting medium.

For those parts of rhizome sprouts that will stand above the medium, we suggest retaining enough to bear two leaves but clipping beyond those leaves. This will remove upper nodes that might form lateral sprouts and contribute to excessive transpiration, even under intermittent mist (*Edward S. Elliott, personal communication*).

Among stem cuttings collected in April, rooting percentages increased as IBA concentration increased from 0.1 to 0.8 percent. The September collection showed a similar pattern except in one sample that seemed aberrant—juvenile stems at 0.1 percent IBA (table 2). This indicated that the optimum concentration was at least 0.8 percent and that higher concentrations should be tried. Auxin at higher concentrations may retard shoot development (*Hartmann and Kester 1968*) and benefit root formation through maintaining carbohydrate reserves in the cuttings.

Other variables that we have not tested but that seem promising are: selection of cuttings from greenbrier clones that root easily (*James L. McConnell, personal communication*); layering in the field (*Hoy C. Grigsby and Robert C. Hare, personal communications*); and use of slat-bottom beds and bottom heat (78 to 80 F) in the greenhouse (*Grigsby, personal communication*).

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FOREST SERVICE, U.S. DEPT. OF AGRICULTURE, 6816 MARKET STREET, UPPER DARBY, PA. 19082

LABORATORY ASSAY OF CACODYLIC ACID AND ®META-SYSTOX-R[1, 2] ON SCOLYTUS MULTISTRIATUS AND PSEUDOPITYOPHTHORUS SP.[3]

Abstract. Cacodylic acid and Meta-Systox-R were applied to oak and elm bark beetle diets. Diets containing 900 to 1,000 ppm of cacodylic acid and diets containing 100 to 200 ppm of Meta-Systox-R killed both oak and elm bark beetles.

One problem still confronting investigators of oak wilt and Dutch elm disease is to control overland spread of the causal fungi. Control depends mostly on suppressing populations of the European elm bark beetle, *Scolytus multistriatus* (Marsham), and oak bark beetles, *Pseudopityophthorus* sp., vectors of the pathogens.

A herbicide, cacodylic acid (Silvisar 510®),[4] has shown promise as a systematic pesticide for the suppression of several species of bark beetles in the western United States. A systemic insecticide, Meta-Systox-R®,[5] is effective against many insect pests of ornamentals, but had not been tested against bark beetles.[6]

We needed to know whether these two pesticides are toxic to oak and elm bark beetles. The objective of our study was to determine whether cacodylic acid and Meta-Systox-R will kill elm and oak bark beetles when the pesticides are present in the insects' diets.

Methods and Materials

Test media.—The basic ingredient of the test media was ground phloem. Bole and limb sections (< 3 inches diameter) of black and scarlet oak (*Quercus velutina* and *Q. coccinea*) and American elm (*Ulmus americana*), 10 to 20 years old, were debarked with a drawknife. The fresh phloem strips were placed immediately in a drying oven at 122° F for 18 hours, then ground in a No. 3 Wiley mill using

[1] Mention of a particular product does not constitute an endorsement by the Forest Service or the United States Department of Agriculture.

[2] This paper reports research involving pesticides. It does not contain recommendations for their use nor does it imply that the uses discussed here have been registered. All uses of pesticides must be registered by appropriate state and/or federal agencies before they can be recommended.

[3] Coleoptera: Scolytidae.

[4] Trade name for a product of Ansul Company.

[5] Trade name for a product of Chemagro.

[6] Personal correspondence with Dr. Robert A. Fisher, field research representative, Chemagro.

a ½-mm mesh sieve. The ground phloem was stored at room temperature until used. The entire bark was macerated; no attempt was made to separate inner and outer bark.

The components of the oak bark beetle test medium were: 10 g of ground oak phloem, 2 g agar-agar dissolved in 50 ml of distilled water, 35 g alphacel to add non-nutritive bulk, and a sufficient quantity of the chemical being tested to provide the specified concentration. The mixture was thoroughly blended, then pressed to reduce the moisture content to approximately 45 percent. The elm diet was prepared in the same way, but because elm bark is bulkier, only 25 g of alphacel were used.

Beetles.—The adult beetles were obtained from naturally infested elm and oak bole and limb sections (3 to 5 inches in diameter) near Delaware, Ohio. One-foot bolts were cut and placed in cylindrical cages *(Rexrode 1969)* until natural emergence occurred. Only newly emerged beetles were used for the tests. Both sexes were used indiscriminately. Two species of oak bark beetles, *P. pruinosus* and *P. minutissimus*, were used for the tests, and no distinction was made between them.

Feeding cage.—The caging apparatus (fig. 1) was a glass tube, 10 mm in outside diameter by 75 mm in length. The medium was packed loosely into the glass tube. Then a glass rod, 5 mm in diameter and 58 mm in length, was pushed into the center of the glass tube, compressing the medium against the tube walls. This restricted the beetles to the outer edge of the tube for easy and accurate observations. Five adult beetles were placed in each end of each tube. The cage was capped at the ends by size 0 corks covered with aluminum foil to prevent the beetles from feeding on the corks. The tubes containing the diet and beetles were stored in a horizontal position in a darkened constant-temperature cabinet at 26° C and approximately 50 percent relative humidity.

Six concentrations of cacodylic acid, ranging from 900 to 21,000 ppm, and 12 concentrations of Meta-Systox-R, ranging from 100 to 21,000 ppm, were tested on oak bark beetles. Similarly, six concentrations of cacodylic acid, ranging from 1,000 to 28,000 ppm, and 12 concentrations of Meta-Systox-R, ranging from 200 to 28,000 ppm, were tested on elm bark beetles.

Each test was replicated three times, with 10 adult beetles per replicate. There were two sets (10 beetles each) of checks for each series of tests. Observations and mortality counts were recorded daily and continued until all the beetles had succumbed.

Results and Discussion

Cacodylic acid and Meta-Systox-R are toxic to oak and elm bark beetles when the pesticides are present in the beetles' diets (figs. 2 to 5). The data indicated that both chemicals are more toxic to oak bark beetles than to

Figure 1.—Bark beetle feeding apparatus: (a) cork with aluminum foil; (b) glass tube; (c) glass rod; (d) medium.

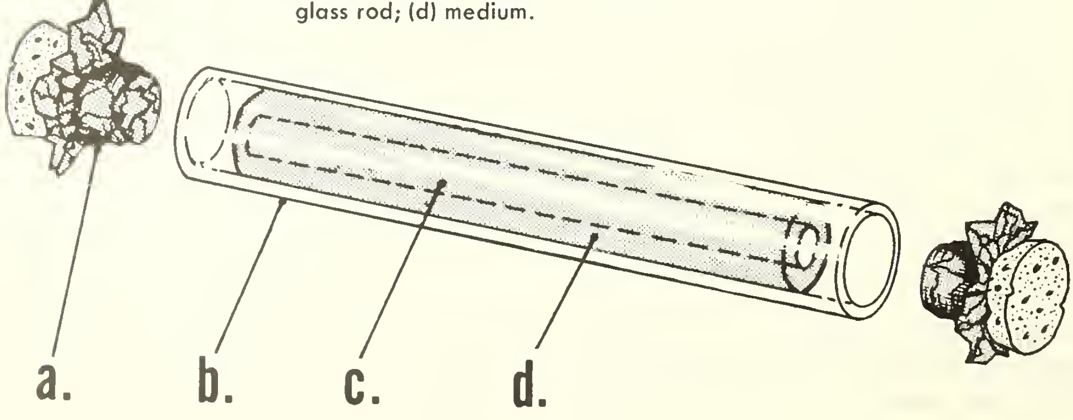


Figure 2.—The effect of cacodylic acid on oak bark beetles, *Pseudopityophthorus* sp.

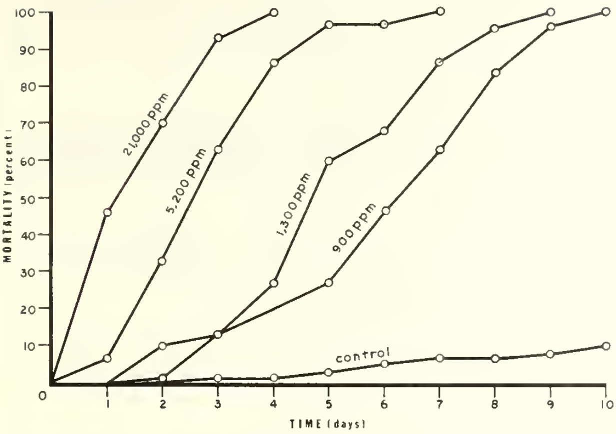


Figure 3.—The effect of cacodylic acid on elm bark beetles, *Scolytus multistriatus*.

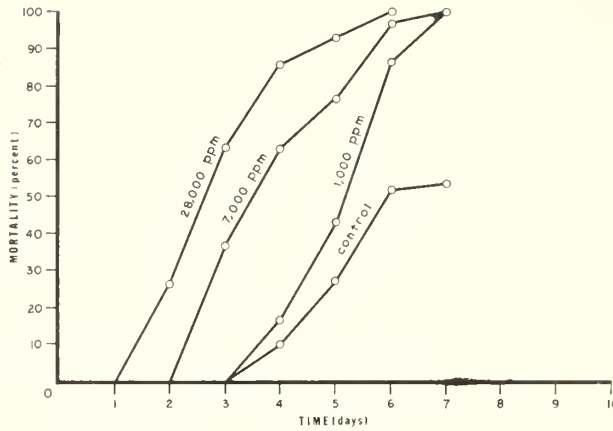


Figure 4.—The effect of Meta-Systox-R on oak bark beetles, *Pseudopityophthorus* sp.

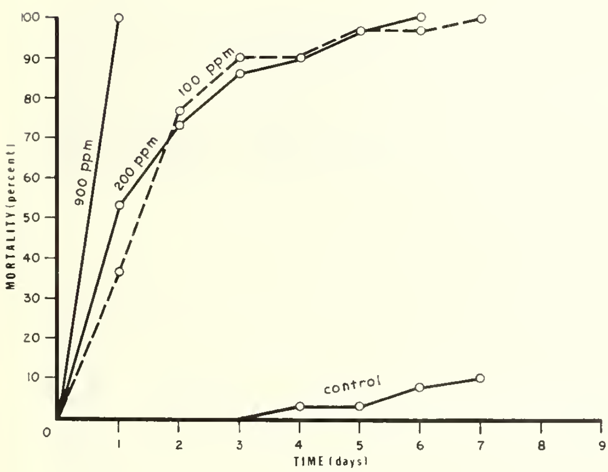
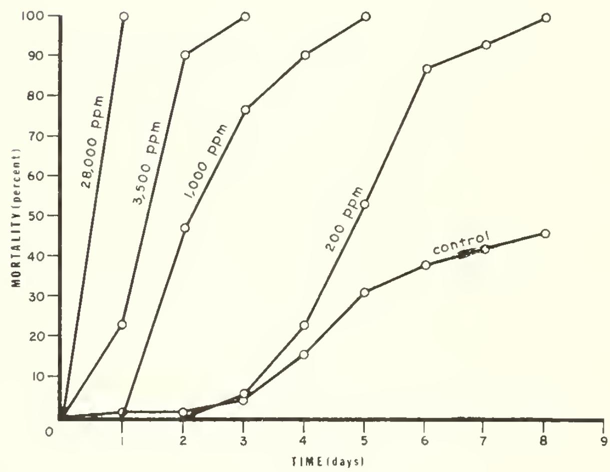


Figure 5.—The effect of Meta-Systox-R on elm bark beetles, *Scolytus multistriatus*.



elm bark beetles. However, oak bark beetles constructed egg galleries at a faster rate than elm bark beetles, so their rate of ingestion was greater.

Diets containing 900 to 1,000 ppm of cacodylic acid were effective in killing both oak and elm bark beetles (figs. 2 and 3). Diets containing 100 to 200 ppm of Meta-Systox-R were also effective in killing both kinds of beetles (figs. 4 and 5).

Egg gallery construction by both types of beetles was slower on the media containing the chemicals than on the control diets.

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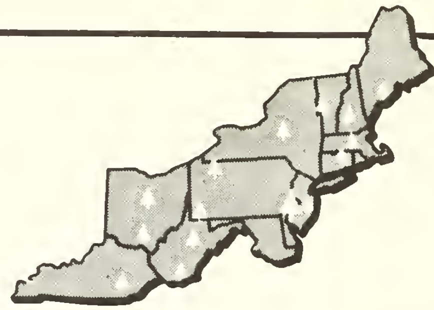

FOREST SERVICE, U.S. DEPT. OF AGRICULTURE, 6816 MARKET STREET, UPPER DARBY, PA. 19082

RELATIONSHIPS BETWEEN OVERSTORY COMPOSITION AND GYPSY MOTH EGG-MASS DENSITY

Abstract.—Most of the silvicultural recommendations for reducing the hazard of gypsy moth outbreaks have been based in part on the premise that gypsy moth density levels are related closely to the proportion of favored food trees in the overstory. This premise did not prove to be true for a series of plots observed in eastern New England between 1911 and 1931.

Most of the silvicultural recommendations for reducing the hazard of gypsy moth outbreaks have been based on the premise that both gypsy moth density and defoliation level are determined by the proportion of favored food trees in the stand *(Baker and Cline 1936; Behre et al 1936; Behre 1939; and Behre and Reineke 1943)*.

Later Bess et al *(1947)* based their recommendations on the premise that a number of other ecological factors are related closely to gypsy moth abundance. They disputed the favored-food theory, arguing that "the history of this insect in the oak forests of Connecticut and western Massachusetts shows that food supply does not normally limit the abundance of the moth in these areas."

The objective of my recent study was to evaluate the relationship between overstory composition and subsequent gypsy moth population density.

Procedures

The data used were collected between 1911 and 1931 from an area in eastern New England by personnel of the Gypsy Moth Laboratory at Melrose Highlands, Massachusetts.

First the plots were stratified to represent two kinds of forest stands: (1) *favored food* stands, in which at least one-half of the overstory was made up of white oak, red oak, scarlet oak, and black oak; and (2) *poor food* stands, in which less than one-half of the overstory was made up of oaks, gray birch, paper birch, river birch, quaking aspen, large-toothed aspen, willow, apple, and larch.

Second, the data were stratified according to zone density (ZD) *(Campbell 1973a)*.

These included ZD ≤ 40, where not more than 40 percent of the acres examined within a given zone contained more than 500 egg masses per acre at the start of year (n); and ZD > 40, where more than 40 percent of the acres contained more than 500 egg masses per acre.

Finally the data were stratified according to M(n − 1), density within each specific plot at the start of year n — 1; M(n), density within each plot at the start of year n; and M(n + 1), density within each plot at the start of year n + 1. Density was stratified five ways for each of these successive years as follows:

1. Not more than 50 egg masses per acre.
2. Between 51 and 500 egg masses per acre.
3. Between 501 and 2,500 egg masses per acre.
4. Between 2,501 and 5,000 egg masses per acre.
5. More than 5,000 egg masses per acre.

Results

Observed frequencies of gypsy moth egg-mass densities in each of five categories in year n + 1, from specified density categories in years n — 1 and n, are shown for both favored food stands and poor food stands when zone densities were low (ZD ≤ 40) (tables 1 and 2) and for both these food categories when zone densities were high (ZD > 40) (tables 3 and 4).

Comparison of frequencies observed in tables 1 and 2 with those in tables 3 and 4 showed that low densities could be expected to be maintained when zone densities were

Table 1.—Observed frequency of gypsy moth egg-mass densities in each of five categories in year (n + 1), from specified density categories in years (n — 1) and (n)

[Stratified on FAVORED FOOD stands when zone density was low (ZD ≤ 40).]

Year (n − 1)[1]	Year (n)[1]	Year (n + 1)[1] I	II	III	IV	V	Total observations
I	I	0.841	0.159	0.0	0.0	0.0	69
	II	.294	.588	.118	.0	.0	17
	III	—	—	—	—	—	0
	IV	—	—	—	—	—	0
	V	—	—	—	—	—	0
II	I	.889	.111	.0	.0	.0	27
	II	.429	.476	.095	.0	.0	42
	III	.100	.500	.300	.100	.0	10
	IV	—	—	—	—	—	0
	V	—	—	—	—	—	0
III	I	.600	.400	.0	.0	.0	5
	II	.500	.500	.0	.0	.0	16
	III	.500	.250	.0	.250	.0	4
	IV	.0	.0	1.0	.0	.0	1
	V	—	—	—	—	—	0
IV	I	—	—	—	—	—	0
	II	—	—	—	—	—	0
	III	.0	1.0	.0	.0	.0	1
	IV	—	—	—	—	—	0
	V	—	—	—	—	—	0
V	I	—	—	—	—	—	0
	II	1.0	.0	.0	.0	.0	2
	III	.0	1.0	.0	.0	.0	1
	IV	—	—	—	—	—	0
	V	—	—	—	—	—	0

[1]I = Not more than 50 egg masses per acre.
II = Between 51 and 500 egg masses per acre.
III = Between 501 and 2,500 egg masses per acre.
IV = Between 2,501 and 5,000 egg masses per acre.
V = More than 5,000 egg masses per acre.

Table 2.—*Observed frequency of gypsy moth egg-mass densities in each of five categories in year (n + 1), from specified density categories in years (n — 1) and (n)*

[Stratified on POOR FOOD stands when zone density was low (ZD ≤ 40).]

Year (n — 1)[1]	Year (n)[1]	Year (n + 1)[1] I	II	III	IV	V	Total observations
I	I	0.816	0.184	0.0	0.0	0.0	152
	II	.273	.576	.061	.090	.0	33
	III	—	—	—	—	—	0
	IV	—	—	—	—	—	0
	V	—	—	—	—	—	0
II	I	.893	.107	.0	.0	.0	58
	II	.452	.512	.036	.0	.0	84
	III	.167	.666	.167	.0	.0	6
	IV	.250	.750	.0	.0	.0	4
	V	—	—	—	—	—	0
III	I	.667	.333	.0	.0	.0	3
	II	.556	.444	.0	.0	.0	18
	III	.0	1.0	.0	.0	.0	6
	IV	—	—	—	—	—	0
	V	—	—	—	—	—	0
IV	I	.500	.500	.0	.0	.0	2
	II	.714	.286	.0	.0	.0	7
	III	—	—	—	—	—	0
	IV	—	—	—	—	—	0
	V	—	—	—	—	—	0
V	I	—	—	—	—	—	0
	II	—	—	—	—	—	0
	III	.0	1.0	.0	.0	.0	1
	IV	1.0	.0	.0	.0	.0	1
	V	—	—	—	—	—	0

[1]I = Not more than 50 egg masses per acre.
II = Between 51 and 500 egg masses per acre.
III = Between 501 and 2,500 egg masses per acre.
IV = Between 2,501 and 5,000 egg masses per acre.
V = More than 5,000 egg masses per acre.

low, and high densities tended to be maintained when zone densities were high *(Campbell 1973a and 1973b)*. The question is whether and to what extent egg-mass density was related to food quality within each zone density stratum. The following scheme was adopted to answer this question.

This system was, and is, in a constant state of flux. Population densities ebb and flow from year to year in response to factors that are reflected only in part by the specific independent variables used. Thus the frequency matrices (tables 1 to 4) can be viewed as reflections of four transient states.

But suppose the system were to follow the observed frequency distributions year after year, as shown in tables 1 to 4. In each case it would then rapidly reach a stable state, in which the number of populations leaving any category from year n to year n + 1 would be identically equal to the number of populations entering that category.

Assume that 1,000 populations meet the following criteria:

1. All populations are in favored food stands.
2. Zone density is low (ZD ≤ 40).
3. Densities in all populations have been less than 50 egg masses per acre in both years n — 1 and n.
4. Each of these 1,000 populations follows the frequency distributions in table 1.

Clearly, 841 of these populations will maintain fewer than 50 egg masses per acre in year n + 1, while 159 will reach densities between 51 and 500 egg masses per acre (table 1). By the end of the following year, 84.1 percent of the 841 former populations, plus 29.4 percent of the 159 latter populations, will have fewer than 50 egg masses per acre; 15.9 percent of the 841 former populations, plus 58.8 percent

Table 3.—*Observed frequency of gypsy moth egg-mass densities in each of five categories in year (n + 1), from specified density categories in years (n — 1) and (n)*

[Stratified on FAVORED FOOD stands when zone density was high (ZD > 40).]

Year (n — 1)[1]	Year (n)[1]	Year (n + 1)[1] I	II	III	IV	V	Total observations
I	I	0.500	0.500	0.0	0.0	0.0	2
	II	.0	.500	.286	.214	.0	14
	III	.200	.200	.400	.0	.200	5
	IV	—	—	—	—	—	0
	V	—	—	—	—	—	0
II	I	.333	.667	.0	.0	.0	3
	II	.278	.500	.194	.0	.028	36
	III	.114	.341	.250	.136	.159	44
	IV	.0	.0	.0	.500	.500	4
	V	.0	.0	.0	1.0	.0	2
III	I	.0	1.0	.0	.0	.0	1
	II	.080	.520	.240	.080	.080	25
	III	.019	.192	.442	.250	.047	52
	IV	.0	.0	.375	.125	.500	16
	V	.053	.158	.263	.368	.158	19
IV	I	1.0	.0	.0	.0	.0	1
	II	.100	.200	.400	.100	.200	10
	III	.0	.118	.412	.235	.235	17
	IV	.0	.125	.500	.125	.250	8
	V	.0	.080	.240	.320	.360	25
V	I	.0	.333	.667	.0	.0	3
	II	.0	.333	.500	.167	.0	6
	III	.038	.231	.346	.231	.154	26
	IV	.0	.174	.217	.217	.392	23
	V	.0	.167	.167	.389	.277	18

[1]I = Not more than 50 egg masses per acre.
II = Between 51 and 500 egg masses per acre.
III = Between 501 and 2,500 egg masses per acre.
IV = Between 2,501 and 5,000 egg masses per acre.
V = More than 5,000 egg masses per acre.

Table 4.—*Observed frequency of gypsy moth egg-mass densities in each of five categories in year (n + 1), from specified density categories in years (n — 1) and (n)*

[Stratified on POOR FOOD stands when zone density was high (ZD > 40).]

Year (n − 1)[1]	Year (n)[1]	Year (n + 1)[1] I	II	III	IV	V	Total observations
I	I	0.750	0.167	0.083	0.0	0.0	12
	II	.063	.374	.500	.063	.0	16
	III	.0	.667	.333	.0	.0	3
	IV	—	—	—	—	—	0
	V	—	—	—	—	—	0
II	I	.750	.250	.0	.0	.0	4
	II	.081	.595	.257	.054	.013	74
	III	.018	.218	.545	.127	.092	55
	IV	.0	.375	.375	.125	.125	8
	V	.0	.333	.334	.333	.0	3
III	I	1.0	.0	.0	.0	.0	1
	II	.054	.571	.321	.054	.0	56
	III	.013	.227	.455	.143	.162	154
	IV	.0	.220	.488	.146	.146	41
	V	.061	.121	.394	.242	.182	33
IV	I	—	—	—	—	—	0
	II	.111	.500	.333	.0	.056	18
	III	.027	.103	.718	.076	.076	39
	IV	.0	.250	.350	.150	.250	20
	V	.0	.038	.385	.308	.269	26
V	I	.0	1.0	.0	.0	.0	1
	II	.0	.400	.400	.200	.0	5
	III	.0	.212	.545	.152	.091	33
	IV	.0	.129	.323	.258	.290	31
	V	.0	.0	.179	.393	.428	28

[1] I = Not more than 50 egg masses per acre.
II = Between 51 and 500 egg masses per acre.
III = Between 501 and 2,500 egg masses per acre.
IV = Between 2,501 and 5,000 egg masses per acre.
V = More than 5,000 egg masses per acre.

Table 5.—*Percentage of hypothetical cohort of gypsy moth populations in each of five density categories after specified number of generations*

[All members of this cohort, which obeys frequency distributions in table 1, contained not more than 50 egg masses per acre in years (n − 1) and (n).]

Year	Percent in each density category[1] I	II	III	IV	V
n + 1	84.1	15.9	0.0	0.0	0
n + 2	75.4	22.7	1.9	.0	0
n + 3	71.8	25.0	3.0	.2	0
n + 4	70.4	25.7	3.5	.4	0
n + 5	69.8	26.1	3.7	.4	0
n + 6	69.5	26.3	3.8	.4	0
n + 7	69.3	26.4	3.8	.5	0

[1] I = Not more than 50 egg masses per acre.
II = Between 51 and 500 egg masses per acre.
III = Between 501 and 2,500 egg masses per acre.
IV = Between 2,500 and 5,000 egg masses per acre.
V = More than 5,000 egg masses per acre.

Table 6.—*Percentage of four hypothetical cohorts of gypsy moth populations in each of five density categories at stable state*
[All members of each cohort follow frequency distributions of table 1, 2, 3, or 4 respectively.]

Zone density	Food quality	Percent in each density category[1]				
		I	II	III	IV	V
ZD > 40	Favored	69.3	26.4	3.8	0.5	0.0
	Poor	68.4	29.1	1.5	1.0	.0
ZD ≤ 40	Favored	8.9	29.2	26.3	18.3	17.3
	Poor	11.9	30.7	36.6	11.2	9.6

[1] I = Not more than 50 egg masses per acre.
II = Between 51 and 500 egg masses per acre.
III = Between 501 and 2,500 egg masses per acre.
IV = Between 2,501 and 5,000 egg masses per acre.
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of the 159 latter populations, will have between 51 and 500 egg masses per acre; and 11.8 percent of the 159 latter populations will have between 501 and 2,500 egg masses per acre. This process was summarized through eight successive generations (table 5).

The 1,000 hypothetical populations described above assumed a virtually stable-state condition after four generations, and this same state is approached with equal rapidity regardless of the original state of the system as long as it obeys the rules as shown in table 1.

Stable-state population density distributions (tables 1 to 4) are shown for each stratum in table 6. This is the basis for most of the following discussion of relationships between overstory composition and gypsy moth egg-mass density.

Discussion

There was virtually no difference between the stable-state distribution of gypsy moth egg-mass densities in favored food stands and in poor food stands when zone densities were low, and there was surprisingly little difference when they were high. About 17 percent of the favored food stands could be expected to support more than 5,000 egg masses per acre when zone density was high, as compared with only about 10 percent of the poor food stands. An almost identical proportion of the stands in each cover type could be expected to support fewer than 500 egg masses per acre at high zone densities.

These results indicate that the favored food theory had little merit at the time it was propounded, at least with respect to relationships between overstory composition and subsequent gypsy moth population density. A similar study is also being conducted in relationships between overstory composition and subsequent defoliation by this insect, using these same data.

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FOREST HABITAT MANAGEMENT FOR NON-GAME BIRDS IN CENTRAL APPALACHIA

Abstract.—To woodland owners or managers who are interested in bird-habitat improvement, the authors suggest managing for: (1) people with slight to moderate knowledge of birds; (2) high numbers of both individual birds and bird species, particularly the conspicuous species; (3) seeing and hearing birds near trails and other human-activity areas; (4) bird nesting; and (5) natural-appearing habitat. The nesting-habitat preferences of 31 representative species are listed. Guidelines are offered for trails, sites, plants, growth stages, dimensions and lay-out, and treatments.

Birds and other wildlife are part of the outdoor experiences of nature observers, hikers, picnickers, and even Sunday drivers. For example, bird-watching and photography recently accounted for 9,900,600 use-days on the national forests, almost one-quarter of the total estimated wildlife-oriented use (*Hooper and Crawford 1969*). Songbirds add color, movement, and pleasing sound to the landscape, and thus contribute much to the enjoyment of woodland experiences.

Approximately 240 species of birds occur regularly in central Appalachia (*Hall 1971*). This exceptional diversity and abundance corresponds to the complexity and abundance of the forest vegetation, particularly the rich and varied shrub understory (*Brooks 1943*). Because the central Appalachian region contains such abundant and diverse wildlife and habitat, suitable habitat can expose the forest visitor to many species in a relatively small area. This potential is the reason for the management that we propose.

Management Objectives

Nearly everyone has some appreciation of birds, even though he may be able to identify only the most common species. We believe the goal in managing bird habitat should be to enhance the quality of woodland experiences of the kinds of people who may be only nominally aware of the birds they encounter. A bird-watcher who wants to increase his list of birds he has seen will be greatly rewarded if he glimpses one relatively rare species. But most people may derive the greatest reward from seeing and hearing *many* individual birds and species at close range and enjoying the activity and song around them.

If we manage habitat for common birds, we should put emphasis on increasing the numbers of both species and individuals, particularly those species that are conspicuous for their boldness (chickadee, *Parus atricapillus*), bright color (cardinal, *Cardinalis cardinalis*), song (wood thrush, *Hylocichla mustelina*), or size (pileated woodpecker, *Dryocopus pileatus*).

The general habitat requirements of a representative group of such birds, 31 species, is presented in table 1. We selected these species because they all breed in central Appalachia and they represent birds adapted to all of the common forest habitats. Nearly all forest-dwelling birds that are not on the list have habitat requirements similar to those of some of the listed species. Management, including the development of a thick understory to favor the listed species, can also be expected to benefit other animals such as ruffed grouse, white-tailed deer, and rabbits.

The first question is: Where to manage? To benefit people, habitat management must be concentrated in places where people go: along secondary roads, trails, and streams, and especially around attractive recreational sites. Because most songbirds are relatively immobile during the breeding season (*Pettingill 1970:311*) and fairly tolerant of human activity, good bird habitat can be maintained near travel routes or sites of human activity. Actually, many of the candidate species for management (table 1) are those that inhabit edge habitats—the borders between different habitat types. Man's activities have created such habitats and the complex mix of types is conducive to diversity of bird species.

Of course, habitat management near human activity centers may require compromise, because some of the conditions that benefit birds are unsightly to people who lack appreciation of wildlife-habitat relationships (*Burr and Jones 1968*). Such management practices as tree cutting or deadening to increase the understory, or the retention of dead trees, may not gain easy acceptance.

The next question is: When? Management efforts should concentrate on breeding-season

Table 1.—*Typical nesting habits of selected non-game forest-dwelling birds*

Species	Usual nest height, feet	Concealment	Remarks
Louisiana waterthrush	0	Roots, logs, banks	Near water
Ovenbird	0	Dead leaves	Usually in dry soil
Whip-poor-will	0	Dead leaves, brush	Deep woods, ravines
Brown thrasher	0- 7	Thickets	Prefers thorny vines
Carolina wren	0-10	Cavities, thickets	Often in a building
Rufous-sided towhee	0- 3	Grass, forbs	Brushy openings or deep woods
Song sparrow	0- 6	Grass, thickets	Edges of woods
Yellowthroat	0- 2	Grass, vines	Moist locations
American goldfinch	5-15	—	Forks of shrubs, saplings, vines
American redstart	5-15	—	Forks of shrubs, saplings, vines
Cardinal	3-15	Thickets	Prefers vine tangles
Gray catbird	2-15	Thickets	Prefers vine tangles
Chipping sparrow	1- 4	Thickets	Often near building
Indigo bunting	1- 3	Thickets	Brushy areas in, near woods
Yellow-breasted chat	3-10	Thickets	Often in thorny vines
Yellow warbler	2-10	—	In shrubs, saplings
Red-eyed vireo	2-15	—	Suspended from forks
Robin	2-15	—	Often on a building
Wood thrush	4-15	Thickets	In forks or on a limb
Black-capped chickadee	8+	Cavities	Often in old woodpecker hole, bird box
Downy woodpecker	6-30	Cavities	Dead tree or dead part of live tree
Screech owl	6-30	Cavities	Woodpecker hole, tree cavity, building, bird box
Tufted titmouse	8+	Cavities	Often in old woodpecker hole, bird box
White-breasted nuthatch	2-60	Cavities	Stump, snag, old woodpecker hole, bird box
Northern (Baltimore) oriole	20+	None	Prefers broad-crowned trees
Blue jay	10-15	—	May prefer conifers
Broad-winged hawk	20-80	None	Builds in a large crotch
Crow	20-80	None	Usually in a large crotch
Eastern wood pewee	20-60	None	Often on edge of clearing
Great crested flycatcher	6-15	Cavities	Tree or stump, woodpecker hole, bird box
Scarlet tanager	16-55	None	Usually in mature woods

habitat, for several reasons. Habitat requirements during the breeding season (April to July) are more likely to limit bird populations than requirements during other seasons. This is due largely to the territorial defense behavior of birds during spring and early summer (*Lack 1933*). Then, most birds prefer the same kind of habitat for nesting and escape cover, although other kinds of habitat may be used for feeding (*Dunlavy 1935*). Secondly, more species of birds are conspicuous and recognizable during spring and summer because they are in their brightest plumage then. Spring is also the time when great numbers of migrant species may be observed; and this, combined with the warming weather, encourages people to visit areas managed for bird-watching.

Songbird habitat can be managed through treating the existing habitat or through artifices such as providing nest boxes, planting exotic or native plants, or providing supplementary feed. Esthetic, economic, and labor considerations generally favor treatment of existing habitat over artificial management that may require intensive effort, needs frequent maintenance, and tends to look out of place in a natural woodland.

Such artificial practices can be used to provide habitat where it may not be immediately available during more "natural" management. For example, nest boxes may be provided for hole-nesters in stands that are too young to provide nesting places. There are other circumstances where such practices may be justified, but we confess to a bias against management practices that look unnatural.

To be successful, management need not increase total bird populations. Because the central Appalachian bird fauna is so diverse, all kinds of forest habitat support some species of birds. Changing a certain habitat usually changes the numbers and species of birds using the area, but the change carries virtually no risk of eliminating all birds or of threatening any species.

Newly created habitat will usually be occupied within one to three years by birds that otherwise would have nested elsewhere or would have failed to find breeding habitat of a quality equal to that of the new site (*Hagar 1960, Lack 1933*). Many species populations include surplus non-breeding individuals (*Hensley and Cope 1951*). For management purposes, it may be immaterial to ask whether or not birds attracted to managed habitat produce an addition to the overall population. What is significant is whether birds and appreciative people are brought together.

The primary habitat characteristic to which management should be directed is the structure of the vegetation. Life form of vegetation is more important to bird-habitat management than individual plant species.

> The main reason one habitat supports more bird species than another is that the first has a greater internal variation in vegetation profile (that is, a greater variety of different kinds of patches). A second reason is of course that a forest with vegetation at many heights above the ground will simultaneously support ground dwellers, shrub dwellers and canopy dwellers. With a few exceptions, the variety of plant species has no direct effect on the diversity of bird species. (*MacArthur et al 1962*).

The specific measures needed to manage bird habitat will differ among forest properties. Such differences preclude the development of a standard prescription that will work everywhere. Nevertheless, knowledge of the general habitat conditions that favor birds will help in planning for a specific area. A knowledge of the existing bird population is helpful; and the land manager who doesn't know his birds can get help from a local birder, or can enrich his own experience by familiarizing himself with birds and their habitats.

Management Practices

Here are some suggestions on forest-habitat management that favors birds for enjoyment by people:

Trails. Trails are the key to bringing people and birds together in good bird habitat. They should be located to take advantage of terrain, scenery, and existing habitat. Effective trail planning and layout can enhance the learning and esthetic aspects of outdoor recreation by providing easy access to varied habitats. There are three basic types of trails: general hiking or walking trails, guided or self-guided interpretive trails, and special-use trails (horseback, off-road-vehicle, etc.). We are primarily concerned with general walking trails. The following considerations are essential to good trail planning:

- Trail layout requires thorough familiarity with the physical characteristics of the site, ensuring that no important site features are omitted.
- Trails should accommodate to people who may be unfamiliar with nature, and must be safe as well as exciting.
- Trails must also provide for protection of the site from the people who use the trail.

Walking trails allow people to pursue their own interests at their own pace. Specifications for walking trails usually can be less rigorous than those for other kinds of trails; thus the walking trail is more primitive, and possibly more exciting. It is certainly less of an intrusion on the landscape than an interpretive trail with signs.

Trail layout should follow a closed-loop design, beginning and ending at the same point. A one-way traffic flow on the loop avoids interference between people and the need to retrace steps. Long, straight stretches should be avoided. Trails with curves and bends at frequent intervals allow a longer trail length at a given site, inject an element of surprise and anticipation, and provide a feeling of remoteness for the walker. Straight stretches of trails should not exceed 100 feet. For more detailed information on trail planning and layout see Ashbough and Kordish (*1965*).

Sites. Management should be concentrated around the more moist and fertile sites. All bird species will visit water occasionally, and moist or wet sites serve as activity centers for many. Development of a swampy or marshy site would be very effective in songbird management. The more lush growth of vegetation in wet places and on the more fertile sites is conducive to more rapid response by birds to management.

Some drier sites may be equally valuable however, particularly if they are capable of supporting a rich understory. Of course, there are bird species that are adapted to each kind of site; blue jays and ovenbirds are found in dry woodlands, whereas song sparrows and catbirds prefer more moist sites. Therefore, a bird-walk trail should traverse most of the available kinds of sites.

Plants. A plant's life form is usually more important to birds than its species (*Pitelka 1941*). Management should favor the most vigorous species of the needed growth form. Other things being equal, management should favor vines of all species, thicket formers, species with showy flowers or foliage, species bearing nuts or fleshy fruits, mixtures of evergreen and deciduous plants, and standing dead or dying trees. Management information about the most important shrubs and woody vines has been compiled by Gill and Healy (*1974*).

Herbaceous vegetation should also be encouraged. Particularly in open areas, it provides home for hosts of insects in the summer and provides many seeds for autumn and winter feeding. In wet areas the aquatic vegetation is useful to many bird species.

Growth stages. The growth stages of the woodland are an important consideration. A moderate to dense understory is desirable among all stages of forest growth from brush to sawtimber. Extensive stands should be multilayered, or be broken into small interspersed units of single or two-layer stands. Poletimber (5 to 11 inches dbh) is usually abundant. If some other stages are scarce, increase them in this priority order:

1. Vines, shrubs, seedlings.
2. Sawtimber (11 + inches dbh).
3. Saplings (1 to 5 inches dbh).
4. Herbaceous growth (on logging roads, landings, and other openings, herbaceous growth takes first priority).

This mix of forest growth stages is important because many of the non-game birds are edge species, which live at the interfaces of forest growth stages. Thus, to achieve the greatest wildlife potential, the amount of edges usually should be increased.

Such edges exist between meadows and brushy areas, between forest and meadow or brush, and between forest types or age groups. Edges of this sort provide variety in plant species, vegetation heights, and growth forms. This variety means more different kinds of cover and food, and therefore more possibilities for songbirds with different diet and cover requirements (*Twight and Minckler 1972*). A meadow provides food for seed eaters, but cover only for a few bird species, such as the meadowlark. A meadow with brushy patches or edges and berry vines provides much more food and cover variety. Nests can be sheltered in brush or vines. Trees increase the vegetative variety further, and dead trees provide cavities for hole-nesting birds and a host of insect foods.

Dimensions and lay-out. The mix or interspersion of the habitat conditions we have discussed should be on a smaller scale than is customary in managing timber or habitat of game animals. This smaller scale for non-game birds stems from the size of their home ranges or territories during the breeding season. Although birds like the crow and broad-winged hawk range over large areas, most species do not, and many stay within a half-acre or less—say a roughly oval-shaped area equivalent to that of a circle having a radius of about 80 feet.

To achieve small-scale interspersion, narrow stands—say 75 to 150 feet wide—are preferable to wider blocks because the narrow shape maximizes the amount of edge habitat. Curving or wavy stand borders further increase the edge, and have the additional advantage of a more natural appearance than straight edges.

The travel route or trail should enter and leave stands at angles that allow the walker to sense a transition rather than abrupt change from one habitat to another. An oblique entry to the stand allows greater opportunity to observe bird activity along the stand edge.

Treatments. The maintenance of early stages of forest growth necessitates frequent cutting or girdling. Cutting in fall or winter disturbs birds less than cutting in spring or summer. In general, an overstory canopy closure of about 50 percent and not more than 75 percent should be maintained. Crown thinning usually works better than a low thinning to open the canopy and leave as many trees and shrubs as possible.

Livestock usually should be kept out because grazing tends to have a negative effect on woodland birds (*Dambach and Good 1940*). However, limited grazing may be useful in certain circumstances such as where walking trails are being choked by thorny vines or where other desirable openings are closing in.

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FORECASTING DEFOLIATION BY THE GYPSY MOTH IN OAK STANDS

Abstract.—A multiple-regression model is presented that reflects statistically significant correlations between defoliation by the gypsy moth, the dependent variable, and a series of biotic and physical independent variables. Both possible uses and shortcomings of this model are discussed.

THE GYPSY MOTH, *Porthetria dispar* (L.), is one of the most destructive pests of hardwood forests in the northeastern United States. Populations of this insect have sometimes achieved densities of more than 5,000 egg masses per acre and have maintained these high densities for several years running (*Campbell 1973a*). Such populations are capable of killing a high proportion of the overstory trees through repeated and heavy defoliations (*Kegg 1971*).

On the other hand, the proportion of the foliage that will be removed by gypsy moth larvae in any given place and year depends not only on the number of insects that are present, but also on other variables. A particular insect density does not determine a particular defoliation level. Rather, an array of defoliation levels may result from that density (*Campbell 1966*). And before we can predict defoliation for any given time and place with reasonable accuracy, it is clear that relationships between defoliation and other heretofore unidentified or at least unquantified variables must be accounted for.

OBJECTIVE

Our objective is to describe a multiple-regression model that reflects statistically significant correlations between defoliation by the gypsy moth, the dependent variable, and a series of biotic and physical independent variables. Although the data used to develop this model were collected from an area in northeastern New England between 1911 and 1931, it seems reasonable to suppose that most of the underlying mechanisms through which a particular defoliation regime is determined today are not much different from those in 1911–31. On the other hand, the system *may* have changed since that time to the point where the model presented is of little or no practical immediate value. In any case, this model will be tested for predictive accuracy in the near future.

PROCEDURES

The biological data used here were accumulated by personnel of the old Melrose Highlands Gypsy Moth Laboratory in Massachusetts. Procedures used to process these data, and a complete list of the independent variables tested, have been described (*Campbell 1973b*).

Processed data included an estimate of each of the following variables for each plot in the Melrose system during each year the plot was examined.

Significant independent variables:

ZDL = Percentage of the plots examined in a zone in the fall of year (n) that contained more than 500 egg masses per acre.

ZDH = Percentage of the plots examined in a zone in the fall of year (n) that contained more than 5,000 egg masses per acre.

MLSTYR = Egg masses per acre in the fall of year (n—1).*

MNOW = Egg masses per acre in the fall of year (n).*

Trend $= \frac{\text{MNOW}}{\text{MLSTYR}}$

DOM = Percentage of the dominant trees in the stand that were favored as food by the gypsy moth (FCA).

TFOL = An index of total foliage per acre.

DCA_n = Percentage defoliation of favored food trees (FCA) during year (n).

PM = Precipitation in May of year (n), in inches.

Dependent Variable:

$DEF_{(n+1)}$ = Percentage defoliation of the whole stand during year (n+1).

First, the above data were stratified to represent only stands where more than one-half of the overstory was composed of oaks, because defoliation in this stratum is of great concern to many people. Other strata were set aside for examination later.

Second, the dependent variable, defoliation in year (n+1) ($DEF_{(n+1)}$), was transformed to $\ln(101\text{-}DEF_{(n+1)})$. Although defoliation in most of the plots ranged between zero and 25 percent during most of the years they were observed, this insect is likely to damage trees only when defoliation is greater than 50 percent; and the above transformation seemed a reasonable way to increase the accuracy of the model for forecasting these higher defoliation levels. By the same token, of course, the model is probably less accurate than another transformation—for example $\ln(DEF_{(n+1)})$—would have been for forecasting situations where little or no defoliation might be expected.

A few relationships were known to exist between defoliation and the independent variables. Others were merely suspected. Nonlinear relationships were presumed to be common. Similarly, interactions were suspected between combinations of the independent variables and subsequent defoliation. So a variety of multiple-regression models were tested, having the general form $Y=b_0+b_1X_1+b_2X_2+\ldots+b_nX_n$; and due provision was made for testing for both non-linearity and interactions.

RESULTS

The equation presented in table 1 represents our best prediction model for defoliation, using the criteria of least squares. Statistical relationships between defoliation and independent variables cannot be visualized just by inspection of the separate terms in the model because both the dependent variable, $DEF_{(n+1)}$, and current egg-mass density, MNOW, were transformed to $\ln(101-DEF_{(n+1)})$ and $\ln(\text{MNOW})$, before the model was developed. On the other hand, the contribution of each term in the model to expected $\ln(101-DEF_{(n+1)})$ can be examined separately, and the expected value of defoliation itself can be determined by simply transforming the expected value of $\ln(101-DEF_{(n+1)})$ back to $DEF_{(n+1)}$. This procedure has been followed in developing figures 1 to 5. Since these figures were all derived by using the mean value of each independent variable

(*One egg mass was always added to observed egg-mass density per acre because no egg masses were observed in some of the Melrose plots during some years.)

Table 1.—Analysis of variance in defoliation in year (n + 1) 1n (101 − DEF (n + 1)) as a function of the specified independent variables (N = 533)

Intercept = 4.5315 Variable	Regression coefficient	Standard error of coefficient	t ratio on 524 d.f.
(DOM) • (1nMNOW)	0.00098977	0.00030319	3.3*
(DMO) • $(1nMNOW)^2$	−.00019212	.00003268	−5.9*
(ZDL) • $(ZDH)^2$	−.00000219	.00000056	−3.9*
(DCA(n)) • (PM) • (1nMNOW)	.00009470	.00002394	4.0*
(TREND) • (1nMNOW)	−.05556634	.01332184	−4.2*
(TREND) • $(1nMNOW)^2$	.01473679	.00329108	4.5*
(TREND) • $(1nMNOW)^3$	−.00097398	.00019814	−4.9*
(TFOL)	.00091184	.00034688	2.6*

*Significant at 0.01 probability level.
$R^2 = 0.41$.

that was not otherwise specified, these mean values are shown below:

Variable	Mean value
Low zone density (ZDL)	53 percent
High zone density (ZDH)	14 percent
Prior egg-mass density (MLSTYR)	2,705 egg masses per acre
Current egg-mass density (MNOW)	2,488 egg masses per acre
Dominance of class-A trees (DOM)	86 percent
Index of total foliage (TFOL)	61
Prior defoliation (DCA(n))	22 percent
Precipitation in May of year (n) (PM)	3.17 inches

Zone densities (ZDL and ZDH).—Defoliation in any particular place within a zone could be expected to increase in year (n+1) as the percentage of the acres examined within that zone in the fall of year (n) that contained high egg-mass densities increased. This relationship is examined in figure 1 for zones where at least 40 percent of the acres examined in the fall of year (n) contained more than 500 egg masses per acre, ZDL, and where at least 10 percent of these same acres contained more than 5,000 egg masses per acre, ZDH.

Presumably, the relationships in figure 1 reflect primarily on an abundant supply of newly hatched larvae within the zone, and on the tendency of these larvae to disperse to other locations. In addition, Leonard (*1967*) has suggested that newly hatched larvae are more likely to disperse when they are crowded than when they are not, and has indicated a mechanism through which this might be determined. These relationships may also reflect a tendency by mobile predators—such as flocking birds—to concentrate on high-level host populations when they are available, thus allowing lower-density populations to survive in larger numbers than they otherwise might, and consequently to subject the stand to more defoliation.

Egg-mass densities (MLSTYR and MNOW).—The relationship between current egg-mass density, MNOW, and defoliation, $DEF_{(n+1)}$, was straightforward as long as the difference in density between last year's density, MLSTYR, and the current level, MNOW, was not great (fig. 2). Although defoliation clearly increased as current density increased, the figure simply does not support a long-held concept of gypsy moth population management, which is that heavy defoliation can be expected at or above 500 egg masses per acre. Indeed, even when current density was about 5,000 egg masses per acre, the model indicates that only about 38 percent defoliation could be expected if the population had been stable at 5,000 egg masses per acre for 2 years running.

Thus, unless the model is greatly in error for this density range, either most egg-mass surveys for proposed control work greatly underestimate actual current egg-mass density, or the usual decision to exercise population control at 500 egg masses per acre should be re-evaluated.

On the other hand, the model indicates that egg-mass populations as low as 500 current egg masses per acre might result in heavy defoliation of the stand following explosive increases in population densities between

Figure 1.—Relationship between defoliation during year (n + 1), and the percentages of acres in the zone in the fall of the year (n) containing more than (a) 500 egg masses per acre (ZDL), and (b) 5,000 egg masses per acre (ZDH). All other independent variables have been held constant at their mean values.

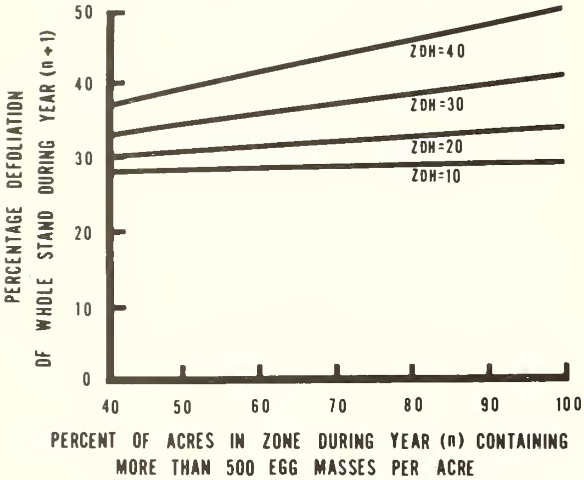


Figure 2.—Relationship between defoliation during year (n + 1) and egg-mass densities in the fall of year (n) and (n — 1), (MNOW and MLSTYR). Outbreak conditions.

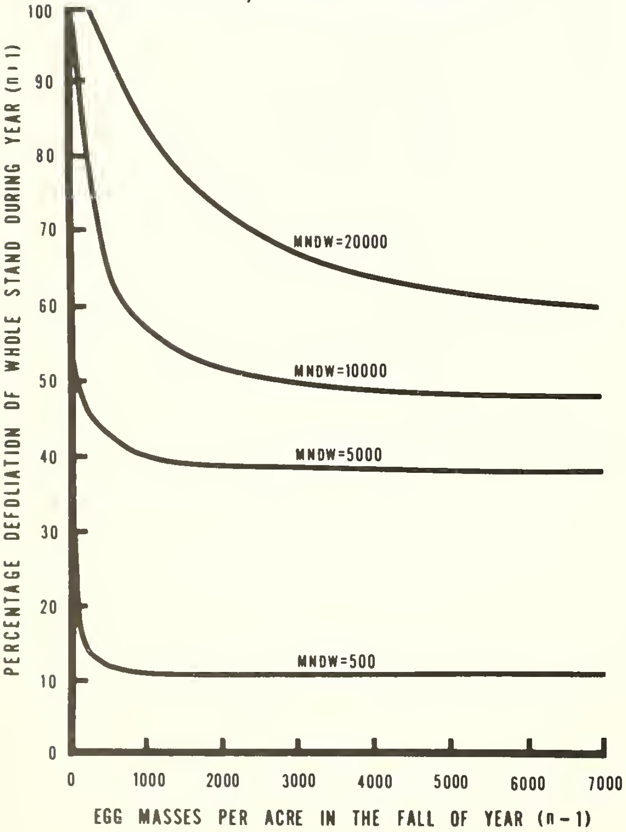


Figure 3.—Relationship between defoliation during year (n + 1), egg-mass density in the fall of the year (n), (MNOW), and the percentage of the dominant trees in the stand that were in food class A (FCA). Outbreak conditions.

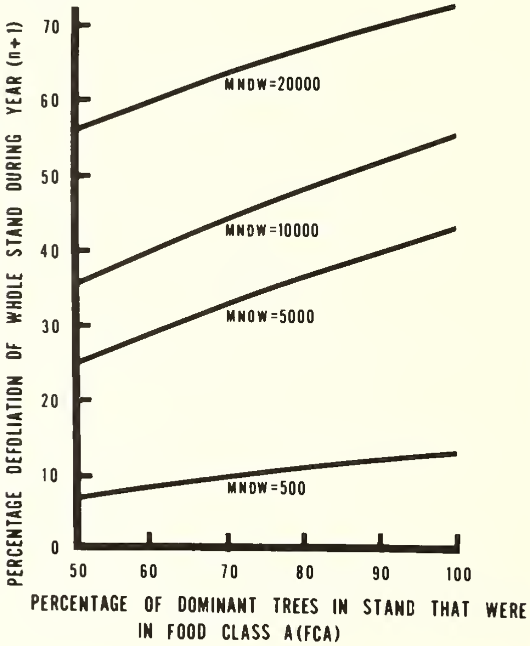


Figure 4.—Relationships between defoliation during year (n + 1), egg-mass density in the fall of year (n) (MNOW), and an index of total foliage per acre (TFOL). Outbreak conditions.

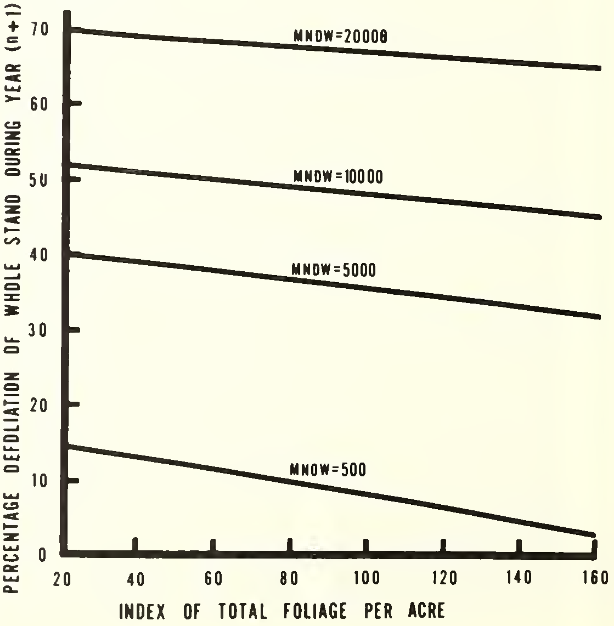
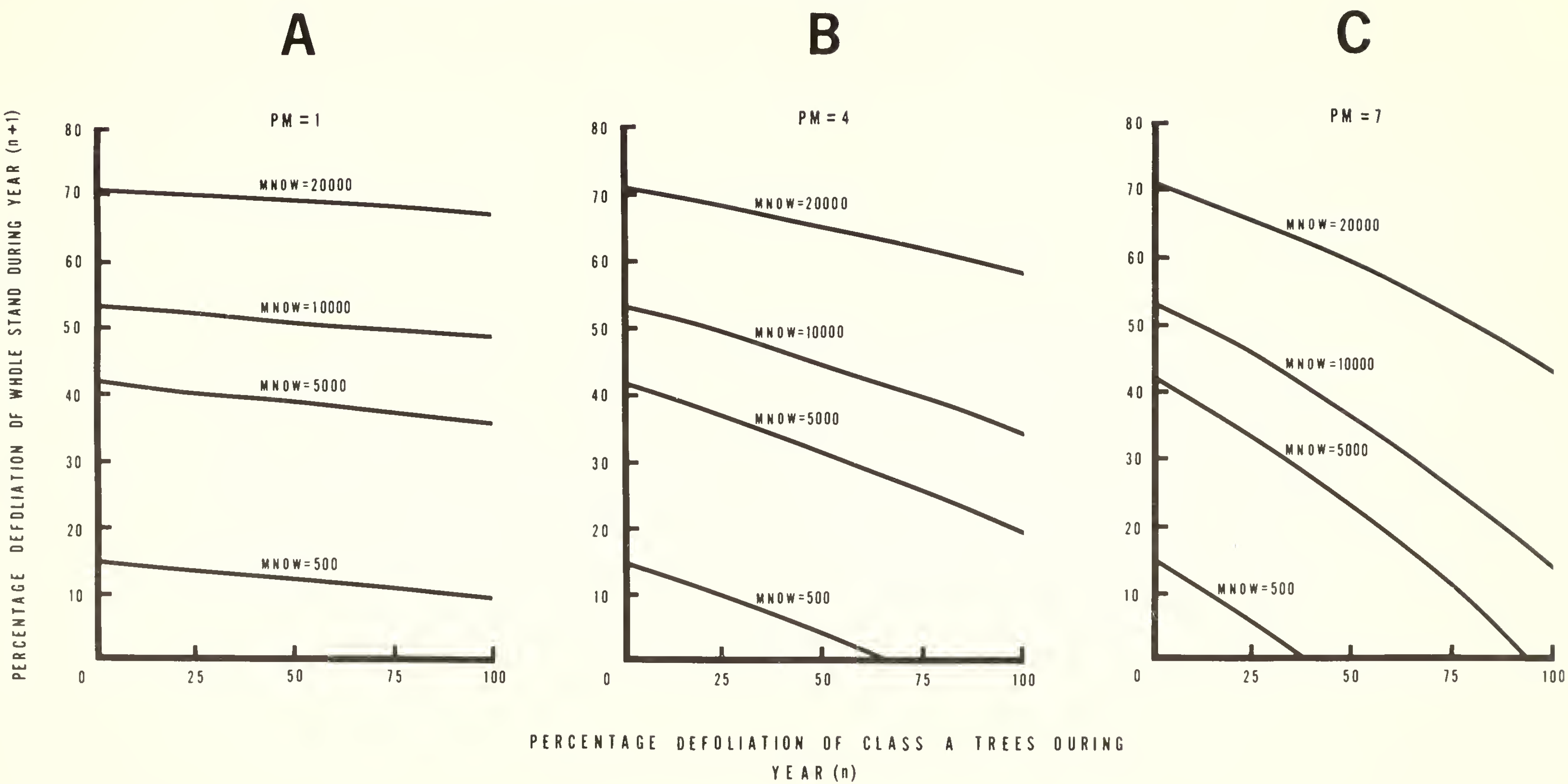


Figure 5.—Relationships between defoliation during year (n + 1), ($DEF_{(n+1)}$), percentage defoliation of food class A trees during year (n), (DCA_n), and egg-mass density in the fall of year (n), (MNOW). A. Relationships between $DEF_{(n+1)}$, DCA_n, and MNOW when precipitation in May of year (n), (PM), is held constant at 1 inch. B. Relationships between $DEF_{(n+1)}$, DCA_n, and MNOW when PM is held constant at 4 inches. C. Relationships between $DEF_{(n+1)}$, DCA_n, and MNOW when PM is held constant at 7 inches. Outbreak conditions.



years (n−1) and (n). Since many control operations have been aimed at just such populations, it seems reasonable to suppose that current population management philosophy for this insect may have been dominated by this latter fact. In any case, though we have observed the tendency of rapidly increasing populations to cause much heavier defoliation than their relatively stable, but equally dense, counterparts, we cannot propose a specific mechanism to account for it. Perhaps it is determined primarily by a time lag for the establishment and/or build-up of the natural enemies of the insect; or it may reflect primarily on the physiological state of the insect itself. Possibly mechanisms of both sorts are involved.

Dominance of class A trees (DOM).—Relationships between the percentage of the dominant trees in the overstory that were favored as food by gypsy moth larvae, DOM, current egg-mass density, MNOW, and subsequent defoliation, $DEF_{(n+1)}$, are somewhat puzzling at first glance (fig. 3), because the dominance of class A trees was more closely related to defoliation when current density was high than when it was low. This difference may reflect the imposition of a food limitation on the insect as density increased.

Foliage index (TFOL).—Defoliation tended to decrease as the total amount of foliage available to the larvae hatching from a given egg-mass density increased (fig. 4). This is only logical because the proportion of the total foliage consumed per larva was certain to decrease as the total amount of that foliage increased. However, defoliation only decreased by about 3 to 5 percent as the index of total foliage doubled, which may indicate either that dispersal losses among the newly hatched larvae tended to be greater within poorly stocked stands, or that much more foliage was consumed per larva as the total amount of available foliage increased, or both.

Prior defoliation ($DCA_{(n)}$) and precipitation (PM)—Defoliation in year (n+1) was reduced as a function of prior defoliation of the class A trees during the preceding summer, $DCA_{(n)}$; and more defoliation could be expected in year (n+1) when precipitation in May of year (n) was low than when it was high (fig. 5). Probably this latter relationship reflects a greater tendency, in part, for a disease epizootic to develop in the insect population issuing in year (n+1) as a consequence of the higher humidity conditions present during the larval stage in year (n).

In fact, neither mechanisms that are associated with heavy prior defoliation, such as reduced fecundity, nor those that may be associated with high May precipitation levels in year (n), such as increased disease incidence in year (n+1), offer a completely plausible rationale for the results shown in figure 5. Another rationale might suggest that mechanisms similar to those described by several authors (*Wellington 1965; Morris 1969*) may alter the physiology of the insect in generation (n+1) through directly influencing the maternal parent during generation (n). This possibility should be explored.

DISCUSSION

These results, in our opinion, emphasize two immediate needs:

First, the model accounted for only 41 percent of the variation in $\ln(101-DEF_{(n+1)})$, the variable chosen to reflect defoliation in OAK stands. This may imply that we either do not have, or have not used, a truly relevant index of a fundamentally important—but currently unknown—process in determining a defoliation level. Thus, although our primary purpose was to produce a prediction model for defoliation by this insect, our results emphasize the need for specific studies to identify and understand the processes through which particular levels of defoliation by this insect are determined.

Second, agencies charged with the management of this population system should review their criteria for control. Unless the population system is now behaving quite differently from what is indicated by this model, current criteria for control may sometimes lead to the treatment of populations that would have caused little defoliation if they had been left untreated.

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RADIOGRAPHING PUPARIA OF TACHINID PARASITES OF THE GYPSY MOTH, AND APPLICATION IN PARASITE-RELEASE PROGRAMS

Abstract.—A radiographic technique has been developed for observing and quantifying development and mortality of *Blepharipa scutellata* (Robineau-Desvoidy), *Parasetigena agilis* (Robineau-Desvoidy), and *Compsilura concinnata* (Meigen), tachinid parasites of the gypsy moth, *Porthetria dispar* (L.). Puparia can be examined and sorted immediately after collection and decisions on further collecting and release can be made in the fall. Healthy tachinid pupae can be placed directly in a release area eliminating the handling of adults the following spring.

Recent increase in the geographical spread of the gypsy moth, *Porthetria dispar* (L.), has stimulated new efforts by state and federal agencies to develop biological control programs that can be used effectively, at new points of infestation, to inhibit population increase and prevent further spread. A major component of this approach has been the introduction of parasites into the incipient gypsy moth populations.

Blepharipa scutellata (Robineau-Desvoidy), *Parasetigena agilis* (Robineau-Desvoidy), and *Compsilura concinnata* (Meigen), are three important tachinid parasites of the gypsy moth in natural populations in the Northeast. Procedures for collecting, holding, and releasing these dipterous parasites have changed very little since the first parasite-introduction programs were initiated in the early 1900s (*Burgess and Crossman 1929*).

The general procedure has been to mass-collect gypsy moth larvae and pupae and hold them until the parasite maggot emerges. *C. compsilura* has two to three generations per year. The first-generation maggots are collected as they drop from third- and fourth-instar larvae and then are held in a moist regime until the adult emerges from the puparium. Adults may then be released at desired locations in the same year. *B. scutellata* and *P. agilis*, which have only one generation per year, are allowed to drop directly into sand or some other overwintering medium, or are collected after pupariation (*Fraenkel and Bhaskaran 1973*) and placed in the overwintering site. The next spring the relatively fragile adult flies are collected as they emerge and are released at the desired points.

Although the procedures are relatively simple, a number of practical problems have appeared that greatly reduce the efficiency of the method. 1. Recent investigations into the population dynamics of tachinids at our laboratory indicate that a high prehibernation mortality of 30 to 40 percent may occur between pupariation and pupal formation. 2. In areas in which the tachinids are collected, the parasites are themselves parasitized, while in the gypsy moth, by the hyperparasite *Brachymeria compsilurae* (Crawford), which may then overwinter as a larva in the tachinid puparium. 3. There is evidence that excessive handling of puparia and adults can cause significant mortality.

Techniques have not been developed for periodically sampling overwintering tachinid puparia to determine the number of healthy, diseased, and parasitized fly pupae. Thus it is currently impossible to predict how many adult flies will be available for release in the present procedures for collecting, holding, and releasing.

The problem of observing and measuring the development and activity of insects when they are concealed in a host or by pupal coverings has been successfully solved for a variety of insects and host material by using radiography (*Holling 1968*; *Demars 1963*; *Graham et al 1964*; *Kirkpatrick and Wilbur 1965*). In 1973, a radiographic technique was developed at the U.S. Forest Service's Northeastern Area State and Private Forestry field laboratory at Stroudsburg, Pennsylvania, for observing and quantifying development and mortality of tachinids while they are concealed in the puparium.

Radiographs of puparia were taken with a Faxitron shielded cabinet X-ray system, model 8050-010. (Mention of brand-name materials should not be construed as endorsement by the U. S. Department of Agriculture or the Forest Service.) A series of test exposures of puparia of various sizes were made, using Kodak Type M X-ray film. The radiographs with the best definition were shot at

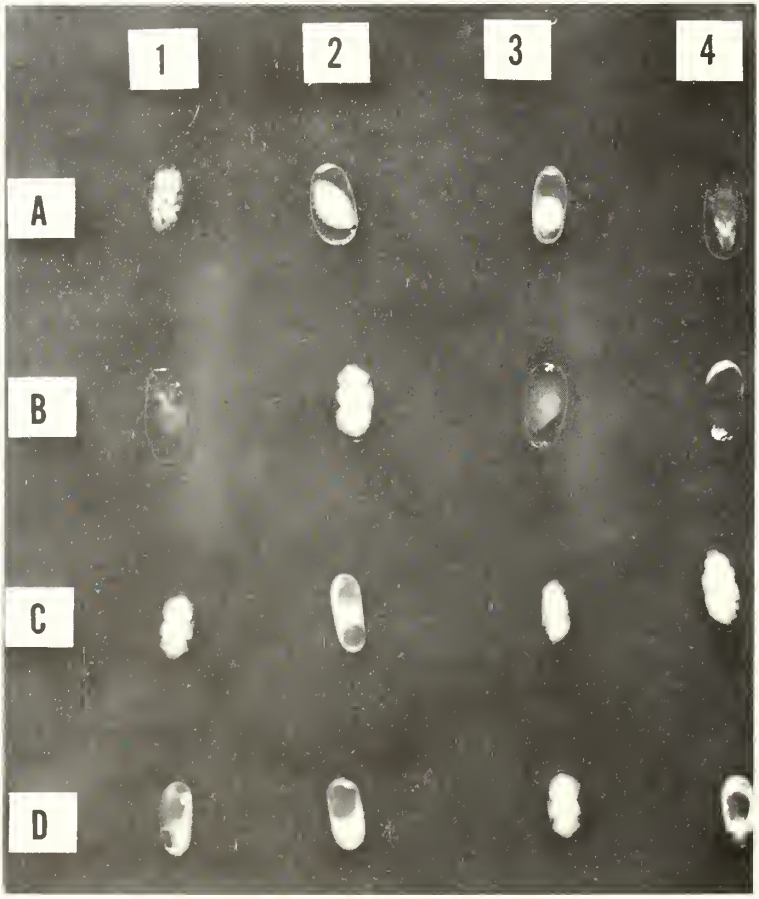

Figure 1.—Radiograph of *Blepharipa scutellata* puparia. Puparia of *Parasetigena agilis* had similar contents and can be identified just as easily.

A1. Hyperparasite, polyembryonic hymenoptera.
A2. Hyperparasite, diapausing hymenoptera larva.
A3. Hyperparasite, diapausing hymenoptera larva.
A4. Dried *Blepharipa scutellata* pre-pupa.
B1. Dried, did not pupate.
B2. Fully formed *B. scutellata* pupa.
B3. Liquified, partially dried.
B4. Empty except for small amount of dried material at posterior end.
C1. Fully formed *B. scutellata* pupa, dorso-ventral view; on a radiograph you cannot distinguish dorsal or ventral because specimen is radio-transparent.
C2. Liquified, two air spaces.
C3. Fully former *B. scutellata* pupa, lateral view.
C4. Fully formed *B. scutellata* pupa, lateral view.
D1. Liquified, partially dried.
D2. Liquified, one large air space at anterior end.
D3. Fully formed pupa, dorso-ventral view.
D4. Liquified, air space in middle.

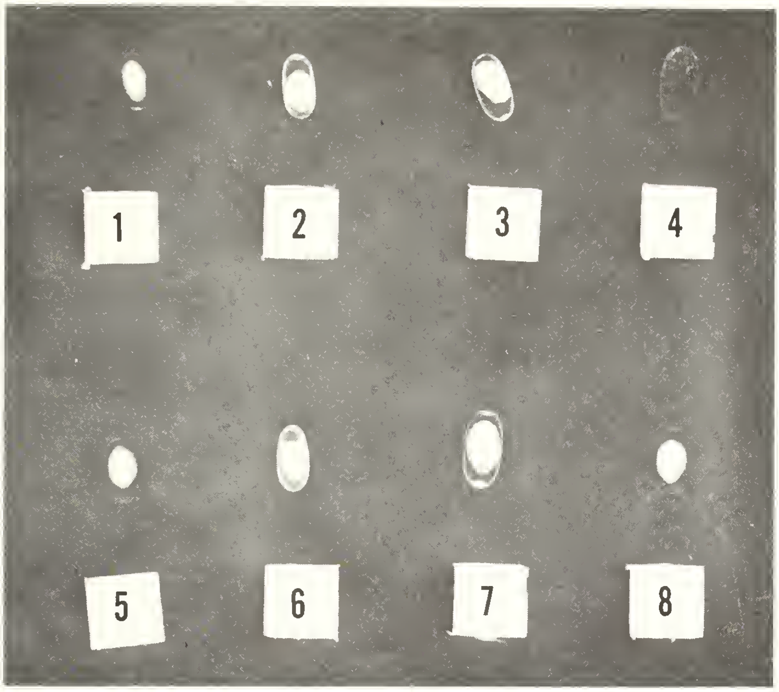

Figure 2.—Radiograph of *Compsilura concinnata* puparia. All but number 4 contain diapausing hymenopterous hyperparasites. Number 4 was completely dry, but there was no external evidence to indicate that it was empty.

25 KV, 9 mas (large puparia, fig. 1) and 20 KV, 3 mas (small puparia, fig. 2).

Thirty-seven puparia were radiographed in three groups: 10, 10, and 17. (Puparia were held in moist sand or vermiculite until they were radiographed and dissected.) The contents of each puparium were described on the basis of radiographic evidence and then were dissected for verification. Groups were examined, described, and dissected in sequence so that radiographic diagnosis would improve with each group. Puparia were categorized as containing one of the following: (1) a developed pupa; (2) liquified or dried tissue; (3) a hyperparasite. Overall, only two were misidentified and both of these were in the first group (table 1).

Although the technique was developed with a relatively small number of puparia, only a few modifications would be necessary to screen larger collections. Holling (*1958*) developed a lucite holder that permitted X-raying 250 *Neodiprion sertifer* (Geoffroy) cocoons at one time. His technique proved feasible for classifying cocoons containing healthy, parasitized, and diseased sawflies.

Beyond our immediate research requirements, the radiographic technique would be applicable in parasite release programs in several ways:

1. The number of parasites released for either the establishment of the species or as an inundative procedure for immediate control will most certainly require that certain

Table 1.—*Verification, by dissection, of radiographic predictions made for contents of* Blepharipa scutellata, Parasetigena agilis, *and* Compsilura concinnata *puparia.*

State	Radiograph prediction	Dissection
Normal fly pupa	17	19
Liquified or granular	15	14
Hyperparasitized	3	3
Diseased pupa	1	1
Deformed pupa	1	0
	37	37

numbers be available. If mass collection is to be part of such a program, then we must be able to assess the number of healthy pupae in any particular collection. In terms of costs and benefits (man-hours spent collecting), knowledge of the presence of healthy specimens might indicate whether collecting in any particular site would be worthwhile.

2. Fall introduction would eliminate holding cages and the handling of emerging adults in the spring.

3. Fall collections of puparia could be placed immediately in a target area because the possibilities of introducing hyperparasites concealed in puparia would be eliminated.

4. Radiography provides a sampling tool for assessing the overwintering population in any particular area.

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WEIGHTED REGRESSION ANALYSIS AND INTERVAL ESTIMATORS

Abstract.—A method for deriving the weighted least squares estimators for the parameters of a multiple regression model. Confidence intervals for expected values, and prediction intervals for the means of future samples are given.

Weighted regression analysis is applicable to many forestry problems. Cunia (*1964*) discusses in detail weighted regression analysis and analyzes the relationship between volume and diameter in black spruce. Many elementary statistics books cover weighted regression analysis, but generally there is little or no discussion of interval estimators. The purpose of this paper is to discuss: (1) confidence intervals for expected values; (2) prediction intervals for means of future samples when the parameters of a multiple regression model are estimated by weighted least squares.

THE REGRESSION MODEL

Suppose we have a sample of n individuals. The model for i^{th} observation is

$$y_i = x_{1i}\beta_1 + x_{2i}\beta_2 + \ldots + x_{pi}\beta_p + e_i$$

or

$$y_i = x_i\beta + e_i. \qquad (1)$$

The set of n observations can be succinctly written

$$y = X\beta + e \qquad (2)$$

where y is the nx1 vector of observations, X is the nxp design matrix, β is a px1 vector of unknown constants, and e is the nx1 vector of errors. It is also assumed that the errors are normally distributed with a mean and variance-covariance matrix

$$E(e) = 0$$

$$\Sigma_e = E(e\,e') = V\sigma^2$$

where V is a known positive definite matrix. σ^2 is a positive scalar and is assumed to be unknown. In many cases V is a function of X.

The form of V depends on the variances and covariances of the observations. Suppose that the errors have unequal variances and are mutually independent. In this case, the variance-covariance matrix of the errors is

$$V\sigma^2 = \begin{bmatrix} v_1 & & & 0 \\ & v_2 & & \\ & & \cdots & \\ 0 & & & v_n \end{bmatrix} \sigma^2.$$

V can be written in the form $V = P'P = PP = P^2$.

Since V is diagonal we have $P = V^{1/2}$ and $P^{-1} = V^{-1/2}$.

WEIGHTED LEAST SQUARES ESTIMATORS

Weighted least squares estimators can be obtained by transforming the original observations to variables that satisfy the assumptions for ordinary least squares. Pre-multiplying equation (2) by P^{-1} gives

$$P^{-1} y = P^{-1}X\beta + P^{-1}e$$

or

$$Z = Q\beta + f. \qquad (3)$$

Equation (3) is an ordinary multiple regression model; that is,

$$E(f) = 0 \text{ and } E(f f') = I\sigma^2.$$

Unweighted least squares theory can be applied directly to the transformed model. The sum of squares of the transformed errors is

$$S = f'f$$
$$= e'V^{-1}e.$$

Since V is diagonal, the sums of squares can be written as

$$S = \Sigma_i v_i^{-1} e_i^2.$$

Hence S is the weighted sums of squares of the errors.

Weighted least squares estimates are obtained by minimizing S for variation in b where b is the solution vector corresponding to the parameter vector β. The weighted normal equations are

$$Q'Qb = Q'Z$$

or

$$X'V^{-1}Xb = X'V^{-1}y.$$

Solving the weighted normal equations for b gives the weighted least squares estimator. The solution is

$$b = (Q'Q)^{-1}Q'Z$$
$$= (X'V^{-1}X)^{-1}X'V^{-1}y.$$

The sums of squares of transformed residuals is

$$SSR = Z'Z - b'Q'Z$$
$$= y'V^{-1}y - y'V^{-1}X (X'V^{-1}X)^{-1}X'V^{-1}y.$$

The sample variance is

$$s^2 = SSR / (n-p)$$

which is an unbiased estimator of σ^2. The variance-covariance matrix of b is

$$\Sigma_b = (Q'Q)^{-1}\sigma^2$$
$$= (X'V^{-1}X)^{-1}\sigma^2.$$

The sample variance-covariance matrix of b is

$$\hat{\Sigma}_b = (Q'Q)^{-1}s^2$$
$$= (X'V^{-1}X)^{-1}s^2.$$

Given V, values of b, s^2, and $\hat{\Sigma}_b$ are easily obtained by ordinary least squares analysis on the transformed variables z and q.

PREDICTED VALUES AND INTERVAL ESTIMATORS

Consider a future sample of k independent observations $(y_1^o, x_1^o), (y_2^o, x_2^o), \ldots, (y_k^o, x_k^o)$. The average of the future values of the dependent variable is

$$\bar{y}^o = \Sigma_{j=1}^k y_j^o/k.$$

The statistic $\bar{y}^o$ is normally distributed with a mean and variance

$$E(\bar{y}^o) = \bar{x}^o\beta$$

and

$$\sigma^2(\bar{y}^o) = \Sigma_{j=1}^k \bar{v}_j \sigma^2$$

The sample estimator of $\sigma^2(\bar{y}^o)$ is

$$s^2(\bar{y}^o) = \bar{v}\, s^2/k.$$

Now consider the predicted values of dependent variable based on the regression estimates. The prediction for the value of the j^{th} future observation is

$$y^*_j = x^o_j b.$$

The average of the regression estimates is

$$\bar{y}^* = (1/k)\, \Sigma_{j=1}^k\, y^*_j = \bar{x}^o b$$

where $\bar{x}^o = (1/k)\, \Sigma_{j=1}^k x_j^o$

= average of the vectors x_j^o.

The statistic $\bar{y}^*$ is normally distributed with a mean and variance

$$E(\bar{y}^*) = \bar{x}^o\beta$$

and

$$\sigma^2(\bar{y}^*) = \bar{x}^o\Sigma_b\bar{x}^{o\prime}.$$

The sample estimator of $\sigma^2(\bar{y}^*)$ is

$$s^2(\bar{y}^*) = \bar{x}^o\, (Q'Q)^{-1}\bar{x}^{o\prime}s^2.$$

Under the assumptions of the model the statistic

$$t = (\bar{x}^o b - \bar{x}^o \beta) / s(\bar{y}^*)$$

has a Student's t distribution with n-p degrees of freedom. Consequently, the confidence interval for the expected value of the average of the regression estimates is obtained from the probability statement

$$P(\bar{x}^o b - ts(\bar{y}^*) \leq \bar{x}^o \beta \leq \bar{x}^o b + ts(\bar{y}^*) = 1-\alpha$$

where $t = t_{1-\alpha/2, n-p}$. (4)

We are also interested in a prediction interval for the future mean $\bar{y}^o$. The prediction interval gives on a probability basis the range of error of the future mean.

Let $d = \bar{y}^o - \bar{y}^*$. The statistic d is normally distributed with a mean and variance of

$$E(d) = E(\bar{y}^o) - E(\bar{y}^*) = \bar{x}^o\beta - \bar{x}^o\beta = 0$$
$$\sigma^2(d) = \sigma^2(\bar{y}^o) + \sigma^2(\bar{y}^*)$$
$$= \sigma^2(\bar{v}/k + \bar{x}^o(Q'Q)^{-1}\bar{x}^{o\prime}).$$

The sample estimator of $\sigma^2(d)$ is

$$s^2(d) = s^2(\bar{v}/k + \bar{x}^o(Q'Q)^{-1}\bar{x}^{o\prime}).$$

Note that the statistics $\bar{y}^o$ and $\bar{x}^o b$ are statistically independent since they are based on independent samples.

It follows from the assumptions that the quantity d/s_d has a Student's t distribution with n-p degrees of freedom. Therefore the prediction interval for the future mean $\bar{y}^o$ given $(x_1^o, x_2^o, \ldots x_k^o)$ can be calculated from the probability statement

$$P(\bar{x}^o b - ts_d \leq \bar{y}^o \leq \bar{x}^o b + ts_d) = 1-\alpha. \quad (5)$$

Several examples of situations where these types of intervals arise follow.

I. In regression analysis the confidence intervals for the expected value of y given x^o can be calculated for several values of x^o. The upper and lower confidence limits are often plotted about the estimated regression line. Also, it is a common practice to plot the prediction interval for one future value given x^o. In this case, the quantities $\bar{x}^o$ and $\bar{v}$ in the interval estimators are replaced by x^o and v respectively. The vector x^o is single vector of specific values say $(x_1^o, x_2^o, \ldots x_p^o)$ and v is the weight associated with x^o.

II. Consider a population of a large number (N) of trees where the trees are measurable for volume (y) and diameter at breast height (d). A random sample of n trees is measured and a parabolic regression $E(y) = \alpha + \beta d + \gamma d^2$ is estimated by weighted least squares. Suppose that sometime in the near future, k trees of preselected diameters are to be sampled from the forest. The sample will consist of k_1 trees of diameter d_1, k_2 trees of diameter $d_2, \ldots, k_s$ trees of diameter d_s. Also assume that the size of the future sample k is small in respect to the number of trees in the population N.

We are interested in

(1). A point estimator of the average volume $\bar{y}^*$. The estimator is

$$\bar{x}^o b = (1, \bar{d}, \bar{d^2})\ (1, \hat{\beta}, \hat{\gamma})'$$

where $\bar{d} = \Sigma_{i=1}^{s}\ k_i d_i / k$,

$\bar{d^2} = \Sigma_{i=1}^{s}\ k_i d_i^2 / k$, and $\hat{\beta}$ and $\hat{\gamma}$ are the weighted least squares estimates of β and γ.

(2). The 1-α confidence interval for the expected value of $\bar{y}^*$ which is obtained from equation (4).

(3). The 1-α prediction interval for the future mean $(\bar{y}^o)$ which is obtained from equation (5).

III. Consider the case where an entire forest is harvested. All values of the vector x are measured. Let u be the mean of all vectors x_j. A small random sample of observations (y, x) are measured and the weighted parabolic regression is estimated.

(1). The multiple regression estimator of the average volume is u b.

(2). The confidence interval for u b is is given by

$$u\,b \pm t_{1-\alpha/2,\ n-p}\ [u\ (Q'Q)^{-1}u' s^2]^{1/2}$$

IV. It may be too expensive to measure the diameter of all the trees. Instead, the diameter is measured on a second large independent sample. The double sampling estimator of $u\beta$ is $\bar{x}_d b$ where $\bar{x}_d$ is the mean vector from the second sample. Equation (5) is not the proper expression for the confidence interval for $\bar{x}_d\beta$ because $\bar{x}_d$ is a random vector. An approximation of $\sigma^2(\bar{x}_d b)$ is given by Sen (1973).

EXAMPLES

Cunia (*1964*) found a curvilinear relationship between the volume and diameter in black spruce. The relationship can be written

$$y_i = \alpha + \beta d_i + \gamma d_i^2 + e_i \qquad (6)$$

where y_i is the volume and d_i is the diameter of the i^{th} tree. He also found that the variance of the volume can reasonably be assumed to be proportional to the fourth power of the diameter. Assuming the errors are independent, the variance-covariance matrix is

$$\Sigma = \begin{bmatrix} d_1^4 & & & 0 \\ & d_2^4 & & \\ & & \cdots & \\ 0 & & & d_n^4 \end{bmatrix} \sigma^2.$$

The matrices P and P^{-1} are

$$P = \begin{bmatrix} d_1^2 & & & 0 \\ & d_2^2 & & \\ & & \cdots & \\ 0 & & & d_n^2 \end{bmatrix} \text{and } P^{-1} = \begin{bmatrix} d_1^{-2} & & & 0 \\ & d_2^{-2} & & \\ & & \cdots & \\ 0 & & & d_n^{-2} \end{bmatrix}$$

Premultiplying the set of observations by P^{-1}, results in a set of equations whose i^{th} row is

$$y_i/d_i^2 = \alpha(1/d_i^2) + \beta(1/d_i) + \gamma(1) + e_i/d_i^2$$

$$\text{or} \quad z_i = \alpha q_{1i} + \beta q_{2i} + \gamma q_{3i} + f_i \qquad (7)$$

The first step in the weighted regression analysis is to transform the data. Cunia (*1964: Table 3*) gives diameters and volumes for 25 black spruce. The original measurements have the form

Tree No.	*Diameter (d) (inches)*	*Volume (y) (cubic ft.)*
1	3.9	1.0
2	4.1	1.6
—	—	—
—	—	—
—	—	—
25	12.7	25.4

The transformed values needed for analysis for the weighted multiple regression are

Tree No.	$q_1=1/d^2$	$q_2=1/d$	$q_3=1.0$	$z=y/d^2$
1	.065740	.2564	1.0	.0657
2	.059487	.2439	1.0	.0952
—	—	—	—	—
—	—	—	—	—
—	—	—	—	—
25	.006193	.0787	1.0	.1575

The transformed data can be analyzed with any multiple regression program. Most regression programs print b, s^2, and $(Q'Q)^{-1}$. Computer programs with the option for testing hypotheses of the form $x\beta = d$ should also print the quantities xb and $x(Q'Q)^{-1}x'$.

An ordinary least squares analysis of the transformed values was done with BIOMEDX63.* The statistics of interest are

$$b' = (\hat{\alpha}\ \hat{\beta}\ \hat{\gamma}) = (1.19040, -0.76579, 0.19638)$$

$$(Q'Q)^{-1} = \begin{bmatrix} 6218.83 & -2024.18 & 145.87 \\ -2024.18 & 672.12 & -49.59 \\ 145.87 & -49.57 & 3.79 \end{bmatrix}$$

and $s^2 = 0.0053/22 = 0.000241$.

Confidence Intervals for $x\beta$ and Prediction Intervals for one future observation y^o

Suppose we want the expected volume and interval estimates for a 10 inch diameter black spruce. The estimate is $xb = (1, 10, 100)\ b = 13.17070$ cubic feet. To compute the .95 confidence interval we also need

$$x(Q'Q)^{-1}x' = 912.12102$$

and $t_{.975,22} = 2.074$.
Then from equation (4) we have

$$P(12.20 \leq \alpha + 10\beta + 100\gamma \leq 14.14) = .95$$

To compute the prediction interval for volume of a single future observation for a 10 inch black spruce we need

$$\bar{v}/k = d^4/1$$
$$= 10^4$$

The prediction interval is

$$P(9.81 \leq y^o \leq 16.53) = .95.$$

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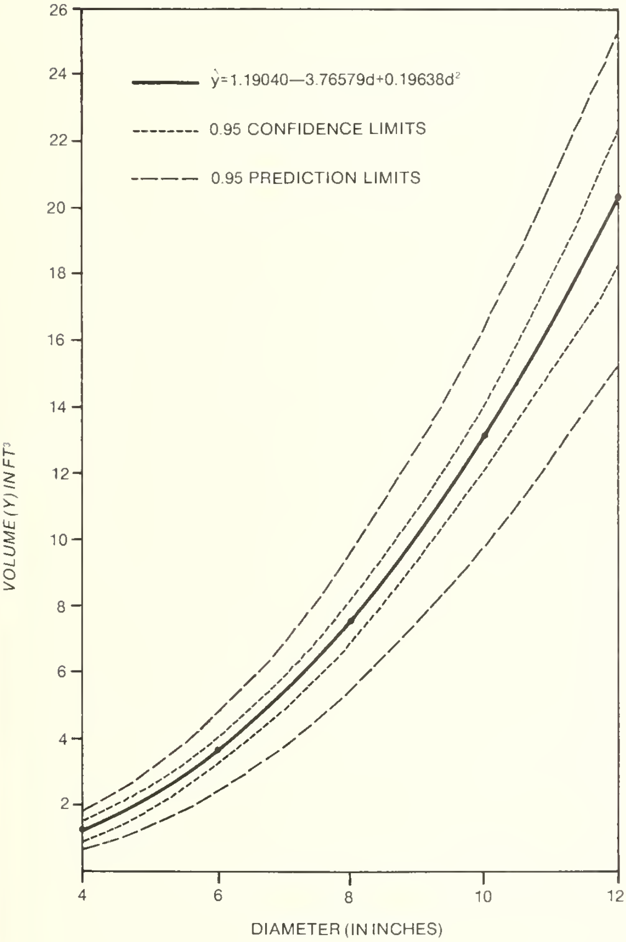
* See BIOMEDX63-multivariate general linear hypothesis. Univ. Cal. Publi. in Autom. Comput. 3. W. J. Dixon, Editor. Univ. Cal. Press. 1969.

The sample regression line, confidence intervals, and prediction intervals for one future value are shown in Fig. 1. Note the increasing width of confidence and prediction intervals with increasing diameter. The flare in the intervals is the result of assumption that the variance of the volume is proportioned to the fourth power of the diameter.

Figure 1.—Weighted regression line, 0.95 confidence intervals, and 0.95 prediction intervals based on the sample of 25 black spruce.



Multiple Regression Estimate

Cunia (*1964: Table 2*) gives the following diameter distribution for 1188 black spruce.

Diameter	*Number*
4	156
5	321
6	265
7	130
8	146
9	84
10	19
11.5	51
13.5	12
15.5	4

The mean vector is $u = (1, \bar{d}, \bar{d}^2) = (1, 6.44, 45.77)$. The estimated mean volume for this population of trees is 5.247 cubic feet per tree. The variance of ub is $u(Q'Q)^{-1}u's^2 = 0.023208$. and the 0.95 confidence interval for $u\beta$ is

$$5.247 \pm 2.074\ (.023208)^{1/2}$$
$$= 5.247 \pm 0.315957$$

The examples show that weighted regression is no more difficult than ordinary least square analysis. Interval estimates are easily obtained from ordinary multiple regression analysis of the transformed data. Special computer programs are not needed.

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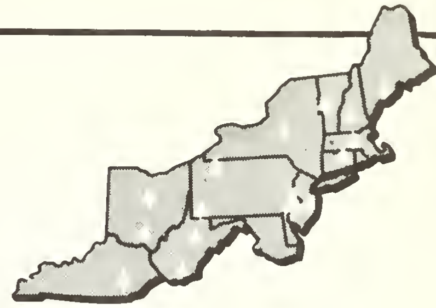

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A PREVIEW OF VERMONT'S FOREST RESOURCE

Abstract. Forest land occupies 75 percent of the total land area in Vermont. Nearly one-half of this forest land is the beech-birch-maple forest type. The inventory data show volume increasing but at a lower rate than in neighboring states. This is due to large losses from cull and mortality. Total growing-stock volume is now 4.7 billion cubic feet.

A third inventory of the forest resources of Vermont had been completed by the U. S. Forest Service, Forest Survey. Data from the 1973 inventory along with the earlier inventories of 1948 and 1966 provide a view of the recent history of forest resource changes in Vermont. A detailed statistical and analytical report on the current inventory with an analysis of the trends it reveals is being prepared for publication. This is a preview of that report.

Three of Four Acres Are Forested

Forest land occupies over 75 percent of the total land area in Vermont. Nearly all of the 4.5 million acres of forest land was classified as commercial. About half of this is the maple-beech-birch forest type. White and red pine and spruce-fir are the major softwood types. These two softwood types occupy 32 percent of the forest area. The remaining 21 percent consists of the elm-ash-red maple, aspen-birch, and oak forest types. This distribution shows no major shift in forest-type acreages in the seven years since the last inventory.

The 63.8 thousand acres of noncommercial forest land in 1973 is a 135 percent increase in noncommercial forest land since 1966. Nearly half of this increase was the result of the classification of Christmas tree plantations as productive reserved forest land rather than as commercial forest land. The remainder of this increased acreage was State-owned forest land that was reclassified as productive reserved land by various state resource agencies between 1966 and 1973.

Nearly half of the current commercial forest land is in sawtimber stands. Poletimber stands comprise 22 percent of the area, and seedling and sapling stands make up another 31 percent. The stand sizes shown for 1973 are classified differently from those used in 1966. When the 1973 data were arranged like those of 1966, the following changes in stand size were apparent.

	Percentage of total commercial forest land	
	1966	*1973*
Sawtimber	41	48
Poletimber	35	33
Seedling, sapling	23	18
Nonstocked	1	1
	100	100

A glance at the stand-size distribution by forest types indicates that sawtimber stands comprise a higher-than-average proportion of the area for the white and red pine and maple-beech-birch types.

All of the counties included in the inventory are more than 50 percent forested. Franklin County is the least forested, with 56 percent of the land area in forest. Essex County is nearly 94 percent forested. In the northern counties, softwood types occupy nearly as much acreage as hardwood types. Hardwood types predominate in the southern counties, where they occupy about three times as much area as the softwood types. Essex County has the largest acreage of softwood types, while Windsor County has the largest area in hardwood types.

A study of the owners of private commercial forest land was conducted concurrently with this forest survey. This study revealed that less than one-third of the owners of private commercial forest land have harvested timber from their land. However, these individuals own two-thirds of the private commercial forest area.

Growing-stock Volume Averages Over 1,000 Cubic Feet per Acre

The total volume of growing stock is now 4.7 billion cubic feet. The sawtimber portion totals 9.7 billion board feet. Total growing stock averages 1,068 cubic feet per acre of commercial forest land. This is over 13 cords per acre.[1] The sawtimber portion of the growing stock averages 2,194 board feet per acre. Essex County has the highest average volume per acre—1,212 cubic feet and 2,519 board feet. Franklin County has the lowest average volume per acre—805 cubic feet and 1,547 board feet.

The distribution of growing-stock volume by species has changed very little in the past 7 years. Hardwood volume is still twice softwood volume. Sugar maple is the most prevalent species in the State. It accounts for 23 percent of the total cubic-foot volume of all species. Spruce is the most prevalent softwood, with 11 percent of the total cubic-foot volume. Other important species are red maple, hemlock, white pine, balsam fir, yellow birch, and paper birch. Each of these comprise 6 percent or more of the total cubic-foot volume.

Net Growth is Low

The volume of timber growing on commercial forest land in Vermont has increased during the past 7 years. However, this increase has been considerably less than it might have been had the full growth potential of the forest been realized. The last timber resource report for the State indicated that growth was considerably below potential[2] and the results of this third inventory reinforce this conclusion. As the following data show, Vermont's forest lands have lower annual net growth than those in the rest of New England:

	Vermont	*New England except Vermont*
	Net cubic feet/acre	
Gross growth	41.14	52.26
Cull increment	10.28	6.29
Mortality	6.79	6.21
Net growth	24.07	39.76

Net growth equals gross growth minus cull increment and mortality.

A comparison of growing stock in Vermont with that of the other five New England states shows that gross growth per acre is 21 percent less in Vermont than in the re-

[1]Based on 80 cubic feet of solid wood per standard cord.

[2]Kingsley, N. P. and J. E. Barnard, 1968. The Timber Resources of Vermont, USDA Forest Service Resource Bulletin NE-12, p. 25.

mainder of New England. This is not because of poorer site potential in Vermont but because only 26 percent of the forest land is fully stocked with growing-stock trees. By comparison, in the other New England states between 46 and 59 percent of the commercial forest land is fully stocked. This means that in Vermont there is a smaller growing-stock base on which growth can occur.

A second problem is loss of growing stock to cull increment and mortality. Mortality is the volume of growing-stock trees that have died since the beginning of the measurement period. Cull increment is the volume of trees that were classified as growing stock at the beginning of the measurement period but were of too poor quality at the end of the period to be classed as growing stock. In Vermont the result of these factors was that net growth was only 58 percent of gross growth. In the remainder of New England, net growth was 76 percent of gross growth.

The fact that 25 percent of the gross growth in Vermont is lost because of cull increment points to the need for a major program of timber stand improvement. These cull trees, unlike those lost by mortality, continue to live and occupy valuable growing space in a stand. Their removal and replacement with better quality stems is necessary if net growth is to be increased.

Table 1.—*Land area in Vermont, by county and land classes, 1973*

County	Total land area[a]	Nonforest land area	Forest land area[b]		
			Noncommercial[c]	Commercial	
	Thousand acres				*Percent*
Addison	501.5	209.2	6.5	285.8	57
Bennington	430.2	54.1	5.4	370.7	86
Caledonia	391.9	96.3	4.3	291.3	74
Chittenden	341.1	127.9	17.5	195.7	57
Essex	424.5	27.2	1.2	396.1	93
Franklin	422.7	184.6	1.2	236.9	56
Grand Isle	53.3	53.3	—	—	—
Lamoille	303.6	49.2	3.2	251.2	83
Orange	441.7	105.3	.5	335.9	76
Orleans	457.4	118.3	.1	339.0	74
Rutland	593.3	139.3	9.1	444.9	75
Washington	452.8	86.8	4.7	361.3	80
Windham	503.6	72.1	3.0	428.5	85
Windsor	617.8	118.1	7.1	492.6	80
Total	5,935.4	1,441.7	63.8	4,429.9	75

[a] Source: Area Measurement Report, Bureau of the Census, Areas of Vermont: 1960, (January, 1967).
[b] Except where noted otherwise, all tables include data for the Green Mountain National Forest.
[c] Includes unproductive and productive reserved forest land.

Table 2.—*Number and area held by private owners of commercial forest land, by form of ownership and timber harvest activity, Vermont, 1973*

Form of ownership	All owners		Owners who have harvested timber	
	Number	*Thousand acres*	*Number*	*Thousand acres*
Individual	73,891	2,935.6	20,234	1,709.1
Partnership	195	48.3	31	19.3
Corporation	714	859.5	629	791.9
Other[a]	2,509	144.9	2,140	115.9
Total	77,309	3,988.3	23,034	2,636.2

[a] Includes associations, clubs, and undivided estates.

Table 3.—*Area of commercial forest land, by forest types and size classes, Vermont, 1973*

(In thousands of acres)

Forest type	All stands	Saw-timber stands	Pole-timber stands	Sapling-seedling stands	Nonstocked areas
White and red pine	650.1	437.7	45.2	156.9	10.3
Spruce-fir	784.4	178.3	224.1	372.7	9.3
Oak-pine	85.3	30.9	19.4	35.0	—
Oak-hickory	70.9	42.7	28.2	—	—
Elm-ash-red maple	504.9	180.5	118.2	196.0	10.2
Maple-beech-birch	2,082.4	1,143.7	436.2	502.5	—
Aspen-birch	251.9	47.2	83.2	113.4	8.1
All types	4,429.9	2,061.0	954.5	1,376.5	37.9

Table 4.—*Area of commercial forest land in Vermont, by county and forest type, 1973*

County	Softwood types	Hardwood types	All types	Sampling error of total[a]
	— — —	*Thousand acres*	— —	*Percent*
Addison	69.5	216.3	285.8	16
Bennington	78.1	292.6	370.7	3
Caledonia	124.5	166.8	291.3	8
Chittenden	56.4	139.3	195.7	14
Essex	147.3	248.8	396.1	2
Franklin	112.7	124.2	236.9	15
Lamoille	95.5	155.7	251.2	5
Orange	140.2	195.7	335.9	7
Orleans	142.0	197.0	339.0	8
Rutland	104.5	340.4	444.9	7
Washington	137.1	224.2	361.3	6
Windham	103.1	325.4	428.5	4
Windsor	123.6	369.0	492.6	6
Total	1,434.5	2,995.4	4,429.9	2

[a]For total commercial forest land at the 68 percent probability level.

Table 5.—*Annual net growth and removals of growing stock and sawtimber on commercial forest land, by species groups, Vermont, 1972*

Species groups	Growing stock		Sawtimber	
	Net growth	Removals	Net growth	Removals
	Thousand cubic feet		*Thousand board feet*[a]	
Softwoods	46,500	19,400	129,000	52,000
Hardwoods	60,100	28,400	133,000	66,000
Total	106,600	47,800	262,000	118,000
	— — — — — — — —	*Percent*	— — — — — — — —	
Sampling error of totals	9	29	13	29

[a]International ¼-inch rule.

Table 6.—*Net volume of growing stock on commercial forest land in Vermont, by county and species group, 1973*

County	Softwoods	Hardwoods	Total	Sampling error of total
	———	*Million cubic feet*	————	*Percent*
Addison	68.7	207.8	276.5	9
Bennington	99.2	300.7	399.9	7
Caledonia	148.7	153.6	302.3	9
Chittenden	53.8	135.2	189.0	13
Essex	212.7	267.3	480.0	7
Franklin	98.5	92.3	190.8	13
Lamoille	129.2	163.4	292.6	10
Orange	162.9	189.5	352.4	9
Orleans	170.3	194.8	365.1	9
Rutland	119.3	343.5	462.8	7
Washington	176.5	228.3	404.8	8
Windham	127.0	346.3	473.3	7
Windsor	151.2	389.5	540.7	7
Total	1,718.0	3,012.2	4,730.2	2

Table 7.—*Net volume of growing-stock trees*[a] *on commercial forest land, by species and tree size, Vermont, 1973*

Species	All trees	Poletimber trees	Sawtimber trees	
	————	*Million cubic feet*	————	*Million board feet*[b]
Spruce	532.3	245.1	287.2	1,142.0
White and red pine	387.1	125.6	261.5	1,070.4
Hemlock	378.6	114.6	264.0	1,050.6
Balsam fir	337.7	210.7	127.0	485.3
Other softwoods	82.3	48.7	33.6	127.2
Total softwoods	1,718.0	744.7	973.3	3,875.5
Sugar maple	1,083.2	528.4	554.8	2,325.4
Red maple	450.3	265.3	185.0	744.5
Yellow birch	331.7	156.4	175.3	736.5
Paper birch	282.1	199.7	82.4	333.2
Beech	236.3	100.7	135.6	561.4
Ash	181.3	105.8	75.5	305.6
Aspen	135.2	97.3	37.9	153.7
Select red oaks	113.1	37.4	75.7	315.0
Other hardwoods	199.0	108.5	90.5	369.9
Total hardwoods	3,012.2	1,599.5	1,412.7	5,845.2
All species	4,730.2	2,344.2	2,386.0	9,720.7

[a]Growing stock trees are trees that satisfy national specifications for form and cull. Net volumes are given for all such trees 5.0 inches dbh and larger.
[b]International ¼-inch rule.

Table 8.—*Net volume of sawtimber on commercial forest land in Vermont, by county and species group, 1973*

County	Softwoods	Hardwoods	Total	Sampling error of total
	Million board feet[a]			*Percent*
Addison	166.7	405.3	572.0	12
Bennington	251.2	574.8	826.0	9
Caledonia	314.8	307.8	622.6	13
Chittenden	137.6	243.7	381.3	18
Essex	456.4	541.3	997.7	10
Franklin	187.2	179.3	366.5	17
Lamoille	274.4	330.3	604.7	14
Orange	334.1	379.8	713.9	13
Orleans	358.4	392.5	750.9	13
Rutland	301.5	649.7	951.2	10
Washington	370.4	465.7	836.1	11
Windham	331.9	643.1	975.0	10
Windsor	390.9	731.9	1,122.8	10
Total	3,875.5	5,845.2	9,720.7	3

[a] International ¼-inch rule.

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A PREVIEW OF NEW HAMPSHIRE'S FOREST RESOURCE

Abstract.—Forest continues to be the dominant land use in New Hampshire. Three inventories of the State between 1948 and 1973 show little change in the total forest area but significant shifts in forest type and stand size. Average volume per acre has increased to over 1,400 cubic feet and 2,785 board feet. Growth continues to exceed removals.

Forest is the major natural resource of New Hampshire. Since 1948, this resource has been inventoried three times by the USDA Forest Service, Forest Survey. Each inventory was designed to provide a reliable estimate of the extent and condition of the forest resource, and to indicate what changes were occurring. A detailed statistical and analytical report of the most recent inventory is being prepared for publication. It will give a comprehensive analysis of the current situation and trends in the forest resource. This is a preview of that report.

Forest Land Dominates the New Hampshire Landscape

In 1973, forest occupied 86 percent of the total land area of New Hampshire. It has held this dominant position with very little change in total acreage for 25 years. However, there have been important shifts: forest land area has increased in the three northern counties and decreased in the southern part of the State. There has been a decrease in the area classified as commercial forest land. The amount of forest land classified in the unproductive and productive reserved categories has increased. Most of this increase was the result of administrative reclassification of public forest land.

Of the nearly 5 million acres of forest, 4,692,000 acres are classified as commercial forest land. In both 1948 and 1973, commercial forest land occupied 81 percent of the total land area; the 1960 inventory showed it occupying 85 percent. However, the difference for 1960 is within the sampling errors associated with each of these statistics. And it is evident that there have been no significant changes in the total area of commercial forest land during the past 25 years.

However, there have been real shifts within the commercial forest land. This third inventory of the State's forest lands revealed several major shifts in the distribution of forest types. The acreage occupied by the spruce-fir and oak forest types declined appreciably, but the growth on the remaining stands produced increases in volume of the species comprising these types. The acreage losses in these types were offset by an increase in the area of the elm-ash-red maple type. Most of this is in the local red maple type. The acreages in northern hardwood and white pine types remained stable.

Since the 1948 forest survey of New Hampshire, size distribution has changed because of the growth of individual trees. The current data show a continued increase in the area in sawtimber stands. The area in poletimber stands has decreased, and the area in seedling and sapling stands has increased. This latter change is probably the result of management in mature stands that were ready for harvest.

Concurrently with this third inventory of the forest resource, the Forest Survey conducted a study of forest landowners. The study indicates that less than one in five of the owners of forest land has harvested timber from his lands. However, these 18 percent of owners own 65 percent of the private commercial forest land in New Hampshire.

Dramatic Increases in Growing Stock and Sawtimber Volume

The most noteworthy change since the earlier inventories is the dramatic increase in both growing stock and sawtimber volume. During the past 13 years, the average volume per acre increased by nearly 50 percent. Total growing-stock volume averages over 1,400 cubic feet per acre. This is nearly 18 cords.[1] The sawtimber portion of growing stock averages 2,785 board feet per acre.

The increase in growing-stock volume has not been uniform for all species. Since 1948 significant changes have occurred in the species composition of the growing stock. Here are the relative positions of the 10 species with the largest cubic-foot volume in 1948 and in 1973:

Species	*1948*	*1973*
White pine	1	1
Yellow birch	2	8
Spruce	3	5
Red maple	4	2
Hemlock	5	4
Paper birch	6	9
Sugar maple	7	7
Balsam fir	8	6
Beech	9	10
Red oak	10	3

White pine continues to be the most common species. Yellow birch, the most prevalent hardwood in 1948, has not increased in volume. The 1948 and 1973 estimates of yellow birch growing stock are the same. With yellow birch dropping to eighth position, red maple, red oak, and sugar maple are now the most prevalent hardwoods in that order. Red maple and red oak each have more volume now than the spruces. Hemlock has now become the second most prevalent softwood, replacing spruce.

Although the volume of sawtimber continues to increase for all species, the quality of the current sawlog supply has declined. In 1948, 36 percent of the board-foot volume of hardwoods was in standard-lumber log grades 1 and 2. Only 29 percent of the current hardwood volume is in these grades. Less than 15 percent of the 4.2 billion board feet of white pine is grade 1 or 2, a drop from 17 percent in 1948.

Net Growth Averages ½ Cord

Average annual net growth of all growing stock was 43.6 cubic feet per acre during the past 13 years. Removals during this period averaged 14.1 cubic feet per acre. Expressed in cords, this was an average annual growth of .54 cords per acre with .18 cords per acre of removals. Removals were approximately one-third of growing-stock growth in both softwoods and hardwoods. The sawtimber portion of growing stock also had a positive balance between growth and removals. However, considerably more of the total sawtimber removals were from softwoods than from hardwoods.

[1] Based on 80 cubic feet of solid wood per standard cord.

Table 1.—Land area in New Hampshire, by county and land classes, 1973

County	Total land area[a]	Nonforest land area	Forest land area: Noncommercial[b]	Forest land area: Commercial	
	Thousand acres				*Percent*
Belknap	256.1	50.2	2.3	203.6	80
Carroll	600.2	50.8	34.6	514.8	86
Cheshire	457.8	66.9	8.0	382.9	84
Coos	1,164.7	57.1	101.0	1,006.6	86
Grafton	1,108.3	114.9	103.0	890.4	80
Hillsborough	571.6	115.5	14.6	441.5	77
Merrimack	595.3	110.1	6.9	478.3	80
Rockingham	442.0	111.4	14.8	315.8	71
Strafford	240.3	56.1	2.7	181.5	76
Sullivan	344.8	63.0	5.2	276.6	80
Total	5,781.1	796.0	293.1	4,692.0	81

[a] Source: Area Measurement Report, Bureau of the Census, Areas of New Hampshire: 1960, (December, 1966).
[b] Includes unproductive and productive-reserved forest land.

Table 2.—Number and area held by private owners of commercial forest land, by form of ownership and timber harvest activity, New Hampshire, 1973

Form of ownership	All owners: *Number*	All owners: *Thousand acres*	Owners who have harvested timber: *Number*	Owners who have harvested timber: *Thousand acres*
Individual and joint	85,600	2,459.1	14,700	1,194.0
Partnership	280	239.0	180	191.0
Corporation	1,150	1,241.0	770	1,130.0
Other[a]	460	143.0	450	135.0
Total	87,490	4,082.1	16,100	2,650.0

[a] Includes associations, clubs, and undivided estates.

Table 3.—Area of commercial forest land, by forest types and size classes, New Hampshire, 1973

(In thousands of acres)

Forest type	All stands	Saw-timber stands	Pole-timber stands	Sapling-seedling stands	Non-stocked areas
White and red pine	1,344.6	836.8	237.1	256.4	14.3
Spruce-fir	635.9	169.7	253.8	212.4	—
Pitch pine	35.8	14.8	—	14.3	6.7
Oak-white pine	72.7	37.0	7.2	28.5	—
Oak-hickory	322.9	107.5	158.1	57.3	—
Elm-ash-red maple	737.6	164.8	287.0	278.7	7.1
Maple-beech-birch	1,308.3	580.7	527.9	192.6	7.1
Aspen-birch	234.2	34.9	84.5	114.8	—
All types	4,692.0	1,946.2	1,555.6	1,155.0	35.2

Table 4.—Area of commercial forest land in New Hampshire, by county and forest type, 1973

County	Softwood types	Hardwood types	All types	Sampling error of total[a]
	— — — *Thousand acres*		— — —	*Percent*
Belknap	97.1	106.5	203.6	5
Carroll	206.8	308.0	514.8	2
Cheshire	166.4	216.5	382.9	3
Coos	446.2	560.4	1,006.6	1
Grafton	323.7	566.7	890.4	2
Hillsborough	198.0	243.5	441.5	4
Merrimack	206.3	272.0	478.3	3
Rockingham	156.8	159.0	315.8	4
Strafford	84.6	96.9	181.5	5
Sullivan	130.4	146.2	276.6	5
Total	2,016.3	2,675.7	4,692.0	1

[a] For total commercial forest land, at the 68 percent probability level.

Table 5.—Net volume of growing stock on commercial forest land in New Hampshire, by county and species group, 1973

County	Softwoods	Hardwoods	Total	Sampling error of total
	— — — *Million cubic feet*		— — —	*Percent*
Belknap	145.5	141.0	286.5	8
Carroll	318.1	395.9	714.0	7
Cheshire	250.8	282.5	533.3	7
Coos	718.5	735.2	1,453.7	4
Grafton	535.7	727.6	1,263.3	5
Hillsborough	308.4	311.9	620.3	6
Merrimack	302.0	333.3	635.3	6
Rockingham	247.0	207.6	454.6	8
Strafford	130.1	117.9	248.0	10
Sullivan	183.8	185.8	369.6	8
Total	3,139.9	3,438.7	6,578.6	2

Table 6.—Net volume of sawtimber on commercial forest land in New Hampshire, by county and species group, 1973

County	Softwoods	Hardwoods	Total	Sampling error of total
	— — — *Million board feet*[a]		— — —	*Percent*
Belknap	409.0	182.4	591.4	13
Carroll	665.5	721.8	1,387.3	11
Cheshire	701.8	370.3	1,072.1	10
Coos	1,453.2	1,305.4	2,758.6	7
Grafton	1,123.4	1,345.2	2,468.6	8
Hillsborough	857.1	415.6	1,272.7	9
Merrimack	845.7	433.4	1,279.1	9
Rockingham	695.2	266.1	961.3	11
Strafford	362.9	154.8	517.7	14
Sullivan	511.2	245.6	756.8	12
Total	7,625.0	5,440.6	13,065.6	3

[a] International ¼-inch rule.

Table 7.—Net volume of growing-stock trees[a] on commercial forest land, by species and tree size, New Hampshire, 1973

Species	All trees	Poletimber trees	Sawtimber trees	
	— — —	*Million cubic feet*	— — —	*Million board feet*[b]
White and red pine	1,456.3	407.9	1,048.4	4,286.6
Hemlock	563.9	181.1	382.8	1,462.1
Spruce	547.6	308.1	239.5	922.0
Balsam fir	541.3	314.2	227.1	865.3
Other softwoods	30.8	7.3	23.5	89.0
Total softwoods	3,139.9	1,218.6	1,921.3	7,625.0
Northern red oak	530.2	245.1	285.1	1,170.3
Other oaks	93.0	59.6	33.4	136.1
Red maple	854.8	607.2	247.6	977.7
Sugar maple	450.5	233.5	217.0	895.7
Yellow birch	416.5	199.0	217.5	938.2
Paper birch	399.9	315.3	84.6	349.0
Beech	271.1	146.4	124.7	530.2
Ash	132.2	83.9	48.3	199.2
Aspen	153.2	121.7	31.5	124.0
Other hardwoods	137.3	108.0	29.3	120.2
Total hardwoods	3,438.7	2,119.7	1,319.0	5,440.6
All species	6,578.6	3,338.3	3,240.3	13,065.6

[a] Growing stock trees are trees that satisfy national specifications for form and cull. Net volumes are given for all such trees 5.0 inches dbh and larger.
[b] International ¼-inch rule.

Table 8.—Average annual net growth and removals of growing stock and sawtimber on commercial forest land, softwoods and hardwoods, New Hampshire, 1958-72

Species group	Growing stock		Sawtimber	
	Net growth	Removals	Net growth	Removals
	Thousand cubic feet		*Thousand board feet*[a]	
Softwoods	107,500	38,100	278,500	124,200
Hardwoods	97,200	28,200	172,100	53,900
Total	204,700	66,300	450,600	178,100
	— — — — — — *Percent* — — — — — — —			
Sampling error of totals	6	18	8	20

[a] International ¼-inch rule.

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ODC 160.21:176.1 *Liriodendron tulipifera*

NUTRIENT COMPOSITION OF BLADES, PETIOLES, AND WHOLE LEAVES FROM FERTILIZED AND UNFERTILIZED YELLOW-POPLAR

Abstract. — Nitrogen (N) and phosphorus (P) concentrations in leaf blades and petioles obtained from three fertilized and three unfertilized yellow-poplar sample trees were determined annually during a 4-year period. Concentrations were substantially higher in blades than in petioles. Fertilization increased N and P concentrations in blades, but petioles showed only a slight increase in N and a decrease in P. Because blades were more responsive to changes in external nutrient supply than petioles, and because fertilization affected the composition of blades and whole leaves unequally, blades give a more sensitive and accurate measure of nutrient concentration than petioles or whole leaves.

Key words. Foliar sampling material, *Liriodendron tulipifera*.

Nutrient concentrations in leaves from forest trees are used increasingly to evaluate possible response to fertilization. For accurately judging deficiencies, the tissues used for nutrient determinations should be sensitive to changes in external nutrient supply and relatively independent of other influencing factors.

Nutrient concentrations in blades and petioles of many agricultural plants are often so different that either one or the other should be used for diagnostic purposes *(Goodall and Gregory 1947, Kwong and Boynton 1959, Bould 1961 and 1964, Cassidy 1970)*. For forest trees, Guha and Mitchell *(1965)* reported that the composition of petioles was appreciably different from that of blades for *Acer pseudoplatanus* L. and *Aesculus hippocastanum* L., and that combining these tissues produced noticeable differences for some nutrients. Finn *(1966)*, using pot-culture tests, observed a fourfold increase in N concentration for yellow-poplar leaf blades versus petioles over a wide range of N levels.

In this study, N and P concentrations in blades, petioles, and whole leaves from fertilized and unfertilized yellow-poplar trees *(Liriodendron tulipifera* L.) were compared, and the suitability of each plant part for diagnostic purposes was evaluated by comparing its sensitivity to applied fertilizers.

Methods

Three fertilized and three unfertilized codominant yellow-poplar trees of similar size, age, and form were selected from test plots in a uniform 34-year-old stand near Parsons, West Virginia. The soil was Barbour fine

Table 1.—Fertility of the study soil[a]

Horizon	Depth	Texture	pH	Total N	Exchangeable P	Exchangeable K	Exchangeable Ca	Exchangeable Mg	Exchangeable Mn
	Inches			*%*	*ppm*				
A_1	0-4	sl	4.8	0.139	14	33	322	30	62
A_3	4-8	ls	4.8	.070	6	23	80	18	48
C	8+	ls	4.8	.044	6	24	90	22	44

[a]Values are based on composite samples obtained from 8 soil pits: pH by glass electrode, N by Kjeldahl, P extracted with 0.002 N H_2SO_4, cations extracted with NH_4OA_c.

sandy loam, which had formed in deep well-drained alluvium deposited in a narrow valley bottom. The site was flat, uniform in surface configuration, and of moderate fertility (table 1). Plots were thinned so that tree crowns were exposed to full sun on all sides. The yellow-poplar stand averaged 7.7 inches dbh, was 75 feet tall, and had a site index of 100.

The fertilized plot was treated with 450 lb. /acre of N from ammonium nitrate in the spring of 1967 and 50 lb./acre of N the next spring. In the fall of 1966, P and K were broadcast at 92 and 176 lb./acre from 0-20-20; Mg and S at 66 and 88 lb./acre from Epsom salts; and hydrated lime at 2,500 lb./ acre.

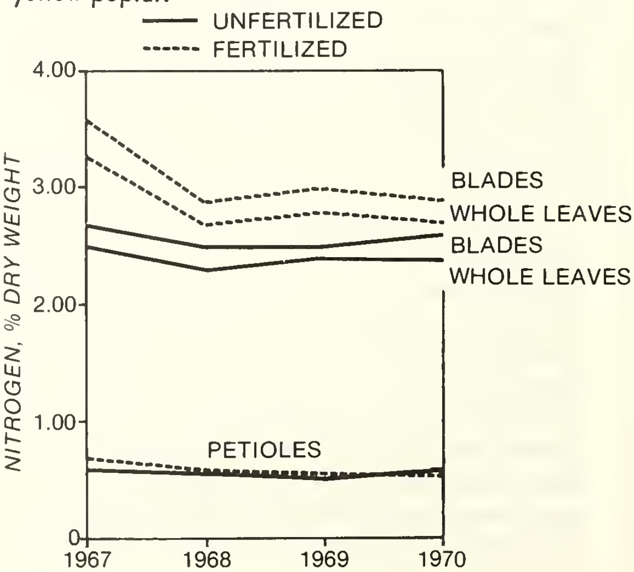
Two separate foliage samples from each of the six trees were collected annually for 4 years, on August 27 each year. Samples consisted of 20 mature leaves free from insect damage and disease, obtained from two separate branches on the upper 8-foot section of crown on the south side. Only the largest of the mature leaves on current-season twigs were sampled.

Petioles and leaf blades (midrib retained) were separated, dried at 70°C, weighed, ground to pass a 20-mesh screen, and stored in glass jars. After the fourth collection, all samples were redried and analyzed for N and P. Nitrogen was determined by the Kjeldahl procedure and P by the vanadomolybdophosphoric yellow method after wet ashing. Nutrient concentrations of whole leaves were calculated by weighting N and P concentrations in blades and petioles by their respective dry weights.

Results

Nitrogen. — Nitrogen concentrations differed markedly among blades, petioles, and whole leaves (fig. 1). Concentrations in blades were about five times greater than concentrations in petioles for fertilized trees, and four times greater for unfertilized trees. As a result, concentrations in whole leaves (blades and petioles) were lower than concentrations in blades alone by 0.23±0.04% N for fertilized trees and 0.18±0.02% N for unfertilized trees. Differences in concentration between fertilized and unfertilized whole leaves resulted not only from changes in blade composition, but also from fertilizer-

Figure 1.—N concentrations in blades, whole leaves, and petioles of fertilized and unfertilized yellow-poplar.



induced differences in dry-weight ratios between blades and petioles (table 2).

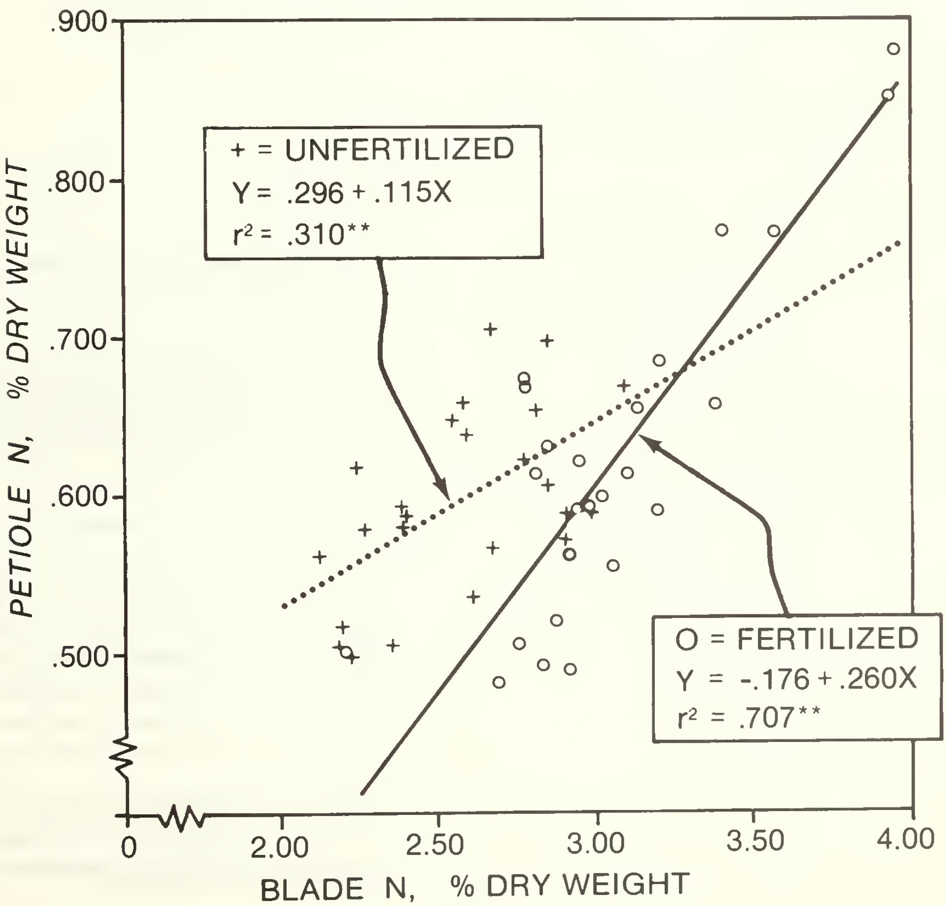
Leaf blades were considerably more sensitive to changes in external N supply than petioles, and whole leaves were slightly less sensitive than blades only. Nitrogen concentrations in blades rose almost 1.0% N during the season when fertilizers were first applied (1967) and averaged 0.4% N higher than controls during the following three seasons (significant at 0.05 level). In contrast, N in petioles rose only 0.15% N in the first season (not significant), and was essentially identical in the following years (fig. 1).

Nitrogen concentrations in blades and petioles were linearly correlated, but the slopes and levels of the regression lines differed significantly between fertilized and unfertilized tissues, and the relationship was stronger for fertilized trees than for unfertilized trees (fig. 2). Compositing petioles with blades could therefore lead to increased sample

Table 2.—Dry weights and dry-weight ratios of blades and petioles from fertilized and unfertilized yellow-poplar

Year	Fertilized			Unfertilized		
	Blade	Petiole	Ratio	Blade	Petiole	Ratio
	mg.	*mg.*		*mg.*	*mg.*	
1967	925	103	9.0/1	721	70	10.3/1
1968	921	96	9.6/1	685	65	10.5/1
1969	1,130	108	10.5/1	900	88	10.2/1
1970	1,110	109	10.0/1	844	85	9.9/1

Figure 2.—Relationships between petiole N and blade N for fertilized and unfertilized yellow-poplar. Sample points from all 4 years of observation.



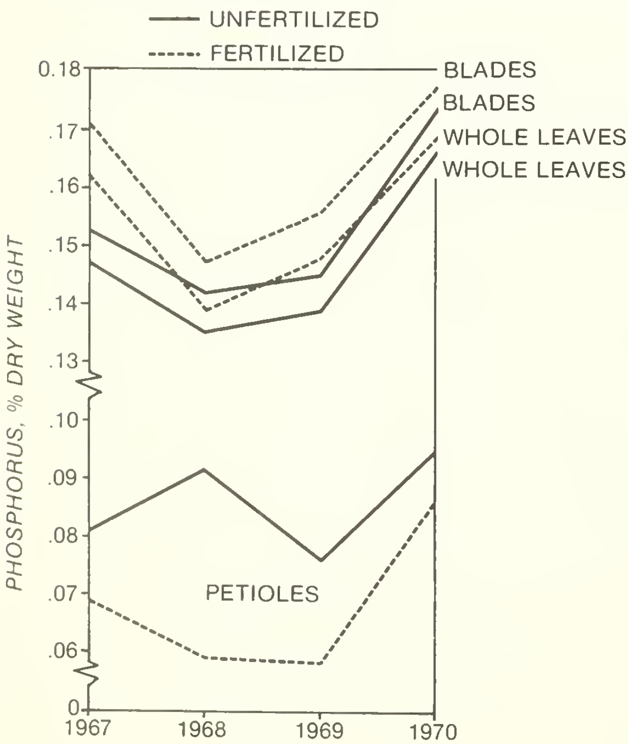
variation and could have unequal effects on whole-leaf concentrations obtained from fertilized and unfertilized trees.

Phosphorus. — Phosphorus concentrations were highest in blades and lowest in petioles (fig. 3), indicating that inclusion of petioles with blades will yield lower concentrations than blades alone. Concentration differences for the 4-year period averaged slightly less than 0.01% P for the whole leaves compared to blades only. The difference in concentration between whole leaves and blades only was not significant.

Fertilization significantly (0.05 level) increased P concentrations in blades in 1967, but thereafter only smaller non-significant differences occurred. In contrast, petioles responded negatively to fertilization, with significant (0.01 level) decreases in concentration lasting for 3 years after fertilizer treatment. Because the actual quantities of P in petioles from both fertilized and unfertilized trees remained nearly identical, this indicates that incorporation of P into petiole tissue of fertilized trees did not keep pace with increases in petiole dry weight (table 2). This shows that petioles are insensitive to changes in external supply of P, particularly where a response in petiole dry weight results from fertilization.

The relationship between blade P and petiole P was closer than that for N (fig. 4). This means that less sample variation would occur for whole leaves analyzed for P than similar samples analyzed for N. The slopes of the regressions were similar, but the P levels were significantly higher for unfertilized trees — indicating that a dilution effect had occurred in the leaf petiole.

Figure 3.—P concentrations in blades, whole leaves, and petioles of fertilized and unfertilized yellow-poplar.

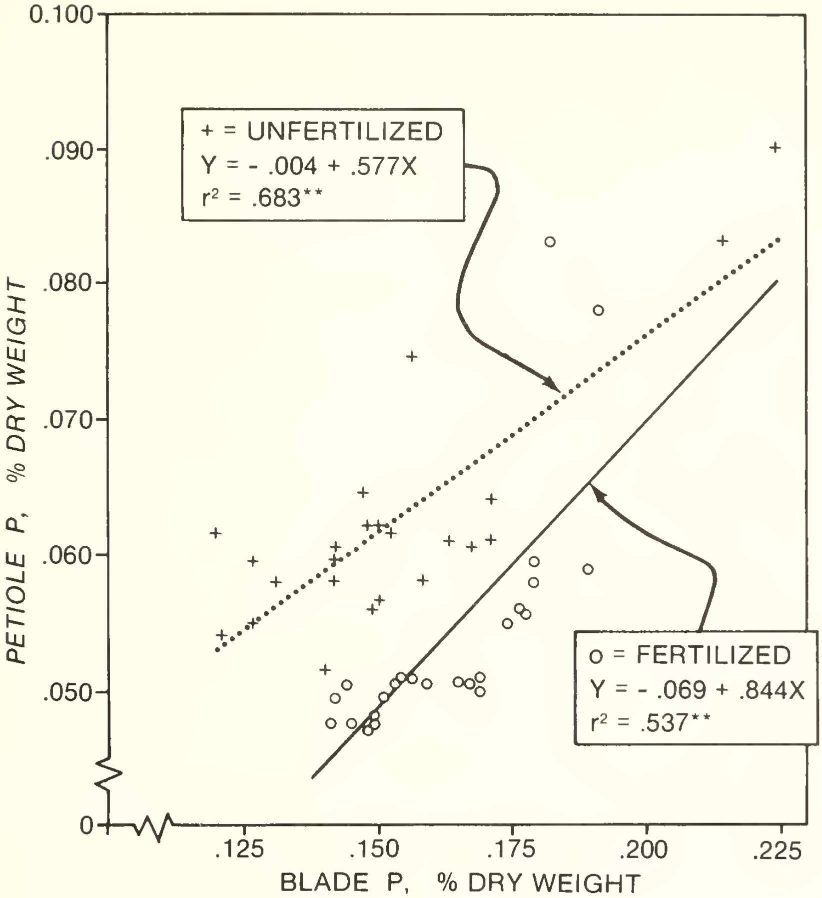


Conclusions

This study of N and P concentrations in blades, petioles, and whole leaves from fertilized and unfertilized yellow-poplar trees has shown that:

1. N concentrations are 4 to 5 times higher in blades than in petioles.
2. P concentrations are nearly 3 times higher in blades than in petioles.
3. Combining petioles and blades for N and P determinations will produce concentrations that are lower for whole leaves than for blades only. This reduction is greater in magnitude for N than for P.
4. Fertilization did not affect the nutrient concentrations of whole leaves and blades equally because of unequal changes in composition of petioles and blades and a change in petiole-blade dry-weight ratios.
5. Concentrations in petioles were not precisely related to concentrations in blades, and these relationships for fertilized and unfertilized foliage were different. Therefore, the use of whole leaves would make nutrient comparisons between fertilized and unfertilized trees less reliable and would add to sample variability.
6. Although this study was based on a small number of sample trees, these findings suggest the need for a standard sampling

Figure 4.—Relationships between petiole P and blade P for fertilized and unfertilized yellow-poplar. Sample points from all 4 years of observation.



tissue for diagnosing nutrient deficiencies in yellow-poplar. It is recommended that petioles not be included with blades in determining nutrient-concentration data, to improve the comparative values generated by different laboratories.

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YIELD TABLE FOR HARDWOOD BARK RESIDUE

Abstract. Bark residue weights are tabulated for eight species of hardwood sawlogs according to log volume by the Doyle, International ¼-inch, and Scribner decimal C log rules. Factors are provided for converting from weight in pounds to volume in cubic yards.

Hardwood sawmills that have debarkers generate large amounts of bark residue. The term "bark residue" as used here includes bark, dirt, and wood fiber removed from the log in the debarking process.

Bark residue from some mills ends up in the dump or incinerator; residue from other mills is processed into useful garden and farm products. No matter how the bark residue is used or disposed of, the sawmiller needs to know how much of it is produced.

This note was prepared to give a practical tool for estimating quantities of bark residue. The table shows the weight of bark residue that can be expected from eight species of hardwood sawlogs according to log size by any one of three log rules: Doyle, International ¼-inch, or Scribner decimal C. And conversion factors are offered for converting from weight of bark residue in pounds to volume in cubic yards.

Procedure

At four sawmills, two with rosserhead debarkers and two with floating cutterhead debarkers, 686 logs were numbered, scaled, and weighed before and after debarking (fig. 1). The weight difference was considered the weight of bark residue. Cubic-yard samples were collected by hand from the bark conveyor and weighed for determining conversion factors for volume. Smaller samples of bark residue were taken for laboratory analyses of moisture content.

Results

The average green weight of hardwood bark residue per 1,000 board feet from all study logs was:

Log rule	*Pounds*
Doyle	1,534
International ¼-inch	1,164
Scribner decimal C	1,255

This weight of residue represented an average of 11 percent of total log weight. The moisture content of bark residue (oven-dry basis) averaged 68 percent.

Since there were differences in bark residue weights due to species, the species are reported separately in the table. The three species that showed no differences—chestnut

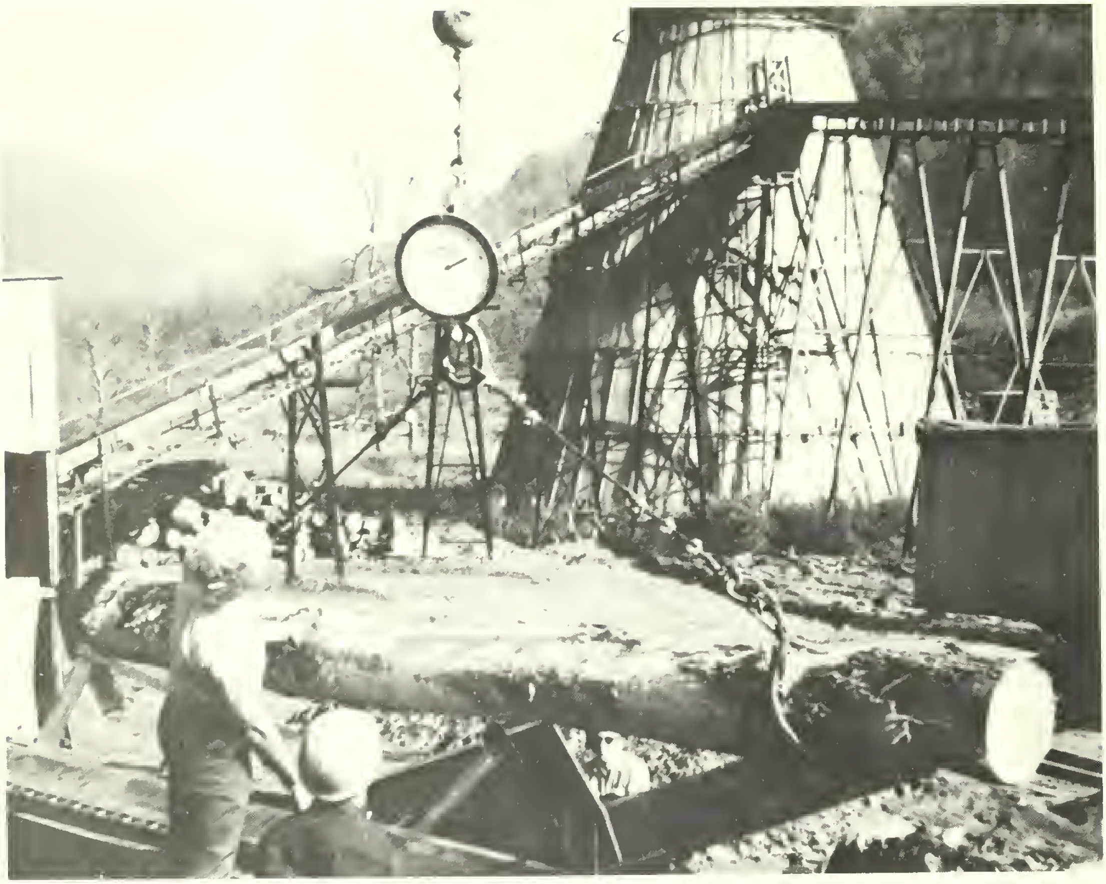

Figure 1.—Method of weighing sawlogs with truck-mounted crane and in-line scale.

oak, white oak, and hickory—are presented as a species group.

Differences also showed up between operators. One operator took more than twice as much bark residue off the same species of logs with the same machine as another operator did. However, it was not practical to classify operators; so the tabular data for each species or species group are shown as the average of the operators in the study. The data are also averaged for the two types of debarkers tested, because differences were not found due to debarker type.

A part of the weight of bark residue is moisture. The table values are green weights according to the average moisture content determined for each species and species group. The moisture contents were (oven-dry basis):

Species	*Percent*
Red oak (*Quercus* spp.)	63
Yellow-poplar (*Liriodendron tulipifera*)	96
Chestnut oak (*Quercus prinus*), white oak (*Quercus* spp.), and hickory (*Carya* spp.)	59
Maple (*Acer* spp.)	55
Beech (*Fagus grandifolia*)	68
Basswood (*Tilia americana*)	114
Average	68

Estimates of bark residue weight can be made from the table for any period of time. First an average log size for that period of time is calculated from log-tally sheets. Then the weight found opposite that average log volume in the table is multiplied by the number of logs debarked. The result is the total green weight of bark residue produced in that period of time.

If the sawmill operator wishes a volume estimate, he simply converts the green

Bark residue weights per log by log volume and species, in pounds[a]

Log volume (board feet)	Red oak	Chestnut oak, white oak and hickory	Maple	Beech	Yellow-poplar	Basswood
DOYLE LOG RULE						
20	70	64	68	35	53	71
40	92	81	89	57	74	87
60	113	99	108	77	94	103
80	135	116	126	96	115	119
100	157	134	142	114	136	134
120	179	151	157	130	157	150
140	201	168	169	146	177	166
160	223	186	181	160	198	182
180	245	203	190	172	219	198
200	266	221	198	184	240	213
220	288	238	204	194	260	229
240	310	255	208	203	281	245
260	332	273	211	210	302	261
280	354	290	212	217	322	277
300	376	308	212	222	343	292
INTERNATIONAL ¼-INCH RULE						
20	51	47	45	17	37	60
40	72	64	67	38	55	74
60	92	81	88	57	73	88
80	112	97	107	75	91	102
100	133	114	124	92	109	116
120	153	131	140	109	127	130
140	173	148	154	124	145	144
160	193	165	167	138	163	158
180	214	182	178	151	181	172
200	234	198	188	164	199	186
220	254	215	196	175	217	200
240	274	232	202	186	235	214
260	295	249	207	195	253	228
280	315	266	210	203	271	242
300	335	283	212	211	289	256
SCRIBNER DECIMAL C RULE						
20	55	50	51	20	39	62
40	76	68	73	41	58	77
60	97	85	93	62	78	92
80	119	103	112	81	97	106
100	140	120	130	99	117	121
120	161	138	145	115	137	136
140	183	155	159	131	156	151
160	204	173	172	146	176	165
180	225	190	182	159	195	180
200	247	208	192	172	215	195
220	268	225	199	183	234	210
240	289	243	205	193	254	224
260	311	260	209	202	273	239
280	332	278	212	210	293	254
300	353	295	212	217	312	269

[a] Green weight at average moisture content for each species and species group. Values were computed using regression equations.

weight in pounds to volume in cubic yards by dividing by the following conversion factors (bulk density of hardwood bark residue, pounds, green, per cubic yard):

Species	*Conversion factor*
Basswood	250
Hickory	287
Yellow-poplar	419
White oak	439
Chestnut oak	457
Red oak	509
Maple	625
Beech	717
Average	474

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This study was made with the cooperation of four sawmills in West Virginia: Pardee Curtin, Frazee Lumber Company, Mullenax Lumber Company, and Hinchcliff Products Company.

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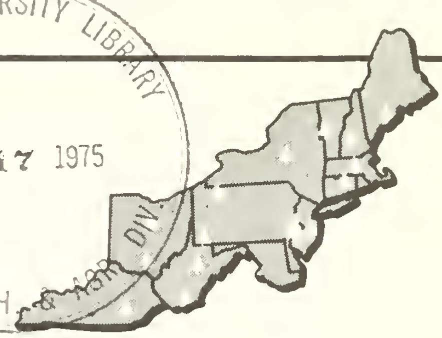

FOREST SERVICE, U.S. DEPT. OF AGRICULTURE, 6816 MARKET STREET, UPPER DARBY, PA. 19082

A FIRST LOOK AT LOGGING RESIDUE CHARACTERISTICS IN WEST VIRGINIA

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Abstract.—In 1973 and 1974, the Forest Products Marketing Laboratory obtained some preliminary information about characteristics of logging residues in West Virginia. Sixteen 1-acre plots were measured in conjunction with a test of the line-intersect sampling method. Findings from the 16 plots showed that hardwood residue volumes ranged from 100 to 1,300 cubic feet per acre, with an average of 467.

KEY WORDS: logging residue, Appalachian hardwoods.

In 1973 and 1974, a study was conducted by the Forest Products Marketing Laboratory in West Virginia to test the feasibility of estimating hardwood logging residues with the line-intersect method. As a part of this study, all residue material 4.0 inches and larger, d.o.b. (diameter outside bark) at the small end, and 4.0 feet long or longer was measured on 16 one-acre plots.

The plots were located mainly in the southern half of the State on both private and public lands. They represented a variety of harvesting conditions. Clearcut and partial-cut units were sampled in both young and old hardwood stands, and utilization ranged from sawtimber only to pulpwood and mine-props. Although the plots were not located according to any planned stratification (since testing the method was our primary goal), the data obtained give some idea of the magnitude of the logging-residue situation in Appalachia.

Residue volumes were determined with Smalian's formula, using length and both end diameters, outside bark (o.b.). Since the line-intersect method was being tested, no attempt was made to estimate defect. I was concerned only with gross volume figures.

Species were also recorded, and of the 2,048 pieces of residue measured, 31 percent were red oak, 25 percent white oak or chestnut oak, 15 percent maple, 7 percent poplar, 7 percent pine, and 4 percent hickory. The remaining 11 percent were made up of 12 other species.

The average gross volume (including bark) on the 16 plots was 467 cubic feet per acre, or approximately 15 green tons. The volumes

Table 1.—Summary of residue characteristics for the 16 one-acre plots for all pieces > 4.0 inches d.o.b. at the small end and > 4.0 feet in length

Plot No.	Average diameter (o.b.)		Average length	Volume/acre
	Small end	Large end		
	Inches	*Inches*	*Feet*	*Cubic feet*
1	4.8	5.9	6.9	290
2	5.2	7.7	12.5	655
3	4.6	6.8	8.0	204
4	5.1	8.5	14.7	805
5	5.3	8.7	18.6	672
6	4.6	8.1	15.9	761
7	4.4	7.0	12.3	264
8	4.5	7.4	17.2	169
9	5.3	8.4	16.5	1297
10	5.1	8.3	13.7	354
11	5.4	8.3	18.2	925
12	4.5	6.2	10.4	397
13	4.4	5.7	8.8	222
14	4.7	6.1	6.4	150
15	4.2	5.5	8.2	199
16	4.2	5.6	6.4	102
Weighted average	4.8	7.1	11.8	467

ranged from about 100 cubic feet to nearly 1,300 cubic feet per acre (table 1). Probably one of the most significant findings was that 57 percent of this volume was in pieces 20 feet long or longer.

Appalachian hardwood residues are generally not large in diameter. Sixteen percent of the volume was in pieces 8 inches (o.b.) and larger at the small end (table 2). Fifty-six percent of the volume was in pieces 10 inches (o.b.) or more at the large end. And 42 percent of the residue volume was in pieces 10 inches (o.b.) or more at the large end *and* 20 feet or more in length.

Average diameter (o.b.) of the residue material was 4.8 inches at the small end and 7.1 inches at the large end (table 1). Average length was 12 feet.

When the residue was measured, a six-way classification scheme was used to describe the type of material. First, it was determined whether the piece was bolewood or limbwood, then whether it was straight (if a straight line between the centers of the ends lay within the piece) or crooked (having sweep or crook greater than the definition for a straight piece). If the piece was crooked, it was determined whether there was one or more than one point of crook.

Table 2.—Average cubic-foot volume/acre by length and diameter class (small end) for all 16 plots

Lower limit of diameter class - small end (inches)	Lower limit of length class (feet)																	Total
	4	8	12	16	20	24	28	32	36	40	44	48	52	56	60	64	68	
4	27.7	24.6	20.9	25.5	26.4	26.0	30.0	23.5	16.9	17.2	11.4	2.5	3.3	—	—	3.5	3.7	263.1
5	9.0	4.6	4.9	5.5	7.8	9.4	6.2	6.7	2.8	3.2	1.9	2.7	—	1.3	—	—	—	66.0
6	5.1	3.9	2.3	2.0	3.8	3.4	2.4	4.6	—	2.4	—	—	—	2.7	5.9	—	—	38.5
7	2.1	4.7	2.1	4.4	1.4	2.1	—	1.1	4.3	—	—	—	—	—	—	—	—	22.2
8	1.8	2.6	3.8	1.2	—	1.1	—	1.8	—	—	—	2.7	—	3.4	—	—	—	18.4
9	1.0	1.1	1.4	4.7	—	—	—	—	—	—	—	—	—	—	—	—	—	8.2
10	.4	1.6	.6	4.3	—	1.5	—	—	—	—	—	—	4.3	—	—	—	—	12.7
11	.3	.4	—	2.0	—	—	2.0	2.0	—	—	—	—	—	—	—	—	—	6.7
12	—	—	.7	1.9	3.3	—	—	—	—	—	—	—	—	—	—	—	—	5.9
13	—	1.1	1.4	—	—	—	2.5	—	—	—	—	—	—	—	—	—	—	5.0
14	3.4	1.1	—	1:3	—	—	—	—	—	—	—	—	—	—	—	—	—	5.8
15	.7	1.0	—	—	2.0	—	—	—	—	—	—	—	—	—	—	—	—	3.7
16	.6	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	.6
17	1.3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1.3
18	2.1	1.2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	3.3
19	—	1.3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1.3
20	.6	1.9	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2.5
21	—	1.4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1.4
Total	56.1	52.5	38.1	52.8	44.7	43.5	43.1	39.7	24.0	22.8	13.3	7.9	7.6	7.4	5.9	3.5	3.7	466.6

Summarizing the data by residue class, I found that 48 percent of the pieces and 76 percent of the volume came from bolewood (table 3). Forty-five percent of the pieces qualified as straight material, and this represented 47 percent of the volume on an average acre. Another 29 percent of the pieces (22 percent of the volume) had only one point of crook. In many cases, at least two straight 4-foot pieces could be obtained from such material. Although defect was not recorded, losses that would reduce the amount of chippable material probably averaged less than 5 percent.

Table 3.—Distribution of residue, by type of material, in percent

Class	Pieces		Volume	
Bolewood:				
Straight	31		42	
1 crook	9		15	
> 1 crook	8		19	
		48		76
Limbwood:				
Straight	14		5	
1 crook	20		7	
> 1 crook	18		12	
		52		24
Total		100		100

To estimate the extent of logging residue in West Virginia, figures from the most recent forest-survey report (*Ferguson 1964*) may be used. In 1961 there were 28.8 billion board feet of sawtimber growing on 11.4 million acres of commercial forest land in West Virginia. This is an average of 2,526 board feet per acre. Dividing this into the annual sawtimber cut of 433.3 million board feet shows that about 171,500 acres were harvested. When the average of 467 cubic feet per acre is applied to this, I get an estimate of 80 million cubic feet of residues left in the woods. This is more than three times the average annual pulpwood production from roundwood in West Virginia (1963-72) of 280 thousand rough cords.

Logging residues constitute a large source of potential raw material for the wood-using industries in Appalachia. Whether or not the material can be removed and processed at a profit is presently unknown.

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GROUND-COVER VEGETATION MANAGEMENT AT BACKCOUNTRY RECREATION SITES

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Abstract.—Increasing use of remote backcountry recreation sites in the Northeast is resulting in a loss of the thin soil mantle and destruction of the ground-cover vegetation. Fencing, fertilization and liming and a combination of fencing, fertilization, and liming were tested as means of reestablishing ground-cover vegetation on bare mineral soils of the Tuckerman Ravine shelter site on Mount Washington in New Hampshire. Results indicate that fencing would be a slow means of reestablishing ground-cover vegetation. Fertilization and liming were not very effective in producing an increase in the area covered by ground vegetation.

Increasing use of remote backcountry recreation sites in the Northeast, where soils in many places are shallow and plant communities fragile, is causing erosion of the thin soil mantle and destruction of the ground-cover vegetation. The situation has become serious enough that backcountry managers now express the need for management techniques that will enable them to reestablish ground-cover vegetation and maintain biologically and physically stable site conditions. In the past, management of the ground-cover vegetation in these areas has been limited, although grass seeding and fertilization have been used successfully in the Adirondack Mountains of New York (*Ketchledge and Leonard 1971*).

The Study

A study was made to investigate cultural methods for reestablishing ground-cover vegetation on the heavily trampled mineral soils of the Tuckerman Ravine shelter site on Mount Washington in the White Mountains of New Hampshire. These areas now have a sparse covering of ground vegetation, ranging up to 30 percent coverage.

The study was designed to obtain a general idea of the potential of various vegetation-management methods. It was assumed that, because of the variety in site conditions and plant-community composition, and because the amount of ground vegetation is limited due to human impact, a study design with good replicates would not be possible. Consequently, it was decided to work with a range of natural and people-induced conditions and rely on generalizations rather than specific comparisons. It was also assumed that some management constraints might be placed on the study. In this case, grass seeding was not permitted, and fertilization had to be limited.

Related research has been done primarily in the Adirondack Mountains of New York by Ketchledge and Leonard (*1971*). They recommended application of a 50-50 mixture of red fescue (*Festuca rubra* L.) and Kentucky bluegrass (*Poa pratensis* L.), with a fertilizer treatment of nitrogen and phosphorus in the forms of urea and triple superphosphate, as the most promising method of reestablishing ground-cover vegetation on the summits of these mountains. Further investigations indicated that if the treatment of fertilizer and seed were stopped after a few years of application, native species would begin to reinvade the site (*Ketchledge and Leonard 1972*).

Other work indicated that losses in the area coverage of ground vegetation can be expected on both new (*LaPage 1967*) and old campsites (*Frissell et al. 1965; Magill 1970*). Moreover, shifts in species composition to more compaction- and drought-resistant species were noted in the second and third years of operation of a newly opened campground (*LaPage 1967*).

The Study Site

The Tuckerman Ravine shelter area is a 40-year-old overnight and day-use backcountry recreation site on the southeastern slope of Mount Washington. It is at an elevation of 3,800 feet, and access to the area is primarily by the 2.5-mile-long Tuckerman Ravine Trail that originates at the Pinkham Notch Camp of the Appalachian Mountain Club. This area is in the White Mountain National Forest and is administered by the U. S. Forest Service.

Spring skiers are the primary users of the area, although backpackers and day-hikers are also frequent visitors. Skiers come to enjoy the late spring skiing in Tuckerman Ravine, while hikers use the area as a gateway to the system of trails in the Presidential Range. It is estimated by personnel of the White Mountain National Forest that nearly 40,000 people visited the area between 1 January and 1 July 1972.

The shelter area is approximately 4 acres in size. It is surrounded by a dense old-growth balsam fir forest, which extends into the site in irregular patterns. In the central portion of the area, as well as along the main trails leading through the site, there are relatively large areas of bare mineral soil with a minimum of ground-cover vegetation. These areas total about 1 acre in size.

The removal of the forest vegetation and the loss of the forest humus layer from these parts of the shelter site were not the result of natural forces. The forest cover was removed through cutting fuelwood, clearing for buildings, and death of trees from the general impact of a large number of people visiting the site each year. The organic soil horizon was lost primarily through disturbance from human use, followed by erosion. The remaining mineral soil is now 10 to 25 centimeters in total depth, overlying large boulders, and is very compacted.

The undisturbed forest soil in the area surrounding the shelter site is 75 to 90 centimeters in total depth to the underlying large boulders. It is well drained. There is an organic horizon composed of an L (litter), F (fermented), and H (humus) layer, and this is 10 to 15 centimeters deep. The underlying mineral soil is distinctly separated from the organic horizon. There is a light gray A_2 horizon, a B horizon ranging from reddish-brown to yellowish-brown, and an olive-brown C horizon. The depth of these horizons is generally as follows: A_2—0 to 12 centimeters; B—12 to 50 centimeters; and C—50 to 90 centimeters. The mineral soil horizons are fine sandy loam.

The organic horizon is dark brown and has a pH of 5. This is somewhat above the 3 to 4 pH reported for the same horizon in other parts of the White Mountains (*Hoyle 1973*). The pH of the mineral soil horizons ranges from 4 to 5.

The main source of nutrient elements in these soils, particularly nitrogen and phosphorus, is the forest humus layers (*Hoyle 1973*). The mineral soil is generally infertile.

The ground-cover vegetation, which was of primary interest in this study, is located in a zone between the edge of the forest surrounding the shelter site and the areas of bare mineral soil. This zone ranges from 0.5 to 1 meter in width up to a maximum of 6 meters. Grasses, common plantain, black sedge, and rushes were the predominate species in this zone. All the ground-cover species identified in this zone are listed in table 1.

There are eight Adirondack-type overnight lean-to's in the shelter area. They can accommodate 10 to 12 persons per night. Total capacity is 86. There are also latrines, storage sheds, and other service buildings at the site.

Study Design and Sampling

In June 1972, eight study plots were laid out in the zone of existing ground-cover vegetation. Each plot was 3.6 meters square. Plot locations were selected to encompass the range of site conditions and species composition. Four treatments were used in this study; each was applied to only two plots, as follows:

1. No treatment.
2. Fenced to exclude people.
3. Fertilized and limed.
4. Fenced, fertilized, and limed.

The fencing was established by a rope strung around four metal fence posts at each corner of the plot. This was installed at the beginning of the study and was not removed until September 1973. The fertilization was 1120 kg/ha of N-P-K (5-10-5) broadcast on the soil surface only once, in June 1972. Agricultural hydrated lime was applied at the same rate and time. It also was broadcast on the soil surface.

Samples were taken in the third weeks of June, July, and August 1972 and 1973 to determine the percentage of area covered by ground vegetation. An 0.09-square-meter sampling quadrat was systematically laid down 48 times on each plot per sampling. Each time the quadrat was laid down, the individual species inside the quadrat were identified, and the percentage of area covered was estimated visually. The data from the 48 samples on each plot were combined to represent the characteristics of that plot.

Table 1.—Ground-cover vegetation identified in the Tuckerman Ravine shelter area

Common name	Latin name
Boreal bentgrass	*Agrostis borealis* L.
Glaucous bluegrass	*Poa glauca* Vahl.
Redtop	*Agrostis alba* L.
Blue-joint	*Calamagrostis canadensis Adans.*
Red fescue	*Festuca rubra* L.
Rhode Island bentgrass	*Agrostis tenuis* L.
Common timothy	*Phleum pratensis* L.
Common plantain	*Plantago major* L.
Black sedge	*Carex nigra* L.
Short-tailed rush	*Juncus brevicaudatus* Fern.
Toad rush	*Juncus bufonius* L.
Sweet white violet	*Viola pallens* Brainerd
Pineapple weed	*Matricaria matricariodes* Less.
Knotweed	*Polygonum aviculare* L.
Yarrow	*Achillea millefolium* L.
White clover	*Trifolium repens* L.
Mountain cranberry	*Vaccinium Vitis-Ideae* L.
Paper birch	*Betula papyrifera* Marsh.
Balsam fir	*Abies balsamea* L.

Results and Discussion

The data from July were selected as being fairly representative of the results in general (table 2).

The treatments applied in this study were not very effective in increasing the percentage of area covered by the most abundant ground-cover species in the shelter area between the summers of 1972 and 1973. The fenced-in plots showed small gains and losses in area coverage—less than 2 percent (table 2).

Time was probably one of the limiting factors of this treatment. If the fencing had been left up long enough to allow the existing ground vegetation to recover from trampling and to allow deposit of some organic matter on the soil surface, this would have contributed to a gradual improvement in the physical condition of the soil and would have provided better conditions for re-invasion by ground vegetation.

Unfortunately, the soils on this site were so compacted from years of trampling that the improvement of soil conditions through the addition of small amounts of organic matter would be a slow process. Moreover, the infertility of the mineral soil in the White Mountains (*Hoyle 1973*) undoubtedly limited the growth of ground vegetation and hence the amount of organic matter deposited on the soil surface.

One possible means of improving the soil nutrient supply and providing better conditions for re-invasion by ground vegetation might be through application of fertilizer and lime. The fertilizer would add the nitrogen and phosphorus necessary for plant growth to these nutrient-deficient soils where the humus layer had been the previous source of these elements. Lime would be helpful in shifting the pH of this acid soil to more neutral conditions and therefore help prevent the phosphorus

Table 2.—Effect of four treatments on the percentage of area covered by important ground-cover species, July 1972 and July 1973

Species	Treatments							
	Control plot—		Fenced plot—		Fertilized and limed plot—		Fenced, fertilized, and limed plot—	
	1	2	3	4	5	6	7	8
Grasses:[1]								
1972	—	16	7	—	30	1	2	4
1973	—	13	6	—	7	2	5	9
Change	—	–3	–1	—	–23	+1	+3	+5
Common plantain:								
1972	1	1	—	—	7	2	16	4
1973	1	3	—	—	4	3	17	3
Change	0	+2	—	—	–3	+1	+1	–1
Black sedge:								
1972	9	—	—	—	—	—	—	—
1973	11	—	—	—	—	—	—	—
Change	+2	—	—	—	—	—	—	—
Short-tailed rush:								
1972	2	—	2	—	—	—	—	—
1973	1	—	—	—	—	—	—	—
Change	–1	—	–1	—	—	—	—	—
Mountain cranberry:								
1972	—	—	1	—	—	—	—	—
1973	—	—	2	—	—	—	—	—
Change	—	—	+1	—	—	—	—	—
White clover:								
1972	—	—	—	—	2	—	—	—
1973	—	—	—	—	1	—	—	—
Change	—	—	—	—	–1	—	—	—

[1] Glaucous bluegrass, Rhode Island bentgrass, redtop.
(—) Species not present.

from becoming fixed by the aluminum and iron in the soil.

The fertilizer and lime applied in the study were not very effective in increasing the percentage of area covered by ground vegetation. Some species showed a loss while others showed a slight gain (table 2). The loss was not due to the treatment. The plot where the loss occurred was on a hillside, which was washed over with rain water shortly after the treatment. The water may have removed the fertilizer and lime, along with some surface soil. The loss in percentage of area covered by ground vegetation was probably due to poor growing conditions on the study plot.

The limited effect of the fertilizer was probably the result of two factors. First, the rate of application was not sufficient to substantially improve the nutrient status of this infertile mineral soil. A heavier rate of application might have been more effective. A heavier rate could also be accomplished through the application of urea (N) and triple superphosphate (P). The main advantage of these two is that they are more concentrated than the 5-10-5 used in the study, and therefore less weight of fertilizer would have to be carried into the backcountry to apply the same amount of nitrogen and phosphorus.

The second factor is that the lime treatment was not sufficient to raise the pH of this acid mineral soil to the neutral range. Therefore the applied phosphorus was probably fixed by aluminum and iron in the soil and rendered unavailable to the plants. An application of 3500 to 4500 kg/ha of lime would have been more effective. In addition, it might be reasonable to use dolomitic limestone rather than the hydrated lime used in the study. Dolomitic limestone has a fertilizing effect through the addition of magnesium, which might have been helpful on this infertile soil.

The combination of fertilizer, lime, and fencing was the most effective of the treatments in encouraging an increase in the percentage of area covered by ground vegetation. The grasses on the plots receiving this treatment showed an increase from 1972 to 1973 of 3 to 5 percent. This indicates that the combined treatment is potentially useful.

Conclusions and Implications

The results of this study indicate that none of the treatments applied in the Tuckerman Ravine shelter area warrant use as the sole means of increasing the percentage of area covered by vegetation over a relatively short period of time. The infertile condition of the mineral soil and the absence of the forest humus layer (and its reserve of nitrogen and phosphorus) dictate the need for a substantial application of fertilizer to improve the nutrient status of the soil. Urea and triple superphosphate, possible sources of these elements, have been used successfully in the acid soils of the Adirondack Mountains of New York (*Ketchledge and Leonard 1971*).

A heavier rate of application of lime should be considered on these acid soils to ensure the availability of the applied phosphorus. A treatment of 3500 to 4500 kg/ha might be reasonable. Dolomitic limestone should be used rather than hydrated lime to take advantage of the fertilizing effect of its magnesium. Fencing areas off from human use without any other treatment will probably be a slow way to increase the regrowth of indigenous ground-cover vegetation on sites such as the one studied.

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WEIGHT / VOLUME RATIOS FOR APPALACHIAN HARDWOODS

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Abstract.—Weight / volume relationships are presented in both English and metric systems for 15 commercial species of Appalachian hardwoods. Two ratios are presented: weight of wood volume alone, and weight of wood plus bark.

KEY WORDS: Wood weight, weight-volume ratios, Appalachian hardwoods.

Buyers and sellers of forest products sometimes need information about the relationship between total wood volume and weight. Consider the increased use of weight-scaling as a marketing practice. Present methods may give a fairly reliable estimate of board-foot volume for a given weight. But what about estimates of chips, sawdust, and bark? All these products now have actual or potential merchantability. Therefore, it is logical that we develop and use ratios of weight to total volume.

Tables showing the relationship between wood weight and volume have been published.[1] However, these data are based on the weight and volume of a 2- by 2-inch (50.8- × 50.8-mm) clear specimen from the top 4 feet (1.22 m) of 16-foot (4.88-m) butt logs of typical trees. We believe that figures showing the association between total log volume and log weight (with bark) would be much more useful.

For this reason, we developed tables of weight / volume ratios for the most common species of Appalachian hardwoods. The data for the report came from logs harvested in western Maryland, West Virginia, and southwestern Virginia. The period of log weighing and measuring ran from early March to late November.

The calculations are based on unbarked logs 8 to 16 feet (2.44 to 4.88 mm) long (table 1). The logs were from trees severed from the stump less than 2 weeks before weighing and measuring. The weight per unit of volume for

[1] USDA Forest Service, Forest Products Laboratory. 1958. Weights of various woods grown in the United States. For. Prod. Lab. Tech. Note 218. 8 p. (Reissued; latest revision in 1953.)

each log was determined by dividing the individual log weight by its volume as derived by Smalian's formula. Measurements were taken both inside and outside bark to establish log volume of wood only and log volume of wood plus bark.

For each species sampled, tables 2 and 3 list the average weight per volume in English and metric units, along with the 95-percent confidence intervals. If you are interested in the association between log weight and *wood* volume, use table 2. If you want to find the ratio between log weight and total volume of *wood plus bark*, use table 3.

Table 1.—Number of and weight range of logs used in construction of weight tables

Species	Logs	Individual weight range
	No.	*Lbs.*
Ash, white (*Fraxinus americana*)	164	160 → 2,120
Basswood (*Tilia americana*)	378	180 → 2,960
Beech (*Fagus grandifolia*)	196	460 → 3,610
Birch, black (*Betula lenta*)	68	330 → 3,510
Blackgum (*Nyssa silvatica*)	74	490 → 4,190
Cherry, black (*Prunus serotina*)	227	200 → 2,760
Cucumbertree (*Magnolia acuminata*)	199	220 → 1,720
Hickory (*Carya* sp.)	406	400 → 5,750
Locust, black (*Robinia pseudoacacia*)	79	170 → 1,330
Maple, red (*Acer rubrum*)	90	290 → 3,040
Maple, sugar (*Acer saccharium*)	264	290 → 4,730
Oak, chestnut (*Quercus montana*)	313	280 → 3,390
Oak, red (*Quercus borealis*)	1,366	270 → 6,440
Oak, white (*Quercus alba*)	209	320 → 4,170
Yellow-poplar (*Liriodendron tulipifera*)	477	270 → 2,860

Table 2.—Weight / volume ratios for Appalachian hardwood sawlogs

[Volume based on *inside* bark measurements[a]]

Species	Lbs./ft.^{3}	Coeff. of var. (%)	Kg./m^3
Ash, white	54 ± 2[b]	23.7	859 ± 31[b]
Basswood	53 ± 1	21.3	846 ± 18
Beech	64 ± 1	15.9	1,019 ± 23
Birch, black	67 ± 4	21.3	1,070 ± 55
Blackgum	66 ± 3	19.5	1,057 ± 48
Cherry, black	53 ± 1	14.7	855 ± 16
Cucumbertree	51 ± 2	22.5	822 ± 26
Hickory	67 ± 1	20.4	1,072 ± 21
Locust, black	59 ± 3	25.8	939 ± 55
Maple, red	57 ± 3	22.9	910 ± 44
Maple, sugar	62 ± 2	22.5	985 ± 27
Oak, chestnut	69 ± 1	18.1	1,108 ± 22
Oak, red	67 ± 1	18.8	1,076 ± 11
Oak, white	64 ± 2	19.8	1,030 ± 28
Yellow-poplar	57 ± 1	21.3	911 ± 17

[a] Weight based on unbarked logs (wood and bark).
[b] + and — values = 95% confidence interval.

Table 3.—Weight / volume ratios for Appalachian hardwood sawlogs

[Volume based on *outside* bark measurements]

Species	Lbs./ft.^{3}	Coeff. of var. (%)	Kg./m^3
Ash, white	46 ± 2[a]	21.3	745 ± 5[a]
Basswood	47 ± 1	20.2	746 ± 15
Beech	60 ± 1	15.4	960 ± 21
Birch, black	59 ± 4	21.2	950 ± 49
Blackgum	56 ± 3	19.0	892 ± 39
Cherry, black	51 ± 1	14.4	814 ± 15
Cucumbertree	46 ± 1	21.6	734 ± 22
Hickory	59 ± 1	18.5	942 ± 17
Locust, black	44 ± 2	20.6	706 ± 33
Maple, red	53 ± 2	20.3	846 ± 36
Maple, sugar	55 ± 1	20.8	887 ± 22
Oak, chestnut	59 ± 1	16.4	948 ± 17
Oak, red	59 ± 1	16.7	945 ± 8
Oak, white	57 ± 1	17.4	919 ± 22
Yellow-poplar	59 ± 1	19.4	787 ± 14

[a] + and — values = 95% confidence interval.

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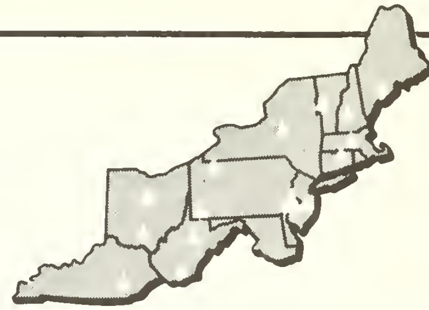

FOREST SERVICE, U.S. DEPT. OF AGRICULTURE, 6816 MARKET STREET, UPPER DARBY, PA. 19082

PREDICTING LOGGING RESIDUES: AN INTERIM EQUATION FOR APPALACHIAN OAK SAWTIMBER

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Abstract.—An equation, using dbh, dbh², bole length, and sawlog height to predict the cubic-foot volume of logging residue per tree, was developed from data collected on 36 mixed oaks in southwestern Virginia. The equation produced reliable results for small sawtimber trees, but additional research is needed for other species, sites, and utilization practices.

The increasing interest in utilizing logging residues has created the need for tools and techniques for doing this effectively. It is relatively easy to evaluate residues after logging, but what is more important is to find a method of evaluating potential residue before logging.

If such a method were available, the logging manager would be better equipped to determine what should be done with the residue. If he could estimate the total amount, along with its characteristics such as lengths, diameters, proportion sawable (for mine materials, pallet parts, etc.), and proportion chippable, he would have the basis for deciding what alternatives are feasible. Combining this information with knowledge of equipment and labor costs, market conditions, etc. would permit him to evaluate his options. If residue volumes were too low for profitable removal, he might still be required to treat the slash in some manner; and in this too, prior knowledge would make for better decisions.

To start the search for such a prediction tool, a pilot study was made in 1974 in southwestern Virginia by the Forest Products Marketing Laboratory. The results provided the bases for developing a regression equation for predicting the volume of residue resulting from the removal of sawlogs.

Methods

Fifty sample trees were selected systematically on a proposed sale area, and the following items were measured before cutting:

- *Species.*
- *Dbh,* taken to 1/10 inch, rounded down.
- *Bole length* (total growing-stock height), between the top of a 1-foot (0.305-m) stump and a 4.0-inch (12.2-cm) diameter outside bark (dob) or to the point where the central stem is terminated by branches, rot, etc., before reaching 4.0 inches (10.2 cm) dob, recorded to the nearest foot. A Wheeler pentaprism was used to locate the minimum top diameter.
- *Sawlog height* (merchantable height), between a 1-foot (0.305-m) stump to the point on the bole above which no sawlog can be produced because of excessive limbs or other defects, or to a minimum top of 9.0 inches (22.9 cm) dob, determined with the pentaprism, recorded to the nearest foot.
- *Crown diameter,* two measurements, taken at a right angle to each other, averaged, and recorded to the nearest foot.
- *Crown class,* either dominant, codominant, intermediate, or suppressed.
- *Defect* (board-foot cull deduction), in accordance with section 102.2 in the *U.S. Forest Service Timber Sale Preparation Handbook.*
- *Tree grade,* in accordance with the procedures in *Interim Hardwood Tree Grades for Factory Lumber,* by Leland F. Hanks (USDA For. Serv. Res. Pap. NE-199, 1971).
- *Branches,* the number of branches that appeared to be larger than 3 or 4 inches (7.6 to 10.2 cm) dob at the small end and 4 feet (1.219 m) or more in length.

The stand was predominately mixed oak (red oak, *Quercus rubra* L.; white oak, *Quercus alba* L.; and chestnut oak, *Quercus prinus* L.) along with some yellow-poplar, *Liriodendron tulipifera* L., red maple, *Acer rubrum* L., and other species. It was an even-aged stand composed of small sawtimber trees. Slopes ranged from 10 to 60 percent. Site index averaged 80 for yellow-poplar and 45 to 50 for oak.[1]

After felling, limbing, and topping, residue measurements were obtainable on 46 of the trees. Large-end and small-end diameters—along with length, defect, and residue class—were recorded for all material $\geq$ 3.0 inches (7.6 cm) dob at the small end. Defect was recorded only if losses for chipping were observed. The residue class indicated whether the piece was bolewood or limbwood, and whether it was straight or crooked. Tree age was determined by counting rings on the stump.

Analysis and Results

Residue measurements were converted by Smalian's formula to volume in cubic feet. Multiple-regression analysis was then applied. Residue volume per tree was the dependent variable, and the standing tree characteristics plus age and dbh^2 were used as independent variables.

The initial tests indicated that yellow-poplar should be omitted, probably because of differences in tree form. The sample contained only a few poplar trees, which by themselves were hardly sufficient for analysis; so the following discussion is based on 36 mixed oaks. Branching habits of the three oak species are very similar; however, they are quite different from that of yellow-poplar.

The variables involved in the analysis are presented in table 1 along with their means, standard deviations, and range within the sample of 36 trees. The simple correlation coefficients for each independent variable versus the dependent variable are also included.

The 12 variables explained 80 percent of the variation in the dependent variable (residue volume per tree). However, after a stepwise deletion process and several subsequent anal-

[1] Hampf, Frederick E. 1965. Site index curves for some forest species in the eastern United States. (Rev.) USDA For. Serv., Upper Darby, Pa. 43 p., illus.

Table 1.—Characteristics of the variables used in the regression analyses

Variable		Mean	Standard deviation	Range within the sample	correlation coefficient Y vs. X_i
Residue volume	(Y)	8.4 ft^3 0.24 m^3	4.6 ft^3 0.13 m^3	1.0-21.0 ft^3 0.03-0.59 m^3	—
Dbh	(X_1)	13.2 in 33.53 cm	1.9 in 4.83 cm	11.1-17.5 in 28.19-44.45 cm	0.598
Dbh^2	(X_2)	178.4 in^2 1150.97 cm^2	51.9 in^2 334.84 cm^2	—	.578
Bole length	(X_3)	48.4 ft 14.8 m	10.9 ft 3.3 m	27.0-72.0 ft 8.2-21.9 m	−.022
Sawlog height	(X_4)	32.2 ft 9.8 m	9.8 ft 3.0 m	15.0-59.0 ft 4.6-18.0 m	−.267
Crown diameter	(X_5)	27.3 ft 8.3 m	5.5 ft 1.7 m	17.0-38.0 ft 5.2-11.6 m	.470
Crown class*	(X_6, X_7)	—	—	—	—
Defect	(X_8)	8%	9%	0 - 30%	.162
Tree grade*	(X_9, X_{10})	—	—	—	—
Branches	(X_{11})	2.6	1.5	0 - 6	.596
Age	(X_{12})	57 yr	11 yr	27 - 75 yr	.199

* Dummy variables were used for the three crown classes and the three tree grades that were encountered in the sample.

yses, it was found that an equation containing four variables (X_1 through X_4) explained 73 percent of the variation in Y (R^2 = .729, $S_{y.x}$ = 2.57):

$$V = -88.209 + 13.224D - 0.415D^2 + 0.177BL - 0.400SH$$

where:

V = Residue volume/tree of all material $\geq$ 3.0 inches dob, in cubic feet.

D = Dbh, in inches.

BL = Bole length(as previously defined), in feet.

SH = Sawlog height (as previously defined), in feet.

If dbh is measured in centimeters, and bole length and sawlog height are measured in meters, residue volume in cubic meters per tree can be estimated with the equation ($S_{y.x}$ = 0.073)

$$V = -2.402 + 0.142D - 0.002D^2 + 0.017BL - 0.037SH$$

Although the four-variable equation differs little in statistical quality from that obtained with the full set of variables, it relates much better to the field data collected in a typical timber cruise. And, of course, measurement time has a direct bearing on costs.

It should be mentioned that even though bole length is poorly correlated with residue volume, and is highly correlated with sawlog height, it is still an essential part of the equation. This is understandable, however, because residue volume is partly a function of the difference between bole length and sawlog height.

Discussion

Because the equation is the product of a preliminary study with limited data, its use should be restricted to the smaller trees in mixed oak stands.

Because of this limitation, we are going to continue the study on a much larger scale. Sampling will be stratified so that differences (if any) between species, sites, cutting practices, merchantability standards, etc. can be detected. If the differences are significant, separate equations and/or tables will be prepared.

Obviously, residue resulting from small merchantable sawlog trees represents only part of the material that remains after logging. However, this study represents a step toward developing more complete knowledge about residue.

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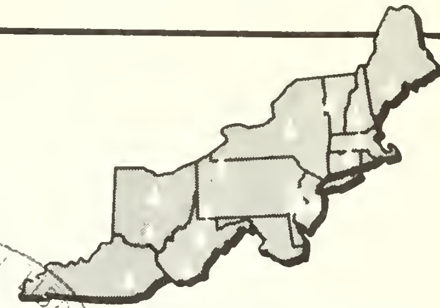

FOREST SERVICE, U.S. DEPT. OF AGRICULTURE, 6816 MARKET STREET, UPPER DARBY, PA. 19082

ODC 176.1 *Quercus* spp. : 232.12

VARIATIONS IN JUVENILE OAK

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Abstract.—Data from research on 13-year-old trees in an oak planting in southeastern Pennsylvania indicate that survival and growth are not correlated with source latitude within all species tested. A complete listing of species and seed origins, along with performance of progenies, is presented for persons interested in oak improvement.

The Michaux Quercetum study is a joint project of the Morris Arboretum of the University of Pennsylvania and the Northeastern Forest Experiment Station of the USDA Forest Service, financed in part by the Michaux Fund of the American Philosophical Society. One of the objectives of the study is to provide information about the variation within oak (*Quercus*) species.

Methods

Seed from individual wild trees was supplied by cooperators. Each collection was accompanied by herbarium specimens; suspected natural hybrids were excluded from the study. Seeds were sown in the fall of 1953, and seedlings were outplanted at seven locations in 1957.

In previous reports, Gabriel (*1958*), Li (*1955*), Santamour (*1960*), Santamour and Schreiner (*1961*), Schramm and Schreiner (*1954*), and Schreiner and Santamour (*1961*) have presented details about the earlier stages of this study and have described juvenile variation in a number of species.

The planting at Longwood Gardens, Kennett Square, Pennsylvania, (lat. 40°50′ W.) was remeasured in October 1966, 10 years after outplanting and 13 years after seeding. This planting includes progeny from 78 trees representing 13 species. The height and diameter of each surviving tree were measured, and its form was rated (table 1).

Differences in mean height and diameter

* Peter W. Garrett is project leader and Harry C. Kettlewood is a forestry technician at the Northeastern Forest Experiment Station's Forestry Sciences Laboratory in Durham, N.H.

Table 1.—Growth form, and survival of oak provenances at Longwood Gardens, Pa., 10 years after outplanting

Number	Species	Source	Number planted	Mean height	Mean diameter	Average form[a]	Survival
				Feet	*Inches*		*Percent*
017	*Q. rubra*	N.H.	31	15.0	1.2	2.4	25.8
018	*Q. rubra*	N.H.	30	19.2	2.7	2.0	46.7
019	*Q. rubra*	N.H.	31	18.0	2.2	2.1	51.6
020	*Q. rubra*	N.H.	32	14.5	1.3	2.2	40.6
376	*Q. rubra*	Penna.	32	15.8	2.1	2.3	15.6
377	*Q. rubra*	Penna.	29	15.7	2.0	2.4	41.4
416	*Q. rubra*	Ill.	30	14.9	1.8	2.6	70.0
418	*Q. rubra*	Ill.	34	17.6	2.0	2.2	67.6
426	*Q. rubra*	Ill.	32	17.4	2.2	1.8	81.2
471	*Q. rubra*	Ill.	32	16.8	2.1	2.2	53.1
052	*Q. rubra*	Kan.	32	15.2	2.2	2.6	53.1
058	*Q. rubra*	Kan.	30	14.5	1.6	2.7	50.0
209	*Q. rubra*	N.C.	30	15.1	1.8	2.3	26.7
210	*Q. rubra*	N.C.	30	15.8	1.7	2.1	30.0
212	*Q. rubra*	N.C.	30	14.7	1.6	2.3	43.3
379	*Q. velutina*	Ill.	29	16.8	2.1	2.1	62.1
422	*Q. velutina*	Ill.	30	15.8	1.8	2.2	36.7
425	*Q. velutina*	Ill.	30	14.0	1.7	2.5	40.0
428	*Q. velutina*	Ill.	27	16.2	1.9	2.2	77.8
372	*Q. velutina*	N.C.	28	15.9	2.2	2.1	71.4
233	*Q. velutina*	Tenn.	32	15.1	2.0	2.1	25.0
234	*Q. velutina*	Tenn.	30	15.3	1.9	2.0	50.0
290	*Q. velutina*	Ala.	28	17.8	1.8	1.9	28.6
291	*Q. velutina*	Ala.	26	15.4	1.7	2.0	46.2
107	*Q. velutina*	Va.	32	14.1	1.6	2.4	40.6
366	*Q. velutina*	Mich.	28	15.7	1.9	1.9	71.4
550	*Q. coccinea*	Ill.	19	12.3	1.1	2.3	21.1
470	*Q. coccinea*	Ill.	32	15.7	1.8	1.8	37.5
231	*Q.coccinea*	Tenn.	31	13.3	1.5	2.4	25.8
232	*Q. coccinea*	Tenn.	30	15.4	1.8	2.1	63.3
289	*Q. coccinea*	Ala.	30	14.5	1.7	2.4	60.0
293	*Q. coccinea*	Ala.	30	14.9	1.8	2.2	60.0
108	*Q. coccinea*	Va.	30	16.1	2.0	2.3	66.7
420	*Q. shumardii*	Ill.	20	17.9	2.5	2.2	85.0
215	*Q. shumardii*	Tenn.	20	17.5	2.4	2.0	60.0
284	*Q. shumardii*	Miss.	20	19.4	2.6	1.9	65.0
332	*Q. shumardii*	Fla.	20	15.4	1.7	2.5	55.0
214	*Q. shumardii*	Tenn.	20	16.3	2.4	2.6	65.0
287	*Q. shumardii*	Miss.	20	11.7	1.3	2.8	65.0
354	*Q. macrocarpa*	Minn.	18	9.3	0.7	2.3	16.7
355	*Q. macrocarpa*	Minn.	17	10.7	0.9	2.0	17.6
185	*Q. macrocarpa*	S.D.	30	12.9	1.5	2.8	33.3
186	*Q. macrocarpa*	S.D.	42	12.5	1.5	2.8	52.4
053	*Q. macrocarpa*	Kan.	13	16.8	3.2	2.7	84.6
402	*Q. macrocarpa*	Kan.	30	16.2	2.6	2.4	56.7
582	*Q. falcata*	Md.	6	13.0	1.5	2.5	33.3
409	*Q. falcata*	Va.	16	13.0	1.6	2.7	37.5
410	*Q. falcata*	Va.	20	14.0	1.9	2.4	50.0
412	*Q. falcata*	Va.	17	16.9	2.3	2.2	29.4
292	*Q. falcata*	Ala.	8	14.0	1.6	1.7	37.5
298	*Q. falcata*	Ark.	10	16.2	2.4	1.8	50.0
462	*Q. imbricaria*	Ind.	18	14.1	1.7	2.4	61.1
350	*Q. imbricaria*	Ohio	19	14.9	1.9	2.3	73.7
351	*Q. imbricaria*	Ohio	20	14.7	2.1	2.5	70.0
417	*Q. imbricaria*	Ill.	20	16.4	2.2	2.4	70.0
031	*Q. nigra*	Md.	20	13.8	1.8	3.0	42.1
033	*Q. nigra*	Md.	14	17.5	1.8	3.0	14.3
408	*Q. nigra*	Va.	17	14.5	1.8	2.5	76.5
414	*Q. nigra*	Va.	18	13.4	1.6	2.8	83.3
286	*Q. nigra*	Miss.	16	13.3	1.5	2.9	75.0
299	*Q. nigra*	Ark.	20	15.0	2.1	2.6	75.0

CONTINUED

Table 1.—Continued

Number	Species	Source	Number planted	Mean height	Mean diameter	Average form[a]	Survival
				Feet	*Inches*		*Percent*
576	*Q. phellos*	Md.	10	14.0	2.5	2.0	10.0
584	*Q. phellos*	Md.	20	15.3	2.2	2.2	45.0
411	*Q. phellos*	Va.	20	13.1	1.9	2.5	30.0
413	*Q. phellos*	Va.	20	16.2	2.3	1.8	40.0
285	*Q. phellos*	Miss.	20	12.6	2.0	2.6	25.0
297	*Q. phellos*	Ark.	20	14.2	1.9	2.4	65.0
227	*Q. marilandica*	N.J.	8	9.5	0.6	3.0	25.0
057	*Q. marilandica*	Kan.	16	10.3	1.3	2.7	37.5
299	*Q. marilandica*	Ark.	20	8.7	1.0	3.0	30.0
016	*Q. marilandica*	Texas	20	9.0	0.9	3.0	15.0
349	*Q. palustris*	Ohio	14	18.4	2.6	1.7	50.0
424	*Q. palustris*	Ill.	14	17.7	2.8	1.6	50.0
348	*Q. palustris*	Ohio	8	18.5	3.6	1.5	25.0
474	*Q. stellata*	Mo.	8	13.5	1.0	2.0	12.5
581	*Q. stellata*	Md.	8	12.0	1.1	2.5	25.0
601	*Q. variabilis*	Va.[b]	5	15.3	3.1	3.0	60.0
602	*Q. variabilis*	Va.[b]	15	14.7	2.1	3.0	40.0

[a] Form rating: 1—single stem, no sweep or crooks. 2—stem bifurcates above 8 feet, may have slight sweep or crook. 3—stem bifurcates below 8 feet; sweep or crook that may make tree worthless for timber use.

[b] Native to Asia. Seed for this study was collected from trees planted in Virginia.

Table 2.—Height differences within species and correlations of height, diameter, and survival with latitude of seed source 10 years after field planting

Species	Sources	Height	Correlation Height/lat.	Correlation Diameter/lat.	Correlation Survival/lat.
	No.	*Feet*			
Q. rubra	15	3.796**	+0.389	+0.044	—0.096
Q. velutina	11	1.305	— .175	+ .102	+ .363
Q. coccinea	7	0.840	+ .027	— .149	— .461
Q. shumardii	6	12.140**	— .062	+ .610	+ .738
Q. falcata	6	0.794	— .386	— .372	— .448
Q. macrocarpa	6	8.960**	—	—	—[a]
Q. phellos	6	1.280	—	—	—
Q. nigra	6	1.030	—	—	—
Q. imbricaria	4	0.101	—	—	—

** Significant at 0.01 level of probability. All others are not significant.

[a] Latitude of seed source no longer available.

were analyzed by ANOVA; and correlation coefficients of height, diameter, and survival over latitude of seed source were obtained for most species (table 2).

Results

Though the data were limited, we felt that the fairly wide range of the sample for some species would provide some estimates of adaptibility (survival in southeastern Pennsylvania). For those species represented by several seed sources from different latitudes, the correlation between latitude and survival was calculated. None of the correlations was statistically significant.

Red oak (*Quercus rubra* L.) was represented by 15 seed sources. Seedlots were significantly different in height after 13 growing seasons. The two tallest sources were both from Hillsboro County, New Hampshire, and had heights that were 123 percent and 115 percent of the grand mean for all *Q. rubra* seedlots. The other two seed lots from the same county had heights that were 93 percent and 88 percent of the mean, the latter being very close to the shortest source.

Black oak (*Quercus velutina* Lamb.) was represented by 11 sources. Differences in mean height were not significant.

Scarlet oak (*Quercus coccinea* Muenchh.) height differences were not significantly different. The range in latitude was small, and this may explain the low correlation between growth and latitude if latitude is an important factor.

Shumard oak (*Quercus shumardii* var shumardii) was represented by sources from Florida to Illinois, and highly significant differences were observed in mean heights. Tree-to-tree variation as contrasted with source location was clearly evident. Sources having the highest and lowest mean heights were from the same county in Mississippi. This means that the variation in growth of progeny from trees from the same area exceeded the variation between trees from other areas.

Burr oak (*Quercus macrocarpa* Michx.) sources were from three states, and highly significant differences were observed in mean heights. The most southerly sources (Kansas) produced the tallest trees; but because the exact locations within Kansas were not available, the correlation between latitude and height growth or survival could not be computed.

Southern red oak (*Quercus falcata* var. falcata Michx.) height differences were not significantly different, and survival was not correlated with latitude of seed source.

Water oak (*Quercus nigra* L.) and willow oak (*Quercus phellos* L.) did not yield significant differences in height within species, and data on county origin were not available for comparing latitude of source with survival.

A few sources of shingle oak (*Quercus imbricaria* Michx.), blackjack oak (*Quercus marilandica* Muenchh.), pin oak (*Quercus palustris* Muenchh.), post oak (*Quercus stellata* Wangenh.), and a species (*Quercus variabilis* Bl.) introduced from Asia with foliage similar to chestnut (*Castanea*) were included in the planting. Remeasurement data are included in table 1. No attempt was made to compare sources within these species.

In Conclusion

The number of trees used, the method of selection, and the design used in the planting at Longwood Gardens do not constitute a valid seed-source test. Even the 15 sources of red oak or the 11 sources of black oak do not adequately sample the botanical ranges.

Our conclusion is that height growth is not correlated with seed-source latitude for the species of oak included in this report. The tallest and shortest trees may be from the same county, which suggests that trees from the same area may contain as much variation in growth potential as trees from widely separated stands. Another finding is that survival was not correlated with latitude of seed source. There is no evidence that trees from one geographic region have a greater chance of surival than trees from any other region, and we found no visual evidence of cold-induced damage on any tree in the planting.

This authenticated collection of oak species at Longwood Gardens is available for breeding programs, particularly interspecific hybridization, with this important hardwood genus. Individual-tree information can be obtained from the genetics project of the USDA Forest Service, Northeastern Forest Experiment Station, at Durham, New Hampshire.

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ODC 145.7 x 19.88 *Enaphalodes rufulus*--131.6

RED OAK BORERS BECOME STERILE WHEN REARED UNDER CONTINUOUS LIGHT

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Abstract.—Red oak borers, *Enaphalodes rufulus* (Haldeman), reared under continuous light for 12 weeks became sterile. Sterility is thought to have been caused by light destroying vitamins essential for fertility.

Photoperiod influences diapause in many species of insects. However, continuous light can adversely affect the physiology of some insects.

Lum and Flaherty (*1970*) reported that *Plodia interpunctella* (Hubner) females mated with males reared under continuous light laid fewer eggs than females mated with males reared under alternating light and dark conditions. Poor quality of spermatozoa from males reared under continuous light was believed to be the reason for the difference.

When artificially reared, the red oak borer, *Enaphalodes rufulus* (Haldeman), diapaused in the last instar. During testing to see if photoperiod affected diapause, I found that continuous light had deleterious effects on the larvae and ensuing adults.

Materials and Methods

The artificial medium used in this study was the medium B that I reported earlier (*Galford 1969*). The larvae were reared in ½-oz. round aluminum cups sandwiched between sheets of plate glass taped together. Borer eggs were obtained from field-collected adults.

Forty larvae were reared for 4 weeks in the dark and then divided into two equal groups. One group was placed under a bank of four 40-watt Plant Gro fluorescent lights suspended 0.6 m above the rearing containers. The other group was placed in a cardboard box under the lights, and the box was sealed and covered with a thick black cloth.

The larvae were transferred into cups with fresh artificial medium at weekly intervals for 12 weeks. Then all the larvae in their rearing cups were packed in a cardboard box, and the box was sealed and put in a refrigerator set at 4° C. The larvae were removed after 50 days and returned to the test conditions. The adults that emerged were paired, and records were kept of fecundity and fertility.

Results and Discussion

Of the larvae reared under continuous light, one died during the rearing period, two developed abnormally long legs and died in the refrigerator, one "normal" larva died in the refrigerator, and two adults emerged with malformed antennae and elytra. The remaining adults looked normal. Eight females laid 467 eggs, none of which hatched.

Of the larvae reared in the dark, one died during the rearing period, one died in the refrigerator, and one adult had malformed antennae. Ten females laid 1,128 eggs, of which 81 percent hatched.

All the larvae in both groups went into diapause, so the test photoperiod did not inhibit diapause.

The most significant result of the test was the complete sterility of adults from larvae reared under continuous light for 12 weeks. No tests were made to determine if one or both sexes were sterile, because the tests were completed before it was known that the beetles were sterile.

The cause of adult sterility was not determined, but it may have been due to a nutritional deficiency. Certain vitamins, such as riboflavin (a nutritional requirement for red oak borers), are readily destroyed upon exposure to light; and some of the light-liable vitamins are essential for most insects' fertility. In later studies, I found that, when red oak borer larvae developed long abnormal legs, it was related to a nutritieonal deficiency that caused the larvae to have an extra instar. Two of the larvae reared under continuous light developed long abnormal legs.

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RELATIVE IMPORTANCE OF ROOT GRAFTS AND BARK BEETLES TO THE SPREAD OF DUTCH ELM DISEASE

— R. A. CUTHBERT
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and J. W. PEACOCK*

Abstract.—Root-graft transmission of Dutch elm disease (DED) is sometimes ignored in both research studies and city programs to control DED. Our results indicate that elms adjacent to 1-, 2-, or 3-year-old stumps have a disease rate three to five times higher than elms not adjacent to stumps. We conclude that in Detroit, which has elm plantings typical of many United States cities, root grafts were probably responsible for more than 50 percent of the DED transmission in 1973.

Treatments for controlling elm bark beetles, vectors of Dutch elm disease (DED), commonly are evaluated by the changes in the annual disease rate after treatment. This criterion has been used despite the fact that the disease fungus is known to be transmitted through root grafts as well as by beetle vectors. A treatment for controlling beetle vectors will have little direct effect on the number of elms that become infected through root grafts. Therefore, where root-graft transmission of the fungus is extensive, a measurement of beetle control based on the changes in disease rate may have little or no significance. In view of this, we conducted studies in Detroit, Michigan, to: (1) distinguish between root-graft and beetle-transmitted cases of Dutch elm disease, and (2) determine the relative importance of both kinds of disease transmission.

Methods and Materials

Three plots (A, B, and C) were established in 1973 about 400 m apart in a residential district of Detroit, Michigan. Most elms in the plots were 50 to 65 cm dbh, 11 to 18 m tall, and spaced about 12 m apart both along and across streets (except for gaps due to removals). The plots differed in area, number of elms, and average DED rate from previous years. Plot A was 1,200 X 1,200 m, and plots B and C were 600 X 1,200 m each.

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There were 1,469 elms in plot A, 607 in B, and 850 in C. Each year since 1970, city crews have removed about 8 percent of the residual elms in plot A, 6 percent in B, and 4 percent in C. City crews carried out their regular DED control program of sanitation and spraying with methoxychlor in all plots.

We surveyed the plots to locate all elms and 1-, 2-, and 3-year-old stumps (DED elms removed in 1972, 1971, and 1970). The elms were classified according to whether they were adjacent to stumps, and disease rates were calculated for each class to determine the spatial relationship between newly diseased elms and previous cases of DED. ("Adjacent to" is defined as on the same side of the street and within 12.2 meters.)

We first surveyed the plots for DED elms from June 11 to June 15 (just after full leaf expansion) and again from July 16 to July 20 (about 2 weeks after most overwintering beetles had emerged). In addition, city crews independently conducted their regular disease survey during July and August; and their data were included in this analysis.

Results and Discussion

About 75 percent of the cases of DED that have occurred in the plots since 1970 are within 20 m of other cases of DED, resulting in clusters of diseased elms and stumps along city streets. This clustering may be due to beetles feeding intensively near their emergence sites in diseased elms (*Collins 1938, Wolfenbarger and Jones 1943, Zentmyer et al. 1944*). However, because most diseased elms in Detroit are removed before beetles emerge, the clustering is unlikely to be caused primarily by beetle inoculations. Further, if new cases of DED resulted primarily from beetle inoculations, elms on both sides of the street should be exposed with near-equal frequency because elm crowns overlap across the street as well as along it. Conversely, if new cases resulted primarily from root-graft transmission, new disease should occur more often in elms adjacent to previous DED because root grafts are less likely to occur in the relatively dry and compacted soil under streets.

We found that the incidence of new disease was higher for elms adjacent to stumps than for those across the street from stumps. For example, there were 97 diseased elms in plot A within 20 meters of previous DED. Only 12 of these trees were across the street, but not adjacent to previous DED. Of the other 85 diseased elms, 56 were adjacent to previous DED, and 29 were both adjacent to and across the street from these stumps. The 12 elms not adjacent to previous DED were probably inoculated by beetles. However, because the disease was primarily associated with elms on the same side of the street as previous DED, we concluded that the DED fungus was transmitted to most of the 85 adjacent elms through root grafts.

The average DED rate for all the plots for elms suspected of contracting the disease through root grafts (elms adjacent to previous cases of DED) was 22.4 percent (table 1). Although only 653 elms in the plots were adjacent to stumps, they accounted for 53.1 percent (146 out of 275) of the DED. On the other hand, the DED rate was less than 6 percent in the 2,273 elms that could have been inoculated by beetles (those elms not adjacent to stumps); these trees accounted for 46.9 percent (129 out of 275) of the disease in these plots.

Neely and Himelick (*1963*) reported that root grafts commonly occur between adjacent elms. They recommended that root grafts be destroyed with Vapam[1] to prevent disease transmission when elms are less than 10.7 m apart (*Neely and Himelick 1967*). Our data indicate that extensive root-graft transmission of the DED fungus occurred at distances of 12.2 m. Thus city foresters should consider the importance of controlling the spread of DED through root grafts at distances up to 12.2 m.

The emphasis of DED control should be on elms adjacent to stumps. In Detroit, these elms accounted for less than 25 percent of the population, but for more than 50 percent of the DED. Further, the data indicated that

[1] Mention of a particular brand name does not imply indorsement by the USDA Forest Service.

Table 1.—Classification of elms and Dutch elm disease (DED) rates based on proximity to previous DED, Detroit, Michigan 1973

Description of class[a]	Plot	Elms in class	Percent of total in plot	DED elms in class	Percent DED in class
		No.	*Pct.*	*No.*	*Pct.*
All elms	A	1,469	100	150	10.2
	B	607	100	55	9.1
	C	850	100	70	8.2
	All	2,926	100	275	9.4
All elms not adjacent to previous DED[b]	A	1,086	73.9	65	6.0
	B	503	82.9	32	6.4
	C	684	80.5	32	4.7
	All	2,273	77.7	129	5.7
Elms adjacent to 1970-1972 stumps or 1973 DED elms	A	383	26.1	85	22.2
	B	104	17.1	23	22.1
	C	166	19.5	38	22.8
	All	653	22.3	146	22.4
Adjacent to 1973 DED elms	A	172	11.7	39	22.7
	B	60	9.9	9	15.0
	C	132	15.5	27	20.5
	All	364	12.4	75	20.6
Adjacent to 1972 stumps	A	137	9.3	38	27.7
	B	43	7.1	12	27.9
	C	48	5.6	15	31.3
	All	228	7.8	65	28.5
Adjacent to 1971 stumps	A	73	5.0	16	21.9
	B	27	4.4	7	25.9
	C	17	2.0	4	23.5
	All	117	4.0	27	23.1
Adjacent to 1970 stumps	A	66	4.5	15	22.7
	B	—[c]	—	—	—
	C	26	3.1	4	15.4
	All	92	4.0	19	20.6

[a] Classes are not necessarily mutually exclusive because individual elms may be adjacent to more than one stump.

[b] "Adjacent to" is defined as on the same side of street and within 12.2 m.

[c] Data for 1970 stumps not available in Plot B.

an elm adjacent to a stump has a high probability of contracting disease for up to 3 years. The disease rate for these elms was over 20 percent whether the adjacent stumps were 1, 2, or 3 years old (table 1). Thus healthy elms adjacent to elms infected with DED in 1973 have about a 60 percent chance of dying by 1976.

In evaluating treatments for controlling insect vectors of DED, we should put the emphasis on changes in the DED rate only for those elms not adjacent to previous cases of DED. Disease in these elms is clearly due to beetle inoculations, whereas the overall DED rate may include many diseased elms not affected by beetle-control treatments.

Acknowledgments

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ODC 651.7 : 244 : 442.3 : 176.1 *Vitis aestivalis*

COST OF CUTTING GRAPEVINES BEFORE LOGGING

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Abstract.—To reduce damage to hardwood stems by grapevines, it is recommended that grapevines be cut near ground level several years before the harvest cutting. Cost of completing this practice on 117 acres supporting 22 vines per acre was found to be about $3.50 per acre.

In recent years the pros and cons of even-aged management—and particularly the use of clearcutting methods — have been thoroughly discussed in relation to esthetics, utilization, logging methods, soil and watershed protection, wildlife habitat, reproduction, and future stand development. Meanwhile a little-mentioned situation is beginning to emerge on some clearcut areas of the central Appalachians: the establishment and uncontrolled growth of grapevines on good and better hardwood sites.

In West Virginia we have observed with increasing concern the prolific growth of grapevines and the damage the vines do to young stands after clearcutting (fig. 1). Measures for controlling grapevines are limited. However, a recommendation has been made to control grapevines by cutting vines near ground level several years before logging. The purpose of this note is to report a cost figure for this treatment.

Of the several species of grapes in the central Appalachian mountains, those of major concern are the summer grape (*Vitis aestivalis* Michx.) and a variety silverleaf grape [*V. aestivalis* var. *argentifolia* (Munson) Fern]. The problems with grapevines have been summarized by Shutts (*1968*, *1974*), Trimble (*1973*), and Trimble and Tryon (*1974*).

Grapevines break and deform stems and crowns of trees, resulting in the reduction of stem quality and growth rates. Often tree reproduction is so severely damaged by grapevines that recovery is doubtful.

Figure 1.—A tree crown damaged by a combination of vines and possibly snow or ice.

Figure 2.—Severe grapevine damage to reproduction. The vines have formed a mat over the trees.

However, we are not advocating the elimination of all grapevines. Grapevines provide habitat and food sources for many wildlife species (*Shutts 1974*); consequently, a recommendation to kill all vines on an area is not a desirable forestry practice. But where the production of wood products on good to excellent sites is a major objective of the owner, control of grapevines is advisable and should be considered where even-age management practices are used.

As newly established reproduction and grapevines grow on former clearcut areas, only a few treatments are available for controlling the vines. Individual stems cannot be treated easily because they are too numerous or too small (fig. 2). In large areas, basal spraying and mistblowing with a backpack are impractical. Aerial mist blowing of herbicides is possible, but it is expensive and often difficult to control. Thus it appears that grapevines cannot be controlled after cutting without the cost of considerable time and expense.

As an alternative, Trimble and Tryon (*1974*) suggested that grapevines that spread into the tops of second-growth stands could be cut near ground level several years before a harvest reproduction cutting—long enough before cutting for the stumps of the vines to die from the shading effects of the overstory canopy. Although we have other methods under study, cutting vines before logging seems to be a simple and effective method for reducing the number of grapevines in the new stand.

Method

We cut vines on 117 acres of a 65- to 70-year-old second-growth Appalachian hardwood stand on the Fernow Experimental Forest near Parsons, West Virginia. Slopes in this area range from 50 to 60 percent. The trees were more than 75 feet tall at age 50, averaging 17,500 board feet (International $\frac{1}{4}$-inch log rule) to the acre. The area had been logged between 1900 and 1910, with high-grading practices, and openings were created throughout the residual stand. Wildfires were numerous during and after this early logging. Perhaps the occurrence of fire was one reason why grapevines have not been a serious problem in second-growth hardwood stands.

An experienced 3-man woods crew located and cut grapevines near the ground during the last week of June, when the foliage was well developed. Locating grapevines was more difficult at this time than it would have been if the treatment had been applied during the dormant season. The crew used a Woodsman's Pal (fig. 3) or a small ax to cut the vines, and a tally-whacker to count the number of vines cut. Also, they were not aware of the time-cost aspects of this study.

Figure 3.—Cutting a 4-inch grapevine stem.

Results

It took 78 man-hours for a 3-man crew to cut 2,510 vines on 117 acres. These 78 man-hours included 7.5 man-hours for lunch and periodic breaks whenever the men so desired. However, travel to and from the study area was not included in these estimates. About 32 stems were cut per man-hour. Looked at in another way: one man treated 10.5 acres in a 7-hour work day—excluding travel. If we assume a cost of $35 per man-day, the per-acre cost was about $3.50—a low price to pay for controlling the potential grapevine damage. The reader may apply his own hourly rates to obtain his dollar cost per acre.

Naturally, we expect cost of this work to vary with a number of factors such as steepness of the area, number of vines cut per acre, difficulty of getting around the stand, and efficiency of the crew members. However, these results should serve as a base estimate for anyone interested in the cost of cutting grapevines several years before logging central Appalachian hardwoods.

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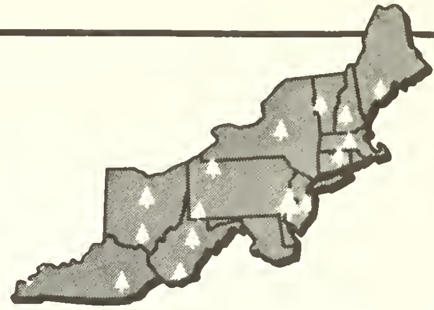

Northeastern Forest Experiment Station

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UDC 839.811

DOUBLE-DRUM SAWDUST STOVE

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Abstract.—An inexpensive home-made stove for burning loose sawdust is described. The stove, which is in common use in other parts of the world, can heat a room 20 feet square for 6 to 10 hours without tending.

In the United States, sawdust traditionally has been burned in large furnaces for industrial heating, in smaller furnaces for home heating, and in fireplaces in the form of compressed logs. In other parts of the world, loose sawdust has been burned for years in inexpensive double-drum stoves. These stoves are well suited for heating cabins or workshop areas.

The double-drum sawdust stove has other advantages. It is inexpensive to fabricate; it uses recycled components; it burns inexpensive fuel; and it heats a long time with minimum tending.

After seeing these stoves heating homes in Chile and reviewing plans[1, 2] for the types used in Afghanistan and England, I fabricated an experimental stove (fig. 1) at the Forest Products Marketing Laboratory in Princeton, West Virginia. Then I learned how to use the stove by firing it with several kinds of fuel having different moisture contents.

[1] The plan is available from Volunteers in Technical Assistance (VITA), 3706 Rhode Island Avenue, Mt. Rainier, Maryland 20822.

[2] Wood Waste as a Fuel. For. Prod. Res. Lab. Res. Leafl. 41. Princes Risborough, England. 11 p. 1956.

Figure 1.—The double-drum sawdust stove.

Fabrication

The experimental double-drum stove was made from a 55-gallon steel drum and a 30-gallon drum, plus about $25 worth of other materials, including stovepipe. Tools needed for fabrication are tin snips, hammer and anvil, pop rivet tool, drill and bit, metal-cutting saber saw, and equipment for brazing with bronze.

The stove (fig. 2) consists of two drums, one inside the other. A false floor inside the outer barrel supports the inner barrel. A drawer opening below the false floor provides draft, and the drawer catches dropping ashes, which are then easily removed. Three-inch holes in the center of the false floor and the inner barrel bottom let air pass up to the fuel and let ashes fall into the drawer.

A tightly fitting lid covers the outer barrel. Under this lid are about 3 inches of clearance to the top of the inner barrel. Two 6-inch diameter stovepipes exit from the outer barrel, allowing smoke to exhaust. The outer barrel is supported by three legs to keep excess heat from the floor and prevent rocking.

The false floor and drawer were fashioned from 20-gage sheet metal. Drawer tabs and curved front were fastened with pop rivets. The false floor rests on two parallel ½-inch steel rods, which were run through holes on opposite sides of the outer barrel, and were brazed to it.

Two handles of the lid and one on the drawer were made of ½-inch steel rod, bent to shape, and attached by brazing.

The two joints of stovepipe were brazed to the outer barrel, one near the top of the stove and the other directly beneath it. These two horizontal pipes join into a common vertical pipe. The upper horizontal pipe is fitted

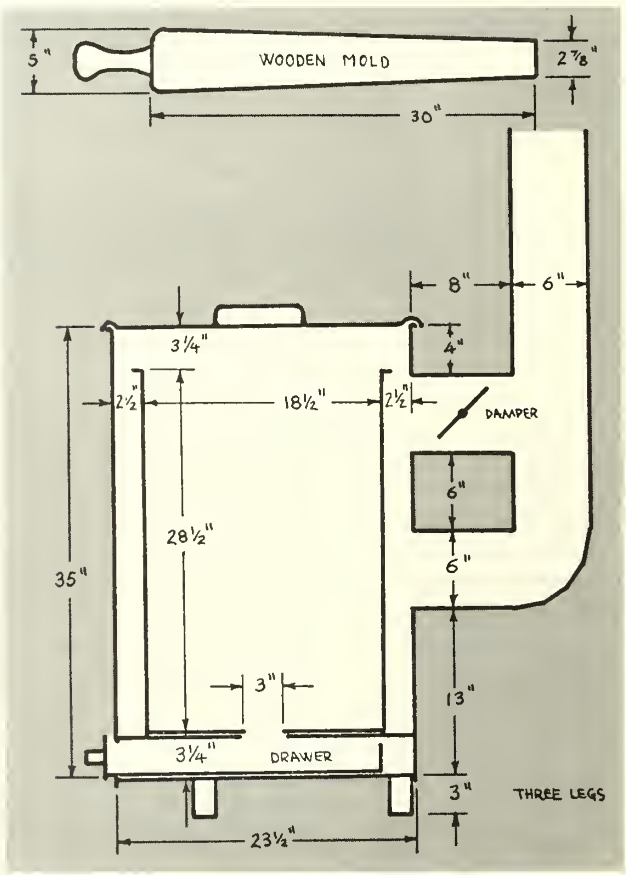

Figure 2.—Design of the experimental double-drum stove.

with a damper. The vertical pipe is fitted with elbows, straight lengths, wall or ceiling thimble, and a vent cap to suit the individual installation.

Smaller or larger stoves can be fabricated with heavy-gage sheet metal (about 14 gage). The relative sizes of the components should be roughly proportional to the dimensions of our experimental stove.

Installation

The stove should be placed at least 24 inches away from any combustible wall or floor material.[3] It should be set on a fireproof floor pad that extends at least 18 inches in front of the drawer opening. A wall thimble or triple wall pipe should be used where the pipe goes through the wall or ceiling and roof. The flue pipe should not have long horizonal sections, as they favor condensation of flue gas. The condensates leak at the joints and cause pipe corrosion.

Fuels

In addition to sawdust, bark residue from sawmills and planer shavings from planing mills can be burned in the stove. The limiting factor for fuels is their moisture content. Though fuel having more than 100 percent moisture content (oven-dry basis)[4] will burn, most of the heat is used in evaporating fuel moisture. Fuel below 60 percent moisture content works well. Fresh sawdust, shavings, and bark typically have moisture contents

[3] Using Coal and Wood Stoves Safely. National Fire Protection Association NFPA HS-8. 12 p. Boston. 1974.

[4] The water in the material weighs as much as the dry material itself.

Figure 3.—The stove filled and ready for firing (lid removed). Notice the hollow center in the fuel charge.

ranging from 50 to 110 percent. The best source of fuel is sawdust or shavings from dried lumber.

Fuel can be stored in a bin or in plastic garbage bags. If a bin is used, the inner barrel is either removed and taken to the bin for filling, or a large bucket is used to transfer the fuel from bin to stove.

How to Use the Stove

A round wooden mold, 3 feet long, tapering from 5 inches to 2⅞ inches, is used to shape the fuel charge.

To fill the stove, place the small end of the wooden mold in the hole at the bottom of the inner barrel. Then tamp sawdust or bark around it until the inner barrel is full. Wet fuel should not be tamped as much as dry fuel. Carefully remove the mold, leaving a vertical hole in the center of the fuel charge (fig. 3).

Before lighting the fire, open the drawer and damper. Then crumple waste paper, drop it down the hole in the fuel, and place the lid on the outer barrel. Place additional crumpled paper in the drawer and light it; move the drawer in so the flames will ignite the paper in the hole.

Once the fuel is burning, adjust the drawer and damper to obtain the desirable rate of burning and output of heat. Closing the damper forces hot air to circulate lower in the stove before leaving through the bottom stovepipe. Thus more heat is transferred to the room and less is lost through the pipe.

CAUTION: Do not open the lid while the fuel is burning. Oxygen thus mixed with flammable gases can cause a flare-up.

With dry sawdust and a good draft, one charge of this stove can heat a room 20 feet square for 6 to 8 hours with no tending. Wetter fuel heats less but lasts longer. During the first 2 hours of burning, there is enough heat at the center of the lid to boil water or cook with. As burning progresses, the heat on the lid is distributed more toward the rim.

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SULFUR CONTENT OF HYBRID POPLAR CUTTINGS FUMIGATED WITH SULFUR DIOXIDE

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Abstract.—Hybrid poplar cuttings were fumigated with sulfur dioxide ranging in concentration from 0.1 to 5 ppm for periods of 5 to 80 hours. At the end of the fumigation periods, the cuttings were harvested and the sulfur and chlorophyll contents of the leaves were measured. At 0.1 ppm and 0.25 ppm the sulfur content initially increased, but decreased as fumigation continued. At 3 ppm and 5 ppm the sulfur content of the leaves significantly increased, and foliar injury was apparent. No statistically significant change in chlorophyll content was observed.

Much interest has been shown in the importance of vegetation in removing sulfur dioxide (SO_2) from the atmosphere *(2, 6, 8)*. Since forests constitute a major portion of the earth's vegetation, studies are being made to determine whether forest vegetation can remove SO_2 from the air. This study was designed to determine whether hybrid poplar cuttings will absorb SO_2 from the atmosphere. The relationships among chlorophyll content, sulfur content, and foliar injury were also examined.

Methods and Materials

Hybrid poplar cuttings (*Populus deltoides* Bartr. x *P. trichocarpa* Torr & Gray) were placed in 6-inch plastic pots in a mixture of sand, soil, and peat (1:1:1). After 4 weeks, plants with similar foliage were selected and placed in fumigation chambers.

The fumigation chambers, 24 x 30 x 36 inches, have been described by Heck and others *(5)*. The air temperature in the chambers ranged from 25 to 30° C, and relative humidity ranged from 50 percent to 80 percent. Light was supplied by a bank of cool white fluorescent bulbs with a light intensity of 1,200 foot-candles. SO_2 was added to the inlet air from a gas cylinder before the air entered the chamber. The SO_2 concentration was monitored with a Malpar[1] flamephotometeric sulfur analyzer calibrated by the permeation-tube method.

Cuttings were fumigated from 8:30 a.m. to 4:30 p.m. daily, except on weekends. Cuttings fumigated with 0.1 ppm were harvested after 13, 22, 38, and 80 hours of fumigation. Cuttings fumigated with 0.25 ppm were harvested after 13, 22, and 38 hours. Another group of cuttings was fumigated for 38 hours at 0.25 ppm; these were returned to the greenhouse for 7 days before they were harvested. The other fumigation treatments were at 0.5 ppm SO_2 for 6.5 and 13 hours, 1 ppm and 3 ppm for 6.5 hours, and 5 ppm for 5 hours.

Leaves were removed from each of four control cuttings and four fumigated cuttings at the end of each treatment and were weighed immediately. One-half gram of fresh leaf tissue was removed for chlorophyll analysis and frozen. The remainder of the leaf tissue was dried in an oven at 100° C for 20 hours. The dry leaf tissue was reweighed, combined, ground in a Wiley mill, and re-dried. The sulfur content of the redried leaf tissue was determined with a Leco sulfur analyzer. The chlorophyll content of the frozen tissue was measured according to the official method of the Association of Official Agricultural Chemists *(1)*. Sulfur and chlorophyll content of leaves from each treatment were compared with those of their corresponding controls.

[1] The use of trade names is for information only and should not be considered an official endorsement by the U. S. Department of Agriculture or the Forest Service.

Results and Discussion

The sulfur content of leaves increased with SO_2 fumigation (table 1). Leaves fumigated

Table 1.—Sulfur content of hybrid poplar leaves
[mg/gm dry weight]

Treatment	Hours of fumigation						38 + 7 days recovery
	5	6.5	13	22	38	80	
Control	—	—	3.39	3.37	2.96	2.97	—
0.1 ppm	—	—	3.73	3.76**	3.31	3.14	—
%[1]	—	—	110	112	112	106	
Control	—	—	2.24	1.88	2.22	—	1.90
0.25 ppm	—	—	2.95**	2.76**	2.76**	—	2.16
%	—	—	132	147	124	—	114
Control	—	2.44	2.38	—	—	—	—
0.5 ppm	—	3.15**	3.34**	—	—	—	—
%	—	129	140	—	—	—	—
Control	—	2.81	—	—	—	—	—
1 ppm	—	3.38**	—	—	—	—	—
%	—	120	—	—	—	—	—
Control	—	2.29	—	—	—	—	—
3 ppm	—	3.24**	—	—	—	—	—
%	—	141	—	—	—	—	—
Control	2.75	—	—	—	—	—	—
5 ppm	4.02**	—	—	—	—	—	—
%	146	—	—	—	—	—	—

* Significant at 0.05 level.
** Significant at 0.01 level.
[1] Percentage of control.

with 0.1 ppm SO_2 all increased in sulfur content, but only the difference after 22 hours was statistically significant.

With fumigation at 0.25 ppm SO_2, significant differences were found in all treatments when the leaves were harvested immediately after fumigation. No significant difference was found when the leaves were harvested 7 days after fumigation had ended. All other fumigations with higher SO_2 concentrations caused significant increases in the sulfur content of the leaves.

The increase in sulfur content of hybrid poplar leaves fumigated with SO_2 demonstrates that SO_2 can be absorbed by hybrid poplar foliage. These findings, supported by other investigators *(2, 3, 4, 8)* suggest that vegetation may remove measurable amounts of SO_2 from the atmosphere. As the concentration of SO_2 increases, and the area exposed to it become larger, vegetation may be important as a cleaning agent in removing SO_2 from the atmosphere.

The increase in sulfur content of plant tissue was not directly related to the concentration of the SO_2 in the atmosphere. With a fivefold increase in pollutant concentration, from 0.1 to 0.5 ppm, the percentage increase in sulfur content of leaves after 13 hours of fumigation was only fourfold higher; and with the sixfold increase from 0.5 to 3.0 ppm, the percentage increase in sulfur content after 6.5 hours of fumigation had not doubled.

At the two low levels of fumigation, 0.1 and 0.25 ppm, the amount of sulfur in the leaves initially increased, but then tended to drop back to the level of the controls as fumigation continued. The decrease reported by other researchers *(3, 4)* was probably due to a reduction in the absorption rate as exposure continued, the translocation of sulfur from the leaves to other parts of the seedlings, the leaching of sulfate out of the plant through the roots, or the release of hydrogen sulfide gas back into the atmosphere.

Foliar injury was observed on the seedlings fumigated with 3 and 5 ppm SO_2. The injury was due to the high concentration of the pollutant in the atmosphere and not to the high sulfur content in the leaf tissue. The sulfur content of the leaves was 141 percent of the control after the 3-ppm fumigation, 146 percent of the control after the 5-ppm fumigation, and 147 percent of the control after 0.25-ppm fumigation for 22 hours. Injury was observed in the first two cases, but not in the latter. Injury apparently occurs when the plants are unable to convert the SO_2 into sulfate fast enough to prevent injurious sulfurous acid from accumulating *(7)*.

Foliar injury observed in the 3- and 5-ppm fumigations was not correlated with a decrease in chlorophyll content, as no significant differences were found in the chlorophyll content in any of the treatments. This may have been due to the leaves being harvested immediately after fumigations, when the water-soaked appearance of the leaves first suggested injury, but before there was any browning of the leaf tissue. Thomas and Hill *(9)* reported a tendency toward a slight reduction in chlorophyll content in SO_2-fumigated plants.

Hybrid poplar cuttings initially accumulated sulfur from a sulfur dioxide-polluted atmosphere. However, the sulfur content then tended to decrease. The reasons for the decrease are not clear, but may be very important in determining how effective tree foliage is in removing this pollutant from the atmosphere. Further studies are needed to determine the capacity and efficiency of tree foliage as an atmosphere-cleansing agent.

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FOREST SERVICE, U.S. DEPT. OF AGRICULTURE, 6816 MARKET STREET, UPPER DARBY, PA. 19082

TRENDS IN THE HIGHWAY MARKET FOR WOOD PRODUCTS

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Abstract.—Forty-eight million cubic feet of wood products, about 50 million dollars worth, were used in the Nation's highway construction program in 1972. Expenditures for highway construction increased 2½ times from 1954 to 1972. The volume of wood products used in highway construction changed little during this period because other materials were substituted for wood products for both structural forms and structure members.

Key words: wood use on highways; highway market; highway construction

Since World War II, expenditures for highway construction have increased on an average of about 9 percent annually. There has also been an increase in use of construction materials. The use of wood products, however, has not kept pace with the use of other materials.

Wood products are only a small part of the total cost of highway construction. But in 1972, the highway market consumed about 50 million dollars worth of wood products. Thus, this market is an important one for wood producers.

This report includes a summary of trends in the use of lumber, piling, and posts in highway construction in the United States. It also includes a description of the products and how they are used, estimates of the quantities used, and a discussion of trends in use.

Procedure

This report was compiled from information obtained from the Federal Highway Administration, state highway officials, and road contractors. I estimated the quantities of wood products used by applying the material usage factor for each product to the amount of money expended for highway construction. (A material usage factor is the units of a given material used per million dollars of construction costs.)

The lumber usage factor includes lumber, plywood, and building board. It does not include the wood products used for signs, sign posts, and light standards. An estimated 60 percent is lumber, and 40 percent is plywood and building board; building board is a relatively minor component. Post usage factors are not available.

The total number of posts installed was estimated from usage factors for the lineal feet of guardrail and fence installed. Guardrail posts were assumed to be spaced 6¼ feet apart, and fence posts were assumed to be 10 feet apart. An estimated 50 percent of the guardrail and fence posts installed are wood.

Wood Use on Highways

Lumber and plywood are used for shoring, scaffolding, formwork, and falsework in building bridges, drainage facilities, and other highway structures. Lumber, plywood, and building board are also used as an itegral part of bridges and buildings at rest areas. Posts are used for guardrails and for fencing the right-of-way. Piling is used to support bridges and other structures in swampy and sandy areas.

Nearly all the wood products used in highway construction are softwoods. Most of the hardwoods used are for guardrail posts. Treated wood products are used for bridges, guardrail posts, fence posts, and piling. Plywood used for structural forms is often oil-treated or plastic-coated.

Structural form lumber and plywood are purchased in standard sizes and are cut to the required sizes at the job site; these materials are often reused. Structural lumber and piling are generally special-order items, cut and finished to design specifications.

Guardrail posts are either round or sawed and are about 6 feet long. Sawed posts are usually 6 x 8 inches or 8 x 8 inches in cross section, and round posts are 6 to 8 inches in

Table 1.—Construction expenditures[a] for all public highways, roads, and streets and estimates on the wood product volumes by year

Year	Construction Expenditures	Lumber[b]	Piling[b]	Posts[c]	Total
	Billions	*Million fbm*	*Million fbm*	*Million ft³*	*Million ft³*
1954	3.670	355	85	—	—
1955	3.915	355	85	—	—
1956	4.247	360	100	—	—
1957	4.586	355	100	—	—
1958	5.178	375	100	—	—
1959	5.237	360	105	—	—
1960	4.913	325	85	—	—
1961	5.301	355	70	—	—
1962	5.727	345	55	—	—
1963	6.256	380	55	—	—
1964	6.488	385	60	—	—
1965	6.523	370	50	—	—
1966	7.208	410	50	—	—
1967	7.531	415	50	—	—
1968	8.120	400	45	11	48
1969	8.119	340	45	11	43
1970	9.196	380	45	12	47
1971	9.519	390	45	10	46
1972	9.826	420	40	10	48

[a] Includes the costs of (1) materials and supplies, (2) labor, and (3) equipment, overhead, and profit, but does not include the costs of preliminary engineering and right-of-way acquisition. All Federal, state, and local expenditures are included.

[b] 1972 estimates from trend lines, figures 1 and 2.

[c] Guardrail, median, and fence posts. In 1971, an estimated 3,600,000 wood guardrail and median posts; 4,022,000 wood fence posts. Conversion factors: 12 board feet per cubic foot; 2.0 cubic feet per guardrail and median post; 0.6 cubic foot per fence post, 6.54 board feet per lineal foot piling.

diameter. Fence-line posts are about 6½ feet long and 4 inches in diameter. Posts used for corner, gate, end, and pull posts for stretching the fence are 6 to 8 inches in diameter and about 8 feet long.

Trends in the Use of Wood Products

During the period 1954 to 1972, expenditures for highway construction increased from 3.7 billion dollars to 9.8 billion dollars; total requirement for lumber and piling generally ranged between 400 and 500 million board feet. Requirements for posts from 1968 to 1972 ranged from 10 to 12 million cubic feet (table 1).

Highway construction expenditures include three cost components: (1) materials and supplies; (2) labor; and (3) equipment, overhead, and profit. The material and supply component has increased from about 30 percent of total costs in the mid-Fifties to about 45 percent in 1972. The increase was brought about because higher highway design standards required more materials and supplies. Improvements in earth-moving, paving, and other road-construction equipment caused a decrease in the labor requirement.

Figure 1.—Lumber-plywood usage factor trend.

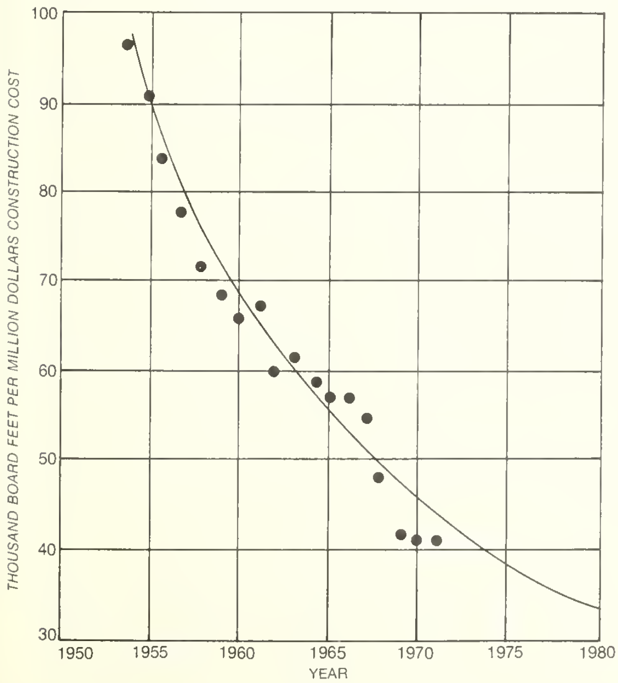
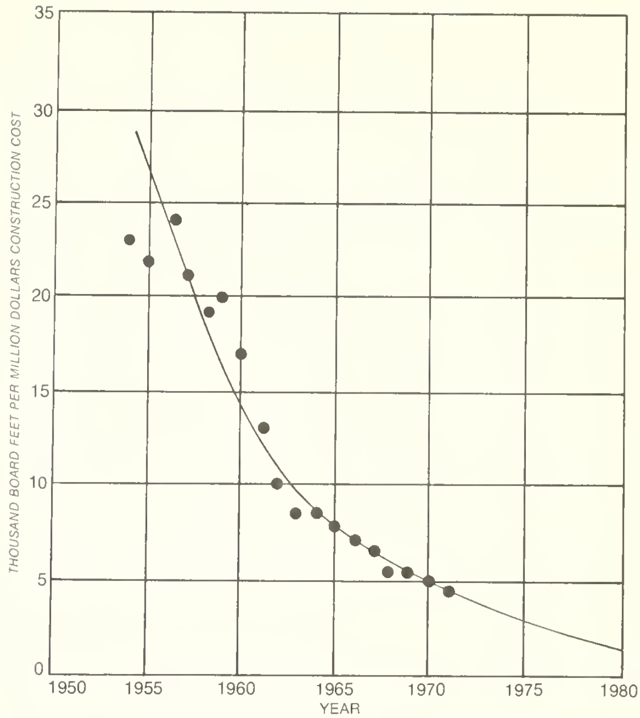


Figure 2.—Piling usage factor trend.



Requirements for lumber and piling did not increase along with requirements for other materials and supplies. Although total expenditures increased about 2½ times from 1954 to 1972, lumber requirements increased only slightly; and piling requirements decreased considerably (table 1). In fact, total requirements have held the 400 to 500 million-board-foot level only because of an increase in total expenditures.

The use of lumber and piling declined because of changes in materials specifications and in construction methods. The downward trends are a result of (1) a reduction in the use of structural forms, and (2) the substitution of competitive materials for wood. Wood-product costs have not affected the downward trends because these costs constitute only 1 to 2 percent of the total cost of materials and supplies.

Many states now permit the use of component parts for highway structures. For example, precast deck slabs are formed at a factory or field site and delivered to the project site. The use of precast deck slabs reduces the need for structural forms on-site, thus reducing the requirements for wood. Another change that has reduced wood requirements is the trend to use steel, aluminum, and other materials rather than wood for fabricating on-site structural forms.

The use of wood products for bridge members has declined sharply, particularly on interstate and other primary highways. On secondary highways and rural roads, timber piling and lumber are still used to some extent for bridges. The trend in bridge replacement, however, is to steel and concrete products. Other than for buildings at roadside rest areas and for similar non-roadway purposes, lumber and piling do not offer serious competition to steel and concrete products.

Discussion

The use of lumber and piling declined in highway construction because of changes in material specifications and in construction methods. The 400 to 500 million-board-foot level of usage was maintained only because of an increase in total expenditures. Under normal circumstances, the expected trends in usage for these products would show a continuation at about this level.

Within the past several years, however, the nation has begun to experience shortages along with rapid price increases in many of the construction materials derived from nonrenewable resources. Because timber is a renewable resource, it is likely that wood products will become more attractive to the highway construction industry. The wood products industry should act now to demonstrate its ability to meet the demands of the highway construction industry and state highway departments. The most important demand is for a ready supply of uniform high-quality products. At present, the secondary highway and rural road segments of the market show the greatest potential for an increase in use of wood products.

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RELATIONSHIP OF STAND AGE TO STREAMWATER NITRATE IN NEW HAMPSHIRE

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Abstract. Streamwater nitrate content of six watersheds during spring and summer was apparently related to stand age or age since disturbance. Nitrate concentration averaged 10.3 ppm right after cutting, dropped to a trace in medium-aged stands, and then rose again to a maximum of 4.8 ppm as stands became overmature.

Clearcutting results in accelerated discharge of NO_3- (in addition to other nutrients) into mountain streams in New England (*Pierce et al. 1972*). However, investigations in the White Mountains of New Hampshire (*Pierce et al. 1972*) and investigations in the Bowl Research Natural Area (*Leak 1972*), indicate that NO_3- discharge during the spring-summer period varies considerably among streams draining forest stands that apparently have not been disturbed recently.

The cause of this variation is not known. However, at least two hypotheses exist. Some believe that NO_3- discharge may increase during years when the soil freezes; and there is some evidence from New England watersheds as basis for this point of view. However, soil frost occurs only sporadically in New England watersheds below elevations of 2,500 to 3,000 feet, and the preliminary evidence to date indicates that its effects on nutrient discharge occur during the winter and do not carry over into the spring-summer period (*Hornbeck 1973*). Thus, soil frost does not seem to explain the consistent year-to-year high or low nutrient discharges that characterize a given stream during the spring-summer period.

The other hypothesis is that consistent spring-summer nutrient discharge rates (NO_3- in particular) may be related to stand age. Marks and Bormann (*1972*) suggested that very young fast-growing pioneer stands are effective in reducing nutrient loss from ecosystems. It is not unreasonable to suggest that old overmature stands that are not increasing rapidly in vegetative mass or humus depth become less effective in utilizing available nutrients, resulting in an increased nutrient discharge into the streamwater.

To gain some additional information about the relationship of stand conditions to NO_3^- discharge, we cruised six of the control watersheds reported by Pierce *et al.* (*1972*) and related certain stand features to the reported streamwater concentrations of NO_3^-.

Methods

The six control areas examined were the Dartmouth Outing Club (D.O.C.) tract, Davis Brook, Conner Brook, Underhill Brook (the control area for the Stony Brook cutting area), Greeley Brook, and Church Pond (*Pierce 1972*). However, the Church Pond control was very small and apparently influenced by recent logging, so it was dropped from the study. Available information from a portion of the Bowl was incorporated into the investigation.

Each control area was cruised, using a metric prism (factor of 4 m^2 hectare). Points were systematically located at a square spacing of approximately 120 meters (6 chains). On one small watershed (Davis Brook) the sampling intensity was doubled. Numbers of points per watershed were:

D.O.C.	40
Davis	7
Conner	28
Underhill	41
Greeley	15

These numbers generally reflect the relative sizes of the watersheds. However, the Greeley, Underhill, and Conner tracts have a sizable acreage of steep and rocky spruce-fir land that could not be cruised readily. The Bowl tract also contains some acreage of steep ledge that was not cruised.

There is some evidence that size of drainage should be considered in evaluating nutrient discharge. However, no clear relations between drainage size and nutrient discharge were noted in this study. (Stuart, G. Effects of timber harvest on water chemistry. White Mountain National Forest. Unpublished report, 10 p., 1973.)

At each point, the immediate stand was classified visually into one of three structural classes recognized by silviculturists: (1) even-aged (a single recognizable age class); (2) holdover (a young even-aged stand with a few old trees); and (3) uneven-aged (more than two age classes or age classes unrecognizable). The first two classes commonly denote fairly recent cutting.

Basal area was measured at each point, by species. Holdovers were tallied separately. On even-aged plots, one of the dominant stems was bored for age. Borings also were taken regularly in the even-aged stands underlying holdovers. An occasional holdover or larger stem on uneven-aged plots was bored to determine age.

Results

Four areas — D.O.C., Davis, Conner, and Underhill — support mixtures of hardwoods, with a smaller proportion of softwoods. Greeley is a spruce-fir area, with mountain paper birch. The Bowl stand is primarily hardwoods, with some inaccessible high-altitude spruce-fir, as mentioned earlier (table 1).

Stand composition may indicate the history of these areas. Intolerant hardwoods (paper birch and pin cherry) denote recent disturbance in hardwood types. A high percentage of even-aged or holdover stands indi-

Table 1.—Species composition, in percent of basal area[1]

Area	Tolerant-intermediate hardwoods	Intolerant hardwoods	Softwoods
D.O.C.	47	24	29
Davis	53	5	42
Conner	72	6	22
Underhill	76	3	21
Greeley	—	18	82
Bowl	93	—	7

[1] Percentages for the Bowl are based on number of stems 200 mm diameter (at root swell) or larger (*Leak 1975*).

cates heavy cutting within the past 100 years or so. The D.O.C. tract contains the highest percentage of intolerants (24 percent) and has a very high percentage of even-aged and holdover stands (95 percent). Davis and Conner have only 5 to 6 percent intolerants, but 86 percent or more of even-aged and holdover stands. Greeley has a high percentage of mountain paper birch, but this is a natural associate of spruce-fir and does not reflect recent cutting. Also, the even-aged condition of Greeley reflects the tendency of spruce-fir to grow in small even-aged stands. Both Underhill and the Bowl have very few intolerants and are primarily uneven-aged (table 2).

The age summaries indicate that the even-aged stands and young stands under holdovers on the D.O.C. tract range up from 30 years of age (table 3). About one-fourth of these stand types fell within the 30- to 50-year class. Logging roads, stumps, and collapsed shelters were present. Apparently, the D.O.C. tract was cut heavily 30 to 35 years ago. Much of this cutting was concentrated along the stream that was water-sampled. The stand-age data indicate that another heavy cutting was made 60 to 85 years ago.

Table 2.—Percentage distribution of plots among stand-structure classes

Area	Even-aged stands	Holdover stands	Uneven-aged stands
D.O.C.	44	51	5
Davis	100	—	—
Conner	50	36	14
Underhill	13	23	64
Greeley	80	7	13
Bowl	—	—	(100)[1]

[1] The Bowl stand is predominantly uneven-aged.

The presence of stone walls in the Davis tract indicates that it was pasture land that was abandoned 55 to 95 years ago. The range in age reflects the fact that old pastures often were abandoned gradually and did not regenerate completely within a short time.

The Conner tract contained slightly older second-growth stands than the Davis tract. Although the range in plot ages begins at 40 years (table 3), the majority of the even-aged and holdover stands fall within the 60- to 140-year range. We suspect that two heavy cuttings took place, one 60 to 85 years ago, the other 100 to 140 years ago.

The uneven-aged stands that predominate in the Underhill area contain trees up to about 185 years of age (table 3) or a little more. Most of the timber is old and mature. However, the ages are not as great as those in an overmature stand such as the Bowl, which contains trees up to 240 years or older (*Leak 1972*). Furthermore, the largest trees in the uneven-aged plots at Underhill were about 790 mm (at root-swell), both yellow birch and sugar maple. In contrast, birch and sugar maple in the Bowl commonly run over 800 mm (sugar maple) or 900 mm (yellow birch). One holdover yellow birch at Underhill was 995 mm, but holdover trees commonly run large for their age.

The stands at Greeley Brook run from 65 to 350 years of age (table 3). The Greeley stands are old overmature spruce that are

Table 3.—Range in approximate stand age, by stand-structure classes, in years

Area	Even-aged stands		Young Stands under holdovers		Uneven-aged stands		Approximate weighted average age
	Range	*Aver.*	*Range*	*Aver.*	*Range*	*Aver.*	
D.O.C.	30 - 85	60	30 - 80	60	80 - 230	155	65
Davis	55 - 95	75	—	—	—	—	75
Conner	85 - 160	125	40 - 110	75	—	(155)	110
Underhill	65 - 80	70	60 - 105	70	110 - 185	155	125
Greeley	100 - 350	200	65	65	175 - 350	260	200
Bowl	—	—	—	—	—	200	200

near the maximum age for the species (nearly 400 years). There is no evidence of any logging. Many trees are dead and dying.

The Bowl stand is recognized as one of the best examples of virgin overmature hardwoods in New Hampshire.

If an average age is determined for each tract by weighting the average age per stand-structure class by the percentage of plots per structure class, the tracts rank in order of increasing age as follows: D.O.C., Davis, Conner, and Underhill, with Greeley and the Bowl about tied for the oldest (table 3).

Streamwater concentrations of NO_3- for the spring-summer period are given in table 4 for the several stand conditions covered by this study. The nutrient data for the Bowl are taken from Leak (*1974*), covering the summer period primarily. The watershed for Tributary 3 is most representative of the Bowl hardwood stand; Tributary 2 also drains part of the stand as well as some mixedwood stands and high-elevation spruce-fir.

The other nutrient data are directly from Pierce *et al.* (*1972*). For comparison, table 4 includes comparable nutrient data from the recent clearcuttings examined by Pierce. Notice that NO_3- discharge is high in recent clearcuttings. It is much lower in the area cutover 30 to 35 years ago. Minimum NO_3- content occurs in even-aged second-growth hardwoods. NO_3- content picks up a little in mature hardwoods. And it becomes noticeably higher in overmature stands, both spruce and hardwoods. This trend is in line with the hypothesis described earlier on the relationship of nutrient release to stand age or age since disturbance.

Table 4.—Comparison of NO_3- streamwater contents (spring-summer period) by stand conditions listed in order of increasing time since disturbance

Stand Conditions	NO_3- ppm Range	Average
Recent clearcuttings (*Pierce et al. 1972*)	0.2-28.3	10.3
Cut 30 to 35 years ago—D.O.C.	.4- 5.4	2.3
Second-growth even-aged hardwoods—Davis, Conner	<.1- .9	.15
Old-growth mature hardwoods—Underhill	<.1- 3.6	.8
Overmature spruce—Greeley	.8- 3.5	2.4
Overmature hardwoods—Tributary 2	1.7- 2.6	2.2
Overmature hardwoods—Tributary 3	3.6- 5.3	4.8

Discussion

The results of this study seem to show a good relationship between streamwater NO_3- during the spring-summer period and stand age or age since disturbance. Beginning with high concentrations of NO_3- right after heavy cutting, the concentrations drop off to a minimum in medium-aged stands and then rise again as the stand goes through maturity into overmaturity.

The study dealt with spring-summer concentrations because of the availability of nutrient data for this period. However, recent evidence indicates that differences among stands in spring-summer concentrations hold up during the winter period when nutrient concentrations and streamwater discharge are highest.

Since completion of this manuscript, we found through personal communication that P. M. Vitousek and W. A. Reiners, of the Department of Biological Sciences at Dartmouth College, Hanover, N.H., have independently uncovered the same relationships. They found that nitrate concentrations throughout the year in streams draining old-aged forest ecosystems on Mt. Moosilauke were consistently higher than those draining successional (intermediate-aged) ecosystems. A manuscript about this, entitled "Ecosystem Succession and Nutrient Retention: A Hypothesis", was submitted in November 1974 to Bioscience.

It is difficult to make an extremely positive statement about the relationship of stand age to nutrient discharge. The subject is complex; many factors other than stand age must influence the nutrient-discharge pattern. Additional research is needed to show how these results relate to the inhibition of nitrification that has been observed in certain climax ecosystems (*Rice and Pancholy 1972*). However, the study certainly has strengthened the hypothesis of a stand-age/nutrient-discharge relationship.

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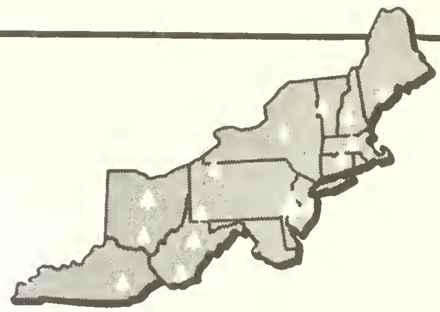

FOREST SERVICE, U.S. DEPT. OF AGRICULTURE, 6816 MARKET STREET, UPPER DARBY, PA. 19082

REST: A COMPUTER SYSTEM FOR ESTIMATING LOGGING RESIDUE BY USING THE LINE-INTERSECT METHOD

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Abstract.—A computer program was designed to accept logging-residue measurements obtained by line-intersect sampling and transform them into summaries useful for the land manager. The features of the program, along with inputs and outputs, are briefly described, with a note on machine compatibility.

KEYWORDS: Logging residue, computer program.

The forester and the land manager who are concerned with improving the utilization of wood fiber produced by a forest want to know how much is left behind after a logger has harvested a forest stand. One way to estimate logging residues is by means of the line-intersect method.

Logging residues include the unwanted, generally unutilized woody material in the forest that originates from the activities of timber harvesting. Of course the line-intersect method can also be used for other forest residues, such as those resulting from natural processes or other activities of man.

The line-intersect method for sampling logging residues is well documented *(Bailey 1970a, 1970b, Bailey and Lefebure 1971; Howard and Ward 1972; Van Wagner 1968; and Warren and Olsen 1964)*. Briefly, the method requires that a sample line be established on the cutover area and that the diameters of all logging residues that cross the line are measured at the point of intersection.

Sample lines may be continuous or segmented, and they may be oriented either systematically (using a grid network) or randomly. Volume in cubic feet per acre is estimated by using a very simple formula after diameters have been converted into cross-sectional areas. Weight may also be estimated if specific gravity is known. If desired, information about lengths, end diameters, defects, etc. may be determined by subsampling a portion of the sample line.

Line-intersect sampling is highly recommended for several reasons:

1. For the same level of accuracy in volume estimation, the line-intersect method requires only one-fourth to one-half the time needed for fixed-area plots.
2. There is no problem with pieces overlapping a boundary as there is with fixed-area plots.
3. When the line-intersect method is used, there is no difficulty in determining what has or has not been tallied, because measuring proceeds systematically along the sample line.

However, less attention has focused on a general system for compiling a useful picture of residue conditions for a particular area. Bailey does describe some of the techniques needed in such a system, but all the details are not combined in a step-by-step manner.

The REST System

The REST (Residue ESTimation) system described in this note is one approach for putting residue information into a format that will be useful to industry, resource analysts, and resource planners. REST incorporates the methods developed by Bailey, along with some additional measures for assigning the residue volumes (or weights) to the appropriate diameter and length classes. This information can be subdivided further by species or species groups and by type (sawable or chippable only, straight or crooked, etc.).

Although this sounds like a straightforward procedure, the computations are lengthy because of the assumptions on which the line-intersect method is based. By using the line-intersect sampling scheme, we are saying that a satisfactory volume (or weight) estimate is possible when only the diameter at point of intersection is measured. When a total per-acre figure is our goal, we have no problem. However, when we subsample the residue and attempt to group the data by length class, we run into difficulty because the probability of intersecting a piece is proportional to its length.

Bailey resolved this by what he calls a five-step rectification procedure. The computations involved are incorporated into REST along with provisions for assigning the pieces to the proper diameter classes. REST is primarily the result of taking what has been developed by others and organizing a systematic means of translating field data into a workable description of residue conditions.

The steps in the REST system have been programmed in FORTRAN IV for use with an IBM System/370 computer. However, the aim in programming was to achieve generality so that REST could be used with most computer facilities (fewer than 45,000 bytes of core storage are needed). Flexibility was another programming goal, so that REST should fill the need of users in any timber-growing region.

Features of REST

Virtually any approach to field measurements with the line-intersect method is compatible with REST. Sample lines (sampling units) may be referenced to a grid system and oriented unidirectionally, randomly, or paired at right angles to each other. Another possibility is to use a continuous line with a random change in direction after a predetermined number of feet or chains have been measured. The REST system is set up so that information collected from a subsample of the sampling units can be used easily for developing a conversion ratio — to adjust cross-section area at the point of intersection to correspond with the mean of piece end areas and to adjust for defective wood *(Bailey 1970b)*—and for developing length and diameter distributions etc.

The user will have to decide on appropriate procedures. However, REST is designed to handle the summarization for any field layout and for any intensity of subsampling (from 0 to 100 percent). Other specific features are:

1. Use of the conversion ratio (as recommended by Bailey) is optional.

2. An estimate of the residue weight (in tons) can be obtained if an appropriate specific gravity is supplied.
3. The length of each sampling unit is selected by the user.
4. Diameter and length classes to be used in the output tables and the minimum diameter and length limits are set by the user.
5. Per-acre figures can be adjusted for the effects of slope if so desired.

Inputs

1. Title card
2. Control card:
   a. Tables to be printed.
   b. Diameter-class width.
   c. Length-class width.
   d. Data-printing code.
   e. Conversion-ratio use code.
3. Parameter card:
   a. Minimum diameter limit used when sampling.
   b. Minimum length limit used when sampling.
   c. Slope—optional.
   d. Length of each sampling unit.
   e. Number of sampling units.
   f. Number of sampling units that were subsampled.
   g. Specific gravity—optional.
4. Data cards:
   a. Species code.
   b. Diameter at the point of intersection. For pieces in the subsample, any or all of the following items may be obtained.
      Both end diameters.
      Length.
      Defect.
      Classification code—assigned by the user.

Outputs

1. A complete listing of the data cards — optional.
2. A summary of the sample data, showing average volume (and weight if desired) per acre, the input parameters, average diameters, average length, etc.
3 A set of nine tables, showing the data summarized by diameter and length classes. In addition to the final volume and weight summaries, there are tables showing the number of pieces and volume in the subsample as well as tables showing the intermediate steps used in obtaining the final summaries. The user has the option of printing all, none or any combination of these tables.

Discussion

Sampling logging residues with the line-intersect technique is a means of establishing what has already happened. However, with sufficient sample data, collected on past operations, timber managers may be able to predict residue conditions on future timber sales. And resource analysts could use line-intersect sampling to monitor the residue situation over time so that future assessments of changing utilization patterns can be made readily.

The REST system could be useful because it was developed to help these people convert basic data, with a minimum of effort and no intermediate computations, to useful secondary information.

Program Availability

Complete documentation of the REST system is available upon request from the USDA Forest Products Marketing Laboratory at Princeton, West Virginia 24740. The user's guide contains the program source listing, input instructions and forms, and examples of the printed output.

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FOREST SERVICE, U.S. DEPT. OF AGRICULTURE, 6816 MARKET STREET, UPPER DARBY, PA. 19082

SUGAR MAPLE SAP VOLUME INCREASES AS VACUUM LEVEL IS INCREASED

by RUSSELL S. WALTERS and H. CLAY SMITH[1]

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Abstract.—Maple sap yields collected by using plastic tubing with a vacuum pump increased as the vacuum level was increased. Sap volumes collected at the 10- and 15-inch mercury vacuum levels were statistically significantly higher than volumes collected at the 5-inch level. Although the 15-inch vacuum yielded more sap than the 10-inch vacuum, the difference was not statistically significant. An efficient vacuum system should have a vacuum level of at least 10 inches of mercury at the taphole.

Sugar maple sap yields are known to be greater when sap is collected on a hillside by gravity in a closed plastic pipeline than when a vented system is used *(Blum 1967)*. This is because a natural vacuum is created by the weight of the sap flowing through the closed tubing line. A vacuum pump connected to an unvented tubing system can also increase sap yields. However, we did not know how much vacuum is needed to get the greatest sap yield.

Collecting sugar maple sap at three different levels of artificial vacuum—5, 10, and 15 inches of mercury—we found greater yields from the higher vacuum levels.

Study Methods

In late February 1971, 15 trees located in a northwestern Vermont sugarbush were selected and tapped. Three tapholes were drilled in each tree. All the tapholes were drilled to the same dimension: 7/16 inch in diameter and 3 inches deep inside the bark. A gasoline-powered tapper was used to make the holes.

Each of the three tapholes per tree was

[1] At the time this study was made, both authors were at the Northeastern Forest Experiment Station's laboratory at Burlington, Vermont. H. Clay Smith is now at the Experiment Station's laboratory at Parsons, West Virginia.

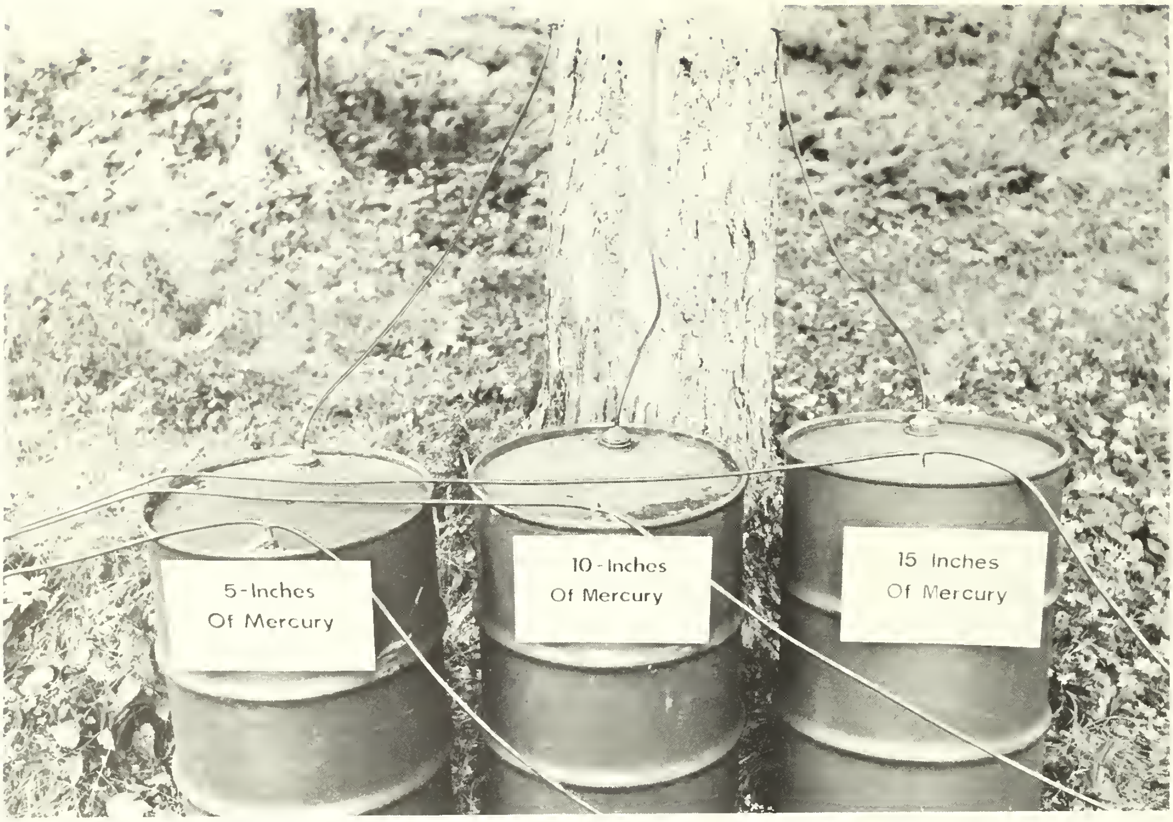


Figure 1.—Sap from each taphole was collected in individually sealed 55-gallon steel drums.

assigned, at random, to one of three different vacuum levels—5, 10, or 15 inches of mercury. Each taphole was connected by 5/16-inch plastic tubing to a separate 55-gallon steel drum, in which the sap from the taphole was collected (fig. 1).

In each system, vacuum was developed in a central tank by a vacuum pump and transferred through plastic tubing to the individual collection drums located at each tree. The desired vacuum levels were maintained in each system by regulating pressure-control valves. Vacuum levels were monitored by gages located at the ends of the tubing systems farthest from the pumps.

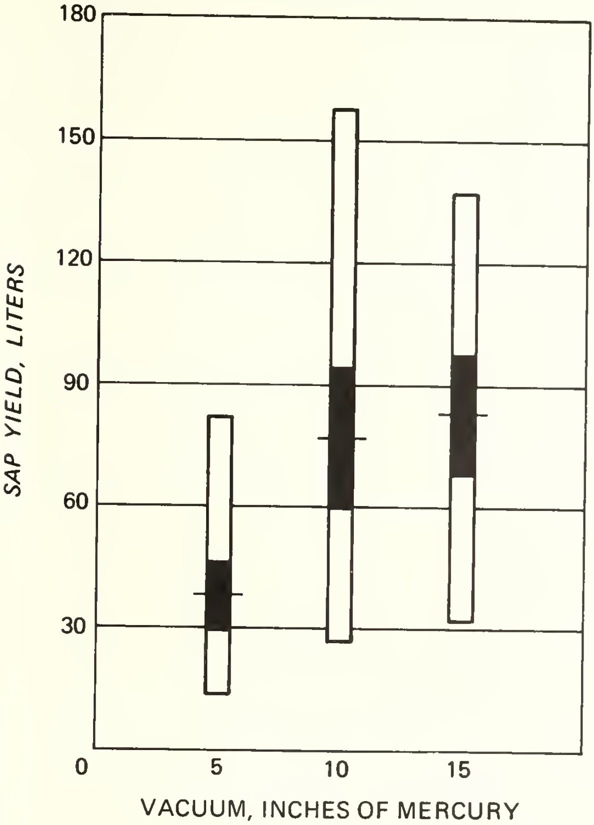
Vacuum was applied to the systems for approximately 130 hours during the sugaring season from March 19 to April 18. At the end of the sugaring season, the sap in each drum was measured to the nearest ½ liter.

Results

The results of this study indicated that the average sap-yield volumes per taphole varied positively with the vacuum levels. The greater the vacuum level, the greater the average sap yield. The average volumes were 37.8, 76.8, and 82.7 liters (40.0, 81.2, and 87.4 quarts) for the 5-, 10-, and 15-inch vacuum levels respectively. The sap volumes collected at the 10- and 15-inch vacuum levels were statistically significantly greater than the amount of sap collected at the 5-inch vacuum level. Sap volumes between the 10- and 15-inch vacuum levels were not statistically significantly different. Significant differences were determined at the 1-percent level.

These results are illustrated graphically in figure 2. The range of total per-taphole sap yields for each vacuum level is represented by the unshaded boxes. The average per-

Figure 2.—Average sap yield per tap for each vacuum level is indicated by the crossbar. The shaded areas indicate ±2 standard errors of the means. The total length of the unshaded boxes represents the total range of individual taphole yields.



taphole yield is indicated by a crossbar, and the shaded boxes represent ±2 standard errors of the mean *(Dice and Leraas 1936)*. A summary of the basic data is presented in table 1.

Discussion

It has long been known that maple sap will exude from a taphole or wound in dormant sugar maples when the internal pressure of the tree becomes greater than the external, or atmospheric, pressure *(Jones and others 1903; Marvin 1958)*. This is a function of changes in temperature. Cold nights induce a negative pressure within a tree, resulting in moisture being absorbed through the roots. Warm days provide a positive internal pressure, forcing sap from the tree at tapholes or wounds. The volume of flow is not related to the temperature rise on the day of the flow, but rather to the length of the preceding cooling period.

A theory developed by Sauter[2] suggests that the mechanism of the sap-flow phenomenon is due to gas (mainly CO_2) expanding and contracting in response to temperature changes. Under cooling conditions, CO_2 contracts and dissolves in the sap, causing negative tree pressure. During warm daylight hours, CO_2 is produced by living cells. Also, warming of tree drives the CO_2 out of sap solution. The gas accumulates in spaces of the fibrous tissue and expands, creating positive tree pressure on the vessel, causing sap to flow out through the taphole.

Maple sap cannot be pulled or sucked from a taphole. Rather, it is forced out by a positive pressure differential when the pressure inside the tree is greater than the atmospher-

[2] Sauter, Jörg. 1971. A new hypothesis for the mechanism of sap flow in sugar maple. Botany Seminar, University of Vermont, 10 May 1971.

Table 1.—Summary on analyses for comparing yields and vacuum levels

Vacuum level	Average sap volume/taphole	Standard error of mean	Analyses comparisons	
			Vacuum level	F. value
Inches of Mercury	*Liters*	*Liters*	*Inches of Mercury*	
5	37.8	±4.1	5 vs. 10	44.4**
10	76.8	±8.5	5 vs. 15	50.5**
15	82.7	±7.3	10 vs. 15	0.5NS

** Significant at 1-percent level.
NS Nonsignificant.

ic pressure outside. Applying vacuum to a taphole has the effect of artificially reducing the external pressure, thus creating the pressure differential necessary to allow sap to flow from the tree.

In each sap season there are a number of days when conditions are almost right for a sap run. That is, the tree's internal pressure is about equal to the atmospheric pressure. This situation also occurs for a period at the beginning and end of each sap run. It is during these times that a sap flow can be induced or prolonged by vacuum pumping to create a pressure differential. During periods of good sap-flow conditions, even heavier flows may be induced by vacuum.

The use of vacuum has raised questions about its effect on the composition of the sap collected. Maple sap is a very complex solution of sucrose, other sugars, minerals, and organic compounds. A large amount—about 98 percent of the dissolved solids—is sucrose. For the most part, these solutes diffuse from the living ray and parenchyma cells into the sap in the vessels. Because of the complexity of the constituents in maple sap and the mechanism whereby sap enters the vessels, concern developed that vacuum might possibly increase the amount of water in the sap, resulting in diluted sap.

Maybe various sap constituents respond selectively to the exertion of vacuum at the taphole, and maybe sap composition is altered by extracting more or less of the individual solutes. Vacuum may even cause the extraction of substances that do not normally appear in sap flowing from the taphole. Laing and others *(1971)* considered these possibilities and concluded that, under normal conditions of gravity flow, only a small volume of the available vessel sap reaches the taphole, and that vacuum pumping (as high as 25 inches of mercury) simply removes additional unaltered vessel sap.

Conclusions and Recommendations

We found that the higher the vacuum level generated within an unvented tubing system, the greater the sap yield will be. A vacuum level of at least 10 inches of mercury should be mainained at the taphole. The sap volume yielded by both the 10- and 15-inch vacuum levels was significantly greater than that yielded by the 5-inch level. However, the 15-inch volume was not significantly greater than that of the 10-inch level.

Further, results of this study and from other research strongly emphasized the importance of maintaining high vacuum at each taphole. To check the effectiveness of the vacuum system, gage readings should be made at the ends of the pipeline system farthest from the pump. There is, of course, a loss of vacuum through friction in long tubing lines. This means that a vacuum level higher than 10 to 15 inches should be maintained at the pump, perhaps as high as 20 to 25 inches, in order to achieve the desired level at the taphole. Maintaining high vacuum requires constant inspection and maintenance of the tubing system.

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FOREST SERVICE, U.S. DEPT. OF AGRICULTURE, 6816 MARKET STREET, UPPER DARBY, PA. 19082

AN IMPROVED APPARATUS FOR PRESSURE-INJECTING FLUID INTO TREES

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Abstract.—Our original tree-injection apparatus was modified to be more convenient and efficient. The fluid reservoir consists of high-pressure plastic plumbing components. Quick couplers are used for all hose connections. Most important, the injector heads were modified for a faster and more convenient and secure attachment with double-headed nails.

The desirability of injecting fluids into trees for correction of mineral deficiency, therapy of diseases, prevention of disease, and attack by insect pests has been recognized for some time *(1, 2, 3, 4, 5, 6, 7, 8)*. Furthermore, injection of chemicals into trees should be environmentally more acceptable than spray or soil applications because a minimum amount of chemical is used, and it is confined within the treated tree.

Until recently, most tree-injection units were of the gravity-feed type. The current trend is to inject under pressure (20 to 400 psi). Pressure injection saves time and labor and makes it possible to treat trees that otherwise would take up fluid very slowly.

Our original injection apparatus *(4)* had a low-volume iron reservoir attached to the nitrogen pressure cylinder. This unit was heavy and difficult to move.

Also, the pipe connections and hose connections to the injector heads were made of pipe unions. The injector heads were attached to the trees with belts and forced against the tree with a hydraulic jack to make a pressure-tight seal.

Our improved device has a much higher volume reservoir, but is made of plastic so it is not so heavy. All connections are made by means of quick couplers, and the injector heads have been modified so they can be nailed onto the trees with double-headed

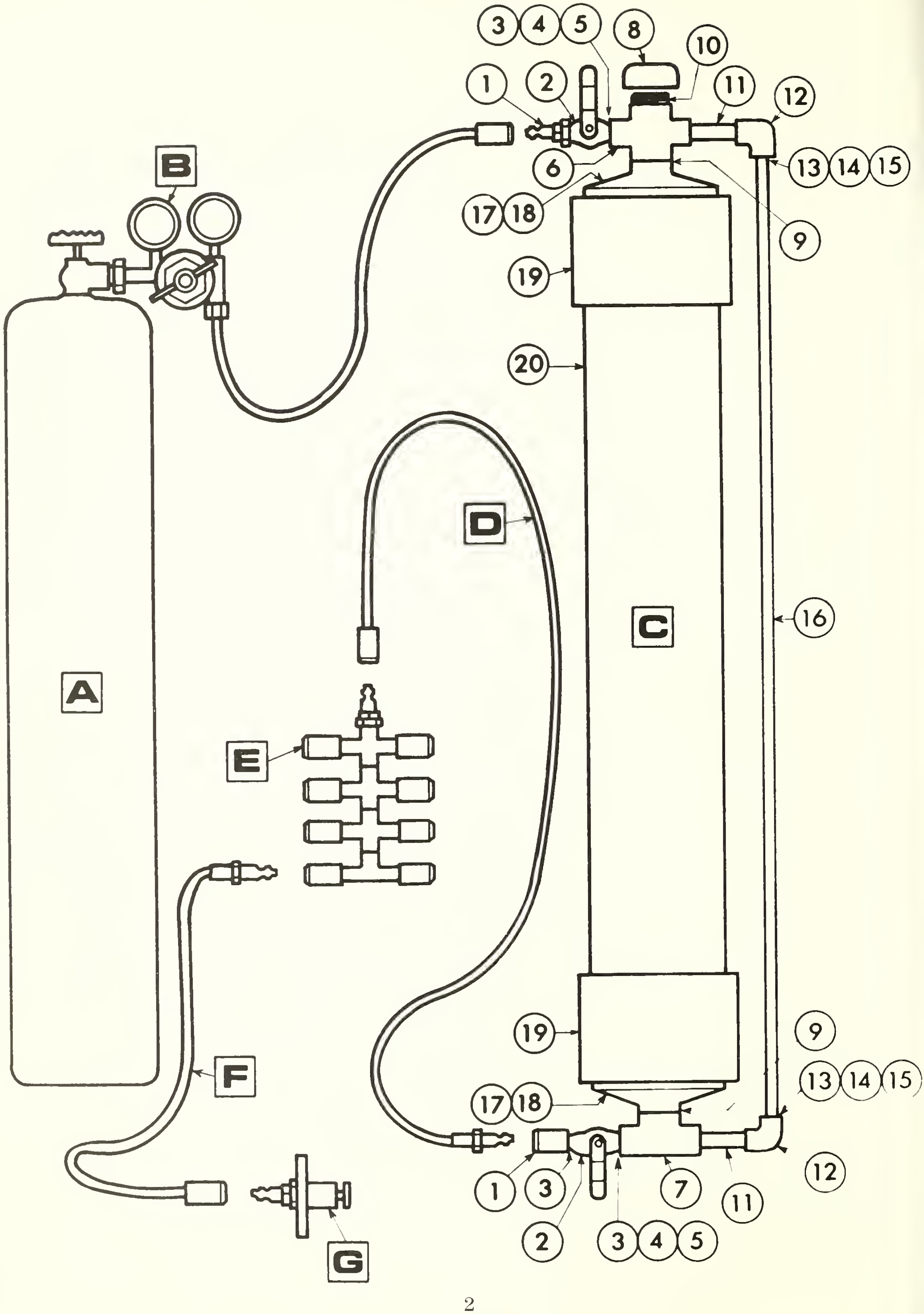
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Figure 1.—Schematic drawing of the improved injection apparatus.

A, Gas pressure cylinder containing water-pumped nitrogen at 2,200 psi (Matheson Gas Products 1A cylinder or equivalent contains 227 cubic feet of gas at atmospheric pressure, enough to inject approximately 50 elms 24 inches in diameter).[1]

B, Gas pressure regulator with a range of 0 to 200 psi (National Cylinder Gas No. 1608 or equivalent). Reinforced PVC 3/8-inch i.d. hose (225 psi working capacity) attached to regulator and connected to a female portion of a quick coupler (1 X 919, 1/4-inch coupler assemblies consisting of female body and male coupler), by means of a 1/4 X 3/8-inch brass pipe-hose connector. Hose is approximately 6 feet long.

C, Fluid reservoir with gage consisting of:

1. One 1/4-inch quick coupler (male top, female bottom).
2. Two brass ball valves (1 at top, 1 at bottom).
3. Three galvanized iron all-thread 1/4-inch pipe nipples (1 at top, 2 at bottom).
4. Two 1/4-inch x 1/2-inch galvanized iron threaded bushings (1 at top, 1 at bottom).
5. Two 1/2-inch x 1-inch PVC thread-socket bushings (1 at top, 1 at bottom).
6. One 1-inch PVC 4-socket cross connection (top).
7. One 1-inch PVC 3-socket tee connection (bottom).
8. One 1-inch PVC cap, threaded (neoprene gasket cut to fit).
9. Two 1-inch PVC pipes, unthreaded, 2 1/4 inches long (1 at top, 1 at bottom).
10. One 1-inch PVC pipe nipple 2 1/2 inches long, threaded one end (top).
11. Two 1-inch PVC pipe nipples 3 inches long, unthreaded (1 at top, 1 at bottom).
12. Two 1-inch PVC 2-socket elbows (1 at top, ! at bottom).
13. Two 1/2-inch x 1-inch PVC thread-socket bushings (1 at top, 1 at bottom).
14. Two 1/4-inch x 1/2-inch galvanized iron bushings, threaded (1 at top, 1 at bottom).
15. Two 1/4-inch x 3/8-inch brass pipe thread-hose connectors (1 at top, 1 at bottom).
16. One 3/8-inch PVC nylon reinforced hose (225 psi working pressure) approximately 5 feet long (cut to fit).
17. Two 1-inch x 3-inch PVC 2-socket bushings (1 at top, 1 at bottom).
18. Two 3-inch x 6-inch PVC 2-socket bushings (1 at top, 1 at bottom).
19. Two 6-inch PVC 2-socket pipe couplers (1 at top, ! at bottom).
20. One 6-inch PVC pipe approximately 4 feet long (unthreaded).

D, Fluid delivery hose. These can be made conveniently in 25-foot lengths and connected for longer distances. PVC nylon reinforced hose, at one end of the hose a 1/4-inch x 3/8-inch brass pipe hose connector, a 1/4-inch pipe coupling, and a male portion of a quick coupler; at the other end of the hose a 1/4-inch x 3/8-inch brass pipe-hose connector and a female portion of a quick coupler.

E, Manifold. One male portion of a quick coupler connected into a 1/4-inch galvanized iron cross which is in turn connected to two or more 1/4-inch similar crosses and ultimately to a 1/4-inch tee by means of 1/4-inch galvanized iron all-thread pipe nipples. All eight arms are then connected to female portions of quick couplers by means of 1/4-inch galvanized iron all-thread pipe nipples. At least two manifolds are supplied with the injection apparatus.

F, Injector hoses. Similar to D except 4-foot long; 16 are supplied per injection apparatus.

G, Injector head. See figure 2 for details.

Note: Schedule 80 PVC pipe and fittings should be used throughout, but are especially important to a capacity for high working pressures in sizes above 1 inch. All threaded joints are sealed with pipe thread compound. All unthreaded joints are connected by first coating the surfaces to be joined by brushing them with PVC primer, followed by a liberal application of PVC solvent cement; then the fittings are pushed firmly together. The hose ends are secured to pipe-hose connectors with stainless steel hose clamps.

[1] Mention of commercial products is for information only and should not be considered an endorsement by the Department of Agriculture or the Forest Service.

nails. The result is that less time and labor are required to attach and detach this model; and in addition, it is safer and more convenient to use.

Construction of the Injection Apparatus

The injection apparatus (fig. 1) consists of seven components: (A) a gas pressure cylinder, (B) a gas pressure regulator, (C) a fluid reservoir, (D) a fluid delivery hose, (E) a manifold, (F) injector hoses, and (G) injector heads.

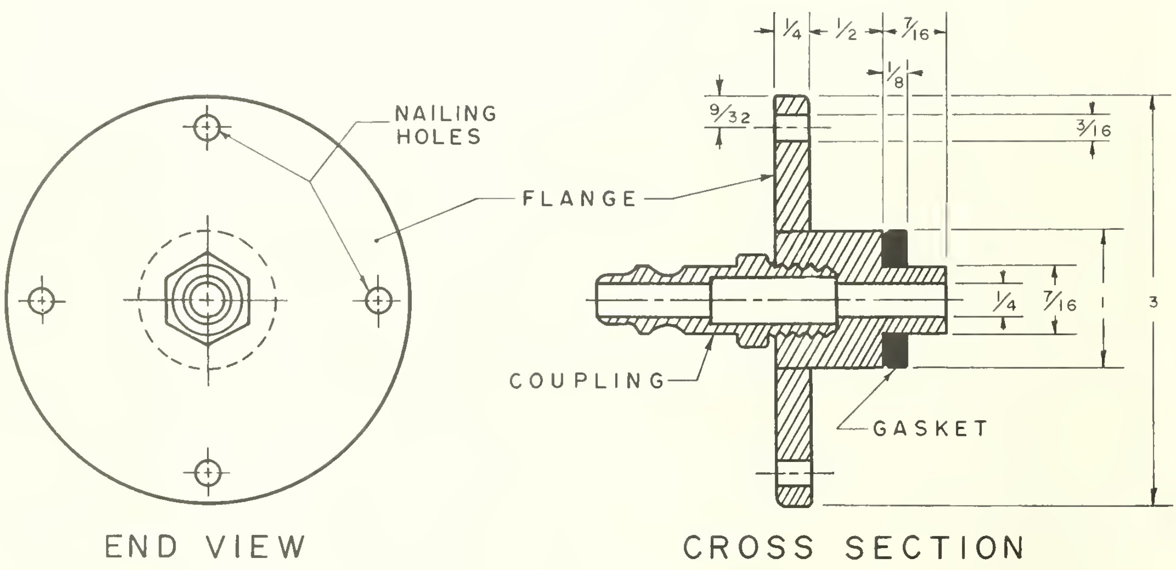
The assembly of the injection apparatus is shown in figures 1 and 2. We provide pressure for the system from a cylinder of compressed nitrogen gas. Though this is convenient, an air compressor could be used.

The clear PVC hose alongside the fluid reservoir provides a gage so that fluid level in the reservoir and rate of fluid uptake during operation can be observed. The neoprene-gasketed 1-inch cap at the top of the fluid reservoir makes a gas-tight seal, but it is easily removed or replaced by hand.

The 1-inch brass ball valves at the pressure inlet at the top and the fluid outlet at the bottom are important, especially the top one, which is necessary for maintaining pressure when not connected to a pressure cylinder and for slowly releasing pressure when injection is completed.

The manifold accommodates eight injector heads; however, it can be made with more outlets by adding more 1/4-inch crosses and female quick-coupler parts. But we found it more convenient to connect two or more manifolds with the short injector hoses when treating especially large trees.

Figure 2.—Details of injector head.



Fabrication details: A 1-inch diameter iron rod 2-3/16 inches long is turned down to 7/8-inch diameter for 1/4 inch at one end and to 7/16-inch diameter for 7/16 inch at the other end. A 1/4-inch centered hole is drilled through the length of the rod and tapped for 1/4-inch pipe threads at the 7/8-inch end so as to accept the male part of a quick coupler.

A 15/16-inch centered hole is drilled through a 3-inch diameter by 1/4-inch-thick iron flange. The 7/8-inch end of the rod is inserted in the flange and welded on the flush side, and the weld is ground smooth. Four 3/16-inch holes are drilled in the flange, 90° apart and 9/32 inch from the edge. These are used for nailing the injector head to the tree. On the 7/16-inch portion of the injector are placed one or two 1/8-inch neoprene gaskets (outside diameter 1 inch and inside diameter 7/16 inch) to seal the injector head to the tree.

Operation of the Injection Apparatus

Before preparing a tree for injection, it is generally desirable to determine the volume and concentration of injection fluid and the number of injector heads to be used. This is frequently determined on the basis of diameter at breast height of the tree. In our work on Dutch elm disease therapy and prophylaxis, we are injecting 675 ml per diameter inch. We use one injector per 8 inches of circumference based on dbh. Injector heads are attached as near the ground as possible or on the roots if they are exposed.

The injection sites are prepared with a brace and a $\frac{7}{16}$-inch wood auger with a 1-inch counterbore, adjusted so that when the 1-inch counterbore has cut almost to the inner bark, the wood auger has drilled through the outer two or three annual growth rings. An injector head is then inserted into each prepared injection site and is secured by four 8- or 10-penny duplex nails.

The injector heads are connected to the fluid reservoir by means of injector hoses, manifold, and the fluid delivery hose (fig. 1).

A trace of azosulfamide solution is added to the injection fluid so that injection may be followed visually. The injection fluid is put in the fluid reservoir, the hose from the pressure cylinder is connected to the fluid reservoir, and the gas pressure valve is opened. The gas pressure is adjusted by means of the pressure regulator. Air can be bled from the hoses ahead of the fluid by disconnecting an injector hose at the injector head and inserting an extra male part of a quick coupler into the end of the hose; however, we have found that bleeding the system is seldom necessary.

When injection is complete, the injector hoses are uncoupled from the injector heads, the valve at the top of fluid reservoir is closed, and the gas-pressure supply hose is uncoupled from it. The ball valve is then partially opened to release the pressure slowly. The injector heads are removed

Figure 3.—The tree injection apparatus in operation.

easily by pulling the duplex nails with a claw hammer.

Results and Discussion

This improved tree-injection apparatus saves time and labor, particularly in attaching and detaching the injector heads. Nailed-on injector heads can be attached quickly and securely.

For a 24-inch American elm tree, about 10 minutes are required for attaching the injectors, 5 to 15 minutes for making the injection, and 5 minutes to detach the injectors.

The fluid reservoir is filled easily and rapidly. Although the fluid reservoir is light and can easily be moved to a tree, we usually leave it fastened in a vertical position on the tailgate of a sedan-delivery automobile (fig. 3). The pressure cylinder contains enough gas for 4 to 5 days of injecting and is secured in the vehicle during transport and use.

The gain in safety and time and labor saved are not at the expense of proficient functioning. The injection site, like that prepared for the original injector, channels the injection fluid into the vessels of the outer two or three annual growth rings (fig. 4). This injection site seems advantageous for injecting most types of injection fluids; for example, trace elements, systemic insecticides or fungicides, and herbicides. This apparatus or smaller models of it, in fact, have been used experimentally for injection of systemic insecticide, soluble fertilizer, herbicide, and systemic fungicide.

Figure 4.—Attachment of injector head. The injector head protrudes into the xylem through a hole that extends about 3 annual rings deep. The neoprene gasket is seated on bark that has been cut smooth by a 1-inch counterbore. The injector head is nailed in place with 8-penny duplex nails.

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A TEST OF POINT-SAMPLING IN NORTHERN HARDWOODS

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Abstract.—Plot- and point-sampling were compared with a complete inventory of two different stands of northern hardwoods. Prisms with basal-area factors of 5, 10, 20, 30, and 40 and a ¼-acre plot were used. Only the 5-factor prism gave a significantly different estimate. Therefore, a prism factor of 10 or greater is suggested for use in northern hardwoods.

Point sampling with a wedge prism is an effective means of estimating basal area per acre in forest stands. The theory and field use of the prism have been thoroughly described and many trials have been conducted (Husch 1955, Grosenbaugh and Stover, 1957). Prism cruising is applicable to most forest stands, but the efficiency of the cruise depends on the prism factor selected, the stand conditions, and the average size of the trees in the stand. The accuracy of cruises with different prism factors can be compared by standard statistical procedures.

Because of the lack of published information on prism cruising of northern hardwoods in New England, I conducted a study on the Bartlett Experimental Forest in the White Mountain National Forest of New Hampshire to compare the estimation of basal area per acre with five common prism factors and a circular ¼-acre plot with a 100-percent tally of the stand being sampled. The prism factors tested were 5, 10, 20, 30, and 40. These cover the range of the factors most commonly used for cruising forest stands in the East. The circular plot of ¼ acre (58.9 feet radius) was selected because it represents the area on which most trees would be sampled with the 10-factor prism. Almost all of the trees sampled by the 20-, 30-, and 40-factor prisms would be within the ¼-acre circular plot and only the larger trees counted by the 5- and 10-factor prisms could be outside the circular plot.

The two kinds of northern hardwood stands studied were: young sawtimber (60- to 80-year-old even-aged timber; Compartments 1 and 14), and sawtimber (over 80-year-old uneven-aged timber; Compartments 21 and

Table 1.—Estimates of basal area per acre obtained with five prisms and with ¼-acre plots, compared with measured basal area

Compartment	Acres	No. of sample points	Prism factor 40 Mean	40 S.D.	30 Mean	30 S.D.	20 Mean	20 S.D.	10 Mean	10 S.D.	5 Mean	5 S.D.	¼-acre plot Mean	¼-acre plot S.D.	Actual B.A./acre
1	34.5	42	105.8	70.6	103.6	60.9	107.6	47.3	103.1	33.1	97.1	29.2	98.1	27.9	100.6
14	68.8	52	119.2	59.8	125.2	58.4	124.6	41.8	117.9	35.3	107.3**	20.2	118.9	17.3	119.2
21	39.6	50	116.0	70.7	120.4	63.4	112.0	50.2	106.6	29.7	94.8**	29.0	113.6	29.7	115.2
27	64.3	86	101.4	60.3	111.3	57.5	111.6	43.6	100.6	36.2	84.4**	24.1	100.0	26.0	102.6

** Significant at .01 simultaneous probability level by t test.

27). These stands provided a range of size classes and proportions of saplings and other undergrowth.

A base line was selected along one side of each compartment. Then cruise lines running north and south were laid out at randomly selected distances 2, 3, or 4 chains apart along the base line. Sampling points were placed at randomly selected intervals of 2, 3, or 4 chains along each cruise line. All five prisms were used at each point and a ¼-acre plot was centered on it. Points were taken wherever they occurred on the ground, except when they were closer than 58.9 feet (radius of the ¼-acre circular plot) to the compartment boundary; then the point was moved back so all of the ¼-acre plot was within the compartment. Point edge effect bias was handled as suggested by Grosenbaugh (1958), and the horizontal distance and dbh of questionable trees were measured to determine whether they should be counted.

Estimates of basal area per acre made with the five prisms and from the ¼-acre plot were compared with each other and with the actual basal area determined from the 100-percent tally. Simultaneous test procedures showed that only the differences between the tally and the estimates made with the 5 factor prism were significant (table 1).

The choice of prism depends upon the variability of the stand and the number of points that can be sampled economically. Prisms with lower factors produce lower standard deviations (s), but they require counting more trees at each point and therefore require more time.

The number of sample points per acre necessary to achieve a confidence interval of half-width d at the .95 confidence level is approximated by

$$n = 4\, s^2/d^2$$

where s^2 is the sample variance.

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