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U.S. FOREST SERVICE RESEARCH NOTE NE-51
1966

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

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WHO STARTS FOREST FIRES IN MAINE — AND HOW?

In 1964 the Maine Forest Service, in cooperation with the Northeastern Forest Experiment Station, conducted intensive investigations of a systematically selected sample of the fires that occurred in the State that year. The immediate purpose was to determine precisely how the fires started and who or what started them, and to assemble relevant information about the people and circumstances involved. The basic objective of any such work is, of course, to reduce forest fires. The information gleaned from these investigations was expected to provide helpful guides for making the State's forest-fire-prevention program more effective.

The sampling was done on a district basis. The procedure was to investigate every fifth fire in each district. All together, 171 fires were investigated.

Results

For 88 of the 171 fires, or 51 percent, the cause was positively identified. For 66 of them, or 39 percent, cause was not positively identified but evidence pointing to probable cause was obtained. For 17 of the fires, or 10 percent, the evidence was too inconclusive to justify assigning even a probable cause. Table 1 gives a breakdown of the causes for the 154 fires for which positive or probable identifications were made.

Some causes of fires are more easily and positively determined than others. Debris-burning and lightning are among the more easily identifiable causes; smoking and incendiarism, for example, are much harder to indict with certainty. The data in table 1 tend to bear out these generalizations.

Table 1. — Causes of the 154 fires for which positive or probable identifications were made

Cause	Identification positive		Identification probable		Both categories combined	
	Number	*Percent*	*Number*	*Percent*	*Number*	*Percent*
Debris-burning	45	51	14	21	59	38
Smoking	4	5	14	21	18	12
Machine use	10	11	9	14	19	12
Campfires	2	2	—	—	2	1
Lightning	13	15	3	4	16	11
Incendiary	2	2	7	11	9	6
Miscellaneous[1]	12	14	19	29	31	20
All causes	88	100	66	100	154	100

[1] Among the miscellaneous causes, children playing with matches was predominant: 20 of the 154 fires or 13 percent (6 positive and 14 probable identifications) were attributed to this cause alone. The other 11 fires in this category were attributed to various causes, as follows: burning buildings — 3, power line — 2, hot ashes from stove — 2, burning bulldozer — 1, fireworks — 1, exploding can of tar — 1, and sun shining through a bottle — 1.

Lightning accounted for 11 percent of the 154 fires listed in table 1. No other so-called acts of God were involved. Hence, as a round figure, about 90 percent of these fires were man-caused. However, there were 30 of the man-caused fires for which no individual person could be considered responsible. Chief among the causes of these fires were railroads and burning dumps.

For the 108 fires for which an individual person was considered responsible, data were obtained insofar as possible about that person's sex, age, residence, occupation, and what he was doing when the fire started. The data are not complete for all the fires in any of these categories; completion scores range from 93 (86 percent) of the 108 fires for sex of the person involved, down to 82 (76 percent) of the 108 fires for the person's occupation. The data collected about these people are summarized in table 2.

Discussion

The results of our investigations of these fires point to these conclusions:

- That about 90 percent of the forest fires in Maine are man-caused and thus are subject to influence by prevention programs.
- That children under 12 years are an important factor in forest-fire occurrence in Maine. In this study, they accounted for nearly one-fourth of all fires that could be charged to an individual person.

Table 2. — Classification of the people responsible for starting fires investigated in Maine in 1964

Category	Item	Percent
Sex	Male	88
	Female	12
Age	Under 12 years	24
	12 to 20 years	9
	21 to 50 years	47
	Over 50 years	20
Residence	Out of state	3
	Within state	97
	Within town	85
Occupation	Students[1] and pre-school	31
	Farmers	16
	Woods workers	11
	Service employees	7
	Housewives	6
	Retired	6
	Truckers	5
	Unskilled	5
	Miscellaneous other: commercial fishermen, managerial, law enforcement, disabled, unemployed	13
Activity when fire started	Debris-burning	49
	Playing (children under 12 years)	22[2]
	Cutting, yarding, and hauling wood	11
	Fishing	4
	Parking in secluded areas	2
	Miscellaneous other: walking or hiking, joyriding, camping, driving truck, berry-picking, shooting fireworks, repairing a cottage.	12

[1] Includes students more than 12 years old.
[2] This figure does not include fires started by children while engaged in other than strictly play activities.

- That State residents are responsible for almost all of the fires (97 percent in this study); and further that local town residents are responsible for most of the fires in their towns (85 percent in this study).
- That most of the fires that can be charged to individual persons originate from three activities: debris-burning, children playing, and woods work. The respective proportions in the study were 49 percent, 22 percent, and 11 percent, totaling 82 percent.

The information derived from these investigations should be helpful in tailoring a forest-fire-prevention program to the State's needs. Continued emphasis on fire-prevention indoctrination in schools is indicated. Efforts to have more fire prevention incorporated into television programs directed to children at the pre-school and lower-grade levels might be worthwhile. Certainly a continuing barrage of publicity about the dangers in all types of debris-burning is warranted by the study findings.

— WAYNE G. BANKS and FRED E. HOLT[1]

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[1] At the time this study was made, Mr. Banks was project leader in fire research at the Northeastern Forest Experiment Station; at present he is fire control scientist at the North Central Forest Experiment Station, St. Paul, Minnesota. Mr. Holt is Deputy Forest Commissioner, Maine Forest Service, Augusta, Maine.

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U. S. FOREST SERVICE RESEARCH NOTE NE-52

1966

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LAND DISTURBANCES FROM STRIP-MINING IN EASTERN KENTUCKY
1. UPPER CUMBERLAND COAL RESERVE DISTRICT

Open-pit or strip-mining—primarily for coal—has expanded rapidly in eastern Kentucky during the past 15 years. Information about the amount, location, and general characteristics of the disturbed areas is necessary for appraising the economic impacts and overall effects of strip-mining in that section of the state, for planning reclamation programs, and for determining research needs and priorities. To obtain reliable estimates of the acreage disturbed both by the mining itself and by the associated coal-haul roads, and to provide relevant information about the disturbed areas, a survey was made. The survey was based on aerial photographs of all stripped areas as of October 1964.

The survey was broken down in accordance with the six subdivisions or coal-reserve districts delineated by the U. S. Geological Survey.[1] Thus there will be a series of six reports, of which this is the first.

The method used in our survey was a modification of forest-survey procedure. A 3-by-6-inch transparent template with 25 dots per square inch was positioned over the center of each photograph. Areas on the photographs that appeared to be stripped land or coal-haul roads were examined stereoscopically to determine important characteristics, and the amount of area in various categories was estimated by dot counts.

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[1]Huddle, J. W., F. J. Lyons, H. L. Smith, and J. C. Ferm. COAL RESERVES OF EASTERN KENTUCKY. U. S. Geol. Survey Bull. 1120, 147 pp., 1963.

The Upper Cumberland District

The Upper Cumberland Coal Reserve District lies in southeastern Kentucky between Pine Mountain on the northwest and the state boundary (with Virginia and Tennessee) on the southeast (fig. 1). It includes 83 percent of Harlan County, 60 percent of Bell County, 15 percent of Letcher County, and 3 percent of Whitley County.

Commercial coal production began in Bell County in 1879 and in Harlan County in 1911. Until the early 1950's, all production was from underground mines. But by 1963 about 15 percent of the coal came from strip- and auger-mining.[2] However, the percentage varies by county. For example, 50 percent of the coal mined in Bell County in 1963 came from strip- and auger-mining, while only 6 percent from Harlan County was mined this way.

District coal reserves (measured, indicated, and inferred) are estimated to be 3.7 billion tons. Thirty-eight percent of this is in seams more than 42 inches thick. There are no estimates of the tonnage that can be recovered exclusively by strip- and auger-mining.

[2]Mandt, A. H. ANNUAL REPORT. Ky. Dep. Mines and Minerals. 166 pp., 1963.

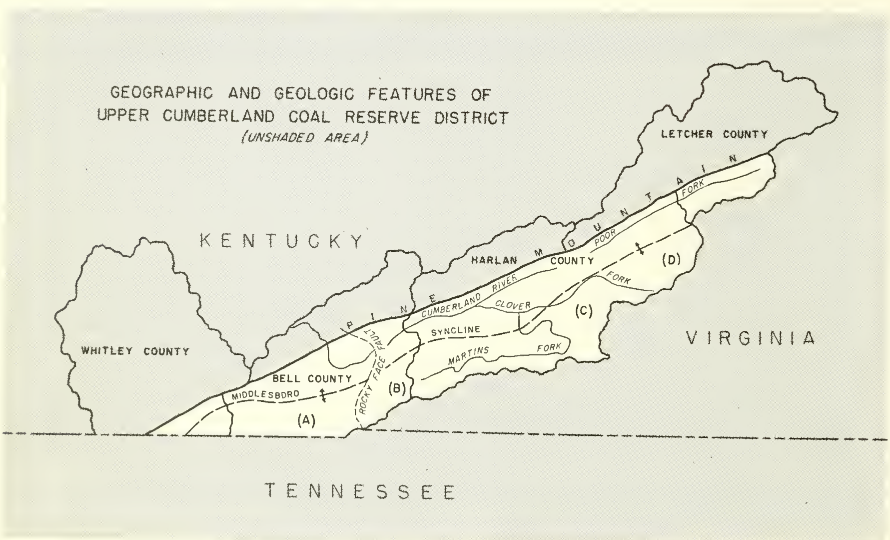

Figure 1.—Geographic and geologic features of the Upper Cumberland Coal Reserve District. The letters (A), (B), (C), and (D) indicate the location of the main stratigraphic columns: Log Mountain, Hance Ridge, Little Black Mountain, and Big Black Mountain, respectively.

Forest Cover

The 1964 Kentucky forest inventory showed that forests cover about 85 percent of the Upper Cumberland Reserve District. Non-forest lands used for agriculture, roads, and urban development are concentrated generally on the lower slopes and valley bottoms. This land-use pattern is also reflected in our survey of lands disturbed by strip-mining. Eighty-five percent of the strip mines were located on the upper slopes and ridges; forested land was immediately below and adjoining 99 percent of the disturbed areas.

Nearly all of the forests have been cut over, but the forest inventory classified 85 percent of the commercial forest stands as sawtimber size. These are predominantly hardwoods, with species of oak and hickory in great abundance. Yellow-poplar, maple, beech, basswood, black walnut, and elm occur frequently in the stands on better sites. Southern pines are not well represented in the district: less than 5 percent of the commercial forests are classified as pine or pine-hardwood types.

Physiography and Geology

The District is characterized by high, narrow ridges, V-shaped valleys, and steep slopes. The Black Mountains east of Harlan are the highest land in the District, rising at one point to an elevation 4,150 feet above sea level—the highest point in the state. Pineville Gap on the Cumberland River, at 1,000 feet, is the lowest spot in the District.

The predominant geologic feature is the Cumberland overthrust block.[3] The leading edge of this block folded and warped upward to form a high, 150-mile-long ridge now known as Pine Mountain.

Another prominent feature, the Middlesboro syncline, runs the length of the district parallel to the southern slope of Pine Mountain. This structure controls the elevation of all rock strata and coal seams, and determines the location and extent of reserves recoverable by strip mining. For example, a given coal seam outcropping on a mountain slope near the Kentucky-Virginia state line may be recovered by open-pit mining; but the same seam further north near the Cumberland River could not be recovered by surface-mining equipment because of its downward dip.

A third feature is the Rocky Face fault—a faulted arch—which formed Cumberland Gap, Rocky Face, and Pineville Gap. Because of this violent shift in the earth's crust, the coal seams in the Log Mountains west of

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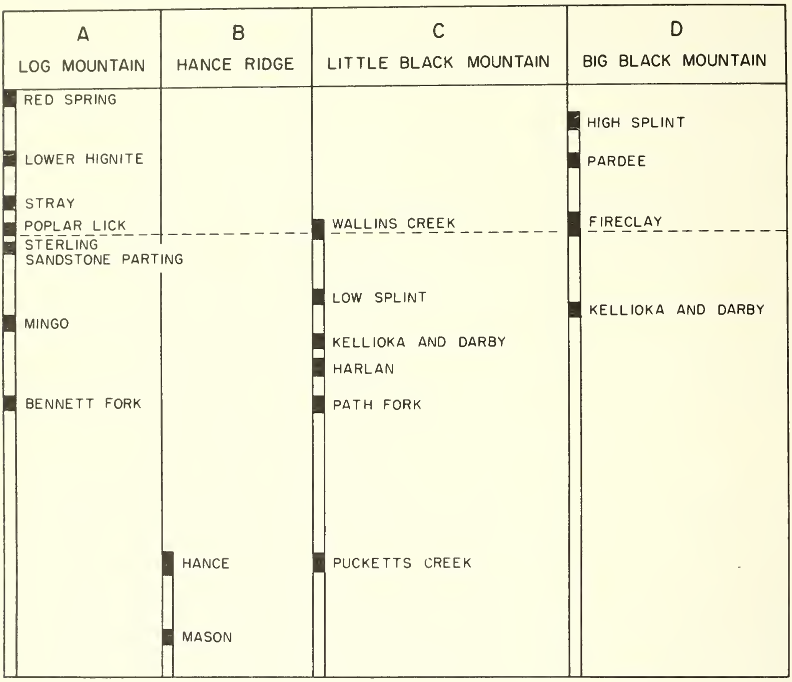
[3]McFarlan, A. C. Geology of Kentucky. Univ. Ky. 531 pp., 1950.

Figure 2.—Stratigraphic position of the principal coal seams mined by surface methods in the Upper Cumberland Coal Reserve District. The elevation of each seam above sea level could not be indicated precisely because of the varying thickness, dip, warp, and tilt of the underlying strata. The Poplar Lick, Wallins Creek, and Fireclay beds are correlated; and they serve as the marker bed for this district.



the fault and those at the same elevation east of the fault are different, as is obvious from differences in the overlying strata. Geologists consequently have difficulty in correlating seams across the fault.

The U. S. Geological Survey recognizes two formations within the District.[1] Their locations are correlated with the formative geology.

The Lee formation, which covers 30 percent of the 434,000 acres in the District, outcrops on Pine Mountain, the Virginia state line, and Rocky Face fault. This formation contains no commercial coal deposits.

The Breathitt formation, which occupies the remainder of the District area, is some 2,500 feet thick and contains 25 commercially important coal seams. Of these, 21 seams have been strip-mined or auger-mined to some degree. The correlation of the principal surface-mined coal seams is shown by stratigraphic position in figure 2. The nomenclature is according to usage accepted by most geologists.

Distribution of Stripped Areas

The area disturbed by strip- and auger-mining in the District in 1964 (excluding coal-haul roads) was 11,845 acres, or 2.7 percent of the total land area. Bell County had the largest acreage and the highest percentage of area disturbed (6,090 acres, 4.3 percent). Harlan County had more than 4,700 acres disturbed, but this was only 1.9 percent of its total area (table 1).

Table 1.—*Disturbed area by counties and coal seams in the Upper Cumberland Reserve District, in acres*

Coal seam	Whitley County	Bell County	Harlan County	Letcher County	Total
Harlan	—	718	1,536	—	2,254
Kellioka-Darby	—	852	902	308	2,062
Path Fork	—	1,765	76	—	1,841
Mingo	486	499	—	—	985
Poplar Lick or Fireclay	—	103	653	83	839
High Splint	—	—	742	83	825
Pardee	—	—	808	9	817
Stray	—	590	—	—	590
Pucketts Creek	—	530	—	—	530
Lower Hignite	—	384	—	—	384
Red Spring	—	311	—	—	311
Sandstone Parting	9	177	—	—	186
Mason	—	116	—	—	116
Bennetts Fork	51	45	—	—	96
Low Splint	—	—	9	—	9
All seams	546	6,090	4,726	483	11,845
Percent of land area disturbed	6.2	4.3	1.9	1.5	2.7

Among coal seams, the Harlan seam, outcropping only in Bell and Harlan Counties, was most extensively mined. Next in acres mined were the Kellioka and Darby seams, lumped together here because they are separated vertically by only 20 to 40 feet and could not be differentiated on aerial photographs. These two seams were worked in Bell, Harlan, and Letcher Counties. The Path Fork seam, mined only in Bell County, ranked third in disturbed area. These four seams account for 52 percent of the acreage disturbed by stripping. Table 1 gives additional details on distribution of the disturbed acreage, by counties and coal seams.

Physical Characteristics of Disturbed Areas

There are two basic types of strip-mining in the eastern Kentucky coal field: contour- or rim-stripping, and area-stripping. Auger-mining usually is employed as a supplement to contour-stripping; it is a means for working a seam beyond the point where removal of the overburden is economically feasible. Of the 434,000 acres comprising the District, 11,845 acres, or 2.7 percent, had been disturbed by strip- and auger-mining as of October 1964.

About 96 percent of all mining disturbance in the District had resulted from contour-stripping on mountain slopes. Contour-stripping employs small shovels of 1- to 6-cubic-yard capacity and bulldozers to expose the coal seams along narrow benches on steep mountain slopes. The benches are generally 100 to 200 feet wide.

In the contour-strippings, 10 percent of the disturbed area was on or above the highwall; 31 percent in pits, inslopes, and leveled or unleveled benches; and 59 percent in outslopes. Of the 6,700 acres of outslope, 800 acres, or 12 percent, were in slides or slumps.

On about 60 percent of the contour-stripping operations, there had been some grading of the spoil between outslope and highwall or pit. On about 25 percent of them, grading to nearly level benches had been done. Probably most of this leveling had been done since the enactment in 1954 of state legislation requiring grading and revegetation of areas disturbed by open-pit mining.

Area-stripping, which made up only 4 percent of the total area disturbed, was done typically where the land surface was less steep and the overburden was relatively shallow over a fairly wide area. Under these conditions, several successive parallel cuts were made. The same type of equipment was used as for contour-stripping. Our survey showed 477 acres in area-stripping, of which 47 acres were on lower mountain slopes and 430 acres were on ridge tops. In the latter locations, the entire top of the ridge or mountain usually was worked over. The breakdown among positions in the area strippings was as follows: leveled or unleveled spoil between pit and outslope—55 percent; outslopes—35 percent; and pits and highwalls—10 percent. No slides or slumps were found in the area-strippings.

In all stripping operations, the operator must build and maintain a network of roads for hauling the coal from the mines. In this survey, we classified the haul-roads as: primary (running from a public road to the mine); secondary (joining two pits or serving as spurs from primary roads); or third-class (service roads and temporary haul-roads).

We found 1,099 acres to be disturbed by coal-haul roads. This figure was computed directly from dot counts on the aerial photographs. After determining the average width of the road rights-of-way by field measurement, which came out as 76 feet, we converted acres to miles of road. By this calculation, there were 121 miles of coal-haul road in the District. This mileage was distributed among the three classes of roads as follows: primary, 87 miles; secondary, 22 miles; and third-class, 12 miles (table 2). Nearly all of these roads ran through forested country.

Table 2.—*Mileage of coal-haul roads in the Upper Cumberland Coal Reserve District, by classes and counties*

Class of haul road	Whitley County	Bell County	Harlan County	Letcher County	Total
Primary	1.1	32.0	50.8	3.4	87.3
Secondary	.8	9.0	11.8	.2	21.8
Third-class	.3	1.7	9.8	.0	11.8
All classes	2.2	42.7	72.4	3.6	120.9

From the totals in tables 1 and 2, we can calculate acres of mine disturbance per mile of road. Thus the District average is found to be 98 acres per road mile. The figure for Bell County is 143 acres per mile, and for Harlan County 65 acres per mile. The comparatively low acreage figure for Harlan County probably reflects the much more rugged topography of Harlan County as compared with Bell County.

—WILLIAM T. PLASS
Plant Ecologist
Northeastern Forest Experiment Station
Forest Service, U. S. Dept. of Agriculture
Berea, Kentucky

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U. S. FOREST SERVICE RESEARCH NOTE NE-53
1966

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EPICORMIC BRANCHING ON EIGHT SPECIES OF APPALACHIAN HARDWOODS

Epicormic branches and associated defects are leading causes of degrade and value loss in lumber sawed from hardwood logs.[1] The degrade may be in the form of small knots, ingrown bark, wood blemishes, and/or rot.

Although only a small amount of research has been done on the comparative tendencies of different species to produce epicormic branches,[2] some species are generally known to be much more apt than others to produce such branches. For example, white oak (*Quercus alba* L.) is well known as a prolific sprouter. White ash (*Fraxinus americana* L.), on the other hand, usually remains relatively free of bole sprouts.

More definite information about species susceptibility to epicormic branching should be of considerable value to forest managers in selecting trees to leave after cutting, and in setting stand density goals. Consequently a study was begun to evaluate bole sprouting of the more important hardwood species found on the Fernow Experimental Forest in West Virginia.

The Study Area

Eighteen clearcut openings, each larger than an acre, were used in the study. All had been cut 3 to 7 years before. Thus sufficient time had elapsed for bole shoots to develop on the border trees, but not a long enough time for reproduction to have seriously shaded the lower shoots.

The openings were all in well-stocked sawlog-size stands of mixed second-growth Appalachian hardwoods about 60 years old. Site indexes

[1] Bryan, W. C. Losses from defect in Piedmont hardwoods. U. S. Forest Serv. SE. Forest Exp. Sta., Sta. Paper 109, 31 pp., illus. 1960.

[2] Jemison, George M., and F. X. Schumacher. Epicormic branching in old-growth Appalachian hardwoods. J. Forestry 46: 252-255. 1948.

(for oak)[3] ranged from 60 to well over 70 feet. Most of the sample trees were on the better sites, as shown below:

Oak site index	*Number of sample trees*
60	90
70+	260

Timber volumes ranged from an average of 7,000 board feet per acre on site index 60 to about 17,000 board feet per acre on the higher sites.

Methods

Data on epicormic branching were taken on 350 trees distributed among 8 hardwood species, as tabulated below:

Species	*Number of study trees*
Black cherry (*Prunus serotina* Ehrh.)	63
Chestnut oak (*Quercus prinus* L.)	61
Hickory (*Carya* spp.)	30
Red maple (*Acer rubrum* L.)	21
Red oak (*Q. rubra* L.)	89
Sugar maple (*A. saccharum* Marsh.)	53
White ash (*Fraxinus americana* L.)	15
White oak (*Q. alba* L.)	18
Total	350

It was originally intended to include yellow-poplar (*Liriodendron tulipifera* L.) in the above list, but not enough suitable sample trees were found during this study to provide reliable data for analysis. However, based on observations made in a previous study[4] of epicormic branching, yellow-poplar is included in a susceptibility rating presented later in this note.

Only trees that were growing on the borders of the clearcut openings were taken as sample trees. To qualify, these trees had to be at least 5 inches in diameter at breast height and had to contain at least one 16-foot log above a 1-foot stump. The sample trees were classified in two dominance classes: (1) dominant and codominant, and (2) intermediate and overtopped.

For each sample tree, the number of epicormic branches on the half-circumference of the bole that faced the opening was tallied. On trees that contained two 16-foot logs above a 1-foot stump, the branches were tallied separately for each log.

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[3] Schnur, G. Luther. YIELD, STAND AND VOLUME TABLES FOR EVENAGED UPLAND OAK FORESTS. U. S. Dep. Agr. Tech. Bull. 560, 88 pp., illus. 1937.

[4] Smith, H. Clay. EFFECTS OF CLEARCUT OPENINGS ON THE QUALITY OF HARDWOOD BORDER TREES. J. Forestry 63: 933-937, illus. 1965.

Results

A summary (table 1) of the data from the trees on the better sites (site index 70 or higher) indicated the following order of decreasing susceptibility to epicormic branching among the eight species in the study:

A	White oak
B	Black cherry Red oak Chestnut oak
C	Hickory Yellow-poplar Red maple Sugar maple
D	White ash

White oak is unquestionably the most susceptible to bole sprouting (fig. 1, A). The groupings indicate species that are susceptible to about the same degree. Thus, black cherry, red oak, and chestnut oak are about equally less susceptible than white oak; the next group of four species represents a still lower degree of susceptibility; and white ash is least susceptible of all (fig. 1, B). Yellow-poplar, as explained earlier, was included in the above rating on the basis of observations in another study.

Bole sprouting (between log positions and tree-dominance classes) was compared within species and for all species (table 1). These two variables appeared in an earlier study[4] to be correlated with sprouting, and the present data substantiate the previous tentative conclusions: that, on the aver-

Figure 1. — Two border trees representing the extremes of susceptibility to epicormic branching. A, an 18-inch, 2-log white oak 7 years after exposure, displaying about 24 epicormic branches on the half-circumference of the bole that faces the stand opening. B, an 18-inch, 3-log white ash 5 years after exposure, entirely free of epicormic branches.

Table 1. — Average numbers of epicormic branches per log[1] by species, tree dominance class, and log position[2]

Species	Dominant and codominant trees				Intermediate and suppressed trees			
	First log		Second log		First log		Second log	
	Logs in sample	Branches per log	Logs in sample	Branches per log	Logs in sample	Branches per log	Logs in sample	Branches per log
White oak	5	7.20	5	9.20	1	12.00	1	14.00
Black cherry	54	4.81	49	6.27	7	17.00	4	12.00
Red oak	51	4.63	51	7.39	15	7.27	12	7.42
Chestnut oak	18	2.00	18	3.39	7	16.14	6	10.50
Hickory	25	1.04	25	3.04	3	5.67	3	9.33
Red maple	5	1.00	5	1.80	6	2.50	4	5.25
Sugar maple	26	1.69	19	1.32	25	1.96	22	2.18
White ash	9	.44	9	.33	3	1.00	3	2.00
All species	193	3.35	181	4.99	67	6.52	55	5.76

[1] Branches per log denotes only the branches on the half-circumference facing the stand opening.
[2] Table covers only the trees growing on sites of index 70 or better.

Table 2. — Epicormic branching by site class[1]

Species	Site index 80		Site index 60	
	Logs in sample	Branches per log[2]	Logs in sample	Branches per log[2]
Chestnut oak	18	3.4	28	7.3
Red oak	39	4.6	20	6.3
White oak	5	9.2	9	13.6

[1] Table covers only the second logs of dominant and codominant trees.
[2] Branches per log denotes only the branches on the half-circumference facing the stand opening.

age, more sprouts develop on second logs than on first logs; and more sprouts develop on intermediate and overtopped trees than on dominant and codominant ones.

In addition, the relationship between site index and bole sprouting was examined. For the species found on both site index 60 and site index 80 — the poorest and the best sites — average bole sprouting was somewhat greater on the poor sites (table 2).

— H. CLAY SMITH
Silviculturist
Timber and Watershed Laboratory
Northeastern Forest Experiment Station
Forest Service, U. S. Dep. Agriculture
Parsons, West Virginia

U. S. FOREST SERVICE RESEARCH NOTE NE-54
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THE ACCURACY OF MEAN-GROWTH ESTIMATES MADE WITH DIAL-GAGE DENDROMETERS

In recent years a great deal of interest has been focused on tree growth as measured with relatively precise instruments over short periods of time. These growth measurements are usually made with vernier-band dendrometers similar to those described by Hall (1944) and Liming (1957), or dial-gage dendrometers similar to those described by Reineke (1932) and Daubenmire (1945).

Most of the dial-gage dendrometers measure growth in more precise units than the vernier-band dendrometers; but unlike the vernier-band type, they measure increment at only one of an infinite number of radii at a given height on a tree bole. The vernier-band dendrometers, on the other hand, measure circumferential growth, which may be converted to mean diameter growth. This measurement includes the increment accrued at all of the infinite number of radii at the cross section of the bole being measured.

For some work, the greater precision and sensitivity to both positive and negative changes in increment make the dial-gage dendrometer more desirable than the vernier-band type. However, it is generally known that growth may vary among the radii at a given height on the bole of a tree; and a number of investigators have cautioned that estimating mean growth from only one or two radial measurements may be misleading (Reineke 1948; Young 1952; Bormann and Kozlowski 1962).

Therefore a study of radial-growth variation and the accuracy of mean-growth estimates derived from as many as six radial measurements per tree was made during the summer of 1964 at the Bartlett Experimental Forest in New Hampshire. The species studied were yellow birch (*Betula alleghaniensis* Britton), paper birch (*Betula papyrifera* Marsh.), and sugar maple (*Acer saccharum* Marsh.).

Methods

Radial growth was measured on a sample of six trees each of the three species and within two size classes: small trees (2.0 to 4.0 inches d.b.h.) and intermediate trees (8.0 to 12.0 inches d.b.h.). Six dial-gage dendrometer stations were placed randomly on each of the 36 individual trees. (Randomization was accomplished by spinning a pinwheel divided into 36 ten-degree segments.) Growth measurements were made weekly at each station, using a two-point dial-gage dendrometer adapted (Blum 1965) for use on the smaller saplings as well as on the larger trees (fig. 1). Individual sample trees were selected for similar phyical characteristics and for similar growing conditions.

The data analysis was based on the seasonal radial growth at each measurement point. The first step was to compute the variance among the six growth measurements on each tree. The variance of the six trees within each species and size group were then tested for homogeneity.[1] Differences in the variances of yellow birch in both size classes were large enough to attain significance at the 5-percent level, but none of the differences in variances was significant at the 1-percent level. Although the assumption may be questioned for yellow birch, all variances within each group were considered homogeneous in order to permit comparable results. The variances were then pooled to obtain a single estimate for each species and size group, and the pooled variances were used to calculate the 95-percent confidence intervals for mean-growth estimates based on two, three, four, five, and six radial measurements.

[1] Homogeneity of variance was tested by using procedures outlined by Walker and Lev (1953) for testing the homogeneity of two or more samples with the same number of observations.

Figure 1.—Measuring growth of a yellow birch sapling with a two-point dial-gage dendrometer.

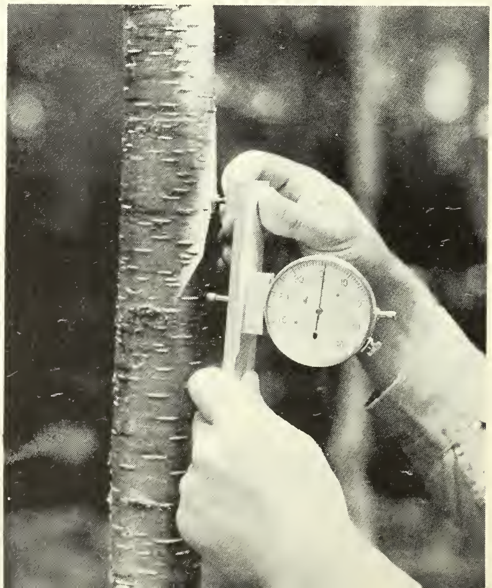

Table 1. — Width of confidence intervals, in inches and percent of overall mean, for mean-growth estimates derived from randomly selected radial-growth estimates[1]

(Basis: 6 dendrometer measurements per tree, 1964 season)

Species	Mean radial growth	2 stations		3 stations		4 stations		5 stations		6 stations	
	Inches	*Inches*	*Percent*	*Inches*	*Percent*	*Inches*	*Percent*	*Inches*	*Percent*	*Inches*	*Percent*
SMALL TREES											
Yellow birch	0.1563	±0.0303	±19	±0.0243	±16	±0.0208	±13	±0.0183	±12	±0.0164	±11
Paper birch	.1532	± .0358	±23	± .0288	±19	± .0246	±16	± .0216	±14	± .0194	±13
Sugar maple	.0835	± .0153	±18	± .0123	±15	± .0104	±13	± .0092	±11	± .0083	±10
INTERMEDIATE TREES											
Yellow birch	.0640	± .0225	±35	± .0181	±28	± .0154	±24	± .0136	±21	± .0122	±19
Paper birch	.0761	± .0218	±29	± .0175	±23	± .0149	±19	± .0132	±17	± .0118	±15
Sugar maple	.0733	± .0132	±18	± .0106	±15	± .0094	±13	± .0080	±11	± .0072	±10

[1] The computation of the confidence intervals was made according to the following:

$$\frac{\pm\ t(.05,\ 30)\ (s)}{\sqrt{n}} \qquad \left(\sqrt{\frac{N-n}{N-1}}\right)$$

Where N = Number of items in population = 36.
n = Number of radial measurements = 2, 3, 4, 5, or 6.

Results and Discussion

The confidence intervals for the trees studied ranged from ± 18 percent to ± 35 percent of the mean growth for two stations per tree to ± 10 percent and ± 19 percent of the mean growth for six stations per tree (table 1). Of course, a higher degree of accuracy is achieved as the number of stations is increased. As a general recommendation, four measurement points would seem to provide a useful compromise between accuracy and practicality. However, even with four points dial-gage dendrometer users should be aware that the true mean growth may deviate 13 to 24 percent from the estimates.

In some dendrometer studies, great accuracy in estimating mean growth is not required. In a study aimed at determining seasonal patterns of growth, for example, the relative fluctuations may be more important than the actual amount of growth. But even in these studies, differences in growth at various radii must be considered to obtain an accurate estimate of the fluctuations.

These results further document the fact that variations exist in the growth of individual trees. Instruments that measure growth at only one radius are therefore at a disadvantage in estimating mean growth, but the extreme sensitivity of dial-gage dendrometers make them especially desirable for many studies. Information presented here provides a guide to the magnitude of variation that might be expected in similar samples, and an approximation of the number of growth measurements needed to obtain a workable degree of accuracy. This information should be especially helpful in the planning of future dendrometer studies.

— BARTON M. BLUM and DALE S. SOLOMON[2]

Literature Cited

Bormann, F. H., and T. T. Kozlowski. 1962. Measurements of tree ring growth with dial-gage dendrometers and vernier tree ring bands. Ecology 43: 289-294.

Blum, B. M. 1965. A new mounting platform for dial-gage dendrometers. J. Forestry 64: 319-322.

Daubenmire, R. F. 1945. An improved type of precision dendrometer. Ecology 26: 97-98.

Hall, Ralph C. 1944. A vernier tree growth band. J. Forestry 42: 742-743.

Liming, Franklin G. 1957. Homemade dendrometers. J. Forestry 55: 575-577.

Reineke, Lester H. 1948. Dial-gage dendrometers. Ecology 29: 208.

Reineke, Lester H. 1932. A precision dendrometer. J. Forestry 30: 692-697.

Walker, Helen M., and Joseph Lev. 1953. Statistical inference. 510 pp. Henry Holt & Co., Inc., N. Y.

Young, Harold E. 1952. Practical limitations of the dial-gage dendrometer. Ecology 33: 568-570.

[2] Barton M. Blum is an associate silviculturist at the Northeastern Forest Experiment Station's research unit at Burlington, Vermont. Dale S. Solomon is an associate mensurationist at the Station's research unit at Durham, New Hampshire.

U. S. FOREST SERVICE RESEARCH NOTE NE-55
1967

Northeastern Forest
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LAND DISTURBANCES FROM STRIP-MINING IN EASTERN KENTUCKY. 2. PRINCESS COAL RESERVE DISTRICT.

Open-pit or strip-mining—primarily for coal—has expanded rapidly in eastern Kentucky during the past 15 years. Information about the amount, location, and general characteristics of the disturbed areas is necessary for appraising the economic impacts and overall effects of strip-mining in that section of the state, for planning reclamation programs, and for determining research needs and priorities. To obtain reliable estimates of the acreage disturbed both by the mining itself and by the associated coal-haul roads, and to provide relevant information about the disturbed areas, a survey was made. The survey was based on aerial photographs of all stripped areas as of October 1964.

The survey was broken down in accordance with the six subdivisions or coal-reserve districts delineated by the U.S. Geological Survey,[1] and a separate report on each district is planned. The first report[2] has been published. This is the second in the series.

The method used in our survey was a modification of forest-survey procedure. A 3-by-6-inch transparent template with 25 dots per square inch was positioned over the center of each photograph. Areas on the photographs that appeared to be stripped land or coal-haul roads were examined stereoscopically to determine important characteristics, and the amount of area in various categories was estimated by dot counts.

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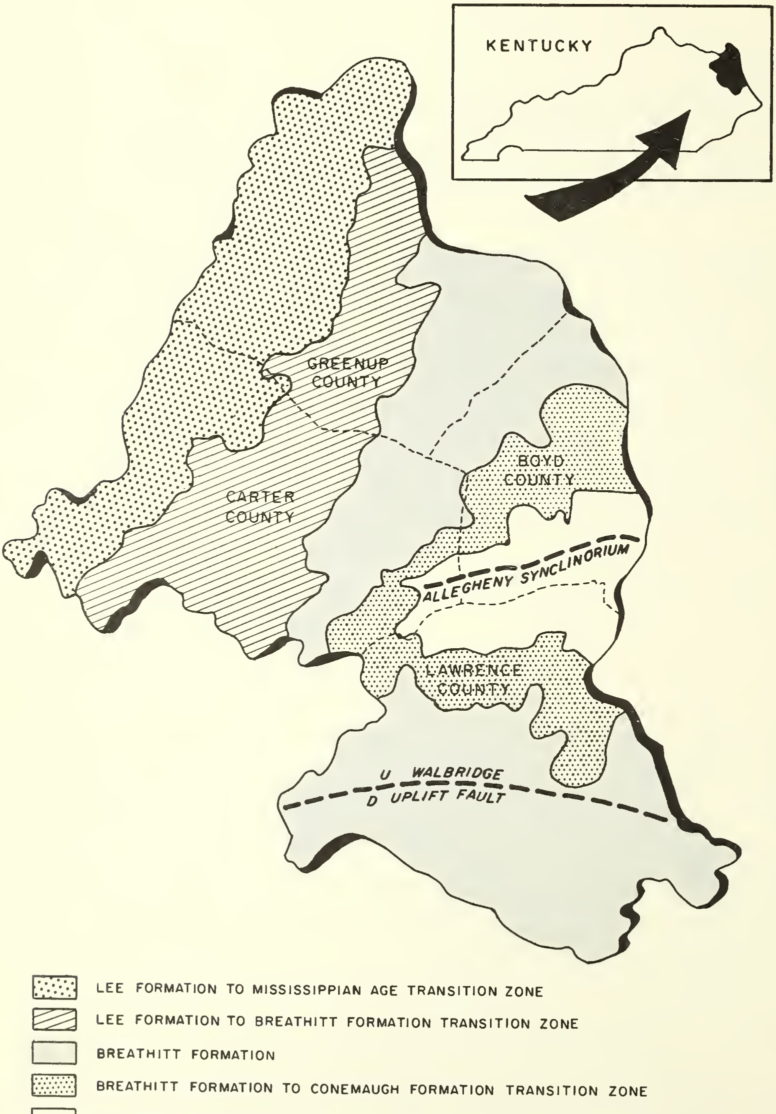
[1] Huddle, J. W., F. J. Lyons, H. L. Smith, and J. C. Ferm. COAL RESERVES OF EASTERN KENTUCKY. U.S. Geol. Survey Bull. 1120, 147 pp., 1963.

[2] Plass, William T. LAND DISTURBANCES FROM STRIP-MINING IN EASTERN KENTUCKY. 1. UPPER CUMBERLAND COAL RESERVE DISTRICT. U.S. Forest Serv. Res. Note NE-52. 8 pp., illus. NE. Forest Exp. Sta., Upper Darby, Pa. 1966.

The Princess Coal Reserve District

The Princess is the most northerly coal reserve district. It includes all of Boyd, Carter, Greenup, and Lawrence Counties (fig. 1). Although it is one of the least important in coal production, it ranks high as a source of refractory clays. Most of the clay is recovered by open-pit mining.

Figure 1.—Geographic and geologic features of the Princess Coal Reserve District.



Coal has been mined in the District for about 140 years. The first production came from mines in Greenup County in 1824. Between 1824 and 1955, the total production by counties was as follows: Boyd County, 13 million tons; Carter County, 12 million tons; Lawrence County, 3 million tons; and Greenup County, 2 million tons.[2]

According to Merz,[3] strip-mining for coal began in Boyd County in the early 1940's. He reported that 707 acres had been disturbed by stripping up to 1949, and that all the stripping was then less than 5 years old.

In 1963, the Kentucky Department of Mines and Minerals[4] reported only two active coal strip-mines in the District: one in Boyd County and one in Lawrence County. Production was 49,000 tons, whereas underground mines produced 63,000 tons.

District coal reserves (measured, indicated, and inferred) are estimated to be 2 billion tons.[2] Ten percent of this is in beds over 42 inches thick and 30 percent is in beds 28 to 42 inches thick. Eighty-five percent of the reserves are located in Boyd, Carter, and Lawrence Counties. There is no estimate of the amount that can be recovered by strip-mining.

Clays have been mined in the district at least since the turn of the century. In comparison to coal, yearly production is small, and it comes from many small mines. Mandt[4] reported that state-wide production from the 10 clay-producing counties was 614,000 tons in 1963. He listed 25 active mines or clay pits in Carter and Greenup Counties.

Clay reserves are assumed to be extensive. However, there are reports that the most accessible reserves of flint clay are diminishing.

Forest Cover

The percentage of forest cover in the Princess Reserve District varies from 56 percent in Boyd County to 82 percent in Lawrence County.[5] There is no distinctive pattern of land use: agricultural, road, and urban developments occur in the valleys, on the ridges, and on the slopes. Forests occur immediately below and adjoining 76 percent of the stripping.

In Boyd, Carter, and Greenup Counties 40 to 50 percent of the stands are of sawtimber size, but in Lawrence County the proportion drops to 23 percent. About 15 percent of the commercial forests are classified as

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[3] Merz, R. W. CHARACTER AND EXTENT OF LAND STRIPPED FOR COAL IN KENTUCKY. Ky. Agr. Exp. Sta. Circ. 66, 27 pp., 1949.

[4] Mandt, A. H. ANNUAL REPORT. Ky. Dep. Mines and Minerals, 166 pp.

[5] Unpublished preliminary report, BASIC FOREST RESOURCE STATISTICS, NORTHERN CUMBERLAND UNIT, KENTUCKY, 1963. U.S. Forest Serv. and Ky. Dep. Natural Resources, 1965.

southern pine or southern pine-hardwood types, and 45 percent are classified as oak-hickory.

Physiography and Geology

In general, the topography of the District is not so rugged as in other parts of eastern Kentucky. The local relief seldom exceeds 600 feet, but the landscape is highly dissected. Although the valleys are generally narrow and winding, some major streams have wide alluvial flood plains. The principal drainages are Tygarts Creek, the Little Sandy River, and the Big Sandy River.

Four geologic formations are exposed at the surface in varying degrees. From top to bottom or youngest to oldest these are: the Conemaugh formation, the Breathitt formation, the Lee formation, and the Mississippian rocks. The commercial clay deposits are found in the Lee formation and the coal deposits are in the Breathitt formation. On the basis of the surface geology, we defined and delineated the following five zones: the Mississippian rocks to Lee formation transition zone; the Lee formation to Breathitt formation transition zone; the Breathitt formation; the Breathitt formation to Conemaugh formation transition zone; and the Conemaugh formation. Transition-zone nomenclature was adopted wherever two formations are exposed over a substantial area in about equal proportions.

The different kinds and intensities of open-pit mining are distinctly associated with certain zones. Most of the mining for clay occurs in the Mississippian to Lee and the Lee to Breathitt transition zones. These zones represent about 45 percent of the land area. Both are located in the western part of the District (fig. 1). Stripping for coal, although centered in the Breathitt formation, also occurs in the Breathitt to Conemaugh transition zone. Together, these two geologic zones represent another 45 percent of the land area. The remaining 10 percent of the area, underlain by the Conemaugh formation, has very limited coal reserves and has not been disturbed by strip-mining.

The Allegheny synclinorium, a southeasterly plunging down-warp, is the largest and most important structural feature in the District. This causes a regional dip in Carter and Greenup Counties from northwest to southeast of about 50 feet per mile. In southern Carter County this may increase locally to 200 feet per mile. Erosion has exposed the coal and clay deposits in the Breathitt and Lee formations at several locations.

The Olive Hill clay bed, a major producer in the District, occurs near the bottom of the Lee formation, generally less than 30 feet above the underlying Mississippian rocks. In the western part of the District this bed is exposed high on the hills, where the clay is readily removed by strip-mining.

In the eastern part of the District the southeasterly dipping Lee formation disappears below grade and is replaced by the coal-bearing Breathitt formation. The latter is 475 to 800 feet thick and has 13 coal seams that have some commercial value. Of these only three have been strip-mined. Further to the east the Breathitt formation with its associated coal seams dips below the Conemaugh formation. Here underground mining becomes necessary to remove the coal.

Distribution of Stripped Areas

As of 1964, 4,761 acres—0.56 percent of the 855,000 acres in the District—had been disturbed by strip- and auger-mining for clay and coal (excluding coal-haul roads). Eighty percent (3,809 acres) was attributed to coal mining and 20 percent (952 acres) to clay mining.

Of the four counties, Boyd County had the greatest amount of stripping in terms of both acres and percentage of total land area: 2,412 acres or 2.37 percent (table 1). All of this was attributed to coal mining. Lawrence County had the least disturbance—125 acres or 0.05 percent of its land area.

For that part of the land surface in the District that is underlain by the coal-producing Breathitt formation, stripping disturbance totaled 2,998 acres or 1.03 percent of the area. The Mississippian to Lee transition zone, a clay producer, ranked second in disturbed acreage, and the coal-producing Breathitt to Conemaugh transition zone a close third.

Most of the disturbance can be attributed to mining the Olive Hill clay bed and the Princess #7 coal seam. Of minor importance are the Richardson or Princess #5 seam in Carter County and the Princess #8 seam in Lawrence County.

Physical Characteristics of Disturbed Areas

Coal and clay are removed by two basic types of mining: contour- or rim-stripping, and area-stripping. About 90 percent of all disturbance in this District has resulted from contour-stripping on mountain slopes. For this type of mining, 13 percent of the disturbed area was on or above the highwalls; 45 percent was in pits, inslopes, or leveled or unleveled benches above the outslopes; and 42 percent was on outslopes. Of the 2,000 acres of outslope, 80 acres, or 4 percent, were in slides or slumps.

Table 1.—*Area disturbed by open-pit mining in the Princess Coal Reserve District, by counties and zones, exclusive of haul-roads*

County	Mississippian to Lee transition zone	Lee to Breathitt zone	Breathitt zone	Breathitt to Conemaugh transition zone	Conemaugh zone	All zones	Percent of land area disturbed
	Acres	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*	*Percent*
Boyd	—	—	1,823	589	—	2,412	2.37
Carter	446	59	742	110	—	1,357	.53
Greenup	423	31	413	—	—	867	.39
Lawrence	—	—	20	105	—	125	.05
Total	869	90	2,998	804	—	4,761	0.56
Percent of land area disturbed	0.46	0.05	1.03	0.80	0	0.56	—

Area-stripping accounted for 505 acres—almost exactly 10 percent of all disturbance. All of this occurred on hill tops where the overburden was shallow and several successive parallel cuts could be made. In the area-stripping, 6 percent of the disturbance was on or above the highwalls; 55 percent was in pits, inslopes, or leveled or unleveled benches above the outslopes; and 39 percent was on outslopes. Four percent of the 200 acres of outslopes were in slides or slumps.

Leveling of the disturbed area is a much more common practice in clay mining than in coal mining. Seventy-nine percent of all clay pits were leveled and another 17 percent partially leveled. For the coal operations, 32 percent were leveled and 7 percent partially leveled.

A total of 250 acres were disturbed by haul-roads. This, plus the 4,761 acres disturbed by the mining itself, make a grand total of 5,011 acres disturbed by all phases of the mining operations.

From field measurements, the haul-roads in this District were found to average 31 feet in width from the top of the cut bank to the lower edge of the fill bank. Therefore, on the average, each mile of road disturbed 3.8 acres. To determine the mileage of haul-roads, we computed from our dot count the acreage disturbed by roads. Then we divided this figure by the acreage disturbed per mile of road. By this method we estimated that there were 65.8 miles of haul-road in the District (table 2).

The average amount of disturbed area per mile of road in clay mining was 32 acres; in coal mining the comparable figure was 106 acres. The difference comes about from differences in the size and tempo of the operations. Clay pits generally are small, their production is relatively low, and many of them are worked only intermittently because of fluctuating demand. Most coal strippings, in contrast, are much larger in both acreage and tonnage extracted, all recoverable mineral usually is removed in one

Table 2.—*Land disturbance attributed to haul-roads*

County	Clay mining		Coal mining		Total	
	Acres	*Miles*	*Acres*	*Miles*	*Acres*	*Miles*
Boyd	—	—	59	15.5	59	15.5
Carter	53	13.9	61	16.1	114	30.0
Greenup	61	16.1	8	2.1	69	18.2
Lawrence	—	—	8	2.1	8	2.1
Total	114	30.0	136	35.8	250	65.8

operation, and one haul-road may serve a comparatively large working area.

We recognized three classes of haul-roads in the overall survey: primary—running from a public road to the mine; secondary—joining two pits or serving as spurs for primary roads; and third class—service roads and temporary haul-roads. In the Princess District about 75 percent of all haul-roads for both coal and clay mining were classed as primary and about 25 percent as secondary; no roads here were listed as third class.

About 90 percent of the roads were on slopes or ridges away from natural drainages and 10 percent were in valley bottoms. Eighty-five percent of the roads ran through forested land; the other 15 percent adjoined land used for agriculture or other purposes.

—WILLIAM T. PLASS
Plant Ecologist
Northeastern Forest Experiment Station
Forest Service, U. S. Dep. Agriculture
Berea, Kentucky

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U. S. FOREST SERVICE RESEARCH NOTE NE-56
1967

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VISIBLE DORMANT BUDS AS RELATED TO TREE DIAMETER AND LOG POSITION

Abstract. Red oaks and yellow-poplars in a stand of second-growth cove hardwoods in West Virginia were studied to determine whether visible dormant buds are related to tree size or log position. No correlation was found between dormant buds and tree size, for either species; but yellow-poplars had a significantly greater number of buds on the upper log.

Dormant buds are frequently found in clusters on the bark surface of tree boles. These small buds, believed to form at the time of shoot development,[1] are attached to the primary xylem[2] by a bud strand. The strand causes a blemish in the wood and is treated as a defect if it is obvious enough to attract the attention of the lumber grader (fig. 1 and 2). Furthermore, these buds often cause the formation of bark pockets; and each has the potential to develop into an epicormic branch —an important source of defect in hardwood lumber.

It is possible that some of the early-formed buds become embedded in the wood or die as tree diameter increases. This would be reflected in more buds on the upper bole than on the lower bole, where the diameter is greater. Therefore a study was made to determine if the numbers of visible dormant buds are related to tree size or log position. This study is one of several in a larger program of research on dormant buds and epicormic branches.

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[1] Büsgen, M., and E. Münch. STRUCTURE AND LIFE OF OUR FOREST TREES. (Translated by T. Thomson). 3rd. Ed., 463 pp. John Wiley and Sons, Inc., New York, 1931.
[2] Roth, Elmer R., and G. H. Hepting. ORIGIN AND DEVELOPMENT OF OAK STUMP SPROUTS AS AFFECTING THEIR LIKELIHOOD TO DECAY. J. Forestry 41: 27-36, illus. 1943.

Study Area and Methods

This study was made in a stand of high-quality second-growth cove hardwoods on the Fernow Experimental Forest near Parsons, West Virginia. The stand has apparently not been disturbed since logging in the early 1900's. The site index for oak was estimated to be 75+.[3]

Two hardwood species were selected for study: red oak (*Quercus rubra* L.) and yellow-poplar (*Liriodendron tulipifera* L.). These species were selected to permit comparisons between one that appears to have a large number of dormant buds (red oak) and one that appears to have a relatively small number of buds (yellow-poplar).

A total of 60 codominant red oak trees and 51 codominant yellow-poplar trees were sampled over a diameter range from 9 to 21 inches at breast height (table 1). On each of these trees, the total number of visible dormant buds was tallied for the first 16-foot log, allowing 1 foot for stump height. Bud occurrence was also recorded for the second 16-foot log of 30 red oak trees and 21 yellow-poplar trees. All bud counts were made from a ladder placed against the tree bole.

It is recognized that, in recording only the buds visible on the bark surface, other submerged buds that are capable of producing epicormic branches may have been overlooked. Kormanik and Brown sliced a 15-inch sweetgum bolt (*Liquidambar styraciflua* L.) into small sections and observed about 40 additional dormant buds that were not evident

[3] Schnur, G. Luther. YIELD, STAND, AND VOLUME TABLES FOR EVEN-AGED UPLAND OAK FORESTS. U. S. Dep. Agr. Tech. Bul. 560, 88 pp., illus. 1937.

Figure 1. — Two dormant bud clusters (¼ inch wide) on the bark surface of a red oak.

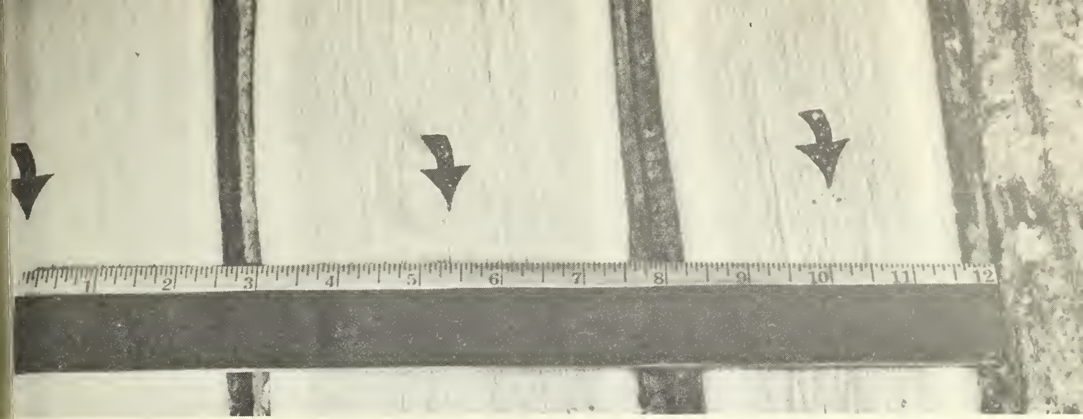

Figure 2.—A red oak bolt sectioned from bark, right, to center, left. Arrows indicate the bud strands from dormant buds, and the resulting blemishes.

on the surface.[4] A longer range study is under way to determine if such buds exist on red oak and yellow-poplar and if they are capable of producing epicormic branches.

Results

As expected, the average number of dormant buds was much higher on red oaks than on yellow-poplars (table 1).

Tree diameter.—Regressions were computed to relate the number of observed dormant buds to d. b. h. These regressions were not significant at the 5-percent level for either species. Coefficients of determination (R^2) were very low in both cases: 0.03 for red oak and 0.06 for yellow-poplar.

As a result of this test, it appears that there is no real change in the number of visible dormant buds with increasing tree diameter, at least for the species observed and for the environmental conditions of the study area.

Log position.—A pairing design was used with a t-test to determine if the number of dormant buds on the second log was different from the number on the first log. The results for red oak indicated that no significant difference existed. The average number of buds was 72 for the butt log and 65 for the upper log. However, for yellow-poplar, a similar test revealed that differences between the two log positions were highly significant. The second log had an average of 20 buds as compared with 7 on the butt log.

[4] Kormanik, Paul P. and Claud L. Brown. ORIGIN OF SECONDARY DORMANT BUDS IN SWEETGUM. U. S. Forest Serv. Res. Note SE-36, 4 pp., illus. SE. Forest Exp. Sta., Asheville, N. C. 1964.

Table 1.—*Number of dormant buds on butt logs, by d. b. h.*

D. b. h. (inches)	Red oak		Yellow-poplar	
	Trees	Average buds per tree	Trees	Average buds per tree
	No.	*No.*	*No.*	*No.*
9	4	61.5	0	—
10	6	58.3	8	8.0
11	0	—	7	2.9
12	10	57.0	3	4.3
13	6	53.3	3	10.7
14	5	74.2	7	2.1
15	6	45.5	7	2.4
16	3	47.3	3	4.7
17	8	61.6	5	2.2
18	2	21.5	2	6.0
19	5	46.0	2	2.0
20	4	17.5	4	.8
21	1	89.0	0	—
All trees	60	53.3	51	4.0

Discussion

The number of dormant buds appears to be independent of stem size. On the upper logs of yellow-poplar the greater concentration of buds may be due to factors other than size, such as proximity to the live crown, which may influence the available food and auxin supply. Also, the bark on the upper stem of yellow-poplar may be thinner and smoother than on the lower bole and thus more buds would be visible. This thinner and smoother bark characteristic would influence bud visibility to a lesser extent with red oak.

However, it is possible that the number of buds actually is related to tree size—but this relationship is masked by large variations in some factors not controlled in this study. Because site quality, tree age, stand stocking, and tree-crown class were more or less constant, the large variations observed may be due to individual genetic differences.

Further study will be needed on both species to determine the factor or factors that affect dormant bud occurrence and persistence. This information is essential to the development of practices that will reduce the defect associated with both dormant buds and epicormic branches.

—H. CLAY SMITH
Associate Silviculturist
Timber and Watershed Laboratory
Northeastern Forest Experiment Station
Forest Service, U. S. Dep. Agriculture
Parsons, West Virginia

U. S. FOREST SERVICE RESEARCH NOTE NE-57
1967

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PRUNING OPEN-GROWN BLACK CHERRY

Abstract. Black cherry trees that had large crown ratios and were 4 to 6 inches d.b.h. were pruned to various heights. Epicormic sprouting was severe and diameter growth at breast height was reduced on trees pruned to 75 percent of their height. Most trees pruned to 50 percent show little or no adverse effect after 3 years.

There are many thousands of acres of poorly stocked black cherry (*Prunus serotina* Ehrh.) stands on the Allegheny Plateau. Most of these stands contain scattered young fast-growing and well-formed trees that are heavily-branched because of the open growing conditions. If left alone, these trees will produce low-quality lumber. In some of these stands with low stocking, it has been necessary to sacrifice existing trees in an attempt to regenerate a fully stocked stand. However, pruning provides a means of salvaging these trees and developing stands of high potential value.

Pruning may also have an important place in the future management of black cherry. The possibilities of very intensive culture are now being considered whereby some cherry on the best sites might be grown at wide initial spacings to facilitate cultivation, fertilization, and even irrigation. To get production of high-quality veneer logs on as short a rotation as possible, pruning would be a key treatment.

In 1962 a study was established to determine the effects of different intensities of pruning on the growth and quality of open-grown black cherry trees. Preliminary results based on 3 years' observations are presented here.

The Study

Scattered black cherry trees in areas on the Marienville District, Allegheny National Forest, were selected for pruning. Trees between 4 and 6 inches in diameter, reasonably straight, free of forks, and with a live crown ratio of about 75+ were selected (figure 1). Tree heights ranged from 23½ to 45½ feet; the average was 35 feet. Live crown ratio actually averaged 83 percent, and ranged from 73 to 92 percent.

A total of 48 trees were used in the study—16 trees each in the 4-, 5-, and 6-inch diameter classes. Equal numbers in each diameter class were randomly assigned to one of four treatments. The treatments and the percent of live crown removed were:

Treatment	*Percent of live crown removed* (*average*)	(*range*)
No pruning	0	0
Pruning to 25 percent of total height	13	0-19
Pruning to 50 percent of total height	42	37-49
Pruning to 75 percent of total height	71	66-75

The trees were pruned in July and early August 1962. Branches were diagrammed to show: (1) their location on each of four faces, (2) whether live or dead at the time of pruning, (3) whether pruned or not pruned, and (4) their diameter to the nearest half inch just above the basal swell. All branches on the first 17 feet of all trees were diagrammed as were all pruned branches on trees pruned higher than 17 feet. In all, 988 branches were pruned; these and 513 branches that were left unpruned are under observation. The 585 live branches that were pruned averaged 1.0 inches in diameter, and the dead branches pruned averaged just over 0.6 inches.

Although the width of pruning wound may be more closely correlated with the rate of healing, the size of branch was used as a variable in this study because it can be measured before pruning; it describes unpruned branches as well as pruned ones, and it could be used to prescribe the upper limit of branch size to prune.

Diameter at breast height and total height of the trees was measured at the time of pruning. Diameters were remeasured each year and heights were remeasured after 2 years. Measurements were taken at the beginning of August. The pruning wounds and diagrammed branches are being observed each year to determine the dates of wound healing and natural pruning. The number and estimated length of epicormic branches is being recorded by 4-foot heights each year. The study will be continued for a few years after the pruning wounds have healed; some dissections will then be made to study wood quality.

Figure 2.—Wound healing and freedom from epicormic branches after 3 years. This tree was 6 inches in diameter when pruned to 50 percent of its height. All pruned branches more than 9 feet above the ground on this side were alive and 1 or $1\frac{1}{2}$ inches in diameter.

gure 1.—A promising 6-inch open-own black cherry tree immediately ter pruning to 17 feet — half its tal height.

Results

Diameter growth.—Diameter growth at breast height was reduced by the most severe pruning treatment—pruning to 75 percent of the total height—but was affected very little, if any, by the other treatments. The difference due to the 75 percent treatment was highly significant, statistically. Differences among the other treatments were not significant. This is true for each year as well as for the three years combined. Average annual and total diameter growth by treatments are shown in table 1.

Height growth.—Height growth on the trees pruned to 50 and 75 percent of their height was slightly greater than on the other trees, but the difference was not significant. The unpruned trees and those pruned 25 percent grew 2.0 and 2.1 feet in height, respectively, in the first 2 years after pruning. Trees pruned 50 percent and 75 percent had average increases in height of 2.7 feet during the same period.

Epicormic branching.—Within a year after pruning it became obvious that epicormic branching would limit the intensity of pruning. After 1 year, trees pruned 75 percent had an average of 35 sprouts that averaged nearly two feet in length (table 2). Sprouting was very light on the 50-percent trees, and practically nil on the others. There was some sprouting even on the unpruned trees and, later, in the unpruned portion of the first 17 feet of some trees pruned to 25 percent. Epicormic sprouts that survive negate the benefits of pruning, of course. Their lengths are an indication of their vigor and chances of surviving. No tests have been made of the possibility of eliminating these sprouts with a second pruning or by other means, such as chemicals. It seems likely that a second pruning would eliminate the weaker sprouts.

In general, epicormic branches have increased both in number and in length since the first year. The slight decline in number on the most severe treatment was the exception.

Table 1.—*Diameter growth at breast height, by treatment and year, in inches*

Year	Percent of height pruned			
	0	25	50	75
1962-1963	0.28	0.27	0.23	0.10
1963-64	.30	.30	.27	.13
1964-65	.23	.25	.24	.13
Total	0.81	0.82	0.74	0.36

Table 2.—*Average number and length of epicormic sprouts on unpruned trees up to 17 feet and on the pruned portion of others*

Treatment	Epicormic branches					
	1963		1964		1965	
	Number	Length	Number	Length	Number	Length
	No.	*Feet*	*No.*	*Feet*	*No.*	*Feet*
0	0.3	0.9	0.2	1.8	0.2	2.0
25	0	0	.2	.5	.2	.5
50	1.9	1.5	3.3	2.0	4.6	2.4
75	35.2	1.8	32.4	2.8	31.5	2.9

Individual trees vary considerably in their sprouting characteristics. For instance, 2 of the heavily pruned trees had only 6 and 10 unusually short epicormic branches after 3 years, even though the average tree had 31.5. Most of the epicormic branches on trees pruned 50 percent were small and weak. However, one tree had nine sprouts that averaged nearly 6 feet in length. Without this tree, the average length of sprouts for the treatment would have been 1.2 feet instead of 2.4 feet.

Epicormic sprouts tend to be most vigorous on the middle and upper parts of the pruned portion while weak or dead sprouts are more likely to be found near the base. Again, there are exceptions to this among individual trees.

Besides pruning intensity, the amount of exposure appears to influence the degree of sprouting. No records were made of the orientation of epicormic sprouts, but from observation it is apparent that they are most numerous on the southwest half of the trunk, particularly if they are not closely shaded on that side. They are sometimes confined to one face (quarter); this tends to keep the loss in wood quality at a minimum.

Branch wound healing.—Wounds that resulted from pruning are healing fairly fast (figure 2). Three years after pruning, 42 percent of the wounds under observation had healed. Healing was complete on some smaller scars after the first year and increasing numbers have become closed since then. Some scars from branches 1½ inches in diameter have healed. The 50-percent pruning treatment had the highest proportion of wounds healed (51 percent), but this proportion did not vary greatly among treatments.

The numbers of branches healed and not healed were compared for several 4-foot stem sections. For wounds of a similar size, significantly more had healed on the upper stem sections. Since diameter growth rate has a major influence on healing rate, this is probably a reflection of the greater diameter growth that takes place near the base of the remaining crown.

Apparent differences that appeared in healing rates between live and dead branch wounds were actually due to other factors. As a group, dead branches were smaller than live ones, and thus the wounds healed faster. But when branches of similar size were compared, it was found that wounds on live branches tended to heal faster than wounds on dead branches. This can be explained by the fact that live branches tended to be located near the tree crown while dead branches were low on the trunks. For live and dead branch wounds of the same size and position, there was no evidence of any difference in healing rate.

Cambium dieback has not been a problem. Only 11 of the hundreds of pruning scars had noticeable dieback; and it usually occurred in a V-shaped area under the pruning wound. Because healing takes place from the sides, dieback should have little or no effect on the rate of healing. In a couple of cases where pruning wounds were very close together, the cambium between them died, making one larger wound.

Smooth young black cherry bark is very susceptible to wounding. At first the flat rung of the metal ladder caused wounds that resulted in extensive dieback, but this was prevented by padding the ladder. The cambium was also killed in places where the sawteeth dragged against the bark.

Pruning methods.—Pruning methods and costs were not tested in this experiment. Pole pruners were used in the beginning but it was difficult to apply pressure, to handle the saw in whorls of branches, or to saw close and parallel to the stem in all cases. Light metal extension ladders were later substituted for the pole pruners: a 16-foot ladder was used for trees pruned to 50 percent of their height and a 40-foot ladder for those pruned to 75 percent. A Meylan pruning saw (blade mounted on an ax handle) was fine for limbs within ground reach.

Conclusions

Although heavy pruning caused a reduction in diameter growth, it is epicormic branching that is most important in limiting the height of pruning. Trees pruned to 75 percent of their height sprouted excessively, nullifying the benefits of the pruning. However, pruning up to 50 percent of tree height can be accomplished on most trees with little adverse effect from either branching or growth reduction. Most wounds appear to be healing rapidly. Pruning of open-grown black cherry promises to be an important tool for improving the quality and value of poorly stocked stands.

Recommendations

Trees similar to those used in this study could be pruned up to 50 percent of their height in one operation, unless the tree is exposed on the south or west side and has three quarters or more of its height in live crown. In all cases, it will be a matter of judging how high pruning can be done without causing serious epicormic branching.

The decision should be based on the exposure and the number and vigor of branches to be removed. Pruning vigorous branches or branches that shade the upper part of the stem probably increases the chances of stimulating epicormic sprouting. It might even be practical, in some cases, to retain more limbs on the exposed side of a stem and to prune higher on the shaded side. On trees with smaller crown ratios, located in less exposed situations, it would be possible to prune 50 percent of the total height.

Since a large proportion of the total tree value in black cherry is contained in the butt log, it will usually be desirable to limit pruning to the first 1 or 1½ logs, from which economic returns will be greatest. This practice will also permit the maintenance of a large crown to sustain rapid growth as the tree matures—an important requisite in any intensive cherry culture.

Care should be taken not to wound or strip the bark when pruning. Pruning cuts should be as close to the stem as possible, but need not—and probably should not—be made into the cambium surrounding the base of the limb.

After a few years it may be desirable to return and prune some of the same trees to gain more clear length, and to prune any epicormic branches that may have developed since the first pruning.

—T. J. GRISEZ
Associate Silviculturist
Northeastern Forest Experiment Station
Forest Service, U. S. Dep. Agriculture
Warren, Pa.

U. S. FOREST SERVICE RESEARCH NOTE NE-58
1967

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

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TREATMENTS NEEDED TO REGENERATE YELLOW-POPLAR IN NEW JERSEY AND MARYLAND

Abstract. In 17 areas, mostly in the Coastal Plain and Piedmont sections of New Jersey and Maryland, treatments were made to favor the establishment and growth of yellow-poplar reproduction. Results emphasize the importance of fairly large overstory openings (preferably 1 acre or more) and of reductions in understories by mistblowing, burning, or disking, but show that seedbed preparation is needed only in areas borderline because of deep litter, scant seed supply, or dense herbaceous growth.

Yellow-poplar is a highly valued tree that is well adapted to many sites on the better soils of the Piedmont and Coastal Plain of the Northeast. However, harvest cutting in stands containing yellow-poplar often fails to provide good stocking of poplar in the succeeding stands. Practicing foresters have long needed more information about how to regenerate this species, both in reproducing relatively pure stands and in converting to poplar those mixed stands that have only a scattered poplar seed source.

Observations by State and Station foresters in the Coastal Plain and Piedmont of the Northeast have indicated that three steps might be necessary to obtain establishment and dominance of adequate amounts of yellow-poplar reproduction. These steps are:

1. Creation of fairly large holes—1 acre or more—in the overstory.
2. Elimination or at least top-killing of the dense woody understories common on many sites.
3. Improvement of seedbeds by burning, disking, or other disturbance.

There is some question about the need for all three of these steps. For example, is seedbed treatment essential where understories are sparse or have been much reduced by the use of herbicides?

To obtain further information about the requirements for regenerating this species, the Northeastern Forest Experiment Station recently conducted a study in cooperation with the Maryland Department of Forests and Parks, the New Jersey Department of Conservation and Economic Development, several private landowners, and the U. S. Department of Defense. The first experimental area was treated in time for reproduction to become established in 1963; a second was treated for 1964 regeneration; and 15 more areas were treated for 1965 regeneration. This report describes the 1965 results in all 17 areas.[1]

Study Methods and Conditions

Our study emphasized seedbed treatment rather than the conditioning of the overstory because open conditions are generally recognized as necessary, and some studies on effective size of holes in overstory stands had already been made by Smith,[2] Roach (1962), and Minckler and Woerheide (1965). Holes in the overstory of about 1 acre, created either by injecting overstory trees with herbicide or by combining a harvest cutting with herbicide injection, were adopted as standard situations for testing the seedbed treatments. Also standard on most of the experimental areas was a mistblower application of 2,4,5-T herbicide to kill back the woody understories.

The injector and mistblower treatments were always made the year before the reproduction was to start. The mistblowing, of necessity, was done during the preceding growing season; the injecting was done during the preceding fall or winter. In the latter operation, about 1.5 milliliters of 2,4,5-T ester in fuel oil (80 pounds aehg) were applied per 3-inch cut in complete frills. In the mistblowing, a less-concentrated mixture (40 pounds aehg) of 2,4,5-T in oil was applied with a back-pack outfit at rates varying from 2 to 7 gallons per acre according to the density of the brush.

Original vegetation.—The 17 experimental areas were all in the Coastal Plain and Piedmont sections of New Jersey and Maryland, except one area in the New Jersey Highlands.

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[1] The author thanks Adna Bond, Clifton Dennis, Charles Keeley, James Klunk, John Michel, and Chester Sewell of the Maryland Department of Forests and Parks; Gordon Bamford, Charles Holsworth, Otto Kunkel, George Moorhead, and Santiago Porcella of the New Jersey Bureau of Forestry; and James Opdycke of the U. S. Department of Defense for their help in selecting sites, surveying areas, making treatments, and tallying reproduction. The establishment work was done under the direction of R. H. Fenton of the Northeastern Forest Experiment Station.

[2] Smith, Henry Wilds, Jr. ESTABLISHMENT OF YELLOW-POPLAR (LIRIODENDRON TULIPIFERA L.) IN CANOPY OPENINGS. Unpublished Ph.D. thesis, Yale University, 1963.

The overstory stands ranged from predominantly poplar to mixtures in which poplar was a minor component, but all had at least enough poplar to serve as a seed source. The associated species at one site or another included various oaks, sweetgum, beech, red and sugar maples, ash, sweet birch, hickory, basswood, and elm. Many of the stands also had a second story composed largely of smaller members of the tolerant and intermediate species in the overstory.

Beneath or blending into the second-story trees were various kinds of shrubs varying in densities from thickets to scattered single stems. The most common species were dogwood, spicebush, viburnums, and sweet pepperbush. Less frequently encountered were high-bush blueberry, mountain-laurel, and witch-hazel.

Many of the sites had little herbaceous ground cover before the overstory was disturbed. However, in a few places a luxuriant growth of May-apple, cohosh, asters, ferns, and similar plants was found.

Seedbed treatments.—The seedbed treatments were scarification (mostly by hand), burning, and no ground disturbance. With a few exceptions, as noted below, scarification and burning were each applied to 10 randomly located 2-milacre quadrats in each study area. The areas, originally planned to be 1 acre each, departed from this standard size in some instances; the range was 0.67 to 1.5 acres.

Scarification was done in most areas with fire rakes in October or November. In one area (Woodstown B) no scarification was done, and in another (Elkton) a bulldozer was used to treat lines about 6 feet wide.

The burns were all light because of low fuel volumes, and sometimes not all the unincorporated organic material was consumed. No burning was done on two areas (Elkton and Mutual). On one other area (Sergeantsville), two plots of 600 square feet each were burned instead of the usual 10 quadrats; and on another (Woodstown B) one plot of 1/3 acre was treated. Most of the burns were made in October or early November, but one was delayed until January and another until April.

To determine the relative importance of seed stored in the forest floor and seed of the current crop, special quadrats were installed at two sites to exclude fresh seed. These quadrats were burned in the fall and then covered with pinned-down window screening before the poplar seeds were shed. Two strips, each 28 inches wide and 25 feet long, were covered at one site (Woodstown B); at the other (Leonardo A), only one 2-milacre quadrat was covered. The screening was removed the following May.

Seedfall and reproduction tallies.—In each area four seed traps were installed to provide estimates of the amount of yellow-poplar seed distributed during the fall and winter when the seedbed treatments were made. The collected seeds were cut to determine the proportions that were sound.

Subsequent reproduction of yellow-poplar was tallied in the fall of 1965. On areas where scarification and burning treatments had each been applied to ten 2-milacre quadrats, the sampling included 40 quadrats as follows: all 20 treated quadrats, and 20 additional quadrats of the same size randomly located on undisturbed seedbeds. On the four areas where the treatment pattern was different or one of the treatments had been omitted, the sampling for reproduction was modified to fit the situation.

These reproduction tallies on the 15 areas that had gone through only one growing season in the fall of 1965 are the basis for most of the following discussion of results. Data from the two older areas are noted briefly where they supplement the 1-year data.

Results

Seedling stocking.—The abundance and distribution of yellow-poplar seedlings in the fall of the first year after the areas were treated seemed to be determined mainly by seed supply, light intensity, and seedbed treatment.

According to the seed-trap records, seedfall from the 1964 crop varied from about 21,000 to 1,626,000 sound seeds per acre. The seed averaged 17 percent sound, varying among sites from 7 to 24 percent sound.

However, the 1964 seed seemed to have little effect on seedling abundance the next year; most of the reproduction that started in 1965 apparently came from seed stored in the forest floor. This was indicated by results on the two areas where sample portions of burned seedbed had been screened to exclude fresh seed. Here the numbers of new seedlings per acre in the fall of 1965 were about the same as in similar unscreened seedbeds, as shown below:

Area	*Not screened*	*Screened*
Leonardo A	Average—17,250	31,000
	Maximum—32,000	(1 quadrat)
Woodstown B	Average—37,600	48,540; 97,080
	Maximum—79,000	(2 strips)

The minor role played by the 1964 seed was also demonstrated on another area (Shiloh) where the quadrats were not burned until April 1965. Although most or all of the 1964 seed was then down and presumably destroyed by the burning, an abundance of seedlings (64,950 per acre) was present the following September.

Table 1.—*Effect of seedbed treatments on the amount of yellow-poplar reproduction and stocking of quadrats at the end of the first growing season*[1]

Area	Seedlings per acre			Quadrats stocked with yellow-poplar[2]		
	Burned seedbeds	Scarified seedbeds	Controls	Burned seedbeds	Scarified seedbeds	Controls
	Number	*Number*	*Number*	*Percent*	*Percent*	*Percent*
Pottersville	62,450	72,650	28,225	100	100	100
Hopewell	82,850	128,550	14,900	100	100	100
Warrenville	27,450	36,150	9,525	100	100	95
Watchung	91,500	66,800	35,600	100	100	100
Woodstown A[3]	53,450	70,750	9,275	100	100	95
Woodstown B[3]	37,600	—	1,467	100	—	60
Shiloh	64,950	88,300	3,125	100	100	80
Leonardo A	17,250	23,250	3,850	100	100	80
Leonardo B	62,100	81,050	30,250	100	100	100
Woodlawn	62,150	55,750	6,875	100	100	70
Dayton	51,200	43,650	6,125	100	100	95
Cedarville	117,450	103,350	11,250	100	100	95
Mutual	—	17,100	2,450	—	100	85
Preston	15,850	17,000	600	100	100	50
	(16,350)	(17,850)	(1,325)	(100)	(100)	(60)
Harmony	4,550	2,150	325	80	100	40

[1] Practically all reproduction is seedlings of 1965 origin. Data for the Preston area are separated because older reproduction was present in sufficient amounts to affect results. The first Preston values are for 1965 reproduction; those in parentheses include 1965 and older reproduction.

[2] 2-milacre quadrats, except in Woodstown B area where 1-milacre quadrats were used.

[3] Area A was treated with both injecting and mistblowing; B had injecting but no mistblowing.

McCarthy (1933) mentioned an instance of dense stocking to yellow-poplar seedlings the first summer after a spring fire in Maryland, and New Jersey foresters have observed similar reproduction after some spring wildfires. These data and observations indicate that much, if not all, of the reproduction after burning comes from seed already in the forest floor. Reproduction on scarified or undisturbed seedbeds may also be mostly from stored seed, as Clark and Boyce (1964) suggest.

In our study, variable amounts of seed stored in the forest floor are believed to have been the chief factor responsible for the wide range in stocking density that was found on the disturbed seedbeds. This range was from 2,150 to more than 100,000 seedlings per acre (table 1). There was no discernible correlation between number of seedlings per acre and seedfall from the 1964 crop.

Light intensities approaching those of full sunlight appear essential for obtaining adequate establishment and survival of yellow-poplar reproduction. In the oldest area of our study, treated in 1962, some quadrats on partially shaded undisturbed seedbeds were stocked in 1963 but by 1965 had no surviving seedlings, while unshaded quadrats on similar seedbeds still had 1,167 seedlings per acre (and were 50-percent stocked). Even first-year reproduction may be reduced by shade in some places: in the Woodstown B area, which was not mistblown, there were only 1,467 seedlings per acre on undisturbed seedbeds, as compared to 9,275 seedlings per acre on similar seedbeds in the adjoining mistblown A area (table 1).

Seedbed treatments increased the amount of reproduction (table 1), but the magnitude of the increase varied greatly—from 2 to 28 times the number of seedlings found on undisturbed seedbeds. There was no consistent difference between those areas burned and those scarified in the number of seedlings each produced.

Even though seedbed treatments greatly favor seedling establishment, they seem unnecessary on most sites. In only 3 of the 15 areas treated in 1964 was the amount of reproduction on undisturbed seedbeds less than 2,000 seedlings per acre and stocking by quadrats less than 70 percent (table 1). In these three areas shade was a confounding factor. Mistblowing had not been used in two (Woodstown B and Preston), and the injector treatment had had little effect during 1965 in the third (Harmony).

However, seedbed treatments may be necessary on the drier sites where relatively thick litters of beech or oak leaves accumulate. In the Shiloh area four undisturbed quadrats with such a litter were unstocked, while two disturbed quadrats had 27,000 seedlings per acre.

Seedling height.—Seedling height at the end of the first growing season was apparently affected by the amount of shade and competition, by available soil moisture, and by the presence of advance reproduction—but not usually by seedbed treatment. Height was measured only for the tallest seedling per quadrat, and the resulting data showed little difference among seedbed treatments. Only in the Woodstown B area was there an appreciable difference—0.41 foot average height on burned quadrats versus 0.14 foot on undisturbed quadrats—and this appeared to be due to the greater shade on the latter (understory not reduced here because no mistblowing done). Even when the height of fewer, more dominant seedlings (100 per acre) was considered, there was no consistent and important difference among seedbed treatments. In only two areas did the average height of these seedlings on disturbed seedbeds exceed by 0.25 foot the height of those on undisturbed seedbeds. In contrast, the differences between study areas were much greater: average heights of the tallest 100 seedlings per acre varied from about 1 foot to 0.2 foot, probably because of differing amounts of light and soil moisture.

Only in the Preston area was enough advance reproduction present to appreciably affect seedling height averages. There, when advance reproduction was included, the average height of the tallest 100 seedlings per acre varied by seedbed condition between 1.5 and 1.8 feet; when advance growth was excluded, the range was 0.2 to 0.3 foot.

The 2-year-old Elkton site, which initially had only a sparse herbaceous ground cover, was similar to the 1-year-old areas in that seedling height was little affected by seedbed treatment. For the tallest 100 seedlings per acre, the average heights were 1.9 and 1.6 feet for scarified and untreated seedbeds, respectively.

Although seedbed treatments do not generally seem to have much effect on seedling height growth, the 3-year-old Sergeantsville site demonstrated that this may not hold true where dense herbacous ground cover is present. This site had a cover of cohosh, May-apple, ferns, and other woodland herbs. Here, excluding data from partially shaded quadrats, the treated seedbeds at the end of the third growing season not only had 3,300 more seedlings per acre and higher quadrat stocking (100 percent) than untreated ones; they also had produced taller seedlings. Average heights of the tallest 100 seedlings per acre for the three treatments were: scarified —2.2 feet; burned—1.8 feet; and untreated—1.4 feet.

The dense herbaceous ground cover apparently accounted for these differences by exerting a greater adverse effect where it remained intact than where it had been set back by the seedbed treatments.

Since the upper canopies of 50-year-old stands need contain no more than 100 to 150 stems per acre, the number, stocking, and growth of the poplar seedlings on the untreated seedbeds in our study areas seem generally to be adequate. When overstories and understories have been sufficiently reduced by herbicides and cutting and a good seed source is (or was) present, the larger catches of seedlings resulting from seedbed treatments will often be superfluous. However, where seed supplies are scanty, seedbed treatments would increase the catch from whatever seed was available, and often would be necessary to obtain adequate reproduction.

Recommendations

For obtaining adequate amounts and growth of yellow-poplar reproduction in the Coastal Plain and Piedmont of the Northeast, the following steps seem essential:

- Create holes 1 acre or larger in the overstory by harvest cutting or by injecting herbicide. In smaller holes, even of 1/4 acre, it is possible to obtain some yellow-poplars, but these holes have a high proportion of shaded edges, which favor more tolerant species. Usually make holes circular or square; don't use narrow strips that receive appreciable shade from the adjoining stands. If preservation of a high-forest appearance is not an important consideration, the size of the clearcut or injected area need not be limited—provided the whole area has been receiving fair supplies of yellow-poplar seed. Don't leave scattered residual trees in the hole: they develop epicormic branches, become low-quality stems, and interfere with yellow-poplar reproduction.

- Kill back or eliminate understories, usually before making overstory treatments. Mistblowing often suffices; disking or burning are alternatives, especially where drift of the herbicide to cultivated crops would be a hazard. Burning or disking will not usually eliminate as many stems as mistblowing. Inject stems not killed by mistblowing, disking, or burning. If Japanese honeysuckle is present, take special measures to eliminate it.
- Use disking or burning for seedbed preparation primarily on the somewhat dry borderline sites where oak or beech litter is deep enough to seriously reduce establishment of yellow-poplar seedlings. Seedbed treatment also seems advisable on sites having a low seed supply in the forest floor, especially if these are covered with dense herbaceous growth. However, herbaceous cover thus far has not severely limited yellow-poplar establishment, survival, and growth in any of the 17 areas in this study.

Literature Cited

Clark, F. Bryan, and Stephen G. Boyce.
1964. Yellow-poplar seed remains viable in the forest litter. J. Forestry 62: 564-567, illus.

McCarthy, E. F.
1933. Yellow poplar characteristics, growth, and management. U. S. Dep. Agr. Tech. Bull. 356. 57 pp., illus.

Minckler, Leon S., and John D. Woerheide.
1965. Reproduction of hardwoods 10 years after cutting as affected by site and opening size. J. Forestry 63: 103-107, illus.

Roach, Benjamin A.
1962. Practical silviculture for central hardwood stands. S. Lumberman 205 (2556): 34-35, 38.

— S. LITTLE

Principal Silviculturist
Northeastern Forest Experiment Station
Forest Service, U. S. Dep. Agriculture
Upper Darby, Pa.

U. S. FOREST SERVICE RESEARCH NOTE NE-59
1967

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CAMPER CHARACTERISTICS DIFFER AT PUBLIC AND COMMERCIAL CAMPGROUNDS IN NEW ENGLAND

Abstract. Early findings from a 5-year panel survey of New England campers' changing leisure habits are reported. A significant number of campers interviewed at four commercial campgrounds differed in their camping behavior from campers at four state park and national forest campgrounds. The most apparent differences are the higher degree of mobility and the larger dollar investment in camping equipment of the commercial campground visitors.

Most managers of forest recreation areas recognize several different categories of visitors. Understanding the characteristics and expectations of these groupings is prerequisite to responsive recreation enterprise management. Camping, for example, takes many forms, and satisfying the camper is easier with the realization that a satisfactory camping experience has many meanings depending upon each visitor's equipment, interests, and past camping experiences.

Some early findings from a 5-year panel survey of campers' changing leisure habits by the Northeastern Forest Experiment Station reveal the existence of several potentially important differences between campers visiting commercial and public campgrounds.

In a sample selected to include a variety of camping experiences throughout New England (fig. 1) a significant number of campers interviewed at four large commercial campgrounds differed in their camping behavior from campers interviewed at four large state park and national forest campgrounds. The campers at the commercial campgrounds also had a greater investment in camping equipment than campers at public campgrounds (table 1).

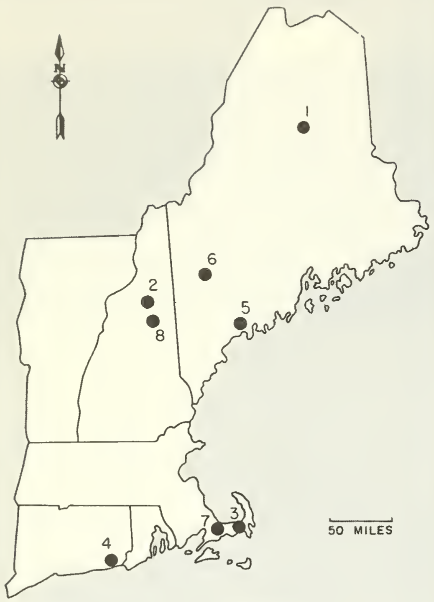

Figure 1.—The public campgrounds sampled in 1964 were· 1. Baxter State Park, Me.; 2. Dolly Copp Campground, White Mountain National Forest, N. H.; 3. Nickerson State Park, Mass.; and 4. Rocky Neck State Park, Conn. The commercial campgrounds sampled in 1965 were: 5. Hermit Island Campground, Bath, Me.; 6. Lakeside Pines Campground, North Bridgton, Me.; 7. Sweetwater Forest Brewster, Mass.; and 8. Eastern Slope Campground, North Conway, N. H.

Although many of the differences are highly significant, they fall short of suggesting that visitors to these two types of campgrounds are opposites. In fact, many campers freely alternate between the two kinds. However, sufficiently dissimilar populations of campers were present at these public and commercial campgrounds to provide a warning that the concept of an average camper is not a useful management tool for either public or private camping enterprises.

Differences in Camping Behavior

Without trying to depict an average visitor to either public or private campgrounds, several useful observations can be made from the findings presented in table 1. Most obvious among these are the interest in mobility and travel and the apparent greater sociability of a large segment of commercial campground visitors.

The high incidence of both sophisticated camping equipment and a preference for travel-type camping trips among the commercial campground respondents has valuable implications for managers of these enterprises. Since the camper's outlook on camping, as well as his equipment are often oriented toward high mobility, private campground managers may find that incentives such as fee reductions are of little value in influencing campers to stay more than a few days in one place. However, a similar incentive geared to influencing campers to return for future visits might be highly successful since the proportion of repeat visitation at private areas without the use of such incentives, was about 57 percent higher than at public areas.

High mobility among campers can influence management and design guidelines through the campers' obvious need for facilities that are designed for ease of access and use. And the highly mobile camper will probably require more personalized services and conveniences at the campground, whereas the extended visit vacation camper might well be satisfied to have these services available at the nearest town or to provide them himself.

Further, this greater interest in travel and mobility might logically be interpreted as a desire for increased social contact. And the implication

Table 1. — Differences between visitors to eight large public and commercial campgrounds in New England[1]

Campers who —	445 commercial campground visitors	421 public campground visitors	Difference
	Number	*Number*	*Percent*
1. Tend to revisit campgrounds rather than try new ones **	274	174	57
2. Are recent initiates to camping (last 9 years) **	350	287	22
3. Do not intend to return for a future visit *	20	36	80
4. Considered an alternative destination for this trip **	121	170	40
5. Selected this campground on the recommendation of others **	86	44	95
6. Own, rent, or have the use of a camping trailer **	217	105	107
7. Consider cross-country travel the most desirable type of vacation **	259	187	38
8. Are members of a camping or outdoor organization **	208	102	104
9. Are on a vacation trip of at least 2-weeks duration*	231	190	22
10. Select campsites by their location rather than condition *	276	227	22
11. Camped for 20 days or more during the current year **	222	160	39

[1] Chi-square analyses of the response proportions at public and private campgrounds revealed these differences were significant at: * the 0.05 level; ** at the 0.01 level.

for management of increased camper contact is the obvious value of word-of-mouth advertising.

The majority of campers are probably not in the woods to follow Thoreau's ideal of living simply and alone. Most campers appear to be gregarious, socially-conscious people, and to say that commercial campground visitors may be more gregarious than those who visit public areas sounds decidedly speculative. However, the fact remains that the proportion of respondents selecting their campsites on the advice of others, and the proportion belonging to a camping organization, were both about 100 percent higher at the commercial campgrounds. And during the year in which they were interviewed, 50 percent of the commercial area respondents camped for 20 days or more, as compared with 38 percent of the public area campers. In short, a significant proportion of the commercial campground patrons were more likely to pick their camping destinations because of their interaction with many other campers even though their individual visits averaged fewer days per campground and their years of camping experience were fewer than those of public campground visitors.

The influence of camping equipment in this relationship is obvious since the more mobile trailer-camper can see more campgrounds and make contact with more campers of similar interests than would be possible for the less mobile tent-camper. Further, the more sophisticated camping equipment attracts the attention of other campers and facilitates the process of socializing in any type of weather.

Additional evidence that a large proportion of these private campground visitors are, in fact, basically more socially oriented in their camping is found in a comparison of camper response to the question of their primary reasons for camping. Approximately 11 percent of the private area respondents camped *primarily* because they enjoyed meeting other campers, although only half as many public area visitors claimed this as their primary motivation. Undoubtedly the desire to meet and visit other campers is a strong secondary motivation for many who go camping primarily for reasons of economy and recreation.

As an interesting comparison, this study's findings about camper motivation are similar to those of an earlier survey of private campground visitors in New Hampshire (table 2).

Since camping at developed campgrounds is not a retreat from socialization, and in fact appears to represent an intentional increase in social contact for many, the design and management of some types of campgrounds should be geared to meeting the social needs of their patrons. For

Table 2. — A comparison of reasons given for camping by private campground visitors in two independent surveys

Reasons for camping[1]	New Hampshire[2] 1964	New England 1965
	Percent	*Percent*
1. Social interest	11	11
2. Travel interest	19	35
3. Economical vacation	30	32
4. Recreational interest	32	—
5. Physical exercise	—	6
6. Closeness to nature	—	11
Size of sample	978	445

[1] The terms social, travel, etc., are simply descriptive shorthand for the actual categories presented in each survey.

[2] Drawn from THE PRIVATELY-OWNED CAMPGROUNDS OF NEW HAMPSHIRE, Study Report No. 7 of the New Hampshire State Planning Project.

example, the entire social atmosphere of a campground can be modified by something as simple as excessive campsite spacing, unnecessary restrictions on the use of facilities, or the lack of organized group recreational programs.

Differences in Camping Investment

Nearly all of the campers interviewed had large family incomes; 44 percent and 37 percent, respectively, of private and public visitors reported a weekly gross income of $200 or more, and 80 percent of all persons interviewed earned at least $150 per week. And they evidently spent a substantial portion of their income on camping trips and equipment. Those having equipment investments of over $1,000 were more common at the private campgrounds. Public campground patrons were slightly less likely to have the major part of their total recreational investment tied up in camping equipment. However, camping equipment alone accounted for more than three-quarters of the total recreational investment for most of the campers interviewed at both public and private areas.

A comparison of camping investment categories reveals that a sizeable expenditure for camping equipment is not uncommon. However, the larger investments are considerably more common among commercial campground visitors, among camping association members, and among those who have been residentially stable for the past 10 years (table 3).

Some indication of the extent to which the heavily-invested camper is involved with camping is revealed by his high rate of membership in camping organizations and his frequently lower level of residential (and

Table 3. — Percentages of campers in four equipment-investment classes visiting commercial campgrounds, belonging to one or more camping or outdoor organizations, and residing at the same address for the past 10 years.

Equipment investment class	Size of class (campers)	Percent of investment who are —		
		At private campgrounds	Members of organizations	Residentially stable
	Number	*Percent*	*Percent*	*Percent*
Under $250	326	39	8	38
$251 to $500	221	48	15	43
$501 to $1,000	152	55	22	37
Over $1,000	166	76	41	54

occupational?) mobility. But, his involvement is also evident from his attitudes toward camping and his level of investment in other outdoor pursuits. The proportion of respondents who agree that camping is "basically a wilderness experience" was significantly higher among campers with a minimum investment of $1,000 in camping equipment, and therefore tended to be higher among private campground visitors even though all of the private campgrounds sampled were highly developed with modern conveniences (fig. 2).

Figure 2. — Ninety-one percent of the campers interviewed at this very modern, carefully landscaped campground felt that camping was basically a "wilderness" experience. Eastern Slope Campground, North Conway, N. H.

Rather than investing in other kinds of leisure activities, the heavily invested camper seems to be totally preoccupied with camping. Eighty-four percent of the campers with an investment greater than $1,000 in camping equipment had few, if any, other outdoor recreational interests. But camping was the dominant interest for only about 46 percent of those having less than a $250 equipment investment (table 4).

Because of their more expensive equipment, it is not at all surprising to find that private campground visitors also averaged a much higher dollar investment in camping. The implication that this higher investment may reflect a more-or-less permanent commitment to camping is a valuable one for private enterprise. For, unless this intensity of camper interest is matched by an equally serious investment of time and money on the part of the campground owner, he may never develop the high rate of repeat visitation that seems to be essential to success in the campground business.

Summary and Conclusions

Like most camper surveys, this one has limitations in the application of its findings to other campgrounds and other regions. Perhaps the major limitation is that all of the campgrounds in this study are relatively large, averaging 200 family units at the commercial areas and 250 units at the public areas, and many of these visitor characteristics may differ considerably at the more common smaller campgrounds. For example, length of camping visits tends to increase directly with campground size, apparently because of a large number of attractions at big campgrounds.

Despite the limitations of the survey, two general and related observations about the visitors to the public and private campgrounds sampled in this study should interest most managers and prospective managers of camping enterprises. Most apparent is the high degree of mobility among a large segment of private campground visitors and its related effects of greater social contact, improved knowledgeability about alterna-

Table 4. — The value of camping equipment as a percent of total recreational investment for each of four camping equipment categories

Percent of total recreational investment	Persons having camping equipment valued at —				
	Under $251	$251-$500	$501-$1,000	Over $1,000	Total
0 to 29	88	26	6	1	121
30 to 69	79	65	42	25	211
70 to 100	141	129	104	139	513
Total	308	220	152	165	845

tive campgrounds, and an increased need for more intensive campground service. And related to that mobility is the large dollar investment of many private campground visitors with its implications of a semi-permanent camping interest, and a willingness to pay a reasonable price for facilities that are attractive and convenient.

To determine how permanent these interests are, how equipment ownership changes over time, and how participation in camping is affected by changing leisure interests and changing financial status, this panel of New England campers is being re-surveyed annually over a 5-year period. Future findings in these trends will be reported as they become evident to provide forest recreation land managers with some better insights concerning their visitor's changing interests and expectations.

WILBUR F. LAPAGE
Research Forester
Northeastern Forest Experiment Station
Forest Service, U. S. Dep. Agriculture
Syracuse, N. Y.

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. S. FOREST SERVICE RESEARCH NOTE NE-60
1967

Northeastern Forest
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A SYSTEMATIC BIAS IN THE INTERPRETATION OF CFI RESULTS

Abstract. It is not generally recognized that a serious bias arises in the estimates of annual ingrowth and accretion, two of the growth components available from continuous forest inventory (CFI). The bias is demonstrated, and suggestions for correction are given.

The continuous forest inventory (CFI) system originated by Stott and described by Stott and Semmens (1960) has become an integral part of many inventory systems in practice on public and private lands. Although most of these systems are modified versions of Stott's CFI concept, the principle of remeasured, fixed-radius plots has been widely accepted for volume-growth estimates. Generally these growth estimates are broken down into these various components: ingrowth, accretion, gross growth (ingrowth + accretion), mortality, net growth (gross growth − mortality), cut, and net change (net growth − cut).

These components are usually converted to an annual basis from periodic measurements taken at the beginning and the end of a 5-to-10-year measurement interval. Average annual growth rates are easily obtained by differencing the two volume measurements of each tree, dividing by the measurement interval, and placing the resultant volumes in the appropriate growth-component summaries. Unbiased estimates of average annual growth-component rates for the period are consequently obtained for net change, cut, net growth, mortality, and gross growth. However, it is not generally recognized that a serious bias arises in the estimates of gross-growth components—annual ingrowth and accretion.

The Problem Defined

Gilbert (1954) defined ingrowth as "the volume, at the end of the period, of those trees that grew into the lowest inventoried diameter class during the period" and accretion as "growth on the initial trees. These are all trees that were measured at the beginning of the period." Depending on the objectives of the inventory, ingrowth and accretion may or may not include the growth on trees that died (mortality) and/or were cut during the interval.

The CFI remeasurement interval may vary from as little as 3 years to as many as 15 years. However, the interval specified by the conventional manner in which CFI results are presented and applied is only 1 year; that is, the average annual ingrowth, as calculated from CFI, is usually interpreted by land managers as the average volume of wood entering the merchantable-size class within a 1-year interval. Similarly, the average annual accretion is interpreted as the average volume increment on the previous year's volume.

Assuming that interpretations are to be made as in the preceding discussion, it can be shown that ingrowth is generally *overestimated* by CFI. And it follows that accretion is generally *underestimated.* This bias arises from misplacing the volume that an ingrowth tree accumulates *after* it passes the threshold diameter; that is, the increment on the ingrowth trees after the year of ingrowth is lumped with ingrowth instead of accretion. And, because the bias increases with an increase in the measurement interval, comparisons of ingrowth and accretion from inventories with different measurement intervals can be meaningless.

Example

The fictitious 1/5-acre plot in table 1 shows the trees present at each year of a 10-year interval—assuming a threshold diameter of 5.0 inches for cubic-foot volume of each tree.

By the usual method for calculating average annual ingrowth, the 1966 volume of those trees (less than 5.0 inches d.b.h.) that were not present in 1956 is divided by the measurement interval and plot size. Including trees 7 through 18 in the calculations, the result is $54.1/(10 \times 1/5) = 27.05$ cubic feet per acre per year. Accretion is then obtained as the volumes of trees 1 through 6 in 1966 minus the 1961 volumes. If this is divided by the interval and the plot size the result is $(97.6 - 22.6)/(10 \times 1/5) = 37.50$ cubic feet per acre per year. Gross growth is then $27.05 + 37.50 = 64.55$ cubic feet per acre per year. *Correct* results, how-

Table 1. — Cubic-foot volume of trees on a 1/5-acre plot at each year of a 10-year interval

Tree No.	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966
1	7.2	7.7	8.3	9.9	11.9	13.6	15.6	18.2	20.5	25.1	28.3
2	5.2	6.0	6.7	8.3	9.9	11.2	13.0	15.5	18.1	19.9	23.2
3	4.0	4.4	5.4	6.4	6.7	8.6	9.9	11.8	13.7	15.8	18.0
4	2.6	2.9	3.3	4.0	5.2	6.0	6.5	7.7	8.3	9.9	11.2
5	1.9	2.1	2.2	2.7	4.0	4.9	5.7	6.2	7.0	8.1	8.7
6	1.7	1.9	2.0	2.5	3.2	3.6	5.0	5.9	6.4	7.1	8.2
1-6	22.6	—	—	—	—	47.9	—	—	—	—	97.6
7	—	1.5	1.8	2.1	2.6	3.0	3.7	5.1	6.1	6.4	8.0
8	—	1.5	1.7	2.1	2.5	3.0	3.6	5.0	5.9	6.2	7.5
9	—	—	1.5	1.9	2.4	2.9	3.3	4.1	5.2	6.0	6.6
10	—	—	—	1.5	2.1	2.5	3.4	4.1	5.1	5.9	6.5
11	—	—	—	1.5	2.1	2.6	3.0	3.4	4.0	5.0	5.8
12	—	—	—	—	—	1.5	1.7	2.2	2.9	3.2	3.6
13	—	—	—	—	—	1.5	1.6	2.0	2.8	3.1	3.9
14	—	—	—	—	—	—	—	1.5	1.7	2.4	2.9
15	—	—	—	—	—	—	—	1.5	1.7	2.1	2.8
16	—	—	—	—	—	—	—	1.5	1.8	2.3	3.0
17	—	—	—	—	—	—	—	—	—	1.5	1.7
18	—	—	—	—	—	—	—	—	—	1.5	1.8
7-18	—	—	—	—	—	17.0	—	—	—	—	54.1
Σ	22.6	28.0	32.9	42.9	52.6	64.9	76.0	95.7	111.2	131.5	151.7

ever, are obtained by using the averages of the accretion and ingrowth volumes *for each year*. This procedure is shown in table 2.

The resulting growth rates indicate that annual ingrowth and accretion calculated by conventional methods are biased to the extent of $|(27.05 - 9.0)/9.0| \times 100 = 201$ percent and $|(37.50 - 55.6)/55.6| \times 100 = 33$ percent, respectively. In general, this bias increases as the measurement interval lengthens. For example, after only 5 years, the bias would be 62 percent for ingrowth and 20 percent for accretion.

Conclusions

The procedure for eliminating the bias is dependent on the method of volume calculation. For instance, if local volume tables are used, the solution is simple. Each ingrowth tree should automatically be placed in two slots: the volume of the tree with a 5.0 inch d.b.h. in the ingrowth slot and the volume at remeasurement minus the volume at 5.0 inches d.b.h. in the accretion slot.

Table 2. — Per-acre growth components in cubic feet for each one-year period

Component	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	Total	Annual average
Ingrowth	—	15.0	7.5	15.0	0	15.0	0	22.5	0	15.0	0	90.0	9.0
Accretion	—	12.0	17.0	35.0	48.5	46.5	55.5	76.0	77.5	86.5	101.0	555.5	55.6
Gross growth	—	27.0	24.5	50.0	48.5	61.5	55.5	98.5	77.5	101.5	101.0	645.5	64.6
Mortality	—	0	0	0	0	0	0	0	0	0	0	0	0
Net growth	—	27.0	24.5	50.0	48.5	61.5	55.5	98.5	77.5	101.5	101.0	645.5	64.6
Cut	—	0	0	0	0	0	0	0	0	0	0	0	0
Net change	—	27.0	24.5	50.0	48.5	61.5	55.5	98.5	77.5	101.5	101.0	645.5	64.6
Total volume	113.0	140.0	164.5	214.5	263.0	324.5	380.0	478.5	556.0	657.5	758.5	—	—

Because of the wide array of volume estimation models, no attempt is made in this paper to provide clear-cut solutions for every case. However, the importance of making the correction is evident and CFI users who depend on average annual rates of growth components should consider the extent to which this bias can affect their program planning and should take steps to eliminate the bias either by proper interpretation of present results or by revised calculations.

Literature Cited

Gilbert, Adrian M.
1954. WHAT IS THIS THING CALLED GROWTH? U. S. Forest Serv. NE. Forest Exp. Sta., Sta. Paper 71, 5 pp.

Stott, Calvin B., and George Semmens.
1960. OUR CHANGING INVENTORY METHODS AND THE CFI SYSTEM IN NORTH AMERICA. Fifth World Forestry Cong. Proc. 1960: 451-454.

—WARREN E. FRAYER
Mathematical Statistician
Northeastern Forest Experiment Station
Forest Service, U. S. Dep. Agriculture
Upper Darby, Pa.

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U.S. FOREST SERVICE RESEARCH NOTE NE-61
1967

Northeastern Forest
[FOR]EST SERVICE, U. S. DEPT. OF AGRICULTURE, 6816 MARKET STREET, UPPER DARBY, PA.
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CONTROLLING TAPHOLE DEPTH IN MAPLE SAP PRODUCTION RESEARCH

Abstract. Because bark thickness of sugar maple trees varies considerably, the depth of tapholes for collecting maple sap should be varied accordingly to get the taphole depth that will produce the best sap flow. A system of removable collars on the drill bit is recommended as a means of regulating taphole depth in research studies.

When tapholes for collecting sap from sugar maple trees are bored to a uniform depth from the surface of the tree bole, which is the usual practice, how deep the hole goes into the wood depends on how thick the bark is. Since sap flows only from the wood or xylem tissues, these differences in penetration of the wood may be a source of variation in sap yields and thus could have serious implications in research work on sap and sugar production.

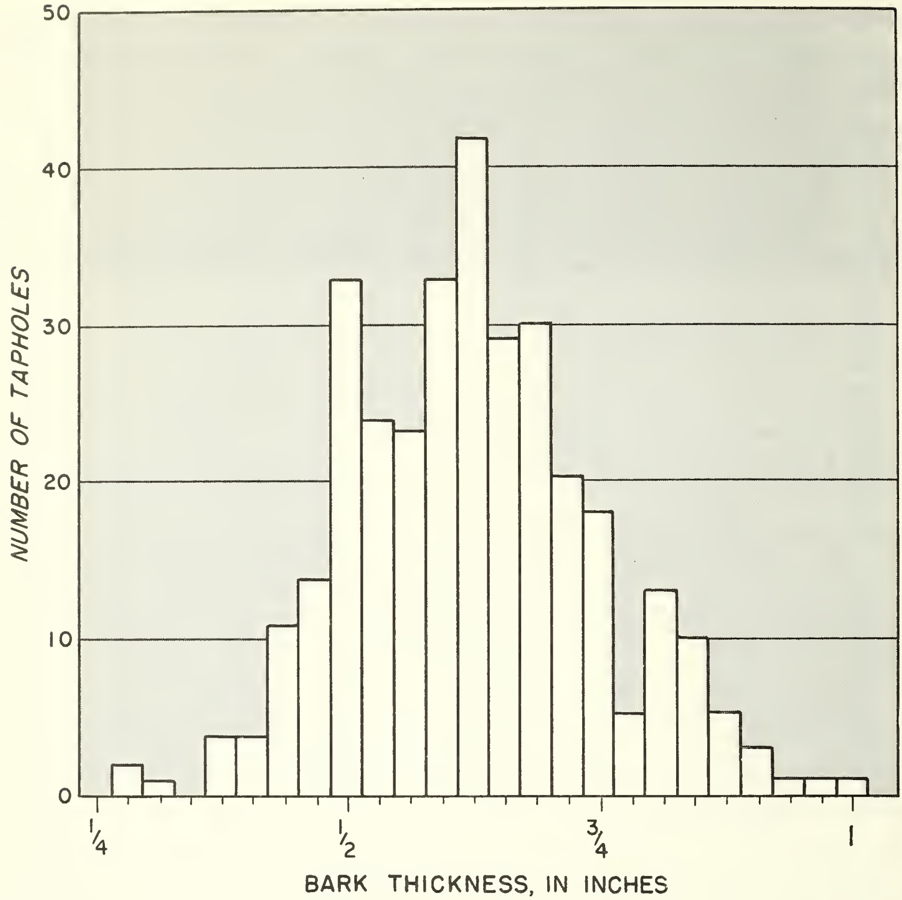
Several investigators have recognized the influence of taphole depth on total maple sap yield. Cope[1] observed that up to one-third of the total sap flow from a 4-inch taphole may be obtained from the innermost 2 inches. Morrow[2] reported a signficant increase in sap yields from 3½-inch tapholes as compared to 2-inch tapholes (depth was exclusive of bark thickness). Robbins[3] found that sap yields from 4-inch deep tapholes (including bark) were significantly greater than from those at 2- or 6-inch depths.

[1]Cope, J. A. DEPTH OF TAPPING IN RELATION TO YIELD OF MAPLE SAP. J. Forestry 47: 478-480, 1949.

[2]Morrow, Robert R. INFLUENCE OF NUMBER AND DEPTH OF TAPHOLES ON MAPLE SAP FLOW. Cornell Univ. Agr. Exp. Sta., N.Y. State Coll. Agr. Bull. 982. 3 pp. 1963.

[3]Robbins, Putnam, W. INFLUENCE OF TAPPING TECHNIQUES ON MAPLE SAP YIELDS. Mich. State Univ. Agr. Exp. Sta. Res. Rep. 28. 11 pp. 1965.

Figure 1.—Distribution of bark thickness by units of 1/32 inch among 327 tapholes in three Vermont sugarbushes.



To minimize error in any experiment, all known sources of variation should be held as nearly constant as possible. Obviously, in maple research, variation arising from taphole depth could be greatly reduced by standardizing the depth of the tapholes into the wood.

If taphole depth is gauged from the outside at the bark surface, effective depth in the wood will vary inversely with bark thickness. Bark thickness was determined for 327 tapholes during the course of recent research investigations in three sugarbushes in northern Vermont. These tapholes were drilled with a commercial bit equipped with a fixed stop 2½-inches back of the tip.

Bark thickness in these tapholes was found to vary from ¼-inch to 1-inch (fig. 1). The mean depth of wood penetration was found to be

$1\frac{7}{8}$-inches. This is considerably less than the optimum depth of $3\frac{1}{2}$- to 4-inches. Such variations in depth almost certainly would affect sap yields among treatments and thereby would increase the experimental error in the data.

To reduce error from variation in taphole depth, attachments for a standard tapping bit were designed to facilitate drilling tapholes to a uniform depth *into the wood.* The attachments enabled us to compensate for variations in bark thickness. Although not designed for use on a commercial scale, a bit thus equipped has been used successfully in research studies where taphole depth must be accurately controlled.

The attachments consisted of a $\frac{1}{2}$- by 1-inch metal collar to slip over a standard 7/16- by 6-inch bit, and 24 hard-fiber washers, each 1/16-inch thick. The collar was fitted with a 3/16-inch Allen screw and clamped securely to the shank of the bit exactly 4 inches back of the cutting tip. The washers were then placed over the bit, resting on the collar (fig. 2). This left $2\frac{1}{2}$-inches of the bit exposed.

When tapping a tree, the bit is first used with all the washers in place. The resulting hole is $2\frac{1}{2}$-inches deep, including bark. The thickness of the bark is then measured in 1/16-inch units (fig. 3). If, for example, the bark thickness is 5/16-inch, five washers are removed, and the bit is then re-inserted in the hole and sunk the additional 5/16-inch into the wood. Thus, the depth of the resulting taphole in actual sap-producing tissue is $2\frac{1}{2}$-inches. Before drilling a new hole, all washers are replaced; then the procedure is repeated. If tapholes of other than $2\frac{1}{2}$-inches effectve depth

Figure 2.—Standard tapping bit equipped with a metal collar and washers to regulate drilling depth.

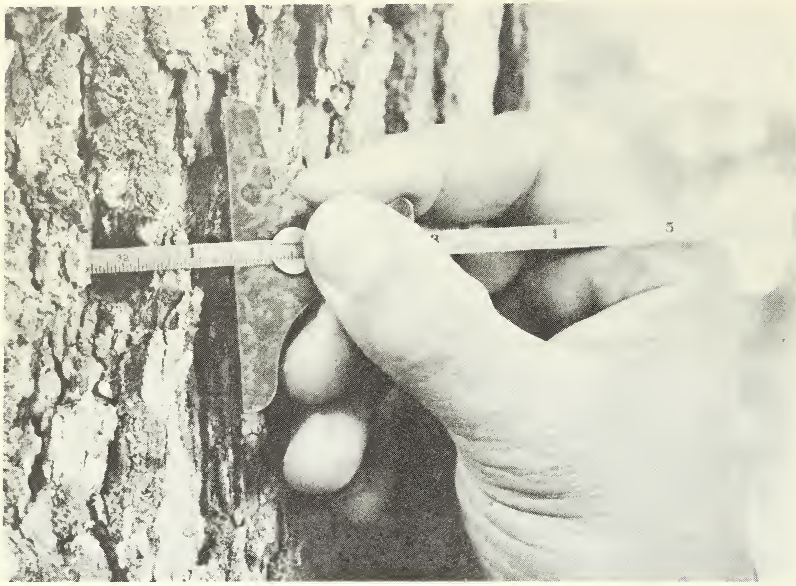


Figure 3.—Measuring bark thickness in 1/16-inch units.

are desired, appropriate compensations can be made in the number of washers removed.

Although these attachments for a tapping bit are suitable only for use in research investigations where the time required to make holes to exact specifications can be justified, the importance of taphole depth as affected by bark thickness should not be overlooked in commercial operations. To achieve closer control of effective depth in commercial tapping, it is suggested that an average bark-thickness value be determined for each sugarbush or, if a bush were not reasonably uniform, for each distinctly different section of it. Then appropriate allowances for bark thickness could be made when drilling the tapholes.

—MELVIN R. KOELLING and BARTON M. BLUM

Research Foresters
Northeastern Forest Experiment Station
Forest Service, U. S. Dep. Agriculture
Burlington, Vermont

U.S. FOREST SERVICE RESEARCH NOTE NE-62
1967

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RESULTS OF HERBICIDE TRIALS TO CONTROL JAPANESE HONEYSUCKLE

Abstract. Three or more annual sprays are required to eliminate Japanese honeysuckle where 2,4-D, a mixture of 2,4-D and 2,4,5-T, or amitrole is applied as either a low-volume (mistblower) or high-volume spray. Dicamba and picloram are more effective. The mixture of 2,4-D and picloram is recommended as the best material for eliminating honeysuckle in a single treatment at the time of harvesting overstory trees. However, 3 gallons of the material, costing about $33, are required per acre.

THE CONTROL of Japanese honeysuckle *(Lonicera japonica)* is important for managing many woodlands of eastern Maryland, Delaware, southern New Jersey, and southeastern Pennsylvania. This vine not only forms a dense cover on the ground, but it may also climb and overgrow shrubs, saplings, and small pole trees so that they are deformed and even killed by smothering. When Japanese honeysuckle is present in openings, its growth is particularly luxuriant and usually prevents reproduction of other vegetation. Foresters often hesitate to harvest trees on sites where honeysuckle occurs for fear that they will be unable to establish a new forest stand.

Although found in some pine stands, honeysuckle is most troublesome on the best hardwood sites—those that should grow high-grade yellow-poplar, oak, and sweetgum. In Maryland this pest was found on 8 percent of the sites in the upper Coastal Plain and Piedmont *(2)*, and it probably occupies similar proportions of the woodlands in northern Delaware, southeastern Pennsylvania, and the inner Coastal Plain of New Jersey.

In 1957, in cooperation with the Maryland and New Jersey forestry departments, the City of Baltimore, and five chemical companies, the

Northeastern Forest Experiment Station of the U. S. Forest Service began testing several herbicides for controlling honeysuckle. Progress reports on these trials were published in 1959 and 1961 *(8, 9)*. This report summarizes the results to date, with major emphasis on the findings since 1961.

Study Methods

The first trials were confined to three materials recommended for controlling honeysuckle in the Southeast. These were 2,4-D (2,4-dichlorophenoxyacetic acid), recommended by Walker *(10)*; and two materials originally recommended by the Southeastern Forest Experiment Station *(1, 5)*—a 2:1 mixture of the butoxy ethanol esters of 2,4-D and 2,4,5-T (2,4,5-trichlorophenoxyacetic acid), and amitrole (3-amino-1,2,4-triazole). The last was first available as a water-soluble powder and later as a liquid formulation (Amitrol-T) that also contained ammonium thiocyanate. More recently, all these materials have again been recommended for use on honeysuckle in the Southeast *(3, 4, 7)*.

Because none of the above materials was effective in our trials as a single treatment, several others that offered promise were tried in 1959 or in subsequent years. During this period, too, increasing use was made of mistblower applications in place of high-volume sprays.

In all, 187 plots were established. Where treatments involved the use of pellets or high-volume sprays, each plot was 1/40 acre or 33 feet square. Where mistblower treatments were made, each plot was 1/10 acre. During the first 3 years of the study, plots were scattered among the Green Bank and Belleplain State Forests in New Jersey and four different properties in the Havre de Grace-Annapolis section of Maryland. All the plots established between 1960 and 1964 were on one property near Towson in Baltimore County, Maryland.

Descriptions of the earlier treatments and their results can be found in the 1959 and 1961 reports *(8, 9)*. The effects of burning and grazing, of honeysuckle density, of the timing of treatments, and of the type and amount of herbicide carrier also are discussed in the first report; and most of the chemical formulations that have been ineffective in our trials are listed and commented upon in the second report. That material will not be repeated here. The following discussion of results is confined to the more effective formulations.

All spray rates given in this paper are on an acre basis. In the initial treatment on each plot the full amount of spray per acre was applied. Amounts used in subsequent treatments were sufficient to wet thoroughly all living honeysuckle foliage seen by the operator.

Results

Five herbicidal materials, essentially the first three tested in 1957 and two newer ones, have shown the most promise of controlling Japanese honeysuckle. The three from 1957 are amitrole, a mixture of 2,4-D and 2,4,5-T, and 2,4-D alone; the two newer ones are dicamba (the dimethylamine of 3,6-dichloro-*o*-anisic acid[1]) and picloram or picolinic acid (4-amino-3,5,6-trichloropicolinic acid)[2].

Amitrole.—Trials with amitrole have included formulations both as liquid (Amitrol-T) and as a water-soluble powder. June or July treatments with this chemical have varied greatly in effectiveness as table 1 shows. In this listing all except the last treatment were high-volume sprays; the last was made with a back-pack mistblower.

As the table indicates, similar treatments repeated up to four or five times may almost eliminate the honeysuckle cover or may cause little or no reduction. Because of this variability, we do not recommend amitrole for general use in honeysuckle control.

[1]Formerly called 2-methoxy-3,6-dichlorobenzoic acid.

[2]Trade names are Banvel D and Tordon, respectively. Mention of trade names should not be construed as an endorsement of a particular commercial product by the Forest Service or the U. S. Department of Agriculture.

Table 1.—*Trials with Amitrole*

Spray mixture: active ingredient in pounds, water in gallons	Number of annual treatments	Reduction of honeysuckle by plots
5 pounds in 125 gallons	5	Complete elimination ....1 plot Reduction to about 6 clumps....2 plots
5 pounds in 125 gallons	4	Reduction to 8 — 10 clumps...3 plots No reduction ....1 plot
5 pounds in 250 gallons	5	Reduction to light cover down to scattered clumps ....all plots
5 pounds in 250 gallons	4	Almost complete elimination....2 plots Reduction to light cover.......2 plots
4 pounds in 100 gallons	3	Reduction to light cover down to 9 or 10 clumps.............all plots
8 pounds in 100 gallons	3	Reduction to 3 — 5 clumps.....2 plots Reduction to about 10 clumps...1 plot Reduction to light to medium cover ....1 plot
8 pounds +1 gallon +4 teaspoons of Triton B-1956 spreader-sticker (mistblower)	2	Reduction to light cover.......all plots

2,4-D and 2,4,5-T mixture.—The combination of 2,4-D and 2,4,5-T has been appreciably more effective and consistent than amitrole. In all plots that received five or six treatments with this mixture, the old growth of honeysuckle was eliminated. In eight plots that received three or four treatments, the honeysuckle was eliminated in four plots and reduced to one to three clumps in the others. Although the 1961 paper *(9)* stated that 8 pounds acid equivalent of the chemicals in 125 gallons of water was slightly more effective than the same amount in 250 gallons, little difference was evident in our more recent results.

Mistblower applications of the mixture of 2,4-D and 2,4,5-T were tried in early December and in July or August at two rates: 4 pounds of active ingredient in 4 gallons of water, and 8 pounds in 4 gallons. In these treatments the 8-pound rate was slightly more effective than the 4-pound one, but not enough to warrant the extra cost. The December treatments, although fairly effective, produced somewhat less foliage kill and stand reduction than the summer applications. Two treatments in July or August, a year apart, almost eliminated heavy stands of honeysuckle; however, occasional runners usually survived.

2,4-D.—Results from using 2,4-D alone have been similar to those from the mixture with 2,4,5-T. Again, in all plots receiving five or six treatments, the old-growth honeysuckle was eliminated. In the eight plots that got three or four treatments of 8 pounds acid equivalent of 2,4-D in 125 or 250 gallons of water, honeysuckle was eliminated in three plots and was reduced to one to four sprout clumps per plot in the others. Although in the earlier report *(9)* 250-gallon treatments with butoxy ethanol, ethyl, or isopropyl esters of 2,4-D were said to be slightly better than 125-gallon treatments, this difference was not borne out in the later results.

Three newer formulations of 2,4-D and related compounds also were tried in high-volume sprays. These were the 2,4-D emulsifiable acid,[3] 2,4-DB [4-(2,4-dichlorophenoxy) butyric acid], and dichlorprop or 2,4-DP [2-(2,4-dichlorophenoxy) propionic acid], all used at 4- and 8-pound acid equivalent rates in 100 gallons of water. Three annual treatments of 2,4-DB or 2,4-DP failed to eliminate the old growth of honeysuckle; each plot still contained four to seven sprout clumps. The 2,4-D emulsifiable acid was somewhat more effective, but after three treatments it had completely eliminated the honeysuckle on only one plot; two or three clumps still survived on each of three other plots.

In mistblower applications the isopropyl ester, butyl ester, and emulsifiable acid of 2,4-D produced somewhat variable results. Spray mixtures

[3] Trade name is Weedone 638.

contained 4 or 8 pounds of the active ingredient in water; total volumes were 5 or 6 gallons; and applications were made on some plots in July or August and on others in early December. The emulsifiable acid was also tried in five other concentrations: 4 pounds in a total volume of 2.65 gallons, 8 pounds with no additional carrier, 8 pounds in volumes of 4.2 and 5.6 gallons, and 12 pounds in a volume of 6 gallons. The emulsifiable acid was at times more effective than the older esters, but not consistently.

All chemicals and concentrations were generally more effective in summer treatments than in early December treatments, but, again, not consistently more effective. In one December treatment of 8 pounds acid equivalent of the butyl ester in 6 gallons of spray, the initial top-kill approached 100 percent, but other December treatments were not similarly effective. An application of 8 pounds of the emulsifiable acid in 5.6 gallons of spray in July 1961 eliminated an exceptionally high proportion of the honeysuckle, but re-treatment a year later failed to eliminate the scattered sprouts. And similar treatments in other summers were not nearly as effective as the 1961 application.

Thus, even though two treatments almost eliminated honeysuckle in some plots, the results were so variable that not one of these 2,4-D formulations can be recommended as effective in eliminating honeysuckle in less than three annual treatments.

Dicamba.—Dicamba was tried only in mistblower treatments and in the July-August period, at two rates: 4 and 8 pounds of active ingredient in water, with spray volumes of 5 and 6 gallons respectively. The initial treatments were extremely effective, eliminating more of the honeysuckle cover than any of the 2,4-D treatments; but re-treatments a year later failed to eliminate the scattered regrowth. Results with the two rates were about the same.

The failure of second treatments to eliminate the scattered regrowth may have been due to the protection provided by a dense, tall cover of herbaceous weeds that developed between treatments. These weeds, mostly wild lettuce, were 6 to 8 feet tall and only about a foot apart when the re-treatments were made.

Picloram.—In 1963 and 1964, three formulations of picloram were tried: Tordon 101 Mixture, which contained 0.54 pound of picolinic acid and 2 pounds of 2,4-D acid per gallon as the triisopropanolamine salts; Tordon 22K, which contained 2 pounds of picolinic acid per gallon as the potassium salt; and Tordon 10K, a pelleted formulation containing 10 percent of picolinic acid as the potassium salt in an inert carrier.

The pellets were relatively ineffective in our trials. Two August treatments, each using 80 pounds of Tordon 10K (8 pounds active) and made a year apart, still left a light cover of honeysuckle.

If enough of the formulation was used, Tordon 101 and Tordon 22K proved effective both years in single August treatments. With Tordon 101, one application of 3 or 5 gallons per acre in water, 250 gallons total volume, completely eliminated the honeysuckle on most of the test plots. But 1 gallon per acre in the same volume did not provide complete control, even after two August treatments a year apart. Tordon 22K, used only at 2½ gallons per acre (same total volume), also eliminated honeysuckle in one treatment.

Plots where honeysuckle had been eliminated by picloram remained conspicuously devoid of vegetation during the following year, and thus were in marked contrast to the dicamba-treated plots with their rampant weed growth. However, in 1965 scattered plants and patches of pokeberry and wild lettuce developed in the picloram plots that had been sprayed in 1963. So, presumably, natural tree reproduction might start or seedlings might be planted the second spring after a picloram treatment with little risk of mortality from residual herbicide.

The residual effect of picolinic acid in the Baltimore area seemed to last much longer than the residual effect Brender and Moyer *(6)* observed in Georgia. Six months after spraying picloram at rates up to 3¾ pounds acid equivalent per acre, they planted loblolly pine seedlings and noted no residual effect of the chemical on pine survival. However, reports from the manufacturer, Dow Chemical Company, state that decomposition and leaching of this herbicide are greatly affected by climatic conditions, so the apparent difference between Maryland and Georgia is perhaps to be expected.

Discussion

Japanese honeysuckle is a tenacious weed: once established, it is exceedingly difficult to eradicate. Grazing, burning, repeated cutting, and various herbicides will reduce it, but usually only temporarily. Some root crowns survive all but the most intensive eradication measures and soon re-establish a full cover by rapid regrowth of sprouts. In one block of plots of this study, the average 1-year growth of marked sprout runners, including laterals and sublaterals, was about 25 feet. In most plots where kill was mainly confined to the tops, two growing seasons were sufficient for the vines to regain their original density.

On the other hand, reinvasion by seedlings is relatively slow. The many honeysuckle seedlings reported in 1961 *(9)* later proved to be Tartarian honeysuckle *(L. tatarica)*; usually no more than one or two seedlings of Japanese honeysuckle had started per 1/40-acre plot. The growth of the seedlings was slow at first, but by the third or fourth year they had developed four to seven runners 4 to 8 feet long. It appears that seedlings of Japanese honeysuckle will not be a serious problem if reproduction of tree species is promptly established after the original vines have been killed.

Some authors believe that honeysuckle infestations need not always be eliminated before tree seedlings are planted. Bruner and Shearin *(7)* report that in South Carolina successful plantations of loblolly pine can be established by planting in furrows where the vines are less than knee deep. However, where the honeysuckle is more rampant and drapes over shrubs and trees, they recommend two sprays of 2,4-D or amitrole before planting.

In our section more control of honeysuckle than Bruner and Shearin advocate seems advisable. Mechanical methods of control are not generally feasible. Herbicides seem to offer the best solution. The ideal herbicidal treatment would be one that would eradicate the honeysuckle in a single treatment, and that could be used just before regenerating a timber stand —that is, a treatment without adverse residual effects.

Because the older herbicidal materials have to be applied in three or more successive annual sprays to eliminate honeysuckle, the two newer materials, dicamba and picloram, appear most promising. This is true despite the demonstrated residual effects of picloram and the likelihood that both dicamba and picloram may damage established trees if sprayed on honeysuckle growing under them. Therefore, spraying with either of these chemicals should be done in forest stands only as a conditioning treatment at the time the stands are harvested.

Dicamba was not as effective as picloram in our trials, and re-treatment often would be required. If the re-treatment were delayed until the second spring when herbaceous plants were small and not effective in screening honeysuckle regrowth, the period before tree reproduction could be established would be longer than for picloram. Furthermore, dicamba at the 4-pound rate and with a re-treatment would be more expensive at present prices than a single application of the Tordon 101 Mixture.

Therefore, Tordon 101 is suggested as the best material to use where its residual effects can be accepted. Although Tordon 22K was also effective, the 101 mixture is much cheaper for what seem to be reasonable rates of application. On the basis of our tests the Tordon 101 Mixture should be used at the rate of 3 gallons per acre. Although we applied it only as high-volume sprays, mistblower application of this amount in 3 gallons of water would seem to be a possible alternative where such a treatment could be safely used. Even so, it will be expensive, costing about $33 per acre for material alone.

For releasing desirable reproduction from honeysuckle, two of the older materials warrant further trials. If the reproduction were hardwoods, 2,4-D applied in the fall (October to early December) might provide temporary release with little damage to the trees. If the reproduction were conifers, Bruner and Shearin's suggested use of amitrole might be tried. Because neither of the above treatments has been tested locally for these specific purposes, they should be regarded only as suggestions for trial in our area.

Literature Cited

1. Anonymous.
1958. Getting rid of honeysuckle. Agr. Res. 7 (3): 14, illus.

2. Bond, A. R.
1956. Maryland's fifth column. Amer. Forests 62 (10): 46-47, 88-90, illus.

3. Brender, E. V.
1960. Progress report on control of honeysuckle and kudzu. S. Weed Contr. Conf. Proc. 13: 187-193.

4. Brender, E. V.
1961. Control of honeysuckle and kudzu. U. S. Forest Serv. SE. Forest Exp. Sta., Sta. Paper 120. 9 pp., illus.

5. Brender, E. V., and C. S. Hodges.
1957. Honeysuckle or trees? U. S. Forest Serv. SE. Forest Exp. Sta., Res. Note 103. 2 pp.

6. Brender, E. V., and Elbert L. Moyer.
1965. Further progress in the control of kudzu. Down to Earth 20 (4): 16-17, illus.

7. Bruner, Marlin H., and A. T. Shearin.
1964. Planting loblolly pine on sites infested with honeysuckle. S. C. Agr. Exp. Sta. Forest Res. Ser. 12: 8 pp.

8. Little, S.
1959. A progress report on tests of controlling Japanese honeysuckle. NE. Weed Contr. Conf. Proc. 13: 360-366.

9. Little, S.
1961. Recent results of tests in controlling Japanese honeysuckle. Hormolog 3 (1): 8-10, illus.

10. Walker, Laurence C.
1956. Controlling undesirable hardwoods. Ga. Forest Res. Counc. Rep. 3. 24 pp., illus.

SILAS LITTLE
Principal Silviculturist

HORACE A. SOMES
Research Technician

Northeastern Forest Experiment Station
Forest Service, U. S. Dep. Agriculture
Upper Darby, Pa.

U. S. FOREST SERVICE RESEARCH NOTE NE-63

1967

Northeastern Forest

ST SERVICE. U. S. DEPT. OF AGRICULTURE. 6816 MARKET STREET. UPPER DARBY. PA

Experiment Station

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SEEDING BLACK CHERRY IN REGENERATION CUTTINGS

Abstract. Small seedbeds were established on three newly cutover areas on the Allegheny National Forest. Site preparation, protection from animals, and season of sowing were studied. It was not necessary to prepare the site or to provide protection to obtain good germination. Seedlings exposed to deer browsing were severely limited in height growth. Best height growth on the protected seedbeds was obtained on seedbeds that were burned with added fuel.

Much of the forest area on the Allegheny Plateau of New York and Pennsylvania contains black cherry *(Prunus serotina* Ehrh.), and this area is well-suited for growing the species. Many landowners would like to regenerate black cherry in their cutover stands because of its high commercial value. Although these cut areas will regenerate naturally for the most part, black cherry may be but a minor component of the new stands. Effective methods for increasing the stocking to cherry are desired. Direct seeding is one possible way to do this.

Our study was undertaken to compare the efficacy of different methods of seedbed preparation for direct seeding on recently cutover sites, and to determine the effects of birds, rodents, and deer on seeding success. The study was somewhat similar to an earlier one conducted on an open-field site.[1]

[1]Huntzinger, Harold J. GERMINATION, SURVIVAL, AND FIRST-YEAR GROWTH OF BLACK CHERRY UNDER VARIOUS SEEDBED AND SUPPLEMENTAL TREATMENTS. U.S. Forest Serv. Res. Note NE-26, 6 pp. NE. Forest Exp. Sta., Upper Darby, Pa. 1964.

The Study

The study was established on the Allegheny National Forest in northwestern Pennsylvania in the fall of 1962. Three newly clearcut patches representative of regeneration cuttings on the Forest were selected. These patch cuttings had just been made in conjunction with stand-improvement cuttings over much larger areas. This combination of patch cutting and stand improvement, which is a regular timber-management practice on the Forest, has been adopted partly because it tends to disperse deer browsing.

The three patches in the study were all on upland areas of well-drained, medium-textured, residual soils. The locations are known locally as Mill Creek, Hook Run, and Seldom Seen Corners. The sizes of the patches were respectively 5 acres, 19 acres, and 7 acres.

The patches had all contained scattered black cherry trees before the cutting. Numerous cherry seedlings had started around the larger cherry stumps, and occasionally seedlings were found elsewhere. These seedlings had started either before or soon after the cutting, but practically all of them were being severely browsed by deer.

The seedbed preparation treatments were applied to individual small plots just before seed ings were done both in the fall and in the spring. These treatments were:

- No treatment.
- Burned: litter supplemented by twigs and small branches to assure effective burns.
- Spaded: litter and humus turned under.
- Scarified: surface layers mixed.
- Treated with herbicide: 0.075 pounds of Dalapon per gallon applied at the rate of 100 gallons per acre 1 week before seeding.
- Blank: no preparation and no seed sown (included to provide an estimate of natural regeneration).

Seedbeds were protected from animals as follows:

- No protection.
- Protected from deer only.
- Protected from deer and rodents.
- Protected from deer, rodents, and birds.

The individual seedbeds or plots were 3 feet square. At each location eight lines of six plots each were laid out, providing four lines for fall seeding and four lines for spring seeding. The few remaining trees in and near the seedbed areas were felled, and all slash was removed to facilitate access to the areas and to lessen variation in ground conditions. All plots were placed out in the open at a distance from the edge of the clearing at least equal to the height of the bordering trees.

Six of the eight lines of plots were enclosed as a group with deer-proof fence; two lines (one for each season of sowing) were left outside the fence and were exposed both to deer and to other wildlife. Inside the fence, two lines of plots were left accessible to rodents and birds; two lines were surrounded by sheet metal barriers 30 inches high to exclude rodents; and two lines were enclosed—tops and sides—with ¼-inch mesh hardware cloth to exclude both rodents and birds. Sheet metal was used for the open-topped enclosures to discourage small rodents from climbing over. The tops subsequently were removed from the hardware cloth exposures to permit free growth of the seedlings.

Within the limits imposed by the deer fence arrangement, the protection treatments and the season of sowing were assigned to the lines of plots at random, and within lines of plots seedbed treatments were assigned at random. Thus the experiment was a split plot design with one replicate at each of three places.

Seed for the study was collected in September 1962. It was cleaned, dried of surface moisture, and stored temporarily in plastic bags. The fall sowing was done in mid-October. Seed for the spring sowing was stratified in peat out-of-doors on November 8, removed and placed in a plastic bag in a refrigerator on April 1, and sown April 15 to 23, 1963.

Fifty seeds were sown in each plot (except the blanks). The seeds were placed in five rows 6 inches apart at 3-inch spacing within rows. The individual seeds were pressed firmly into the soil or litter, but were not buried.

Observations of germination and survival were made weekly in May and June, once in July, and once in September 1963. Additional observations were made each spring and fall in 1964 and 1965. During each of the fall examinations, the height of the tallest seedlings in each bed was measured to the nearest 0.1 inch.

Analysis of variance was used to analyze differences in germination, survival, and height. Germination and survival percentages were transformed to the arcsin.

Results

The blank plots (no seed sown) demonstrated that volunteer black cherry seedlings were not numerous enough on the experimental areas to have any appreciable effect on the results on the seeded plots. Only nine seedlings appeared on the 24 blank plots; consequently, these plots will not be considered further. Because of the regular spacing of the seed on the sown plots, the occasional volunteer seedlings usually could be recognized easily and were omitted from tallies and measurements.

Also, except for an interaction with spring-applied herbicide, discussed later, the season of sowing had no significant effect on germination, survival, or growth. Therefore, except for a breakdown by seasons in the first-year results in table 1, data for the two seasons are combined in the following discussion.

Germination.—Of the 6,000 seeds sown, 57.2 percent germinated the first year, and an additional 12.4 percent germinated the second year. There were no significant differences in germination due to the degree of protection, but there were highly significant (1-percent level) differences due to the method of seedbed preparation. Germination was poorest on the beds treated with herbicide, and second poorest on the burned beds. The control treatment (no preparation) yielded as high a rate of germination as the best of the other treatments (table 1).

Both the herbicide-treated plots and the burned plots were relatively bare during the spring germination period and consequently would have dried rapidly at the surface during intervals of fair weather. This drying probably accounted for the failure of some seeds to germinate.

In addition, the low figure of 33.7 percent germination for the spring sowing on herbicide-treated plots probably reflects injury by residual herbicide. The herbicide, having been applied in both seasons about a

Table 1.—*Germination of black cherry seed and height growth of black cherry seedlings, the first year, by treatment groups*

Treatment	Fall sowing			Spring sowing		
	Germination	Height		Germination	Height	
	All plots	All plots	Protected plots	All plots	All plots	Protected plots
	Percent	*Inches*	*Inches*	*Percent*	*Inches*	*Inches*
Seedbed preparation:						
None	65.3	8.4	10.7	61.2	9.6	12.2
Burned	56.0	13.9	16.4	50.7	13.8	16.7
Spaded	63.8	9.2	10.6	61.5	11.0	13.2
Scarified	62.8	8.4	9.9	62.8	9.7	12.1
Herbicided	54.3	8.7	10.2	33.7	13.4	13.4
Protection:						
Unprotected	52.4	4.0	—	44.0	3.4	—
Protected from deer	59.9	16.1	—	52.8	15.2	—
Protected from deer and rodents	68.9	10.9	—	56.8	12.8	—
Protected from deer, rodents, and birds	60.7	7.7	—	62.3	12.6	—

week before the seeds were sown, would have undergone much less breakdown in the spring-sown plots at the time of germination. Moreover, 29 percent of the spring-sown seed had already sprouted when sown, and the seeds were even more vulnerable to any residual herbicide that they encountered.

Seedling establishment.—At the end of the first growing season (November 1963), the seedlings found and classified as alive represented 34.4 percent of the seed sown. This figure indicated a mortality of 39.8 percent of total germinaton. Differences in first-year survival due to levels of protection were significant at the 5-percent level; the significance is accounted for by the comparatively poor survival in the beds that were not protected against deer (table 2). Differences due to seedbed-preparation methods were significant at the 1-percent level; the significance here is accounted for mainly by the fewer survivors on the herbicide-treated beds. Lower germination was mainly responsible for these lower survival figures.

More living seedlings were present after the second and third growing seasons than were tallied after the first growing season. Some of this increase came from clipped seedlings that had been overlooked or classified as dead the first year but resprouted the second season, and some of the increase came from delayed germination. The number of seedlings living at the end of two growing seasons was 43.9 percent of the number of seeds sown (table 2). This figure had dropped to 36.8 percent by the end of the third growing season.

Table 2.—*Total seed germination, mortality, and seedling establishment, by protection levels*
(In percent of seed sown)

Item	Unprotected	Protected from—		
		Deer	Deer and rodents	Deer, rodents, and birds
First-year germination	48.2	56.3	62.9	61.5
Rodent mortality[1]	11.5	6.8	2.1	2.1
Mortality, miscellaneous, and unknown	16.0	13.7	20.0	19.0
First-year survival	20.7	35.8	40.8	40.4
Second-year germination	5.5	14.3	16.0	13.7
Second-year survival[2]	24.3	47.3	59.7	44.5

[1]Includes seeds consumed by rodents and seedlings clipped by rodents and cutworms.
[2]Includes some seedlings that were clipped or appeared dead at the end of the first season but resprouted the second season.

Height growth.—Differences in height growth among levels of protection were highly significant. Based on the tallest seedling in each seedbed, the mean first-year height of seedlings on protected plots was 12.6 inches, and the mean first-year height of seedlings on plots with no protection was 3.7 inches. In the second year, mean height of seedlings under protection increased to 25 inches, whereas those with no protection added less than 2 inches to their mean height, and considerable mortality was occurring (table 3).

Differences in mean heights of the tallest seedling per plot among seedbed-preparation methods were highly significant only for the protected seedbeds. This was true in all years from the first through the fourth growing seasons. The significance lay in the difference between the burned seedbeds and all other seedbeds collectively: In the first year (table 1), mean heights on the burned seedbeds were 16.4 inches and 16.7 inches for fall and spring sowings compared to a range of 9.9 inches to 13.4 inches on the other seedebeds; in the second year (table 3), the mean height on the burned seedbeds was 31.7 inches compared to a range of 21.3 to 25.0 inches on the other seedbeds. The superior growth on the burned beds presumably was due to nutrient elements released in the

Table 3.—*Two-year height growth by seedbed-preparation and locality for protected beds combined and for unprotected beds*

Treatment	Locality			
	Hook Run	Mill Creek	Seldom Seen Corners	All
	Inches	*Inches*	*Inches*	*Inches*
Protected:				
None	24.1	36.2	5.3	21.8
Burned	35.6	43.3	16.2	31.7
Spaded	25.8	36.4	12.2	24.1
Scarified	20.9	31.1	12.0	21.3
Herbicided	29.4	37.4	8.1	25.0
Average	27.2	36.9	10.8	25.0
Unprotected:				
None	4.0	5.5[1]	6.8	5.4
Burned	5.8	2.0	6.8	4.9
Spaded	7.8	3.2	7.8	6.3
Scarified	6.0[1]	2.0	7.5	5.0
Herbicided	4.0	[2]	9.0[1]	5.7
Average	5.4	2.8	7.4	5.4

[1]Only one bed had seedlings present.
[2]None living in fall or spring beds.

ashes; and this suggests that black cherry seedlings would respond to applications of artificial fertilizer.

Also, differences in height growth among the three plot locations were significant for the protected seedbeds. The significance of the differences held up through three growing seasons, but not through the fourth. As shown in table 3, growth was much poorer on the Seldom Seen Corners site than on the other two sites. A much denser ground cover of briars *(Rubus* spp.), climbing buckwheat *(Polygonum cilinode),* and grass on the Seldom Seen Corners site probably accounted for the slower growth.

Although measurements have been taken through four growing seasons, most of the effects of the experimental variables had been expressed after 2 years, and, consequently, no detailed later data are presented. In the beds protected from deer, growth has continued at a reasonably good rate. For the best seedbed-preparation method—burning—the average 4-year height, based on the tallest seedling in each plot, was 46.5 inches, and the best individual seedling measured 84 inches. However, one seedling in a bed that had received no preparation reached a height of 89 inches.

Discussion and Conclusions

A significant finding in this study was that germination was fully as good with no seedbed treatment as with any of the other seedbed treatments. Scarification and exposure of mineral soil, which consistently favor germination and initial establishment of conifers and such light-seeded hardwoods as the birches, apparently are of no benefit to black cherry.

Further, except for somewhat superior growth on the burned plots, none of the seedbed treatments resulted in better growth than on the controls. This is readily explainable because none of the treatments had any marked effect upon the development of the herbaceous and low woody vegetation that normally appears in forest openings. Even the herbicide treatment with Dowpon checked the grasses only temporarily (until about mid-June) and had no noticeable effect on ferns, briars, annual weeds, and pin cherry reproduction. The superior growth of the black cherry seedlings on the burned plots should perhaps be viewed with reservations because of the extra fuel that was carried onto these plots to assure a good burn. Burning on an area-wide basis probably would have less effect on subsequent seedling growth.

Consumption of seed by birds does not appear to be a problem with black cherry. Rodents take some seed, but, at least on these experimental plots, their seed depredations were not very serious. In certain instances they took as high as 38 percent of the seed on a plot, but in general the seed losses to rodents were in the range of 5 to 15 percent.

Rodent damage is not restricted to seed consumption; considerable clipping of seedlings occurred on our plots in May of the first year and caused some mortality and a severe setback to other seedlings that then resprouted from the base. Some clipping appeared to have been done by cutworms, also. We have no measure of how much of the clipping damage is chargeable to each pest. However, although the damage attributable to rodents (and cutworms) may be considerable, it does not appear to be the determinant of success in regenerating black cherry from seed.

Deer are the really serious problem in regenerating black cherry on the Allegheny Plateau. On the unprotected experimental plots, few, if any, of the cherry seedlings appeared to stand much chance of ever getting tall enough to escape deer browsing. Because all slash had been removed, these seedlings were more exposed than is typical of regeneration cuttings. However, seedlings growing among normal accumulations of slash elsewhere on the cutover patches were not faring much better. At best, no more than an occasional seedling on these patches seemed very likely to grow above reach of the deer.

Although protected seedlings at the Seldom Seen Corners location made the poorest growth of any seedlings in the study, the unprotected seedlings grew somewhat better there than at the other locations. The denser ground cover, which apparently depressed the growth of the protected seedlings, tended to hide the unprotected seedlings and also provided more other browse. However, it is still doubtful that these unprotected seedlings will survive and make satisfactory height growth.

The results of this study support the conclusion that recently clearcut patches on the Allegheny Plateau like those used for our study can be regenerated to black cherry by seeding if present intensities of deer damage were substantially reduced. No specific seedbed-preparation treatments should be necessary to obtain adequate germination and initial seedling establishment. However, in some places, follow-up weeding treatments might be required to get the seedlings through the competition resulting from faster growing hardwood stems such as pin cherry seedlings and from sprouts at the stumps of the harvested hardwood trees.

—HAROLD J. HUNTZINGER
Research Forester
Northeastern Forest Experiment Station
Forest Service, U. S. Dep. Agriculture
Warren, Pennsylvania

U. S. FOREST SERVICE RESEARCH NOTE NE-64
1967

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

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SOIL MOISTURE-SOIL TEMPERATURE INTERRELATIONSHIPS ON A SANDY-LOAM SOIL EXPOSED TO FULL SUNLIGHT

Abstract. In a study of birch regeneration in New Hampshire, soil moisture and temperature were found to be intimately related. Not only does low moisture lead to high temperature, but high temperature undoubtedly accelerates soil drying, setting up a vicious cycle of heating and drying that may prevent seed germination or kill seedlings.

In studies of regeneration, lack of germination or seedling mortality often is attributed either to critically low soil moisture or to extremely high soil temperatures. However, these factors do not operate independently; extremes of one factor seldom occur without corresponding, although opposite, extremes in the other. Evidence of this relationship was found during a birch regeneration experiment on the Bartlett Experimental Forest in New Hampshire.[1] Certain data from that experiment are presented here as an aid to the further understanding of some of the environmental factors affecting the regeneration process.

[1]Marquis, David A. GERMINATION AND GROWTH OF PAPER AND YELLOW BIRCH IN SIMULATED STRIP CUTTINGS. U. S. Forest Serv. Res. Paper NE-54, 19 pp. NE. Forest Exp. Sta., Upper Darby, Pa., 1966.

Study Methods

The regeneration experiment from which these data were taken involved evaluation of seedling responses under artificial screens that had been set up to simulate various types of clearcut openings. Only data from the full sunlight treatment, which was replicated four times, are used here. At each replication, four 6-inch clay flower pots set flush with the ground constituted a plot. Two of each set of four pots were allowed to vary naturally in soil moisture while the other two were maintained near field capacity. The latter condition was achieved by nesting the clay pot in a slightly larger plastic flower pot in which several inches of water were maintained as a reservoir.

The soil for the study was from the B_2 horizon of a Hermon sandy loam. In preparation for use, the soil was dried, thoroughly mixed, passed through a 1/4-inch mesh sieve to remove stones, supplemented with lime and fertilizer, and then placed in the pots and compacted slightly to a bulk density of about 1.0. Field capacity of the soil when thus prepared was 48 percent by volume as determined on a tension table at 60 cm. tension. The wilting point was 9 percent by volume as determined in a pressure membrane at 15 atmospheres pressure.

Cooper-constantan thermocouples placed at the soil surface and 1-inch below the surface were used for soil-temperature measurements. Coleman Fiberglas soil-moisture units were placed on edge in the top inch of soil for moisture measurements. The Coleman units were calibrated against gravimetric determinations in the laboratory. Moisture and temperature measurements were taken three times a week at 12 noon EST, May through September. Germination tests also were run in these same pots, so the moisture and temperature data were not bare-soil readings toward the end of the growing season. However, the effect of the seedlings was slight because they were limited to a maximum of nine per pot and their average height was less than 1/2 inch at the end of the growing season.

A complete series of measurements was taken during each of three growing seasons: 1962, 1963, and 1964. Differences in average moisture and temperature were tested for significance with the analysis of variance under a split-plot design. A probability level of 0.05 was accepted for significance. Further details on study methods are presented in the report on the regeneration phase of the study.[1]

Results and Discussion

Maintenance of soil moisture near field capacity by supplemental watering caused a significant reduction in surface soil temperatures (table 1). Noon temperatures throughout the three growing seasons averaged 10°F.

Table 1.—*Average noon-time soil moisture and soil temperature in full sunlight*

Year	Soil moisture: Natural moisture regime	Soil moisture: Supplemental moisture regime	Soil temperature: Natural moisture regime	Soil temperature: Supplemental moisture regime
	Percent[1]	*Percent*[1]	*Degrees F.*	*Degrees F.*
1962	26	42	88	83
1963	20	44	93	82
1964	17	48	98	84
All 3 years	21	45	93	83

[1]Percent by volume.

cooler on the moist soils. During 1964, the driest of the three years, they averaged 14°F. cooler. These average figures do not show the extreme differences that frequently occurred, because the figures include cloudy as well as sunny days, and periods when recent rainfall equalized moisture on the two treatments. On many individual days, differences in excess of 40°F. were observed. These findings agree fairly well with Maguire's report of reductions in surface soil temperature of as much as 50°F. after rain or artificial watering.[2]

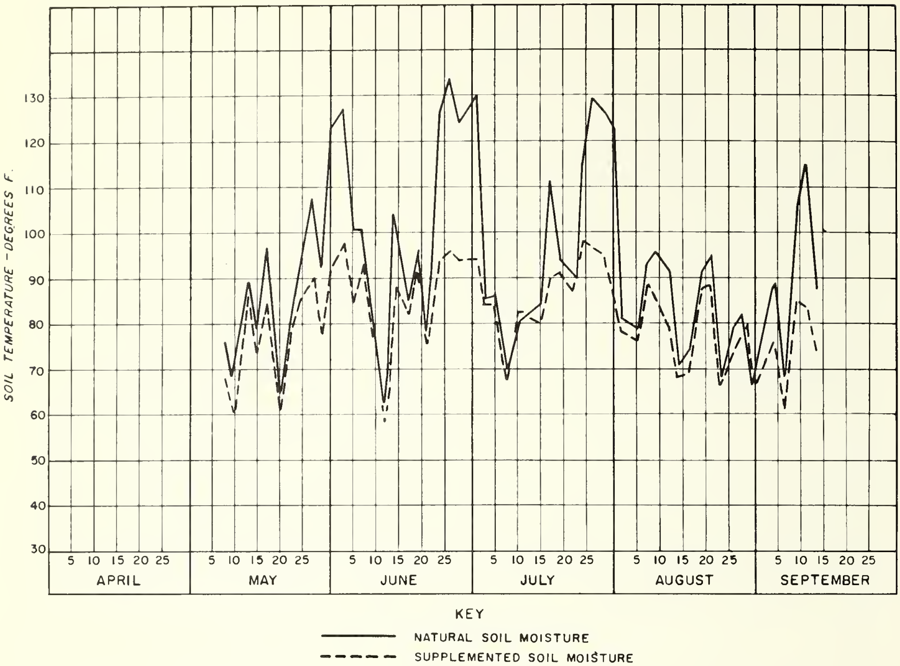
The effect of moisture on average temperature is also apparent in the data for the unwatered plots during each of the 3 years. Average moistures for the consecutive years were 26, 20, and 17 percent; and average surface soil temperatures for the same years were 88°, 93°, and 98°F., respectively. Thus average temperatures were higher in years of lower soil moisture.

Daily temperature readings over the course of the 1963 growing season (fig. 1) illustrate the differences between the two moisture regimes more effectively than seasonal averages. It is apparent that plots with higher moisture had lower surface temperatures. The primary effect of high moisture was to prevent extremely high temperatures. Plots that received supplemental watering did not exceed 100°F. at any time, while the drier plots with a natural moisture regime occasionally exceeded 140°F. (Maximum temperature of 142°F. occurred during early July 1964.)

A further illustration of the interrelationship between soil moisture and soil temperature is obtained by comparing the two factors on the same

[2]Maguire, William P. RADIATION, SURFACE TEMPERATURE, AND SEEDLING SURVIVAL. Forest Sci. 1: 277-285, 1955.

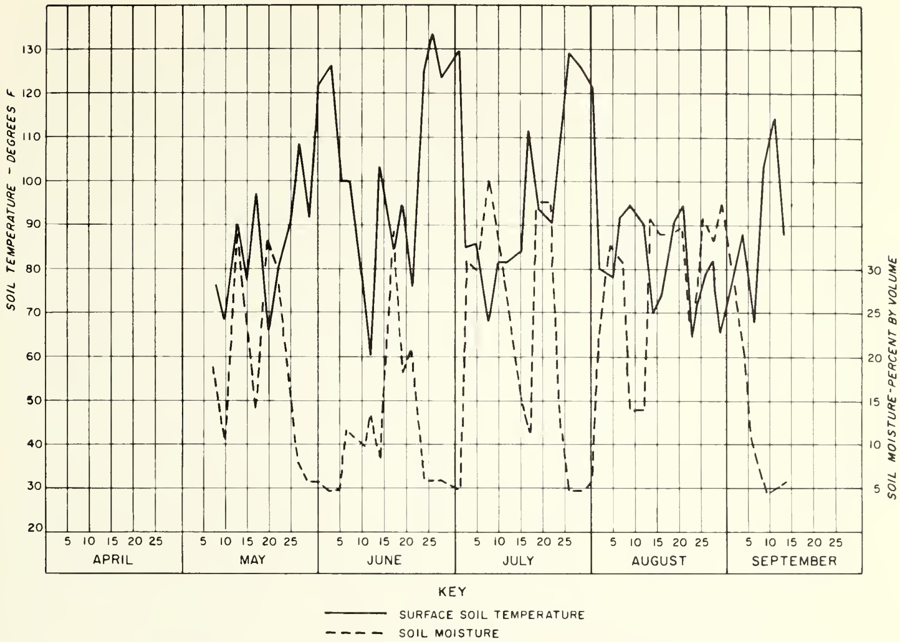
Figure 1.—Surface soil temperatures in 1963 on two moisture regimes.



plots (fig. 2). The two curves are essentially mirror-images of each other. When soil moisture was high, soil temperature remained moderate. But when soil moisture dropped to low levels, temperatures rose extremely high.

This effect of soil moisture in regulating soil temperature probably comes about in at least three ways: (1) On the wetter soil, a large proportion of the incoming energy is spent on evaporation and is not available to warm the soil. (2) Additional water in the wetter soil raises the specific heat of the mixture, requiring more energy to raise a given volume of soil 1 degree. (3) Additional water in the wetter soil increases its thermal conductivity. Therefore heat received at the surface is conducted downward more rapidly; the lower layers are warmed more quickly; and the surface remains cooler than on the dry soil where surface heat is dissipated more slowly. This latter effect is evidenced by a greater spread between surface temperatures and 1-inch temperatures on the dry plots. Average spread over the three seasons was 9°F. on the dry soil as opposed to only 4°F. on the wet soil.

Figure 2.—Soil moisture and soil temperature in 1963 on plots with natural moisture regime.



Although not apparent from the data presented here, the relationship between these two factors probably works both ways. Not only does low moisture lead to high temperature, but high temperature undoubtedly accelerates soil drying, setting up a vicious cycle of heating and drying that may cause seedling mortality or prevent seed germination. Under the conditions of this study, it is unlikely that such effects can be attributed solely to either factor because the two are so intimately related.

—DAVID A. MARQUIS
Silviculturist
Northeastern Forest Experiment Station
Forest Service, U. S. Department of Agriculture
Upper Darby, Pa.

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U. S. FOREST SERVICE RESEARCH NOTE NE-65

1967

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LUMBER GRADE-YIELDS FOR FACTORY-GRADE NORTHERN RED OAK SAWLOGS

Abstract. A report on results of sawing 556 northern red oak sawlogs at four sawmills in West Virginia and Virginia, and the distribution of grades for the standard factory lumber produced. Tabular data on actual yield and curved grade-yield percentages.

As part of a continuing research program, the Forest Service hardwood log and tree grade project is conducting studies to determine the lumber grade-yield of hardwood sawlogs and trees.

In 1964 the project conducted four studies to determine the lumber grade-yield for factory-grade[1] northern red oak (*Quercus rubra* L.) sawlogs. Approximately 60,000 board feet of standard factory lumber[2] was cut from the 556 study logs. The logs were sawed at three mills in West Virginia and one mill in Virginia. This report gives the results of the sawing studies: both the actual and the curved lumber-grade yield percentages for the study logs.

Field Procedure

The logs used in the study were graded by a forest products technologist according to Forest Service standard grades for hardwood factory-lumber logs.[3] The log grade, scaling diameter, length, scalable defect information, and gross and net log scales were recorded for each log in

[1]Vaughan, C. L., A. C. Wollin, K. A. McDonald, and E. H. Bulgrin. HARDWOOD LOG GRADES FOR STANDARD LUMBER. U.S. Forest Prod. Lab. Rep. 63, 53 pp., illus. 1966.

[2]RULES FOR THE MEASUREMENT AND INSPECTION OF HARDWOOD AND CYPRESS LUMBER. National Hardwood Lumber Assn., Chicago, Ill. 112 pp. 1965.

[3]Ostrander, M.D., and others. A GUIDE TO HARDWOOD LOG GRADING (revised). U.S. Forest Serv. NE. Forest Exp. Sta., 50 pp., illus. Upper Darby, Pa. 1965.

the study. The logs were then sawed, and a tally was made of the length, width, thickness, and grade of each board cut from each log.

After the lumber had air-dried to a moisture content of approximately 20 percent it was regraded and the air-dry grade of each board was tallied by log number to determine air-dry yields for each log.

All the lumber produced in the studies was graded by a National Hardwood Lumber Association certified grader.

Office Procedure

Dry-lumber data were transferred to IBM punch cards, and the data were summarized for each log in the study. The actual air-dry lumber yield percentages were computed by log grade and scaling diameter and are shown in tables 1 to 3. The thickness distribution of the lumber produced in the study is shown in table 4, by lumber grade.

When estimating the lumber grade yield for a group of graded sawlogs, it is better to use curved data because curving data tends to increase the precision of the estimate. For this reason we curved the yield data from tables 1 to 3, using a procedure reported by Jensen.[4] This method of

[4]Jensen, C. E. The least squares fit of an algebraically unspecified form. U.S. Forest Serv. Res. Note CS-2, 4 pp., illus. Cent. States Forest Exp. Sta. 1963.

Table 1.—*Actual yield, northern red oak grade 1 sawlogs*

Scaling diameter	Logs	Air-dry lumber grade-yields (actual)							Volume lumber tally
		FAS	FASIF	Sel	1C	2C	3A	3B	
Inches	*No.*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Bd. ft.*
13	12	22.6	15.0	6.7	18.2	19.2	17.1	1.2	1,091
14	17	25.2	13.0	4.4	27.8	16.3	11.1	2.2	2,040
15	18	25.5	14.9	2.6	25.0	21.2	8.7	2.1	2,551
16	22	28.5	14.1	2.8	24.2	17.1	11.7	1.6	3,308
17	22	36.7	13.5	4.0	22.4	15.6	6.1	1.7	4,401
18	14	40.1	16.0	3.6	17.8	13.5	6.9	2.1	2,888
19	16	43.3	14.3	2.7	19.5	13.5	5.5	1.2	3,892
20	8	41.0	14.0	1.4	25.7	9.7	7.2	1.0	1,918
21	4	39.9	16.8	2.2	20.2	13.9	7.0	—	1,072
22	5	55.8	11.2	3.6	12.0	9.3	7.4	.7	1,520
23	2	68.0	8.0	1.0	11.4	10.5	1.1	—	827
24	1	40.7	5.8	5.8	16.7	15.1	10.1	5.8	258
25	1	44.0	6.1	7.5	13.6	16.0	4.3	8.5	375
		Total tally, in board feet							
All diameters	142	9,710	3,612	858	5,537	3,918	2,081	425	26,141

Table 2.—*Actual yield, northern red oak grade 2 sawlogs*

Scaling diameter	Logs	Air-dry lumber grade-yields (actual)							Volume lumber tally
		FAS	FASIF	Sel	1C	2C	3A	3B	
Inches	*No.*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Bd. ft.*
10	8	2.8	8.0	6.2	34.5	20.4	25.0	3.1	388
11	23	8.4	5.1	5.2	22.0	30.7	22.2	6.4	1,453
12	32	8.2	7.5	4.3	24.8	32.1	18.7	4.4	2,495
13	28	5.2	5.6	2.8	31.1	30.6	17.2	7.5	2,406
14	28	9.5	10.5	3.8	27.7	26.2	18.6	3.7	2,801
15	32	14.2	8.4	2.5	29.8	24.7	14.4	6.0	3,937
16	16	7.4	12.2	2.1	29.7	25.9	16.4	6.3	2,205
17	14	20.1	9.5	3.1	33.6	19.6	11.2	2.9	1,986
18	17	12.4	12.3	3.1	28.0	24.6	14.9	4.7	2,889
19	3	14.2	10.9	2.2	43.5	20.3	6.1	2.8	359
20	4	29.0	8.8	1.7	28.9	13.7	8.3	9.6	648
21	1	14.7	5.9	14.7	26.4	14.0	11.8	12.5	136
22	1	69.4	11.4	—	3.9	9.4	5.9	—	307
23	—	—	—	—	—	—	—	—	—
24	2	28.3	17.1	4.7	29.0	17.9	3.0	—	755
		Total tally, in board feet							
All diameters	209	2,897	2,132	753	6,510	5,781	3,537	1,155	22,765

Table 3.—*Actual yield, northern red oak grade 3 sawlogs*

Scaling diameter	Logs	Air-dry lumber grade-yields (actual)							Volume lumber tally
		FAS	FASIF	Sel	1C	2C	3A	3B	
Inches	*No.*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Bd. ft.*
8	23	—	—	3.1	5.0	27.5	41.8	22.6	643
9	35	—	1.2	1.5	14.0	37.0	32.6	13.7	1,265
10	34	1.4	.3	1.4	7.4	35.9	37.0	16.6	1,473
11	30	.8	2.2	1.3	10.6	38.1	34.9	12.1	1,458
12	26	.4	.4	1.3	16.8	33.1	36.0	12.0	1,700
13	20	—	2.5	.3	23.2	33.0	30.0	11.0	1,435
14	20	.8	1.0	.7	17.6	36.6	24.8	18.5	1,738
15	9	—	6.0	1.2	33.6	31.4	22.5	5.3	853
16	6	3.0	5.9	1.9	37.9	32.4	12.0	6.9	725
17	2	—	—	2.0	29.5	33.6	23.5	11.4	149
		Total tally, in board feet							
All diameters	205	75	206	143	2,002	3,952	3,526	1,535	11,439

Table 4.—*Thickness distribution of lumber grade-yields, by log grade and lumber thickness*
(Percent within grade)

Lumber thickness (inches)	FAS	FASIF	Sel	1C	2C	3A	3B
			LOG GRADE 1				
5/8	—	—	—	0.1	0.2	0.2	—
3/4	—	—	—	.4	.8	1.9	—
4/4	54.5	72.1	94.9	90.5	98.4	96.9	100.0
5/4	11.7	8.8	3.7	4.3	.6	1.0	—
6/4	33.8	19.1	1.4	4.7	—	—	—
			LOG GRADE 2				
5/8	0.2	—	—	0.2	—	—	0.3
3/4	.3	—	—	—	0.5	1.0	3.5
4/4	64.3	77.3	97.5	96.6	98.7	98.1	93.7
5/4	4.6	3.2	2.5	1.4	.7	.9	2.5
6/4	30.6	19.5	—	1.8	.1	—	—
			LOG GRADE 3				
5/8	—	—	—	—	0.1	—	—
3/4	—	—	—	0.2	.4	1.5	1.2
4/4	88.0	90.3	100.0	99.6	98.5	97.6	95.9
5/4	—	5.8	—	.2	1.0	.9	2.9
6/4	12.0	3.9	—	—	—	—	—

curving data has been used previously in tree grade lumber-yield development,[5] and has been found to be applicable to averaging yield values in log- and tree-grade work. Tables 5 to 7 present the curved lumber grade-yield percentages by log grade.

[5]Schroeder, J. G. A TREE GRADING AND VALUATION SYSTEM FOR YELLOW-POPLAR. Forest Prod. J. 14: 521-524, illus. 1964.

Table 5.—*Curved yield, northern red oak grade 1 sawlogs*

Scaling diameter	Logs	Air-dry lumber grade-yields (curved)							Volume lumber tally
		FAS	FASIF	Sel	1C	2C	3A	3B	
Inches	*No.*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Bd. ft.*
13	12	24	14	5	22	19	15	1	1,091
14	17	24	14	4	25	19	12	2	2,040
15	18	27	14	4	25	18	10	2	2,551
16	22	30	15	4	23	17	9	2	3,308
17	22	34	15	3	22	16	8	2	4,401
18	14	39	14	3	21	14	7	2	2,888
19	16	42	14	3	19	13	7	2	3,892
20	8	45	13	3	19	13	6	1	1,918
21	4	48	13	3	18	11	6	1	1,072
22	5	50	12	3	17	11	6	1	1,520
23	2	53	11	3	16	10	6	1	827
24	1	55	11	2	16	9	6	1	258
25	1	57	10	2	15	9	6	1	375
		Total tally, in board feet							
All diameters	142	9,710	3,612	858	5,537	3,918	2,081	425	26,141

Table 6.—*Curved yield, northern red oak grade 2 sawlogs*

Scaling diameter	Logs	Air-dry lumber grade-yields (curved)							Volume lumber tally
		FAS	FASIF	Sel	1C	2C	3A	3B	
Inches	*No.*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Bd. ft.*
10	8	8	7	5	24	24	25	7	388
11	23	6	7	4	25	30	22	6	1,453
12	32	6	7	4	27	31	20	5	2,495
13	28	7	8	4	28	30	18	5	2,406
14	28	9	9	3	29	28	17	5	2,801
15	32	11	9	3	30	27	15	5	3,937
16	16	13	10	3	30	25	14	5	2,205
17	14	16	10	3	30	23	13	5	1,986
18	17	18	11	3	30	21	12	5	2,889
19	3	20	12	3	30	19	11	5	359
20	4	23	12	3	30	17	10	5	648
21	1	25	13	3	30	16	9	4	136
22	1	27	13	3	29	15	9	4	307
23	—	29	14	3	29	13	8	4	—
24	2	31	14	2	29	13	7	4	755
		Total tally, in board feet							
All diameters	209	2,897	2,132	753	6,510	5,781	3,537	1,155	22,765

Table 7.—*Curved yield, northern red oak grade 3 sawlogs*

Scaling diameter	Logs	Air-dry lumber grade-yields (curved)							Volume lumber tally
		FAS	FASIF	Sel	1C	2C	3A	3B	
Inches	*No.*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Bd. ft.*
8	23	1	—	2	7	31	40	19	643
9	35	1	—	1	8	34	39	17	1,265
10	34	1	1	1	10	36	36	15	1,473
11	30	1	2	1	13	36	33	14	1,458
12	26	1	2	1	16	36	31	13	1,700
13	20	1	2	1	20	35	29	12	1,435
14	20	1	3	1	23	34	26	12	1,738
15	9	1	3	1	28	33	23	11	853
16	6	1	3	1	33	31	21	10	725
17	2	1	3	1	39	29	18	9	149
		Total tally, in board feet							
All diameters	205	75	206	143	2,002	3,952	3,526	1,535	11,439

Discussion

A comparison of the lumber grade-yield percentages reported here with previously reported[1] percentages for the combined upland red oak group shows the following:

- For any log grade a higher percentage of No. 1 Common and Better lumber was produced from northern red oak sawlogs than from the combined upland red oak group.

- For any log grade a lower percentage of No. 3B Common lumber was produced from northern red oak sawlogs than from the combined upland red oak group.

The above comparisons indicate that we may have been conservative in our value estimates of northern red oak sawlogs when we based our value estimates on the combined upland red oak tables. Use of these new tables in our future appraisals should result in a closer estimate of the value of northern red oak sawlogs than has been possible in the past.

—JAMES G. SCHROEDER and LELAND F. HANKS[6]

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[6]At the time of this study, the authors were forest products technologists on the staff of the Central States Forest Experiment Station, which since has merged with the Northeastern Forest Experiment Station. At present Mr. Schroeder is on the staff of the Southeastern Forest Experiment Station, in Athens, Georgia, and Mr. Hanks is at the Northeastern Forest Experiment Station's research unit in Columbus, Ohio.

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THE MARCRAFT FLOOR-LEVELING SYSTEM FOR URBAN REHABILITATION

Abstract. A speedy and efficient system has been developed for installing wooden screeds that can be used as a base for laying a level new floor over an old sagging floor. The screeds are held in position by means of a new leveling device, and rigid urethane foam is sprayed under the screeds to hold them permanently in a level position.

A Big Opportunity

Urban rehabilitation—now being vigorously promoted by Federal, state, and local governments—has created a vast potential market for new construction materials and a need for faster and cheaper installation methods. The Federal Housing Administration has estimated that in our cities some 9½ to 10 million dwelling units need rehabilitation.

For an example, take New York City. Here there are some 43,000 buildings, mostly 5 and 6 story walk-ups that were erected before the City's 1903 building codes went into effect; and most of them need rehabilitation today. Though these buildings are generally in deplorable condition, the basic structures are sound; they have solid 16-inch brick external walls and 4-by-12-inch floor joists.

One unique feature is that these buildings are almost all identical: 25 feet wide and 85 feet long, with floor joists spanning the full width. They contain some 480,000 apartments, the so-called "railroad flats", consisting of a series of rooms connected by doorless openings.

The FHA has estimated that urban rehabilitation in New York City alone would require 580 million square feet of new floors and an equal amount of new ceilings, 116 million square feet of new roofs, 6.3 million square feet of new windows, 4 million square feet of new doors, and 2.3 billion square feet of new walls.

The wood-products industry is eyeing this potential new market. Already on the market, or being developed, are such new products as panelized strip flooring, self-adjusting wall panels, adjustable wooden windows, and prefabricated wooden kitchen-bathroom units. The key to use of many of these new products is a level floor.

The Problem of Floors

The big problem is that, though the buildings are structurally sound, the floors in most of them have sagged during the past 65 years. In some buildings the sag is as much as 8 inches. In most the sag ranges between 2 and 4 inches.

Complicating the problem is that the sag is in two directions. The floors sag toward the central stairwells, which have settled considerably, pulling the floor joists down with them. And they sag in the middle, because the full-width floor joists have settled under the weight of load-bearing walls.

The key to rapid rehabilitation of these apartment interiors is a level floor. This establishes a level reference surface that lends itself to extensive use of prefabricated components requiring a minimum of on-site fitting. The use of these prefabricated units such as walls, prehung doors, closets, wall paneling, cabinets, kitchens, and bathrooms reduces the time required for installation and lowers on-site costs.

Without first establishing a level floor, most of the advantages of prefabricated components are lost because each piece must be fitted, shimmed, or adjusted to correspond with the irregular floor surface. Thus time and costs go up, and the results are about the same as if the old conventional remodeling methods were used.

A Solution

In an attempt to provide a remedy for sagging floors, scientists at the U. S. Forest Service's Forest Products Marketing Laboratory at Princeton, W. Va., with the technical assistance of the Union Carbide Chemicals Company of South Charleston, W. Va., and the Gusmer Coatings Company, Inc., of Woodbridge, N. J., have developed the Marcraft floor-leveling system.

In this new system, a leveling device is used to hold 2-by-2-inch wooden screeds in a level position over the old floors; and a cushion of urethane foam is sprayed under and around the screeds to bond them to the old floor and make a level foundation for a new floor.

Tried in a railroad flat in New York City, the Marcraft system has proved to be a fast, economical, and structurally sound way of rehabilitating sagging old floors. With this system two men can establish a level floor-bearing base in a 12-by-12-foot room in less than 14 minutes, at a cost for labor, materials, and equipment of less than 7 cents per square foot—about $9.65 for a 12-by-12-foot room.

The leveling device.—Several devices for leveling the wooden screeds were designed and developed by scientists at the Forest Products Marketing Laboratory.

The ones used in the study consisted of two 7-foot long by 1¾-inch square aluminum tubes. These tubes are attached with two machine-fitted bands so that the tubes may be adjusted in length from 7 feet to 13 feet by sliding one tube along the other.

The ends of each tube are fitted with a ⅝-inch diameter screw that is threaded through the tube. The screws have a crank at the top and a 3-inch swivel at the base. The length of the screws allows the leveling devices to be adjusted from 0 to 10 inches in height.

Each tube has 3/16-inch holes drilled at 6-inch intervals along its entire length to provide for attaching it to the wooden screeds with duplex nails.

Several other variations in bar design have shown promise. One is the use of spring clamps instead of duplex nails to hold the screeds to the leveling devices, thereby decreasing screed-attachment time. Another is the use of pinch clamps and smooth rods instead of screws for adjusting height of the bars. This would reduce the time required to bring the screed-bar system up to a level position.

The leveling bars serve two functions: they establish a level or straight edge for the tops of the screeds, and they temporarily support the level screeds at specified spacings while the foam is being sprayed beneath them (fig. 1). Using the height adjustments at each end of the bars, the tops of all the screeds in a room can be brought to a level plane at one time. This reduces time and labor costs considerably.

Installation procedure.—Installing the floor screeds is simple. Before the installation crew arrives, someone marks where the top of the new floor is wanted by use of a string chalk line or some similar means. The height of the new floor depends upon how many rooms are to be leveled to the same plane. If each room is to be leved independently, this step is not necessary since the bars can be leveled by using a carpenter's level.

Because the room dimensions are generally known, the wooden screeds can be cut to room length in advance.

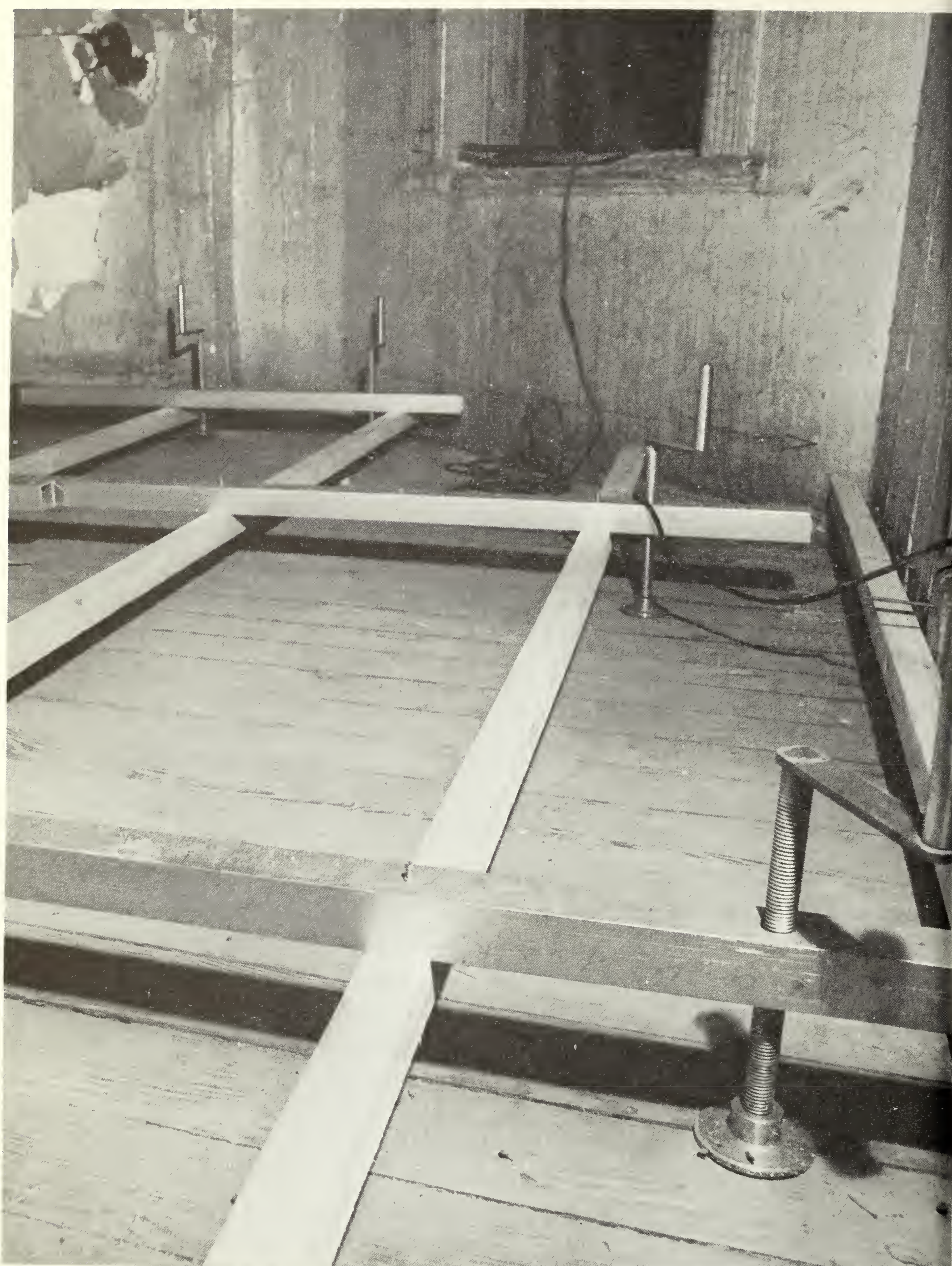

Figure 1.—The 2-by-2-inch wooden screeds held in level position over the old sagging floor by means of the new floor-leveling device. Note the screw jacks on the leveling bars for making fast height adjustments.

Figure 2.—Spraying the urethane foam to fill the sag-space beneath the new floor support. The foam expands 36 times to form a rigid and permanent bond and base for the floor screeds.

Figure 3.—Ready for a new floor. The new floor supports in this room have more than 10 times the normal design strength for residential construction.

Procedures for installation are as follows: First the precut screeds are placed at the approximate desired spacing over the existing floor. Then the leveling devices are placed over the screeds approximately 1 foot from the wall and perpendicular to the screeds. The screeds are nailed to the bar at predetermined spacings, using No. 10d duplex nails. Then the tops of the screeds are brought up to the level reference line on the walls by raising the leveling bars with the screw height adjusters.

The frothed rigid urethane foam is then sprayed between the floor and the bottoms of the screeds (fig. 2). After 5 minutes the duplex nails are pulled, and the leveling bars are moved to the next room to be leveled; and the procedure is repeated (fig. 3).

The most efficient size of crew for this job would be three men. Two men would level the screeds before foaming and would remove the leveling bars after foaming, and the third man would operate the foaming equipment and do the foaming. With three men the work load is balanced and no idle or waiting time would be involved.

The urethane foam.—The chemicals and formulation used to produce the rigid urethane foam were supplied by Union Carbide Chemicals Company.[1] They consisted of a basic resin and an activator. The development of the foam is caused by the production of gases within the liquid mixture of the two chemicals during a polymerization process.

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

The warmed chemicals expand immediately to six times their original volume upon leaving the gun in a frothed condition—like aerosol shaving cream—and then expand six more times as the chemical action takes place to form the rigid foam, a total expansion of 36 times their initial volume in the storage containers. The speed of expansion and curing of the foam is controlled by the amount of activator in the formulation and the temperature of the chemicals.

As the foam expands, it becomes very tacky and adheres to any clean surface it touches. Consequently the foam not only supports the wooden screeds, but if the floor is clean, it also bonds the screeds to the floor.

The foam used with this system weighs only 2 pounds per cubic foot, so it adds little load to the floor. It has good heat resistance, withstanding temperatures of 250°F., is self-extinguishing when ignited, and is highly resistant to fungus growth.

Although the rigid urethane foam appears fragile, the foam-supported wooden screeds placed on 2-foot centers provide 10 times the normal design strength for residential floor construction.

The foaming equipment.—The application equipment used in perfecting the system was designed and patented by Gusmer Coatings Company, Inc., of Woodbridge, N. J., and is sold under the name of GUSCO Process Equipment. In general, the GUSCO system consists of: (1) chemical storage containers for each chemical; (2) transfer pumps and proportioning pumps to supply the correct amounts of each chemical; (3) chemical heaters that are thermostatically controlled to maintain the liquids at spray temperature; (4) 200 feet of special hoses, electrically heated and insulated to maintain the chemicals within the line at spray temperature, to transfer the chemicals to the gun block; and (5) a spray gun that contains a mixing chamber and necessary controls to keep the two basic liquids from mixing before the spray valve is operated.

The entire system can be mounted on a 2-wheel trailer, pickup truck, or carry-all truck for easy transportation between jobs. The only external power requirement is a source of 220-volt single-phase electric power to operate the compressors and heaters.

The Time and Cost

Estimated costs and times for leveling 12-by-12-foot rooms having an average sag of 2 to 3 inches, using the Marcraft floor-leveling system with screeds on 2-foot centers, are as follows:

- Cost of 2-by-2-inch wooden screeds @ \$0.40 each; 7 screeds = \$2.80 or \$0.0194 per square foot.
- Cost of leveling screeds; two carpenters, each at \$7.12 per hour, requiring 6 minutes. Cost is \$1.42 or \$0.0099 per square foot.
- Cost of foam at \$0.46 per pound, using 1¼ pounds per screed, total of 8¾ pounds of foam = \$4.02 or \$0.0279 per square foot.
- Cost of foaming equipment and operator at \$10 per hour. Equipment cost = \$25 per day for power, repairs, and depreciation, plus one operator's salary. Time required is 8 minutes = \$1.33 or \$0.0093 per square foot.
- Total time required.
  a. 3-man crew: 14 minutes total or 0.097 minutes per square foot.
  b. Man-minutes used: 20 man-minutes total or 0.139 man-minutes per square foot.
- Total cost of leveling per square foot of floor area.

a. Screeds	\$0.0194
b. Leveling	.0099
c. Foam	.0279
d. Operator	.0093
Total	\$0.0665/square foot

All costs and times are conservative, and they include such items as moving from room to room. As purchasing quantities increase and greater proficiency is obtained, the total costs should decrease. However, it should be stressed that these are actual costs and do not allow for supervision costs, overhead costs or profit margin.

The Marcraft floor-leveling system provides the advantages of simplicity, flexibility, speed, and economy that are required in the urban rehabilitation work of today. A program is under way to develop a construction scheme that would make possible the rehabilitation of an entire apartment building in 48 hours. If only 1 cent per square foot were saved by using this system, the potential total savings for the New York City rehabilitation project alone could be over 5.8 million dollars.

—DAVID G. MARTENS and E. PAUL CRAFT
Associate Market Analyst and Equipment Specialist
Forest Products Marketing Laboratory
Northeastern Forest Experiment Station
Forest Service, U. S. Department of Agriculture
Princeton, W. Va.

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THE VALUE ADDED BY SAWMILLING IN THE APPALACHIAN HILL COUNTRY OF OHIO AND KENTUCKY

Abstract. The difference between log costs and lumber values at 40 sawmills in the Appalachian hill country of Ohio and Kentucky provides an estimate of the value added by sawmill production. Based on these estimates, sawmilling contributed about $12.8 million to the region's economy in 1962.

The Appalachian hill country of eastern Kentucky and southeastern Ohio is an area rich in hardwood forest resources, but at the same time it is an area of low per-capita income. Sawmilling has continuously provided employment and income for many of the people of this area, yet there is little recorded evidence of its economic importance.

As a part of a study of the sawmill industry in the hill country of Kentucky and Ohio in 1960, we collected information about raw-material costs and product sales so we could estimate what contribution sawmilling makes to the area's economy (fig. 1). This report is based on the operations of 40 randomly selected mills in the area.

Figure 1.—The study area and location of the mills studied.

The mills investigated were actively engaged in lumber manufacture, and normally produced at least 500,000 board feet of lumber products annually. Based on the primary product manufactured, 23 of the 40 mills were classified as grade-lumber mills—those engaged in producing lumber for sale under National Hardwood Lumber Association rules; 9 were classified as pallet-lumber mills—those engaged mainly in producing pallet lumber, blocking, and crating; and 8 were classified as local-use mills—those manufacturing lumber principally for local construction contractors, farmers, and coal mines.

Cost of Raw Material

In 1960, aggregate log costs, mill tally f.o.b. the study mills, were approximately $2.06 million. Grade-lumber mills accounted for 73 percent of this total. Average log costs for the study mills amounted to $41 per thousand board feet at grade-lumber mills and $35 per thousand board feet at pallet-lumber mills and local-use mills.

Higher log costs occurred at grade-lumber mills mainly because mills producing grade lumber require higher quality logs than do pallet-lumber mills or those producing ungraded lumber for local use. Also, grade-lumber mills generally have greater plant investment than other mills and must buy logs throughout the year, even at higher prices, to insure a continuous supply of high-quality logs.

Product Sales

The 40 mills produced more than 52 million board feet of lumber, and grade lumber alone accounted for about 60 percent of the total volume (fig. 2). Product sales in 1960 amounted to about $4.38 million, an average of $84 per thousand board feet (table 1).

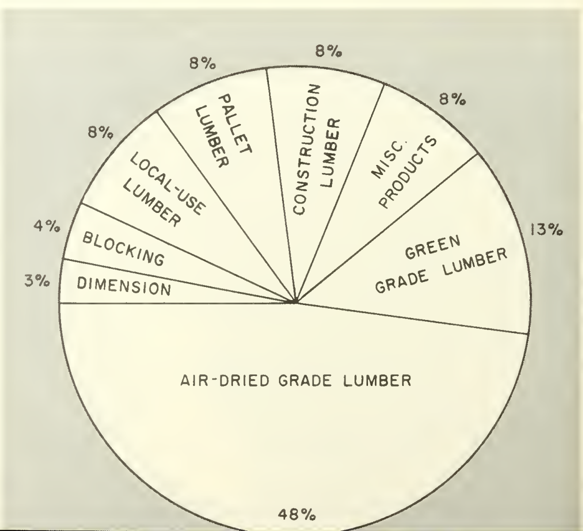

Figure 2.—Distribution of product sales volume.

Table 1.—*Average value per 1,000 board feet f.o.b. mill for products sold by the 40 sample mills*

Product	Average sale value per 1,000 board feet
Air-dry grade lumber	$101
Green grade lumber	78
Pallet lumber	52
Blocking	60
Dimension stock	57
Construction lumber	68
Local-use lumber	57
Others	84
All products	$ 84

The average value per thousand board feet for all lumber sold was higher at grade-lumber mills than at pallet-lumber mills and at local-use mills (table 2) because the former produced a greater volume of higher grade products. Even if we consider only lumber sales of the same grade, the average value per lumber grade was still higher at grade-lumber mills than at the other mills.

There are several reasons for this. Grade-mills usually sell a larger percentage of their lumber air-dry than do the other mills, and air-dry lumber normally commands a higher price than green lumber of similar grade. Also, the pallet-lumber mills and the local-use mills rarely sell

Table 2.—*Production, average product value, average log cost, and average value added through manufacture by mill type for the 40 sample mills*

Mill type	Mills	Lumber production (mill tally)	Average product value per 1,000 board feet	Average log cost f.o.b. mill per 1,000 board feet	Average value added per 1,000 board feet
	No.	*Million board feet*			
Grade-lumber	23	36.7	$90	$41	$49
Pallet-lumber	9	10.9	70[1]	35	35[2]
Local-use	8	4.7	67	35	32
All mills	40	52.3	$84	$40	$44

[1]Includes value of all products except finished pallets.

[2]The value added at pallet-lumber mills is calculated for sawmilling only; it does not include value added by fabrication of lumber into pallets.

directly in the grade-lumber market because they produce relatively small volumes of grade lumber. Their grade lumber is often sold to grade lumber mills or dealers who then resell it.

Value Added by Manufacture

Value added is generally defined as the difference between the cost of raw material and supplies purchased and the value of products sold. Such costs as electricity, fuels, and similar items are usually subtracted from product-sales value. In this study electricity and fuel costs are included in the value added by manufacture, but normally amount to only 2 to 3 percent of total costs.[1]

The total value added by lumber manufacture at the 40 study mills amounted to almost $2.32 million in 1960 for an average margin of $44 per thousand board feet to cover production costs and to provide mill management a return for services (table 2). The value added by manufacture at grade-lumber mills exceeded that at pallet-lumber and local-use mills. As noted earlier, average log costs at grade-lumber mills were higher than at pallet-lumber and local-use mills. However, these greater costs were more than offset by considerably higher product values, thus resulting in greater value added at grade mills.

Estimated total lumber production in the study area for 1962 was 291 million board feet.[2] Assuming that the $44 value added per thousand board feet by the study sawmills is representative of the region, in 1962 sawmilling would add about $12.8 million to the region's economy.

In terms of the volume processed and product value, grade lumber is the most important form of lumber sawed in the region. If we assume that the sample mills are representative of the region, grade-lumber mills are, in turn, the most important class of sawmills in the region in product value and value added by manufacture.

—ORRIS D. McCAULEY and JAMES C. WHITTAKER[3]

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[1]Whittaker, James C., and Orris D. McCauley, COSTS AND RETURNS FOR HARDWOOD LUMBER PRODUCTION IN THE APPALACHIAN REGION OF KENTUCKY AND OHIO. U.S. Forest Serv. Res. Paper NE-55. 16 pp., illus. NE. Forest Exp. Sta., Upper Darby, Pa. 1966.

[2]Estimates are based on U.S. Forest Service Resource Bulletins CS-3, CS-4, and CS-5, Central States Forest Experiment Station, Columbus, Ohio, for the Kentucky portion of the study area and on lumber production statistics published by the U.S. Department of Commerce and estimates from various other sources for the Ohio portion of study area.

[3]The authors are respectively economist, Northeastern Forest Experiment Station, Forest Service, U.S. Department of Agriculture, Berea, Ky. and associate economist, Northeastern Forest Experiment Station, Forest Service, U.S. Department of Agriculture, Syracuse, N.Y.

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LAND DISTURBANCES FROM STRIP-MINING IN EASTERN KENTUCKY. 3. LICKING RIVER COAL RESERVE DISTRICT.

Abstract. Results of an airphoto survey to determine the extent of land disturbance by coal mining and by coal-haul roads in one of the six coal-reserve districts of eastern Kentucky. Describes the district, forest cover, physiography and geology, and distribution and physical characteristics of the 1,456 acres disturbed in this 1.1 million-acre district.

Open-pit or strip-mining—primarily for coal—has expanded rapidly in eastern Kentucky during the past 15 years. Information about the amount, location, and general characteristics of the disturbed areas is necessary for appraising the economic impacts and overall effects of strip-mining in that section of the State, for planning reclamation programs, and for determining research needs and priorities.

To obtain reliable estimates of the acreage disturbed both by the mining itself and by the associated coal-haul roads, and to provide relevant information about the disturbed areas, a survey was made. The survey was based on aerial photographs of all stripped areas as of October 1964.

The survey was broken down in accordance with the six subdivisions or coal-reserve districts delineated by the U.S. Geological Survey,[1] and a separate report on each district is planned. The first two reports[2, 3] have been published. This is the third in the series.

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[1]Huddle, J. W., F. J. Lyons, H. L. Smith, and J. C. Ferm. COAL RESERVES OF EASTERN KENTUCKY. U. S. Geol. Survey Bull. 1120, 147 pp, 1963.

[2]Plass, William T. LAND DISTURBANCES FROM STRIP-MINING IN EASTERN KENTUCKY. 1. UPPER CUMBERLAND COAL RESERVE DISTRICT. U. S. Forest Serv. Res. Note NE-52. 8 pp., illus. NE. Forest Exp. Sta., Upper Darby, Pa. 1966.

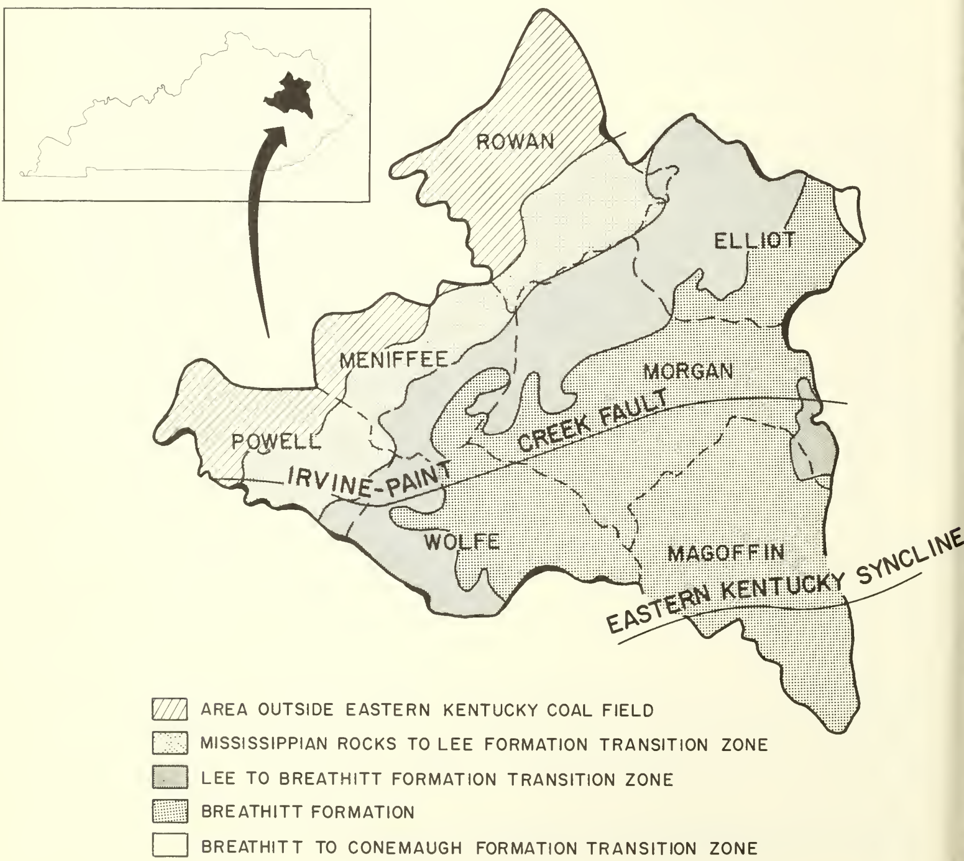
[3]Plass, William T. LAND DISTURBANCES FROM STRIP-MINING IN EASTERN KENTUCKY. 2. PRINCESS COAL RESERVE DISTRICT. U. S. Forest Serv. Res. Note NE-55. 8 pp., illus. NE. Forest Exp. Sta., Upper Darby, Pa. 1966.

The method used in our survey was a modification of forest-survey procedure. A 3-by-6-inch transparent template with 25 dots per square inch was positioned over the center of each photograph. Areas on the photographs that appeared to be stripped land or coal-haul roads were examined stereoscopically to determine important characteristics, and the amount of area in various categories was estimated by dot counts.

The Licking River District

The Licking River Coal Reserve District is located along the western edge of the eastern Kentucky coal field. It includes all of Morgan, Elliot, Magoffin, and Wolfe Counties and portions of Rowan, Powell, and Menifee Counties (fig. 1). The District has produced less coal than any of the

Figure 1.—Geographic and geologic features of the Licking River Coal Reserve District.



other six districts because of limited reserves and generally thin beds. However, refractory clay is an important mineral in Rowan County.

The first coal mining occurred in Morgan County about 1850. Since that date about 10 million tons have been mined in the district. Strip-mining, which probably began in the 1950's, has expanded very slowly and only in a few localities. The Kentucky Department of Mines and Minerals[4] reported 1962 production from all mining to be 178 thousand tons. Seventeen percent of this total came from strip mines.

District coal reserves (measured, indicated, and inferred) are estimated to be 2.2 billion tons. However, less than 1 billion tons are in beds more than 28 inches thick. Magoffin County has more than half of the estimated reserves and has 75 percent of the beds that are more than 42 inches thick.

In Rowan County, clay mining has been active for many years. The mines are small and individually result in small areas of disturbance. It is estimated that there are extensive reserves of refractory clay, but the supplies of specific grades may be diminishing.

Forest Cover

About 75 percent of the district land area is covered with forests.[5] In the clay- and coal-producing areas forests generally cover the slopes and ridges. Eighty percent of the disturbance from surface mining for clay and coal is located on the upper slopes and ridges. Ninety percent of the disturbed areas have forests immediately below and adjoining the disturbance.

About one-half of the commercial forest stands are of sawtimber size. These are generally mixtures of hardwood species but varying percentages of southern pine are found in some stands. In Elliot, Menifee, and Wolfe Counties 20 percent or more of the forest land is in southern pine and southern pine-hardwood types.

Physiography and Geology

The topography of the district is varied. On the western edge, the major streams have cut steep-walled canyons into the Pottsville escarpment. Above the escarpment the topography is gentler and the valleys broaden. Finally, near the headwaters of the major streams, the valleys narrow as they wind into the more rugged uplands.

[4]Mandt, A. H. ANNUAL REPORT. Kentucky Dep. Mines and Minerals. 166 pp. 1963.

[5]Unpublished preliminary report, BASIC FOREST RESOURCE STATISTICS, NORTHERN CUMBERLAND UNIT, KENTUCKY, 1963. U. S. Forest Serv. and Kentucky Dep. Natural Resources, 1965.

Tributaries to three major river basins are located within the district boundaries: the Licking River drains a major part of the district; the Little Sandy River, in the northeast, drains most of Elliot County; in the south and west the Red River, a tributary to the Kentucky River, drains Wolfe and Powell Counties.

There are only a few geologic features that substantially modify the structural geology of the district. Chief among these are the Eastern Kentucky Syncline, which controls a gentle southeastwardly dip of the strata, and the Irvine-Paint Creek fault, which accounts for some discontinuity in coal bed correlation.

On the basis of the surface geology we recognized four zones from west to east: the Mississippian rocks to Lee formation transition zone; the Lee to Breathitt formation transition zone; the Breathitt formation; and the Breathitt to Conemaugh formation transition zone. The Lee formation is a clay producer and the Breathitt formation a coal producer. The Breathitt formation underlies about two-thirds of the land area in the District.

The coal reserves in the Breathitt formation are based on 18 seams. Of these, only four have been mined by open-pit methods.

Distribution of Stripped Areas

As of 1964, 1,456 acres in this 1.1-million-acre district had been disturbed by strip- and auger-mining. Of this total, 926 acres were attributed to coal stripping and 530 acres to open-pit clay mining.

Rowan County had the greatest amount of disturbance, even though only one-third of the County is considered to be in the eastern Kentucky coal field. The disturbance in this portion of the County totalled 520 acres or 0.79 percent of the land area (table 1). All of this was from clay mining.

Morgan and Magoffin County each had about 450 acres of disturbance from strip- and auger-mining for coal. Very small acreages have been disturbed in Wolfe and Elliot Counties and no disturbance from strip-mining was observed in Menifee and Powell Counties.

Of the area underlain by the Breathitt formation, 895 acres or 0.12 percent had been disturbed. Next among the geologic zones in area disturbed was the Mississippian rocks to Lee formation transition zone, with 497 acres. However, the disturbance in this zone was proportionally greater, amounting to 0.33 percent of the land area.

The four coal seams strip-mined were the Zachariah, Fire Clay, Fugate, and Hindman. Sixty percent of the disturbance in the District resulted

Table 1.—*Acreage disturbed by open-pit mining in the Licking Coal Reserve District*

County	Lee to Mississippian transition zone	Lee to Breathitt transition zone	Breathitt formation	Breathitt to Conemaugh transition zone	Total disturbed acreage	Percent of total land area
Elliot	—	10	—	—	10	0.01
Magoffin	—	—	454	—	454	.23
Morgan	—	—	433	—	433	.16
Menifee	—	—	—	—	0	0
Powell	—	—	—	—	0	0
Rowan	497	23	—	—	520	.79
Wolfe	—	31	8	—	39	.03
Total disturbed acreage	497	64	895	0	1,456	0.10
Percent of total land area	0.33	0.02	0.12	0	0.01	—

from mining the Hindman coal seam in Magoffin County. Next in importance was the Fugate or Sebastian coal bed mined in Morgan and Magoffin Counties.

The Olive Hill clay bed is the clay producer in the District, and it outcrops extensively in Rowan County. It occurs near the base of the Lee formation.

Physical Characteristics of Disturbed Areas

There are two basic types of strip-mining in the eastern Kentucky coal field: contour- or rim-stripping, and area-stripping. Auger-mining is usually employed as a supplement to contour-stripping. About 60 percent of the 1,456 acres disturbed in the District results from contour-stripping for clay or coal.

In the contour-stripping, 9 percent of the disturbed area was on or above the highwall; 53 percent was in pits, inslopes, and leveled or unleveled benches; and 38 percent was in the outslopes. Of the 335 acres in outslopes, 67 acres, or 20 percent, were in slides or slumps.

Area-stripping, which made up 40 percent of the total disturbed acreage, was done in most cases on ridge tops where the overburden was relatively shallow. The area-stripping was about equally divided between coal and clay operations. The proportional distribution of the disturbed area by bank position was as follows: on or above the highwalls—2 percent; pits, inslopes, leveled or unleveled benches above the outslopes—54 percent; outslopes—44 percent. Slides and slumps occurred on 49 percent of the 254 acres of outslope area.

Table 2.—*Disturbance by coal haul-roads*

County	Clay mining		Coal mining		Total	
	Acres	*Miles*	*Acres*	*Miles*	*Acres*	*Miles*
Elliot	—	—	2.5	0.7	2.5	0.7
Magoffin	—	—	45.9	12.1	45.9	12.1
Morgan	—	—	23.0	6.1	23.0	6.1
Menifee	—	—	—	—	—	—
Powell	—	—	—	—	—	—
Rowan	40.8	10.7	—	—	40.8	10.7
Wolfe	—	—	5.1	1.3	5.1	1.3
Total	40.8	10.7	76.5	20.2	117.3	30.9

Leveling of the disturbed areas has been required by state law since 1954. In this District, 78 percent of the area disturbed by clay mining had been leveled and 10 percent had been partially leveled. Less leveling had been done on the areas disturbed by coal mining—30 percent completed and 1 percent partially leveled.

According to estimates derived from dot counts on the aerial photos, coal and clay haul-roads built by the mining operators had disturbed 117 acres in the district. The average width of disturbance along these roads was 31 feet, which means that each mile of road disturbed about 3.8 acres. Thus the 117 acres converts to about 31 miles of road (table 2). On the average, there were 47 acres of mining disturbance for each mile of road.

About 80 percent are primary haul-roads built from county, state, or federal highways to the mining site. The remainder are secondary haul-roads, joining two mining sites or serving as spurs for primary haul-roads.

— WILLIAM T. PLASS
Plant Ecologist
Northeastern Forest Experiment Station
Forest Service, U. S. Dep. Agriculture
Berea, Kentucky

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LAND DISTURBANCES FROM STRIP-MINING IN EASTERN KENTUCKY. 4. BIG SANDY COAL RESERVE DISTRICT.

Abstract. Results of an airphoto survey to determine the extent of land disturbance by coal mining and by coal-haul roads in one of the six coal-reserve districts of eastern Kentucky. Describes the district, forest, cover, physiography and geology, and distribution and physical characteristics of the acres disturbed in this district.

Open-pit or strip-mining—primarily for coal—has expanded rapidly in eastern Kentucky during the past 15 years. Information about the amount, location, and general characteristics of the disturbed areas is necessary for appraising the economic impacts and overall effects of strip-mining in that section of the state, for planning reclamation programs, and for determining research needs and priorities. To obtain reliable estimates of the acreage disturbed both by the mining itself and by the associated coal-haul roads, and to provide relevant information about the disturbed areas a survey was made. The survey was based on aerial photographs of all stripped areas as of October 1964.

The survey was broken down in accordance with the six subdivisions or coal-reserve districts delineated by the U. S. Geological Survey.[1] Thus there will be a series of six reports, of which this is the fourth.

The method used in our survey was a modification of forest-survey procedure. A 3-by-6-inch transparent template with 25 dots per square inch was positioned over the center of each photograph. Areas on the

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[1]Huddle, J. W., F. J. Lyons, H. L. Smith, and J. C. Ferm. COAL RESERVES OF EASTERN KENTUCKY. U. S. Geol. Survey Bull. 1120, 147 pp, 1963.

photographs that appeared to be stripped land or coal-haul roads were examined stereoscopically to determine important characteristics, and the amount of areas in various categories was estimated by dot counts.

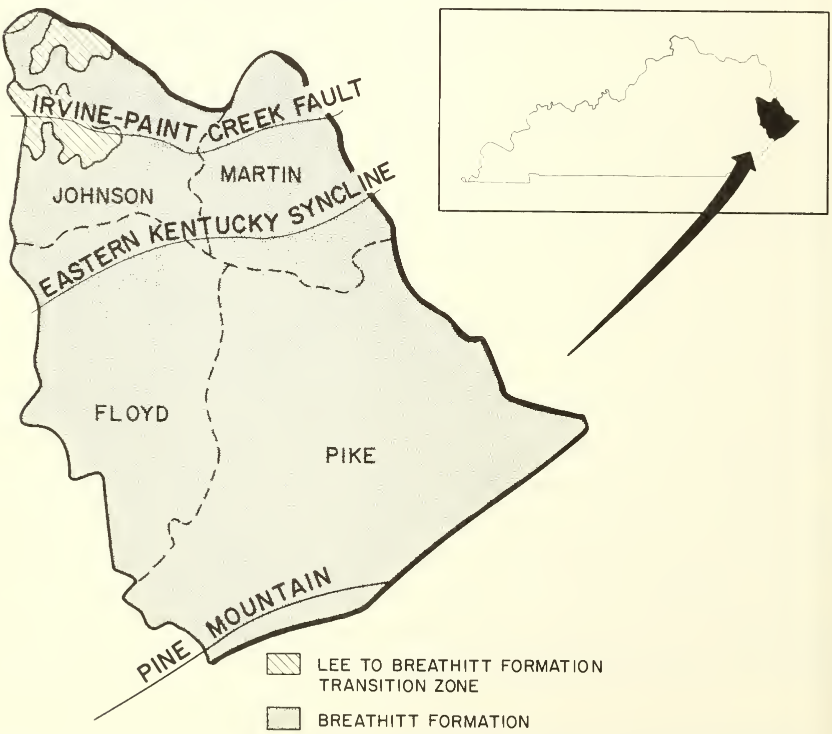
The Big Sandy Coal Reserve District

The Big Sandy Coal Reserve District, one of the major coal producing centers of eastern Kentucky, includes all of Johnson, Martin, Floyd, and Pike Counties (fig. 1). Most of the disturbance due to strip-mining occurs in Pike County.

The first coal mining in the District began in Johnson County in 1879. Production in the other counties began after 1900. The total production up to 1955 was 510 million tons. In 1962, 17 million tons were produced by underground-mining and by strip- or auger-mining.[2] Of this, about 2 percent came from strip mines, and 7 percent came from auger-mining.

[2]Mandt, A. H. ANNUAL REPORT. Ky. Dep. Mines and Minerals. 166 pp., 1963.

Figure 1.—Geographic and geologic features of the Big Sandy Coal Reserve District.



In 1947 Merz found 171 acres of strip-mine disturbance in the District.[3] All of this was in Pike County, and all of the spoils were less than 5 years of age.

District coal reserves, (measured, indicated, and inferred) are estimated to be about 10 billion tons.[1] Three billion tons are in beds more than 42 inches thick, and 4 billion tons are in beds 28 to 42 inches thick. About 60 percent of these reserves are in Pike County, and 30 percent in Floyd County.

Forest Cover

Forests cover about 83 percent of the District's land areas, and nearly all of the non-forest land is located in the valleys.[4] About 60 percent of the strip and auger mines are located on the upper slopes and ridges. Ninety-seven percent of these mines have forest immediately below and adjoining the disturbed area.

Sixty percent of the commercial forest stands are of sawtimber size, with oak-hickory and central mixed hardwood types dominating. Pine and oak-pine types occur on 5 percent of the forest land.

Physiography and Geology

Narrow V-shaped valleys and ridges with moderately steep slopes characterize the topography of the District. The average relief increases from north to south.

The Big Sandy River drains the entire District by two secondary drainage systems. Tug Fork on the east, which is the boundary between West Virginia and Kentucky; and Levisa Fork, which meanders through the heart of the District to headwater in Virginia.

Structural geology in the District is controlled by the eastern Kentucky syncline in northern Floyd County and in central Martin County.[1] To the south the syncline causes a regional dip of about 1 degree to the northwest. North of the syncline, the dip is to the southeast, but it is broken by the Irvine-Paint Creek fault. Along the southern boundary, the Pine Mountain overthrust block influences a very small portion of the District.

The rocks outcropping in the District are confined to the Lee and Breathitt formations of the Pennsylvania Age. The Lee formation out-

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[3]Merz, Robert W. CHARACTER AND EXTENT OF LAND STRIPPED FOR COAL IN KENTUCKY. Ky. Agr. Exp. Sta., Circ. 66, 27 pp., 1949.

[4]U. S. Forest Service and Kentucky Department of Natural Resources. BASIC FOREST RESOURCE STATISTICS, EASTERN UNIT, KENTUCKY, 1963. 1965. (Unpublished preliminary report on file at the Kentucky Division of Forestry and the Northeastern Forest Experiment Station, Upper Darby, Pa.).

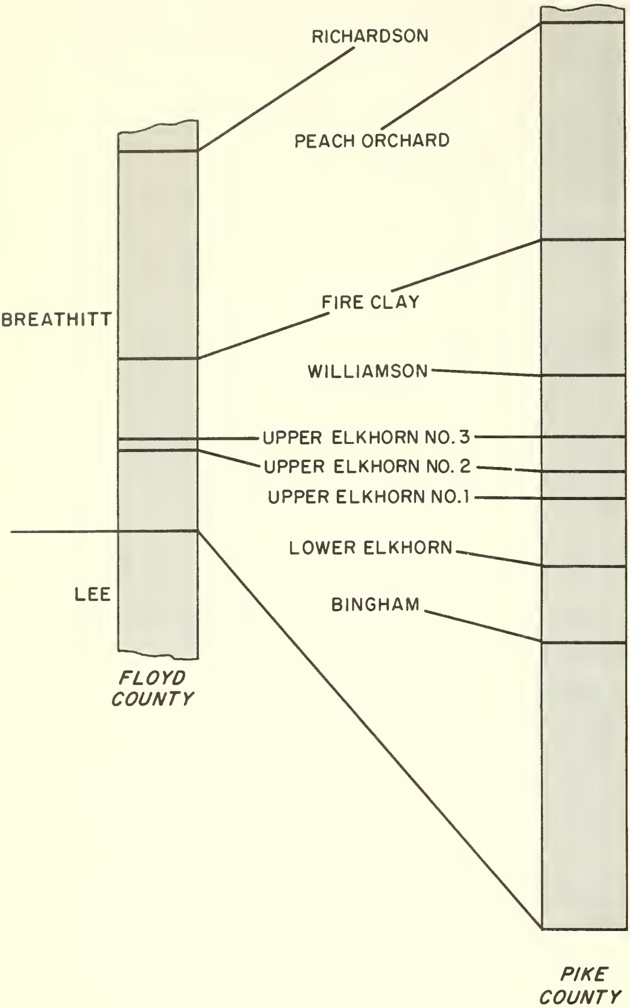

Figure 2.—Relative position of the coal beds mined by the open-pit method in the Big Sandy Coal Reserve District.

crops in a small area in northwestern Johnson County and along Pine Mountain. The remainder of the District is underlain by the coal-bearing Breathitt formation. The thickening of this formation from south to north causes problems in coal-bed correlation. The magnitude of this problem can be measured by the interval between the top of the Lee formation and the Peach Orchard coal seam. In the north these are 900 feet apart, but in southern Pike County the interval increases to 3,000 feet.

In the Breathitt formation the U. S. Geologic Survey recognizes 21 coal beds of commercial importance.[1] Of these, nine have been strip- or auger-mined (fig. 2).

Distribution of Stripped Areas

By 1964 strip- and auger-mining had disturbed (excluding coal-haul roads) a total of 8,343 acres or 0.8 percent of the total land area within the district (table 1). Pike County had the largest acreage (7,719 acres) and the highest percentage of area disturbed (1.5 percent). In Floyd County, 581 acres, or 0.2 percent of the total land area, had been disturbed. Only 43 acres had been disturbed in Martin County, and there was no disturbance in Johnson County.

Of the nine coal seams mined, Upper Elkhorn No. 3 was the most extensively mined. Forty-six percent of all mining disturbance in the District resulted from mining this coal seam. Other seams with large acreages of disturbance were Fireclay, Williamson, and Upper Elkhorn No. 2.

Physical Characteristics of Disturbed Areas

There are two basic types of strip-mining in the eastern Kentucky coal field: contour- or rim-stripping, and area-stripping. Auger-mining usually is employed as a supplement to contour-mining; it is a means for working a seam beyond the point where removal of the overburden by stripping is economically feasible. In this district 97 percent of the disturbance has resulted from contour-stripping. All the area-stripping occurred on the ridge tops.

In the contour-stripping, 11 percent of the disturbed area was on or above the highwall; 43 per cent was in pits, inslopes, and leveled or

Table 1.—*Disturbed area by counties and coal seams in the Big Sandy Coal Reserve District, in acres*

Coal Seam	Floyd County	Johnson County	Martin County	Pike County	Total
Bingham	—	—	—	463	463
Lower Elkhorn	—	—	—	309	309
Upper Elkhorn No. 1	—	—	—	154	154
Upper Elkhorn No. 2	58	—	—	849	907
Upper Elkhorn No. 3	227	—	—	3,613	3,840
Williamson	—	—	43	1,158	1,201
Fireclay	267	—	—	1,158	1,425
Peach Orchard	—	—	—	15	15
Richardson	29	—	—	—	29
Total	581	0	43	7,719	8,343
Percent of land area disturbed	0.2	0	+	1.5	0.8

Table 2.—*Mileage of coal-haul roads in the Big Sandy Coal Reserve District*

Road Class	Johnson County		Martin County		Floyd County		Pike County		Total	
	Acres	*Miles*	*Acres*	*Miles*	*Acres*	*Miles*	*Acres*	*Miles*	*Acres*	*Miles*
Primary	—	—	3	.3	31	3.5	359	40.9	393	44.7
Secondary	—	—	—	—	18	2.0	183	20.9	201	22.9
Third-class	—	—	—	—	—	—	13	1.5	13	1.5
Total: Acres	—	—	3	—	49	—	555	—	607	—
Miles	—	—	—	.3	—	5.5	—	63.3	—	69.1

unleveled benches above the outslope; and 46 percent was in outslopes. Of the 3,723 acres in outslopes, 9 percent or 335 acres was in slides or slumps.

On 77 percent of the contour-stripping operations, there had been some grading of the spoil between outslope and highwall or pit. About 10 percent was graded to nearly level benches. Probably most of this leveling has been done since the enactment in 1954 of state legislation requiring reclamation of areas disturbed by strip- and auger-mining.

All the area-stripping—250 acres—was done on the ridge tops where the overburden was relatively shallow. The proportional distribution of the disturbed area by bank position was as follows: on or above the highwall, 2 percent; pits, inslopes, leveled or unleveled benches above the outslope, 53 percent; and outslopes, 45 percent. Slides and slumps occurred on 18 percent or on 20 of the 112 acres in outslopes.

Some leveling had been done on 77 percent of the area-stripping. Fifteen percent had been graded to a nearly level bench.

In all stripping operations, the operator must build and maintain a network of roads for hauling coal from the mines. In this survey we classified haul roads as: primary (running from a public road to the mine); secondary (joining two pits or serving as spurs for primary roads); or third class (service roads and temporary haul roads).

We estimate that 607 acres had been disturbed by coal-haul roads in this district. This figure was computed directly from dot counts on the aerial photographs. After determining the average width of the road disturbance to be 73 feet by field measurement, we converted acres to miles of road. By this calculation there were 69 miles of road in the District. This mileage was distributed among the three classes of roads as follows: primary, 45 miles; secondary, 23 miles; and third-class, 1 mile (table 2). On the average there are 121 acres of strip-mining disturbance for each mile of coal-haul road.

About 90 percent of these roads ran through forested country. Forty percent of the first-class roads were built in the valley bottoms; the remainder were built along the hillsides. The distribution for secondary roads was as follows: valley, 13 percent; slopes, 64 percent; and ridges, 23 percent. All of the third-class roads were located on the ridges.

—WILLIAM T. PLASS
Plant Ecologist
Northeastern Forest Experiment Station
Forest Service, U. S. Department of Agriculture
Berea, Kentucky

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Experiment Station

A PORTABLE FIELD SHELTER

Abstract. Describes the materials and methods used in constructing a 4-x-8-foot instrument shelter.

Field experiments often require the use of expensive recording equipment. Since study locations are often far from permanent facilities, some type of field shelter must be provided to protect equipment from weather and vandalism. An inexpensive portable shelter providing a floor space of about 4 x 8 feet has been devised and satisfactorily used in experiments in sugar maple sap production by personnel of the Northeastern Forest Experiment Station in Burlington, Vermont (fig. 1). This portable shelter, which is easy to construct and assemble, is used for storage and protection of recording instruments in maple sugar orchards. However, it could be used for a variety of other purposes.

We used the following material in the construction of the shelter:

Plywood, exterior grade 1/4-inch x 4-feet x 8-feet	8 sheets
Plywood, exterior grade 5/8-inch x 4-feet x 8 feet	1 sheet
Spruce blocks, 2-inches x 2-inches x 6 1/2-inches	6 pieces
Spruce framing lumber, 2-inches x 2-inches x 6-feet	6 pieces
Spruce framing lumber, 2-inches x 2-inches x 8-feet	4 pieces
Spruce framing lumber, 2-inches x 4-inches x 8-feet	4 pieces
Spruce framing lumber, 1-inch x 3-inches x 8-feet	4 pieces
Spruce framing lumber, 1-inch x 1-inch x 8-feet	4 pieces
Asphalt roll roofing	40 square feet
Machine bolts, 5/16-inch x 5-inches	36
Washers, 5/16-inch	72
Wing nuts, 5/16-inch	36
Asphalt roofing cement	1 quart
Wood-preservative stain	1 quart
Nails, No. 6 coated	1 1/2 pounds
Nails, No. 10	1/2 pound
Nails, No. 4	1/2 pound
Roofing nails, galvanized 1/2-inch	1 pound
Window sash, 16-inches x 22-inches	1
T-hinges, 4-inch	1 pair

Figure 1.—Portable field shelter used for housing environmental equipment used in maple sugar research investigations.

We used standard 4 x 8-foot sheets of exterior plywood for our principal construction material to reduce the amount of cutting. We used 1/4-inch plywood for the walls and roof, and 5/8-inch plywood for the floor (fig. 2).

The plywood is fabricated into eight panels with 2 x 2-inch lumber used for framing. Figure 2 shows an inside view of each panel and illustrates the location of framing members and the pattern of construction.

The roof panel was made of four pieces of plywood (two 60 x 48-inch pieces and two 30 x 11 1/2-inch pieces). A 1 x 1-inch wooden strip was nailed with No. 4 nails on the underside of the roof, 2 inches outside of the 2 x 2 frame. This strip covers the joint between the roof and wall panels. The roof was covered with roll roofing paper, and asphalt roofing cement was applied around the edges and at the overlapping seams.

The wall panels were fastened with No. 6 nails. In the window panel, the sash may be either fixed with small brackets or hinged in place. The window opening was framed on the outside with 1 x 3-inch boards. The plywood piece cut for the door was framed and braced with 1 x 3-inch boards. A pair of T-hinges were used to attach this door to the wall panel. The door opening was framed on the outside with 1 x 3-inch boards.

Dashed lines in the floor panel represent a foundation base made of 2 x 4-inch boards. This is permanently attached to the floor with No. 10 nails. The small circles on the frames of each panel identify the locations of 5/16-inch holes for machine bolts used in assembling the shelter. Care must be used in drilling these holes to make certain that adjacent panels are properly aligned.

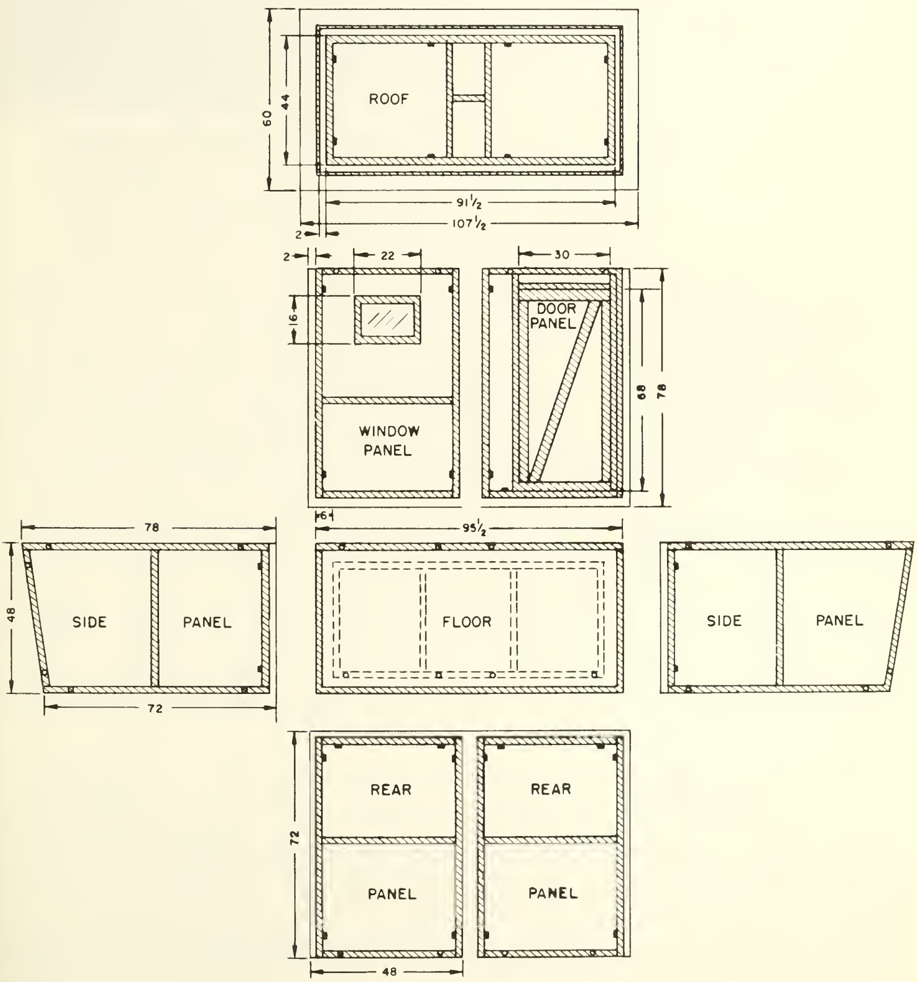

Figure 2.—Expanded view of instrument shelter, showing construction and arrangement of panels. All dimensions are in inches.

Figure 3.—Wing nuts are used for rapid assembly of the instrument shelter.

After construction was completed all exposed portions of the shelter were treated with a wood-preservative stain.

After all the panels are constructed the shelter can be moved unassembled to the desired field location. Here the floor panel is set down and leveled. Then each side panel is bolted through the pre-drilled holes to the floor section and to adjacent panels. Wing nuts are used for rapid fastening of all panels (fig. 3). When the walls of the shelter are all assembled, the roof panel is installed and fastened in a similar manner.

Two men can completely assemble the shelter in less than 20 minutes. The shelter may be readily disassembled and moved by simply removing the bolts and separating the panels. Any section of the shelter can be transported easily by two men. The heaviest section (floor panel) weighs approximately 100 pounds.

The basic structure as described above has been highly useful. A folding table, work bench, or wall shelves can be installed to accommodate instruments, chemical reagents, or other equipment. Through the use of a small oil or gas-heater, the shelter can be used at any time of the year.

—MELVIN R. KOELLING
Research Forester
Northeastern Forest Experiment Station
Forest Service, U. S. Department of Agriculture
Burlington, Vermont

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LAND DISTURBANCES FROM STRIP-MINING IN EASTERN KENTUCKY
5. HAZARD COAL RESERVE DISTRICT

Abstract. Results of an airphoto survey to determine the extent of land disturbance by coal mining and by coal-haul roads in one of the six coal-reserve districts of eastern Kentucky. Describes the district, forest cover, physiography and geology, and distribution and physical characteristics of the acres disturbed in this district.

Open-pit or strip-mining—primarily for coal—has expanded rapidly in eastern Kentucky during the past 15 years. Information about the amount, location, and general characteristics of the disturbed area is necessary for appraising the economic impacts and overall effects of strip-mining in that section of the state, for planning reclamation programs, and for determining research needs and priorities. To obtain reliable estimates of the acreage disturbed both by the mining itself and by the associated coal-haul roads, and to provide relevant information about the disturbed areas, the Northeastern Forest Experiment Station made a survey of eastern Kentucky. The survey was based on aerial photographs of all stripped areas as of October 1964.

The survey was broken down in accordance with the six subdivisions or coal-reserve districts delineated by the U. S. Geological survey[1]. Thus there will be a series of six reports, of which this is the fifth.

The method used in our survey was a modification of forest-survey procedure. A 3-by-6-inch transparent template with 25 dots per square inch was positioned over the center of each photograph. Areas on the photographs that appeared to be stripped land or coal-haul roads were

[1]Huddle, J. W., F. J. Lyons, H. L. Smith, and J. C. Ferm. COAL RESERVES OF EASTERN KENTUCKY. U. S. Geol. Survey Bull. 1120, 147 pp., 1963.

examined stereoscopically to determine important characteristics, and the amount of area in various categories was estimated by dot counts.

The Hazard Coal Reserve District

The Hazard Coal Reserve District lies in the heart of the eastern Kentucky coal fields. It includes all of Breathitt, Knott, Leslie, and Perry Counties and portions of Harlan and Letcher Counties north of Pine Mountain (fig. 1). Over three-fourths of the disturbance from strip-mining in the District occurs in Knott, Letcher, and Perry Counties.

Coal mining in the District began in 1837 in Breathitt County.[1] Production in the other counties began in the early 1900's. Through 1955, the Hazard District produced 454 million tons of coal. Forty-six percent

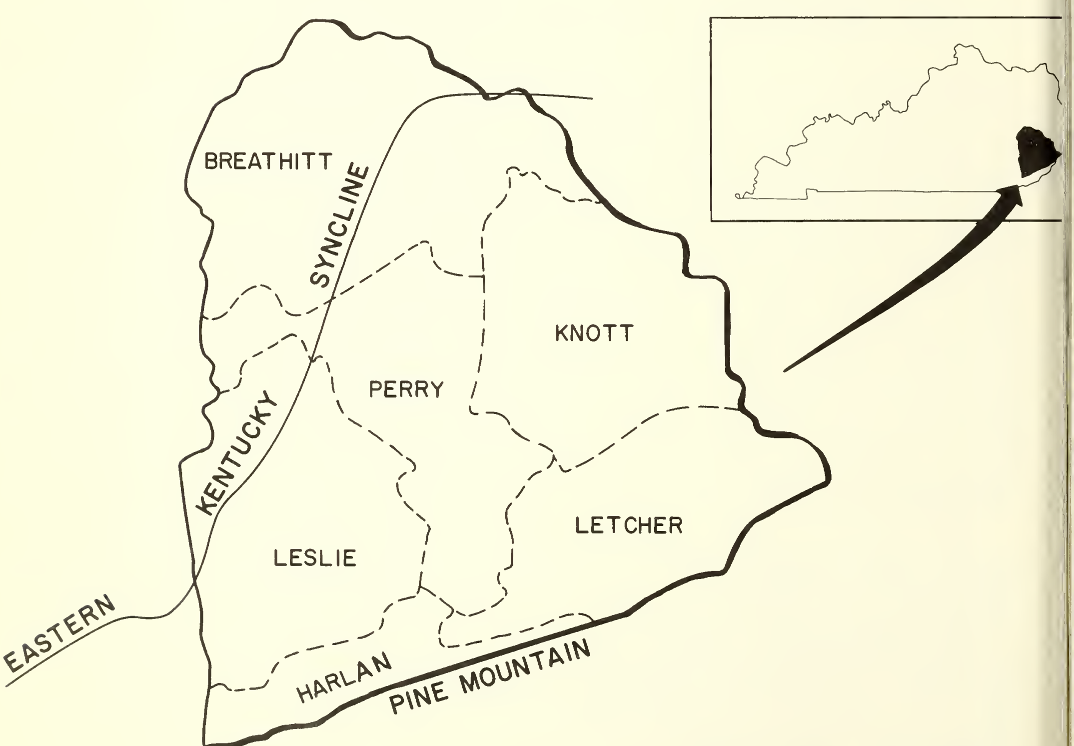

Figure 1.—Geologic and geographic features of the Hazard Coal Reserve District.

of this came from Letcher County, and 42 percent came from Perry County.

Total production from all mining methods in 1962 was 13.2 million tons. Of this, 25 percent or 3.3 million tons were produced by strip mines and auger mines.[2] Nine percent of the total came from strip-mining, and 16 percent came from auger mines or from strip and auger mines.

Merz, in 1947, found 416 acres of strip-mining disturbance in the District.[3] There were 199 acres disturbed near Jenkins in Letcher County and 217 acres disturbed west of Hazard in Perry County. All of this disturbance was less than 5 years old when this early survey was made.

District coal reserves (measured, indicated, and inferred) are estimated to be 11.1 billion tons. About 3 billion tons are in beds more than 42 inches thick, and 4 billion tons are in beds 28 to 42 inches thick. The actual reserves may be much greater since there are many areas in the District where there has been little or no core drilling. The possibility of finding commercially important coal beds in these areas is high because of their geologic similarity with adjoining coal-producing areas.

Forest Cover

About 87 percent of the District's land area is covered by forests.[4,5] The non-forest land generally occurs in the valley bottoms. About 71 percent of the strip and auger mines are located on the upper slopes and ridges. Ninety-six percent of these (strip and auger) mines have forests immediately below and adjoining the disturbed area.

Fifty-seven percent of the commercial forest stands are sawtimber sized with oak-hickory and central mixed hardwood types predominating. Pine and oak-pine types occur on 4 percent of the forest land.

Physiography and Geology

The District lies in a sharply dissected area of the Appalachian Plateau characterized by narrow ridges and deep V-shaped valleys. Local relief in excess of 1,000 feet is not uncommon.

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[2]Mandt, A. H. ANNUAL REPORT. Ky. Dep. Mines and Minerals. 166 pp., 1963.

[3]Merz, Robert W. CHARACTER AND EXTENT OF LAND STRIPPED FOR COAL IN KENTUCKY. Kentucky Agr. Exp. Sta. Circ. 66. 27 pp., 1949.

[4]United States Forest Service and Kentucky Department of Natural Resources. BASIC FOREST RESOURCE STATISTICS, EASTERN UNIT, KENTUCKY, 1963. 1965. (Unpublished preliminary report on file at Kentucky Division of Forestry and the Northeastern Forest Experiment Station, Upper Darby, Pa.)

[5]United States Forest Service and Kentucky Department of Natural Resources. BASIC FOREST RESOURCE STATISTISCS, SOUTHERN CUMBERLAND UNIT, KENTUCKY, 1963. 1965. (Unpublished preliminary report on file at Kentucky Division of Forestry and the Northeastern Forest Experiment Station, Upper Darby, Pa.)

The Middle and North Forks of the Kentucky River drain a major part of the District. Eastern Knott and Letcher Counties are drained by tributaries to the Big Sandy River.

Structural geology in the District is controlled by the eastern Kentucky syncline, which passes through western Leslie County and central Breathitt County. The syncline causes a gentle regional dip of generally less than one-half degree to the northwest. The Pine Mountain overthrust block marks the southern boundary of the District and influences a very small area in its immediate vicinity.

The Breathitt formation of the Pennsylvania Age dominates the surface geology of the District. This formation thickens from north to south and ranges from about 1,300 feet thick in eastern Breathitt County to about 2,500 feet thick in southern Leslie County.

The U. S. Geological Survey recognizes 23 principal coal beds in the District of which 21 contain estimated reserves.[1] Of these, seven have been strip-or auger-mined (fig. 2).

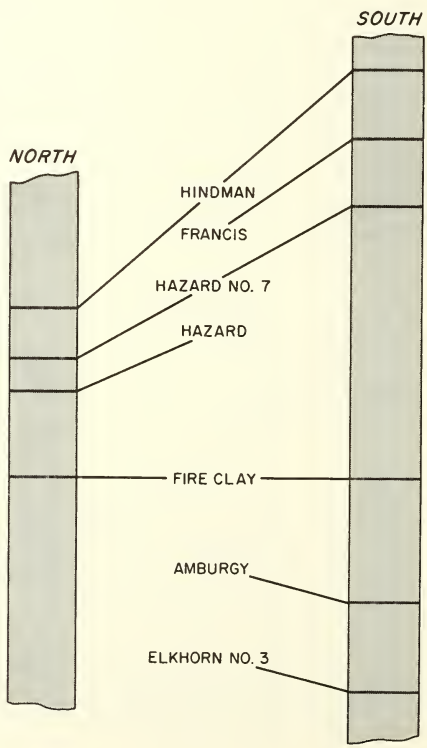

Figure 2.—Relative position of the coal beds mined by the open pit method in the Hazard Coal Reserve District.

Table 1.—Disturbed area by counties and coal seams in the Hazard Coal Reserve District, in acres

Coal seam	Breathitt County	Harlan County	Leslie County	Letcher County	Knott County	Perry County	Total
Elkhorn No. 3	—	—	—	974	—	—	974
Amburgy	—	—	—	381	—	—	381
Fireclay	38	—	215	677	175	—	1,105
Hazard	—	—	108	—	—	223	331
Hazard No. 7	219	—	—	367	662	1,470	2,718
Francis	—	310	92	—	—	—	402
Hazard No. 9	1,554	338	77	—	2,226	2,958	7,153
Total	1,811	648	492	2,399	3,063	4,651	13,064
Percent of land area disturbed	0.6	1.4	0.2	1.2	1.3	2.1	1.0

Distribution of Stripped Area

By 1964, a total of 13,064 acres or 1 percent of the total land area had been disturbed (excluding coal-haul roads) by strip-and auger-mining (table 1). Perry County had the largest acreage disturbed (4,651 acres) and the highest percent of area disturbed (2.1 percent), Letcher and Knott Counties also had large acreages disturbed.

For the seven seams mined, the Hazard No. 9 and Hazard No. 7 accounted for 76 percent of the disturbance. The Hazard No. 9 contributed 55 percent, and the Hazard No. 7 contributed 21 percent. Other coal seams strip-mined in the District were the Fireclay, Hazard, Francis, Amburgy, and the Elkhorn No. 3.

Physical Characteristics of the Disturbed Areas

There are two basic types of strip-mining in the eastern Kentucky coal field: contour-or rim-stripping, and area-stripping. Auger-mining usually is employed as a supplement to contour-mining; it is a means for working a seam beyond the point where removal of the overburden by stripping is economically feasible. In this District 94 percent of the disturbance has resulted from contour-mining. All of the area-stripping occurred on the ridge tops.

In the contour-stripping, 10 percent of the disturbed area was on or above the highwall; 47 percent was in pits, inslopes, and leveled or unleveled benches above the outslopes; and 43 percent was in outslopes. Of the 5,280 acres in outslopes, 11 percent was in slides or slumps.

Table 2.—Coal-haul road disturbed acreage and mileage by county and road classes in the Hazard Coal Reserve District

Class of haul road	County												Total	
	Breathitt		Harlan		Knott		Leslie		Letcher		Perry			
	Acres	*Miles*	*Acres*	*Miles*	*Acres*	*Miles*	*Acres*	*Miles*	*Acres*	*Miles*	*Acres*	*Miles*	*Acres*	*Miles*
I	46	8.1	26	4.6	102	17.9	13	2.3	102	17.8	137	24.0	426	74.7
II	18	3.2	46	8.1	56	9.8	—	—	48	8.4	66	11.6	234	41.1
III	13	2.3	8	1.4	3	.5	—	—	10	1.8	—	—	34	6.0
Total	77	13.6	80	14.1	161	28.2	13	2.3	160	28.0	203	35.6	694	121.8

On 85 percent of the contour-stripping operations, there had been some grading of the spoil between the outslope and the highwall or pit. About 45 percent of the contour-stripping operations was graded to nearly level benches. Much of this leveling has been done since 1954 when the State enacted legislation requiring reclamation of disturbed areas.

All the area-stripping—784 acres—was done on the ridge tops where the overburden was relatively shallow. The proportional distribution of the disturbed area by bank position was as follows: on or above the highwalls, 1 percent; leveled or unleveled benches above the outslope, 49 percent; and outslopes, 50 percent. Slides and slumps occurred on 46 percent or on 180 of the 392 acres in outslopes.

Sixty-eight percent of the area-stripping has not been leveled. Much of this disturbance occurred before enactment of a state reclamation law. Twenty-eight percent has been graded to a nearly level bench, and 4 percent has been partially leveled.

In all stripping operations, the operator must build and maintain a network of roads for hauling coal from the mines. In this survey we classified haul roads as: primary (running from a public road to the mine); secondary (joining two pits or serving as spurs for primary roads); or third class (service roads and temporary haul roads).

We estimate 696 acres had been disturbed by coal-haul roads in this District. This figure was computed directly from dot counts on the aerial photographs. By field measurement we determined that the average width of disturbance for the District's coal-haul roads was 47 feet. Therefore, there were 5.7 acres disturbed per mile of road; and we estimate there are about 122 miles of coal-haul roads in the District. This mileage was distributed among the three classes as follows: primary, 75 miles; secondary, 41 miles; and third class, 6 miles (table 2). On the average there are 107 acres of strip-mine disturbance for each mile of coal-haul road.

Ninety-two percent of these roads run through forested country. Over two-thirds are built along mountain slopes away from tributary streams. Thirty-one percent of the primary roads and 6 percent of the secondary roads were built in the valley bottoms. All of the third class roads were built on the slopes or ridges.

—WILLIAM T. PLASS
Plant Ecologist
Northeastern Forest Experiment Station
Forest Service, U. S. Department of Agriculture
Berea, Kentucky

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LAND DISTURBANCES FROM STRIP-MINING IN EASTERN KENTUCKY 6. SOUTHWESTERN COAL RESERVE DISTRICT

Abstract. Results of an airphoto survey to determine the extent of land disturbance by coal mining and by coal-haul roads in one of the six coal-reserve districts of eastern Kentucky. Describes the district, forest cover, physiography and geology, and distribution and physical characteristics of the acres disturbed in this district.

Open-pit or strip-mining—primarily for coal—has expanded rapidly in eastern Kentucky during the past 15 years. Information about the amount, location, and general characteristics of the disturbed areas is necessary for appraising the economic impacts and overall effects of strip-mining in that section of the state, for planning reclamation programs, and for determining research needs and priorities. The Northeastern Forest Experiment Station made a survey of eastern Kentucky to obtain reliable estimates of the acreage disturbed both by the mining itself and by the associated coal-haul roads, and to provide relevant information about the disturbed areas. The survey was based on aerial photographs of all stripped areas as of October 1964.

The survey was broken down in accordance with the six subdivisions or coal-reserve districts delineated by the U. S. Geological Survey.[1] Thus there will be a series of six reports, of which this is the sixth and last.

The method used in our survey was a modification of forest-survey procedure. A 3-by-6-inch transparent template with 25 dots per square inch was positioned over the center of each photograph. Areas on the photographs that appeared to be stripped land or coal-haul roads were

[1]Huddle, J. W., F. J. Lyons, H. L. Smith, and J. C. Ferm. Coal reserves of Eastern Kentuky. U. S. Geol. Survey Bull. 1120, 147 pp., 1963.

examined stereoscopically to determine important characteristics, and the amount of area in various categories was estimated by dot counts.

The Southwestern Coal Reserve District

The "mechanical" method of strip-mining—using horse-drawn plows and scrapers to remove the overburden—probably began in Kentucky about 1870, at London.[2] The first steam shovel to strip-mine coal in Kentucky began operation near Lily, south of London, in 1905. Therefore we consider the Southwestern District the cradle of strip-mining in eastern Kentucky.

This 2.4-million-acre District includes all of Clay, Knox, Laurel, Jackson, Lee, McCreary, and Owsley Counties as well as parts of Bell, Clinton, Estill, Pulaski, Rockcastle, Wayne, and Whitley Counties (fig. 1). Clay, Knox, Laurel, and Whitley Counties each had 2,000 or more acres disturbed by strip-mining.

The earliest recorded production of coal in Kentucky was from Lee County in 1790. No other District recorded production until 1824, when mines in Greenup County opened. Before the 1840's half of the production in eastern Kentucky came from this District. Today, the District produces less than 10 percent of eastern Kentucky coal. Through 1955, total recorded production from the District's mines was 144 million tons.

In 1962, production totaled 4.8 million tons. Of this, 1.6 million tons or 33 percent of the total production came from strip-and auger-mining.[3] Fifty-eight percent of the tonnage from open-pit mining came from strip mines, and the remainder came from auger mining.

The total disturbed acreage in the District by 1947 was 547 acres.[4] This was located in Laurel and Whitley Counties. About three-fourths of this acreage was less than 5 years old.

The original coal reserves (measured, indicated, and inferred) in the District total 4.6 billion. Of these about 400 million are in beds more than 42 inches thick, and 2.2 billion tons are in beds over 28 inches thick. Clay, Knox, Whitley, and McCreary Counties contain 67 percent of the reserves. The coal reserves in the Breathitt formation represent 69 percent of the total, and the coal reserves in the Lee formation represent 31 percent of the total.

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[2]Montgomery, Robert. STRIP MINING IN KENTUCKY. Kentucky Dep. Natural Resources, 56 pp., 1965.
[3]Mandt, A. H. ANNUAL REPORT. Ky. Dep. Mines and Minerals, 166 pp., 1963.
[4]Merz, Robert W. CHARACTER AND EXTENT OF LAND STRIPPED FOR COAL IN KENTUCKY. Ky. Agr. Exp. Sta. Circ. 66, 278 pp., 1949.

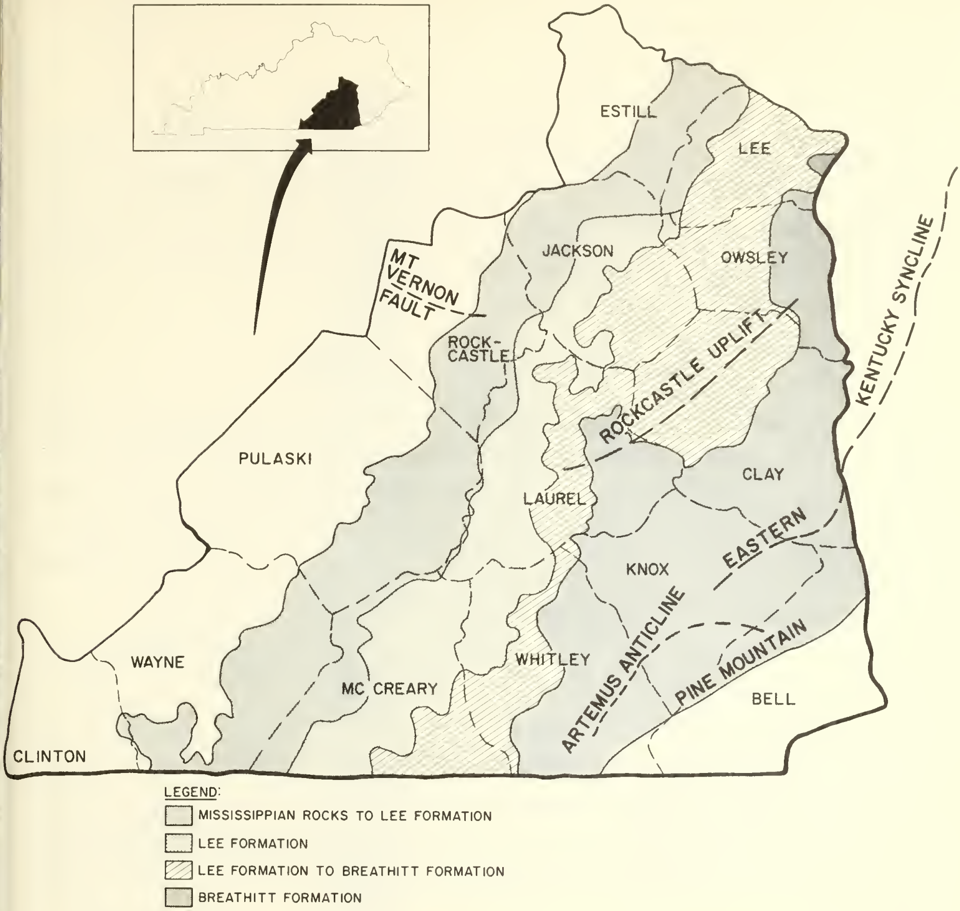

Figure 1.—Geologic and geographic features of the Southwestern Coal Reserve District.

Forest Cover

Forests cover about 77 percent of the District's land area.[5] [6] In the rugged eastern mountains most of the non-forest land occurs in the valley bottoms. To the west along the Cumberland Plateau there is no pattern for forest and non-forest use. About half of the strip and auger mines are located on the upper slopes or ridges. Seventy-eight percent of the disturbed land has forest immediately below the mine site.

[5]United States Forest Service and Kentucky Department of Natural Resources. BASIC FOREST RESOURCE STATISTICS, SOUTHERN CUMBERLAND UNIT, KENTUCKY, 1963. 1965. (Unpublished preliminary report on file at Kentucky Division of Forestry and the Northeastern Forest Experiment Station, Upper Darby, Pa.)

[6]United States Forest Service and Kentucky Department of Natural Resources. BASIC FOREST RESOURCE STATISTICS, PENNYROYAL UNIT, KENTUCKY, 1963. 1965. (Unpublished preliminary report on file at Kentucky Division of Forestry and the Northeastern Forest Experiment Station, Upper Darby, Pa.)

Fifty-three percent of the acreage in forests is in sawtimber-size stands. White oak, hickory, and central mixed hardwood types predominate. The southern pine and oak-pine types represent 21 percent of the total forest acreage. This is the highest percentage of these types for all coal reserve districts in eastern Kentucky.

Physiography and Geology

The District has three physiographic provinces; from west to east they are: the Pottsville escarpment, characterized by steep sandstone cliffs and gorges; the Cumberland Plateau with modified topography; and the eastern Mountains with V-shaped valleys, steep slopes, and narrow ridges. The Kentucky River drains the District on the north and east, and the Cumberland River drains the remainder of the District.

Several minor features control the structural geology and affect correlation of coal seams within the District. The most prominent of these features are the Mount Vernon fault in Rockcastle County; the Rockcastle uplift in Laurel, Clay, and Owsley Counties; and the Artemus anticline in Whitley and Knox Counties. The southwesterly extension of the eastern Kentucky syncline in Clay and Knox Counties and the Pine Mountain fault along the southeastern boundary of the District are also important.

We recognize four zones in the District that characterize the surface occurrence of rocks from the Mississippian era and the Lee and Breathitt formations of the Pennsylvanian era. These zones and the percent of the total District area they occupy are as follows: transition from Mississippian rocks to the Lee formation, 27 percent; the Lee formation, 16 percent; the transition from the Lee formation to the Breathitt, 22 percent; and the Breathitt formation, 35 percent.

In the Lee formation the authors of *Coal Reserves of Eastern Kentucky* recognize three commercially important coal beds. However, geologic quadrangle maps of Pulaski and Rockcastle Counties show another commercial coal bed. Because of this disagreement in nomenclature, we consider the coal seam in Pulaski and Rockcastle Counties as the fourth commercially important coal bed in the Lee formation. All of these have been strip-mined (fig. 2).

Fifteen coal beds have been named in the Breathitt formation, and 13 of these are thick and extensive enough to contribute to the total reserves. Of these, seven have been strip- or auger-minded.

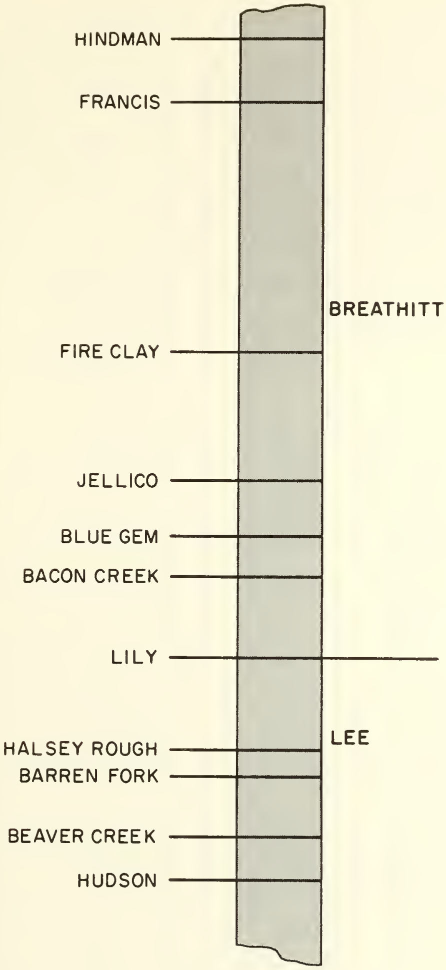

Figure 2.—Generalized geologic column for coal seams strip- and auger-mined in the Southwestern Coal Reserve District.

Distribution of Stripped Areas

By 1964 strip- and auger-mining (excluding coal-haul roads) had disturbed 16,995 acres in the District (table 1). Clay County (4,290 acres or 1.4 percent of the land area) and Whitley County (3,933 acres or 1.3 percent of the land area) had the most disturbance. Knox and Laurel Counties each had over 2,000 acres of disturbance, and Bell and McCreary Counties had over 1,000 acres of disturbance.

Where the Breathitt formation outcrops, 14,840 acres or 11 percent of the land area had been disturbed. For areas where the Lee formation is exposed the disturbance affected 2,155 acres or 0.2 percent of the land area. Most of this disturbance occurs in the Mississippian to Lee transition zone.

Table 1.—Disturbed area by counties and coal meams in the Southweastern Coal Reserve District, in acres

Formation	Coal Seam	County												Total
		Bell	Clay	Jackson	Knox	Laurel	Lee	McCreary	Owsley	Pulaski	Rock-castle	Wayne	Whitley	
Lee	Hudson	—	—	34	—	—	—	—	—	—	—	—	—	34
	Beaver Creek	—	—	—	—	—	—	116	—	26	—	107	271	520
	Barren Fork	—	—	134	—	—	—	232	—	—	—	—	322	688
	Halsey Rough	—	—	—	—	—	—	—	—	584	329	—	—	913
Breathitt	Lily	—	3,629	—	—	1,954	77	966	383	—	—	—	1,132	8,141
	Bacon Creek	—	112	—	15	—	—	—	—	—	—	—	12	139
	Blue Gem	16	386	—	174	—	—	—	—	—	—	—	102	678
	Jellico	430	73	—	1,187	69	—	—	—	—	—	—	1,512	3,271
	Fireclay	—	90	—	1,028	138	—	—	—	—	—	—	582	1,838
	Francis	281	—	—	—	—	—	—	—	—	—	—	—	281
	Hindman	463	—	—	29	—	—	—	—	—	—	—	—	492
Total acreage disturbed		1,190	4,290	168	2,433	2,161	77	1,314	383	610	329	107	3,933	16,995
Percent of District land area disturbed		1.5	1.4	0.1	1.0	0.8	0.1	0.5	0.3	0.4	0.3	0.1	1.3	0.7

The uncorrelated Halsey Rough coal seam had the greatest acreage of disturbance from Lee formation coal beds. In decreasing acreage of disturbance were the Barren Fork and the Beaver Creek coal beds. A very small acreage was disturbed by surface mining from the Hudson coal seam.

Over half of the disturbance (8,141 acres) from coal seams of the Breathitt formation resulted from mining the Lily coal seam. This seam occurs at the base of the Breathitt formation. Next in importance in terms of acreage disturbed were the Jellico and Fireclay coal seams. The Bacon Creek, Blue Gem, Francis, and Hindman coal seams also have been strip- or auger-mined.

Physical Characteristics of Disturbed Areas

There are two basic types of strip-mining in the eastern Kentucky coal field: contour- or rim-stripping and area-stripping. Auger-mining usually is employed as a supplement to contour-mining; it is a means for working a seam beyond the point where removal of the overburden by stripping is economically feasible. In this District 92 percent of the stripping has resulted from contour-mining.

In the contour-stripping, 14 percent of the disturbed area was on or above the highwalls, 45 percent was in pits, inslopes, and leveled or unleveled benches above the outslopes, and 41 percent was on outslopes. Of the 6,410 acres in outslopes, 609 acres or 9.5 percent were in slides.

Forty percent of the contour-stripping had been leveled, and 9 percent had been partially leveled. The remaining 51 percent that is unleveled is assumed to have occurred before 1954, when the Commonwealth of Kentucky enacted a reclamation law.

The 1,360 acres of area-stripping occurred as frequently on the upper slopes and ridges as on the lower slopes and in the valleys. The proportionate distribution of the disturbed area by bank position was as follows: on or above the highwall, 9 percent; pit, inslope, leveled and unleveled benches above the outslope, 70 percent; and outslopes, 21 percent. Slides or slumps occurred on 8 percent or 23 acres of the 286 acres in outslopes.

Forty-three percent of the area stripping had been leveled, and 10 percent had been partially leveled. The remaining 47 percent was considered unleveled.

In all stripping operations, the operator must build and maintain a network of roads for hauling coal from the mines. In this survey we classified haul roads as: Primary (running from a public road to the mine); secondary (joining two pits or serving as spurs for primary roads); and third class (service roads and temporary haul roads).

Table 2.—Coal-haul road disturbed acreage and mileage by county and road classes in the Southwestern Coal Reserve District

County	Class I		Class II		Class III		Total	
	Acres	*Miles*	*Acres*	*Miles*	*Acres*	*Miles*	*Acres*	*Miles*
Bell	86	19.1	28	6.2	20	4.4	134	29.7
Clay	119	26.5	24	5.3	2	.4	145	32.2
Jackson	—	—	5	1.1	—	—	5	1.1
Knox	184	40.9	79	17.6	20	4.4	283	62.9
Laurel	56	12.5	20	4.4	13	2.9	89	19.8
Lee	5	1.1	3	.7	—	—	8	1.8
McCreary	43	9.5	23	5.1	5	1.1	71	15.7
Owsley	20	4.4	—	—	—	—	20	4.4
Pulaski	24	5.3	14	3.1	5	1.1	43	9.5
Rockcastle	31	6.9	28	6.2	2	.4	61	13.5
Wayne	8	1.8	5	1.1	2	.4	15	3.3
Whitley	140	31.1	128	28.4	21	4.7	289	64.2
Total	716	159.1	357	79.2	90	19.8	1,163	258.1

We estimate that 1,163 acres had been disturbed by coal-haul roads in this District. This figure was computed directly from the dot counts on the aerial photographs. After determining by field measurement that the average width of disturbance was 37 feet, we determined that the average road disturbance was 4.5 acres per mile. Therefore, we estimate there are 258 miles of coal-haul roads in the District. This mileage was distributed among the classes as follows: primary, 159 miles; secondary, 79 miles; and third class, 20 miles (table 2). On the average, there are 66 acres of strip-mining disturbance for each mile of coal-haul road.

Eighty-eight percent of these roads were built through forested land. Over 70 percent were built along slopes away from the valley bottoms and streams. About 15 percent were built within 100 feet of streams.

—WILLIAM T. PLASS
Plant Ecologist
Northeastern Forest Experiment Station
Forest Service, U. S. Department of Agriculture
Berea, Kentucky

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U. S. FOREST SERVICE RESEARCH NOTE NE-73
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LIGHT-WEIGHT EXTENSION TUBES FOR COMPRESSED-AIR GARDEN SPRAYERS

Abstract. To hand-spray taller trees safely and efficiently, 8-, 12-, and 16-foot extension tubes for compressed-air garden sprayers were designed and built. These light-weight tubes have been used successfully for spraying white pine leaders for weevil control on the Massabesic Experimental Forest in Maine. Bill of materials and assembly instructions are included.

Garden sprayers of the compressed-air type are often used to apply insecticides or other materials on small jobs or in other situations where power sprayers would not be practical. These garden sprayers usually come equipped with 2 to 3 feet of flexible hose and a 20-inch metal extension tube. Trees up to 6 feet tall can be sprayed with the unit. By replacing the standard tube with a 6-foot length of ¼-or ⅜-inch i.d.[1] aluminum pipe, trees up to 10 feet tall can easily be sprayed.

However, situations often occur where it is necessary to spray trees taller than 10 feet. The need for a longer reach is particularly acute in spray regimes that call for protecting the leaders of young white pine trees from attack by the white-pine weevil (*Pissodes Strobi* Peck.).

But difficulties are encountered in attempting to spray these taller trees because 6 feet is about the practical maximum length of ¼- or ⅜-inch pipe that can be used as an unsupported extension tube for such work. The increased weight of pipe and spray material, and the added leverage created by the longer length, may cause the pipe to break at the threaded end. Moreover, when lengths of pipe 10 feet and longer are assembled,

[1]The abbreviations i.d. and o.d. are used in this note to denote inside diameter and outside diameter respectively.

Figure 1.—Spraying a young white pine for weevil control with the equipment described. The device on the upper end of the tube is a spray deflector, an optional extra attachment that helps direct the spray onto the pine leaders.

greater pressures are needed to support the column of liquid in the tube and to deliver it through the spray nozzle with sufficient pressure for effective coverage. More frequent pumping is required to maintain this pressure. Also, gaskets and hose connections tend to spring leaks or blow out under the higher pressures. Occasionally, the operator is partly soaked with spray material when a connection breaks. This is a hazard to his safety and health.

To hand-spray taller trees safely and efficiently, we designed and built 8-, 12-, and 16-foot extension tubes for compressed-air garden sprayers. These have been used successfully for spraying white pine leaders for weevil control on the Massabesic Experimental Forest in Maine (fig. 1). However, the 16-foot length was found to be too long for easy carrying and handling in stands of trees under normal working conditions in the field. A tube of this length will be useful mainly in research work where its full reach is needed to treat taller trees than would ordinarily be sprayed in routine weevil-control operations.

The extension tube consists of a support member made of aluminum tubing, a 1/8-inch i.d. copper tube to carry the liquid, and a flexible line to connect the copper tubing to the spray tank. If 1/8-inch copper tubing is used instead of the 1/4-or 3/8-inch tubing ordinarily used, the volume of liquid that has to be supported is greatly reduced; consequently both pressure requirements and the danger of leaks and blown gaskets are reduced.

Weights of assembled 1/8-inch tubes of different lengths, without nozzles and shut-off controls, are:

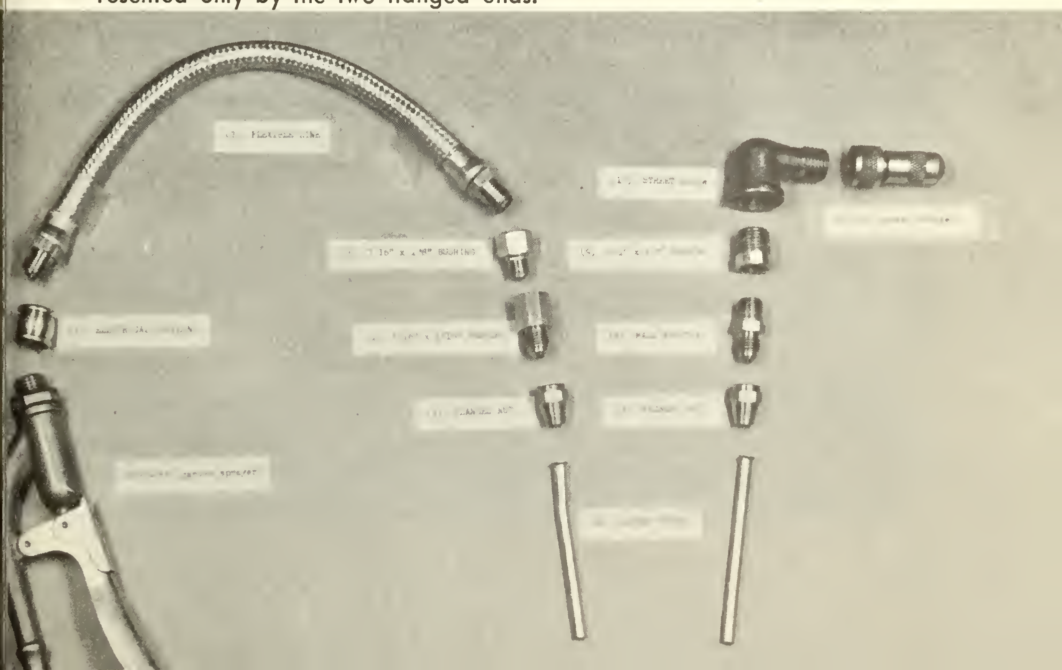
Length (*feet*)	*Weight* (*pounds*)
8	2 1/2
12	3 1/2
16	6 1/2

To assist others who may wish to convert a standard compressed-air garden sprayer into an effective tool for spraying taller trees, a description of the materials needed, together with instructions and illustrations for assembly, are presented below:

Materials

The various items required to assemble 8-, 12-, and 16-foot extension tubes are listed by tube length in the following bill of materials, and are illustrated in figures 2 and 3.

Figure 2.—The separate parts required for assembling an extension tube, except for the supporting aluminum tube. Copper tube is represented only by the two flanged ends.



	Cost[2]
8-Foot Extension	
Aluminum tubing, ¾-inch o.d. x 0.083 inch wall[3], 12 feet	$4.50
Copper tubing, soft, 3/16-inch o.d., 8 feet @ 13c per foot	1.04
Flexible line (Edelmann Co. No. 482-9[4])	1.40
Brass fittings, (see detailed list), set	1.54
	$8.48

12-Foot Extension	
Aluminum tubing, ¾-inch o.d. x 0.083 inch wall, 12 feet	$4.50
Copper tubing, soft, 3/16-inch o.d., 12 feet @ 13c per foot	1.56
Flexible line (Edelmann Co. No. 482-9[4])	1.40
Brass fittings, (see detailed list), set	1.54
	$9.00

16-Foot Extension	
Aluminum tubing, ¾-inch o.d. x 0.083 inch wall, 12 feet	$4.50
Aluminum tubing, 1-inch o.d. x 0.125 inch wall[5], 6 feet	4.25
Copper tubing, soft, 3/16-inch o.d., 16 feet @ 13c per foot	2.08
Flexible line (Edelmann Co. No. 482-24[4])	2.07
Brass fittings, (see detailed list), set	1.54
	$14.44

Brass Fittings	
Electrical coupling, pipe thread, ¼-inch x ⅛-inch	$0.15
Bushings, pipe thread[4], 3/16-inch x ⅛-inch	0.00
Bushing, (pipe thread to flared copper) 3/16-inch x 3/16-inch	.27
Nut, flared copper, 3/16-inch, @ 10c each (2 each)	.20
Male adapter, (flared copper to pipe thread), 3/16-inch x ⅛-inch	.23
Street elbow, ¼-inch, 90°	.50
	$1.54

All items were purchased from established supply sources: aluminum tubing from a regional aluminum supply center; flexible line, including one fitting, from a local auto-parts supply company; and all other items from a local hardware store.

Assembly Instructions

The parts referred to by name or number in the following instructions are identified and pictured in figure 2.

[2]Purchase price as of March 1965.

[3]Aluminum tubing is sold only in 12-foot sections. There is an additional cutting charge if shorter sections are desired.

[4]Mention of a particular product should not be construed as an endorsement by the Forest Service or the U. S. Department of Agriculture. The Edelmann kit contains one fitting used in the assembly: the 3/16- by 1/8-inch bushing.

[5]This is half of a purchased 12-foot section of aluminum tubing that cost $9.50.

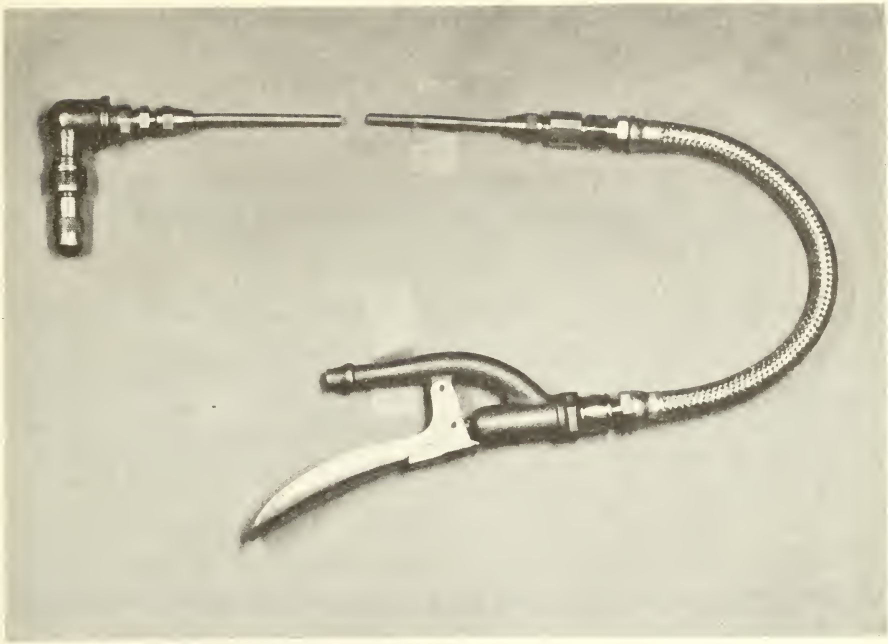


Figure 3.—Same parts as in Figure 2, assembled.

Aluminum Tube Assembly.

1. Ream one end for a distance of about 5 inches with a ⅝-inch drill. This is not necessary for the 16-foot extension tube.

2. At the other end, to take the modified bushing, (part 9—see *parts assembly,* item 3, below), file a short groove in the inner wall of the tube with a triangular file.

3. To make a 16-foot extension, insert the 12-foot section of ¾-inch tube about 2 feet into the 1-inch tube and rivet in that position. Use "pop" rivets and the special tool for placing them so that the inside of the tube will not be obstructed.

Parts Assembly.

In the process of assembly, part of the flexible line is drawn into the reamed end of the aluminum tube in order to cut copper tubing the proper length and to put the nozzle end together. When the nozzle end assembly is seated in place on the aluminum tube, the locations for rivets through the tube will be concealed. Consequently, reference points need to be established and measurements taken to correctly locate rivet holes.

1. Lay out parts as shown in figure 2.
2. File points (the angled corners) of bushing, part 4, so that it fits easily into reamed end of aluminum tube.
3. File all but one point of bushing (part 9) so that it fits snugly into grooved end of aluminum tube. Unfiled point of bushing will fit into groove made for it.
4. Assemble and tighten fittings for shut-off end (parts 1-4). File a groove to enlarge the gap between the bushings (parts 3 and 4). Allow enough room to take $1/8$-inch, off-center rivet through the aluminum tube (see item 14 below). Make a mark on the shoulder of the flexible line in such a way that the position of the groove can be visualized when inside the tube.
5. Measure and record distance from the junction of electrical coupling and flexible line (part 1 and 2) to the groove at junction of bushings (parts 3 and 4).
6. Assemble and tighten fittings for nozzle end (parts 8 to 10). If the gap between parts 8 and 9 is not wide enough to take a $1/8$-inch off-center rivet (see item 16 below), enlarge as in item 4 above.
7. Place a flanged nut on one end of the copper tubing, flange the tubing, and attach flanged nut to flexible line assembly.
8. Insert copper tubing into aluminum tube with the shoulder of the flexible line just inside the reamed end of the aluminum tube.
9. Mark a point on the copper tubing flush with the grooved end of the aluminum tube. Pull copper tubing out as far as it will go (flexible line is pulled 3 or 4 inches into reamed end of the aluminum tube).
10. Measure distance from the larger or near end of the street elbow, (part 10) to the smaller end of adapter (part 8), and measure back this amount from mark previously made on copper tubing. Cut the copper tubing at this point.
11. Place flanged nut on copper tubing, flange the tubing, and attach flanged nut to nozzle end assembly.
12. Measure and record distance from near end of the elbow (part 10) to junction of bushing and adapter (parts 9 and 8).

13. Seat street elbow on end of aluminum tube with point of bushing, (part 9) in groove. The opposite end of the aluminum tube will then be about flush with the shoulder of the flexible line.

14. At this (the shut-off) end of the aluminum tube, mark a point at the distance recorded under item 5. Drill a 1/8-inch off-center hole through the aluminum tube at this point, oriented according to the mark specified in item 4 so the rivet will pass through the groove between the bushings (parts 3 and 4).

15. Insert rivet and head it.

16. Mark point on nozzle end of aluminum tube at distance recorded under item 12. Drill a 1/8-inch off-center hole through the aluminum tube at this point, passing through the gap at junction of the bushing and adapter (parts 9 and 8).

17. Insert rivet and head it. This completes the assembly.

However, there is one additional alteration that will be found helpful, particularly when the spray tank is mounted on a pack board. This is to replace the standard 2- or 3-foot length of hose connecting the tank to the shut-off control with a longer hose. The 3-foot or shorter hose limits movement of the extension tubes; a 6-foot length permits ample freedom of movement and makes it possible to carry the longer extension tubes closer to the center of balance (fig. 4).

It will be noted in the bill of materials that the flexible line specified for the 16-foot extension bears a different manufacturer's number than the lines for 8- and 12-foot extensions. The line for the 16-foot extension is longer, and is recommended because its length allows it to be bent back over the extension tube and taped in that position. This permits the sprayman to use both hands to manipulate the longer, heavier tube and still operate the shut-off valve. With the shorter, lighter tubes, the leverage provided by the use of both hands is not generally needed.

The spray deflector visible at the nozzle end of the tube in figures 1 and 4 is a useful optional attachment when spraying pine leaders. It is a home-made device fashioned from a 1-quart motor-oil can. Both ends of the can are removed, the resulting cylinder is cut lengthwise, and the edges are then pulled apart to leave a gap about 2 inches wide. Then a hole big enough to fit over the male fitting of the nozzle is made in the cylinder wall midway between the ends and about 2 inches from one edge of the gap. The deflector is installed by inserting the threaded end of the

Figure 4.—Sprayer equipped with 6 feet of hose between tank and shut-off valve, which allows the 12-foot extension tube to be carried near its center of balance.

male fitting through the hole so that the cylinder wall rests against the shoulder of the fitting and will be held in place when the female section of the nozzle is attached. Finally, the angle of the deflector should be adjusted so as to be about vertical when the tube is in position for spraying.

In use, the deflector is positioned to surround the pine leader. As the spray solution comes from the nozzle, some of it strikes the near side of the leader and some of it bounces against the deflector to cover the far side.

—THOMAS W. McCONKEY and CHARLES E. SWETT

Silviculturist (retired) and
Forestry Research Technician
Massabesic Experimental Forest
Northeastern Forest Experiment Station
Forest Service, U. S. Department of Agriculture
Alfred, Maine

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MEASURING OXYGEN AND CARBON DIOXIDE IN RED OAK TREES

Abstract.—A method is described for collecting gas samples from tree trunks by placing a permanent probe in the tree and withdrawing samples with a portable vacuum pump. Marked quantitative differences were found between the concentration of gases in tree trunks and the concentration of gases in the atmosphere.

Decay columns in trees may become inactive after the entry point has healed. The inactivation or dying of the decay organism may be due to the formation of adverse levels of gases in the tree trunk after the exchange of gases between the atmosphere and the inside of the tree has stopped (*4*). A study was conducted to develop a method for measuring gas concentrations in tree trunks and to determine if these levels were sufficiently different from those in the atmosphere to justify a more thorough study of gas levels in tree trunks.

Materials and Methods

The method developed to collect gas samples from tree trunks consists of placing a permanent probe in the tree and withdrawing samples from the tree with a portable vacuum pump. The permanent probe is used so that sampling can be repeated.

The probe consists of a 1/4-inch galvanized pipe. A brass on-off valve and a hose connection are sealed on one end of the pipe with Teflon[1] pipe dope. The other end of the pipe is threaded, and the length of the threading equals the depth the pipe will be placed in the tree. Before it is used, the probe is sterilized in an autoclave for 20 minutes at 15 psi.

[1] Mention of a product does not imply endorsement by the U. S. Department of Agriculture.

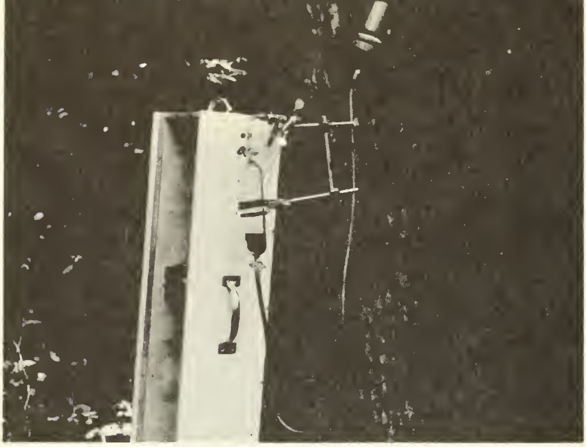

Figure 1.—Gas sampling apparatus and gas analyzer mounted on a red oak tree.

Before the probe is placed in the tree, a layer of outer bark is removed with a drawknife, and the exposed area is surface-sterilized with 95% ethanol. Next, an alcohol-sterilized increment borer is used to remove a core that can be examined for conditions inside the tree. The hole is then enlarged to the desired depth with an alcohol-sterilized 7/16-inch bit. The sterilized probe is placed in the hole by turning the probe with a pipe wrench until the probe is within 2 inches of the bottom of the enlarged hole. The hole is then sealed with a mixture of one part Venice turpentine and two parts beeswax to prevent gas leakage (*1*).

The portable vacuum pump is mounted on a framework made of 1/2-inch aluminum rods and a large support clamp. The framework is attached to the probe (fig. 1).

The portable vacuum pump consists of a gas-collecting cylinder connected to a mercury reservoir. The 250-ml gas-collecting cylinder has a 3-way stopcock on top and a 2-way stopcock on the bottom. This cylinder is mounted in the support clamp. The 3-way stopcock is connected to the probe with capillary glass tubing and 1/4-inch Nalgon plastic tubing, and it is connected to a portable gas analyzer (*3*) with 1/4-inch rubber tubing. The 2-way stopcock is connected to a mercury reservoir by 4 feet of 1/4-inch Nalgon plastic tubing. The reservoir is made of 2-inch galvanized pipe, 6 inches long, and holds 350 ml of mercury.

To operate the pump, the gas-collecting cylinder is filled with mercury by raising the reservoir. The mercury is then removed from the cylinder by lowering the reservoir to create a partial vacuum. The 3-way stopcock is opened so air in the tubing between the cylinder and the probe is pulled into the cylinder. This air is then passed out of the cylinder through the gas analyzer by readjusting the 3-way stopcock and raising the mercury reservoir. A sample is then pulled from the tree by opening the valve on the probe and the 3-way stopcock and lowering the reservoir.

After a sample of the desired size is collected the valves are closed, and the reservoir is raised so the gas can be forced into the gas analyzer.

The trees used in this study were northern red oak (*Quercus rubra* L.) over 10 inches d.b.h. At least 1 week elapsed between the time the probe was placed in a tree and the time the first sample was collected. This time allowed the air in the tree and the pipe to equilibrate.

Results and Discussion

This method gave reproducible results if care was taken to avoid the sources of error. The sources of error are: (1) the length of time required to collect the sample and (2) the size of the sample.

The sample should be collected as rapidly as possible, especially on trees from which the sample is difficult to collect. A sample collected rapidly (15 seconds) contained 4.2% carbon dioxide and 0.9% oxygen; whereas a second sample collected immediately after the first, but at a slower rate (60 seconds), contained 15.2% carbon dioxide and 0.4% oxygen.

The higher carbon dioxide concentration in the latter sample may have been due to the liberation of dissolved carbon dioxide when water inside the tree was subjected to a high partial vacuum for a longer period of time. In laboratory studies, when a high partial vacuum was placed on water that had been exposed to high levels of carbon dioxide, the gas collected contained over 50% carbon dioxide. Therefore, the shorter the sampling time, the smaller will be the amount of carbon dioxide liberated and the smaller will be the carbon dioxide contamination of the gas sample.

The size of the sample should be no larger than necessary. The sample size is especially important in trees that have openings to the atmosphere. On one tree with an artificial opening, a small sample contained no measurable carbon dioxide and 1.9% oxygen; whereas a large sample, collected immediately after the first, contained no measurable carbon dioxide and 11.7% oxygen. The higher oxygen level in the second sample is probably due to oxygen from the atmosphere being pulled into the gas sample when a large sample was collected.

A further reason for using a small sample is that, with repeated sampling, the gas composition in apparently sound trees also changed (table 1). Gas from the atmosphere was apparently being pulled into the tree because the oxygen concentration increased even though no openings were visible. By using a small sample, the contamination of the gas sample by gases from other places in the tree and by gases in the atmosphere can be minimized.

By standardizing the procedure, reproducible results were obtained. In a healthy tree, which was sampled five times at weekly intervals in April and May 1965, carbon dioxide varied from 13.5% to 16.5%, and oxygen varied from 5.5% to 7.5%. These results are similar to those reported by Chase (*2*), who used a different method to collect gas.

These data collected from the various trees also show that the gas concentrations in tree trunks may be markedly different from the gas concentrations in the atmosphere. The concentration of carbon dioxide in the atmosphere is approximately 0.03%, and the concentration of oxygen is approximately 21%. The carbon dioxide concentration in tree trunks may be several hundred times higher than the atmospheric concentration of carbon dioxide, and the oxygen level in tree trunks may be less than 25% of the atmospheric concentration of oxygen.

Table 1. — Changes in gas concentrations with repeated sampling

Sample No.[1]	% CO_2	% O_2
1	30.7	2.3
2	22.4	8.3
3	20.5	10.7
4	20.3	10.7
5	16.9	12.6

[1] All samples were taken within a 40-minute period and were approximately 150 ml each.

Since the method reported here was effective in measuring the composition of gases in tree trunks, and since a marked difference was found between the levels of gases in tree trunks and the levels of gases in the atmosphere, more detailed studies will be conducted to determine the levels of gases both in healthy trees and in decaying trees.

Literature Cited

1. Anonymous. 1945. Burrell manual for gas analysts. 47 pp. Burrell Corporation, Pittsburgh.
2. Chase, Warren W. 1934. The composition, quality, and physiological significance of gases in tree stems. Minn. Tech. Bull. 99, 47 pp.
3. Jensen, K. F. 1966. A portable gas analyzer. Forest Prod. J. 16(6): 38-39.
4. Wagener, Willis W., and Ross W. Davidson. 1954. Heart rots in living trees. Bot. Rev. 20: 61-134.

—KEITH F. JENSEN
Plant Physiologist
Forest Insect and Disease Laboratory
Northeastern Forest Experiment Station
Forest Service, U. S. Dep. Agriculture
Delaware, Ohio

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J. S. FOREST SERVICE RESEARCH NOTE NE-75

1967

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DIAMETER INCREASE IN SECOND-GROWTH APPALACHIAN HARDWOOD STANDS — A COMPARISON OF SPECIES

Abstract.—A study of growth at d.b.h. among eight hardwood species after partial cutting in second-growth stands. Red oak grew fastest, followed in order by yellow-poplar, sugar maple, basswood, black cherry, white ash, beech, and chestnut oak.

Many second-growth Appalachian hardwood stands between 40 and 60 years old are being placed under management. The first operation in most of these stands is a conditioning cut. Before the cut is made, the timber marker has to choose which trees to leave for additional growth and development. So he needs to know the relative growth rates to be expected for the different species. This report provides such information for eight Appalachian hardwood species in middle-aged, previously unmanaged stands.

Study Area and Methods

Data for these comparisons were drawn from 10 compartments on the Fernow Experimental Forest near Parsons, W. Va. The second-growth stands on these areas were initially between 45 and 55 years old and all contained some residual stems from the previous commercial harvest cut. Each stand received a conditioning cut that was either an individual tree-selection cut (seven compartments) or a diameter-limit cut in which all trees over 17.0 inches d.b.h. were removed (three compartments). Most of the old residuals were removed in this first conditioning cut. Basal area after the cut ranged from 52 to 80 square feet per acre in trees over 5.0 inches d.b.h.

The 10 compartments ranged in size from 12 to 60 acres. Site indexes based on oak *(Schnur 1937, Trimble and Weitzman 1956)* ranged from 59 to 84.

Species composition on the better sites included yellow-poplar (*Liriodendron tulipifera* L.), northern red oak (*Quercus rubra* L.) black cherry (*Prunus serotina* Ehrh.), white ash (*Fraxinus americana* L.), basswood (*Tilia americana L.*), hickory (*Carya* sp.), sugar maple (*Acer saccharum* Marsh.), and a scattering of other species. On the poorer sites upland oaks, red maple (*Acer rubrum* L.), black gum (*Nyssa sylvatica* March.), sassafras (*Sassafras albidum* (Nutt.) Nees), and sourwood (*Oxydendrum arboreum* (L.) DC.) predominated.

We studied d.b.h. change, by species, of trees that were in the 13-to-21-inch diameter classes immediately after cutting. The few trees larger than 21 inches were excluded because they were old dominant residuals whose growth rates were not representative of second-growth stands. Trees below 13 inches were excluded because a large portion of them were sub-dominant trees even after the stand was cut, and their growth rates were influenced more by competition than by inherent species capacity. Moreover, many of these smaller stems would be removed in an intermediate cut under an even-aged system. The limitation of the study to trees between 13 and 21 inches was an attempt to work only with the "crop-tree" stand; that is trees in the upper intermediate, codominant, and dominant crown classes that were—after the stand was cut—essentially free to grow.

We computed average d.b.h. for each species on each of the 10 compartments immediately after cutting and again at the end of the measurement period, which ranged from 5 to 12 years.

Direct comparisons of average growth rates among species were not appropriate because site quality and stand density differed among the areas. Instead, comparisons were made by expressing d.b.h. growth of each species on each compartment as a percent of the red oak growth on that compartment. Red oak was chosen as the yardstick because it was the only species occurring in adequate numbers on all 10 compartments. The possibility that growth proportions between red oak and other species might not actually be similar on all study sites was accepted as an unavoidable risk.

Comparisons for a species were made only on compartments where there were 30 or more trees in the 13-to-21-inch group after cutting. No tabular entries were made for a species that was compared on fewer than three compartments.

Table 1.—Relative growth rates of the species studied

Species	Percent of red oak d.b.h. growth: Average	Percent of red oak d.b.h. growth: Range	Areas where species were compared	Total comparison trees
	Percent	*Percent*	*No.*	*No.*
Red oak	100	100-100	10	1,476
Yellow-poplar	85	75-100	6	819
Sugar maple	69	57-78	4	385
Basswood	62	47-81	4	333
Black cherry	58	39-81	6	607
White ash	57	34-94	3	191
Beech	46	38-59	3	221
Chestnut oak	45	41-52	3	162

Results

Of the species compared, red oak grew the fastest in d.b.h. after partial cutting (table 1). Yellow-poplar was a close second and had an average d.b.h. growth rate that was 85 percent that of red oak. This ranking agrees with that of another recently reported study *(Trimble 1967)*. Other species, in decreasing order of growth rate, were sugar maple, basswood, black cherry, white ash, beech (*Fagus grandifolia* Ehrh.), and chestnut oak (*Quercus prinus* L.). There were not enough hickory stems between 13 and 21 inches to meet the minimum-number standards set up for comparison.

Table 2.—Theoretical 10-year d.b.h. growth rates after cutting
(In inches)

Species	Site index 80			Site index 70		
	Average	High	Low	Average	High	Low
Red oak	3.2	—	—	2.4	—	—
Yellow-poplar	2.7	3.2	2.4	2.0	2.4	1.8
Sugar maple	2.2	2.5	1.8	1.7	1.9	1.4
Basswood	2.0	2.6	1.5	1.5	1.9	1.1
Black cherry	1.9	2.6	1.2	1.4+	1.9	.9
White ash	1.8	3.0	1.1	1.4—	2.3	.8
Beech	1.5	1.9	1.2	1.1+	1.4	.9
Chestnut oak	1.4	1.7	1.3	1.1—	1.2	1.0

However, computations made with lesser numbers on five compartments indicated a hickory d.b.h. growth that was 48 percent of red oak growth. This ranks hickory with beech and chestnut oak.

Actual 10-year d.b.h. growth for red oak after cutting in this and other studies has been between about 2.8 and 3.5 inches on site index 80, and between about 2.0 and 2.8 inches on site index 70. Using 3.2 and 2.4 inches as an approximation for site indexes 80 and 70 respectively, we have computed theoretical growth rates for the other species (table 2).

Discussion

These relative d.b.h. growth rates provide one basis for determining which species to favor in partial cuttings. However, these averages mask some important differences among species. For example, vigorous basswood, black cherry, or white ash of dominant crown positions are generally considered to grow faster than sugar maple in the same positions. And yet sugar maples of all types respond strongly to release *(Zillgitt 1950)*, whereas the less vigorous stems of the other three species often appear to respond poorly to release *(Trimble 1967, U. S. Forest Service 1965)*.

These characteristics may be inferred from the data in table 2, in which the growth rate of basswood, black cherry, and white ash in the "high" column is greater than that of sugar maple, even though the average rate of sugar maple growth is higher than that of the other three species. Vigorous yellow-poplar apparently do as well as vigorous red oak *(Holcomb and Bickford 1952, Trimble 1960)* even though they do not do as well on the average or perhaps do not respond as well to release at this age *(Trimble 1967)*.

With these results and inferences we can rate the potential future growth of the various species:

- First preference in selecting trees to leave after a partial cutting should be given to red oak and yellow-poplar. Dominant vigorous individuals of these two species should be rated about equally, but red oak should be favored over yellow-poplar among individuals of lower vigor or dominance class.

- Second preference should be given to sugar maple, basswood, black cherry, and white ash. Dominant vigorous individuals of the latter three species should be favored over sugar maple, but sugar maple should be favored over the other three species among individuals of lower vigor or dominance class.

- Beech, chestnut oak, and hickory should be be retained only when suitable individuals of the other species are not available. Although important differences in growth among these three species were not shown here, other studies indicate that chestnut oak responds well to release on fair sites (Trimble 1967) and that it generally grows faster than beech (Campbell 1955). Another study (Trimble 1960) indicates that it may be a faster grower relative to red oak than the data in table 2 show. It probably should be favored over beech and hickory.

These recommendations are based solely on relative d.b.h. growth rates and do not consider other important criteria like relative species values, merchantable height growth, markets, and owner's objectives.

— GEORGE R. TRIMBLE, JR.
Project Leader, Timber and Watershed Laboratory
Northeastern Forest Experiment Station
Forest Service, U. S. Dep. of Agriculture
Parsons, W. Va.

Literature Cited

Campbell, Robert A.
1955. Tree grades and economic maturity for some Appalachian hardwoods. SE. Forest Exp. Sta., Sta. Paper 53. 22 pp.. Athens, Ga.

Holcomb, Carl J., and C. Allen Bickford.
1952. Growth of yellow-poplar and associated species in West Virginia as a guide to selective cutting. NE. Forest Exp. Sta., Sta. Paper 52. 28 pp., Upper Darby, Pa.

Schnur, G. Luther.
1937. Yield, stand, and volume tables for even-aged upland oak forests. U. S. Dep. Agr. Tech Bull. 560. 88 pp., illus.

Trimble, George R., Jr.
1960. Relative diameter growth rates of five upland oaks in West Virginia. J. Forestry. 58: 111-115, illus.

Trimble, George R., Jr.
1967. Growth of Appalachian hardwoods as affected by site and residual stand density. U. S. Forest Serv. Res. Paper NE-98, In press. NE. Forest Exp. Sta., Upper Darby, Pa.

Trimble, G. R., Jr., and Sidney Weitzman.
1956. Site index studies of upland oak in the northern Appalachians. Forest Sci. 2: 162-173, illus.

United States Forest Service.
1965. Silvics of forest trees of the United States. Agr. Handbook No. 271, 761 pp., illus.

Zillgitt, W. M.
1951. Converting mature northern hardwoods stands to sustained yield. J. Forestry 49: 494-497.

J. S. FOREST SERVICE RESEARCH NOTE NE-76

1968

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DETERMINING SAP SWEETNESS IN SMALL SUGAR MAPLE TREES

Abstract.—Describes a technique based on the use of a hypodermic needle for determining sap-sugar concentrations in small trees. The technique is applicable to pot cultures in greenhouses and also, with the use of a movable shelter, to seedlings in nursery beds.

One of the major objectives in our research on sugar maple at Burlington, Vt., is to develop high-yielding trees for the sugar maple industry. Both sexual and vegetative propagation are used in this program to produce superior stock. This work could be greatly facilitated if we had a way to determine the sap-sugar concentration in small sugar maple seedlings in the nursery or greenhouse. Progress will hinge to a considerable degree on our being able to make early selections for sap sweetness among the various progenies.

A means for determining sap-sugar concentration in very small trees also would be highly useful in fundamental physiological research in sugar maple.

Any technique for measuring sap-sugar concentration must be applicable both to pot cultures used in greenhouse studies and to stock growing in nursery beds. This note reports an attempt to develop such a technique based on the use of a hypodermic needle to obtain sap samples.

Materials

Eighty 2-year-old sugar maple seedlings, produced from randomly collected seed sown in a nursery bed in the spring of 1963, were used in the study. The seedlings were 12 to 18 inches tall, and 3/16 to 3/8 inch in diameter 3 inches above ground. During the first week of December 1965, 40 of these seedlings were potted in 8-inch plastic pots

Figure 1.—Tapping potted seedlings in the greenhouse. Complete hypodermic assembly used in earlier trials is shown at right; detached needle, which worked equally well and was more convenient to use, is shown inserted in a seedling stem at left.

and placed in a room maintained at approximately 33°F. and 85 to 90 percent relative humidity. The 40 seedlings remaining in the nursery bed were enclosed in a 4- by 5- by 20-foot shelter made of polyethylene over a wooden frame. The seedlings had been mulched in November with 4 to 6 inches of leaf litter.

All the seedlings were left under these cold conditions until mid-February, when we first tried to sample for sap-sugar concentration. The instrument we used for tapping was a #22-G Huber point hypodermic needle. At first we used the complete hypodermic syringe, but we found that the vacuum created by the syringe did not increase the flow of sap. So, for most of the work, we used only the detached needle (fig. 1).

Sugar percentages in sap samples were read in a small, portable, hand-held refractometer of the type commonly used in the maple industry for sap-sugar determinations in the field.

Procedures and Results

The most effective tapping technique was to insert the hypodermic needle into the stem to a depth of 1/16 to 1/8 inch in an upward direction at an angle of about 45°. Three to 4 inches above the soil surface appeared to be the most productive tapping height. At best only a small volume of sap was obtained per seedling—usually less than 0.1 ml. This amount is minimal for determining sugar concentration with a standard field refractometer.

In general, sap flow could be induced in the potted seedlings by transferring them from the cold room to a greenhouse where the temperature was near 50° F. Sap usually would flow within 10 minutes after the seedlings were moved to the greenhouse. After one tapping, another flow could be induced 1 or more days later by re-cycling the plants through the cold storage-greenhouse treatment.

In the nursery bed, sap would not flow when the soil was frozen. Some soil freezing had occurred in the bed before the shelter was installed and may have increased afterward. We had to thaw the soil with a heater and then keep it protected from re-freezing. When the soil had been thawed, raising the temperature inside the shelter 10° to 15° F. would induce sap flow, even on days when air temperatures outside were near freezing or below. Later in the season, sap flow could be obtained without artificial heat on days when conditions were favorable.

Because seedling roots are generally shallow, the soil did not have to freeze very deeply to prevent sap flow. With soil frozen to a depth of 8 to 10 inches, sap sometimes would flow from the twigs of larger trees and not from nearby seedlings. Presumably, in such circumstances, most or all of the root system of small seedlings was frozen, whereas only the surface roots of larger trees were frozen.

The sap-flow mechanism in small seedlings is sensitive to temperature changes, and it will operate only within rather critical temperature limits. When unsheltered seedlings are being tapped, slight wind movements over them, which apparently reduce their temperature, can alter the previously favorable conditions enough to stop the flow. External temperature changes appear to be transmitted very rapidly to the internal sap-flow mechanism.

The small seedlings used in this study never produced a continuous sap flow, as larger trees do. The total sap yield from a tapping was always obtained within 10 minutes after the flow started. Apparently a hydrostatic pressure is created within the seedling when conditions favorable for sap flow are developing. When the seedling is tapped, this pressure is released with the flow of a small amount of sap, and the flow then ceases. The insertion of two or more needles in the same general area of a seedling stem did not appreciably increase the sap yield. After a seedling is moved into a warm environment, its flow potential is sustained for only a short time—usually no longer than 30 minutes.

Suggestions for Use of the Method

The hypodermic needle method would be of greatest use in making selections among stock in the nursery. However, the environmental factors important in inducing sap flow will be more difficult to control in the nursery than in the greenhouse.

For early spring tapping in the nursery, the soil must be protected from freezing. This will require application of a heavy mulch in the fall as a minimum treatment. An enclosed shelter will be helpful as additional protection. Although feasible for small sections of a nursery bed, fixed shelters obviously are impractical for larger areas. Moreover, fixed shelters create other problems: sunny days may raise inside temperatures enough to induce early bud break, which may then be followed by frost injury.

Probably the most efficient and practical way to use this method in the nursery will be to delay sampling until midway or later in the sugaring season when the soil has thawed, and then use a portable shelter as needed to provide a suitable environment for inducing sap flow. Mulch, applied to the beds in the fall, would protect the soil from freezing during any recurring cold spells. This combination of mulch protection and portable shelter should permit fairly extensive sampling of nursery seedlings during the later, milder part of the sugaring season.

MELVIN R. KOELLING[1]

[1]When this study was made, the author was associate plant physiologist on the staff of the Northeastern Forest Experiment Station, Burlington, Vt. He is now with the Department of Forestry, Michigan State University, East Lansing, Mich.

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TEN-YEAR EFFECTS FROM ROW THINNINGS IN LOBLOLLY PINE PLANTATIONS OF EASTERN MARYLAND

Abstract.—Four degrees of row thinning were tested in 17-year-old loblolly pine plantations of eastern Maryland. In the following 10 years diameter and basal-area growth of tagged trees increased in relation to intensity of thinning. The heavier thinnings also had the most effect in increasing live-crown lengths and ratios and in favoring crown-class position. Volume growth was high in unthinned checks, and no thinning is recommended for pulpwood rotations. Infections by *Fomes annosus* were common after thinning, especially on stumps, but had no appreciable effect on growth or mortality of residual stands.

Young stands of loblolly and pond pines on Maryland's Eastern Shore usually grow fast for the first 15 or 20 years, but then slow down as competition increases among the dominant stems. Similar decreases in growth apparently occur both in plantations and in well-stocked natural stands.

The usual practice of removing stems around selected crop trees is not always practicable for stimulating growth in these stands. But row thinnings—the cutting of all trees in selected rows through plantations or in regularly spaced lanes through natural thickets—bypass most of the difficulties of conventional thinnings. And, because cut trees lodge less and merchantable wood is removed more easily, row thinnings often provide good stumpage values in stands where conventional thinnings could only be made at a loss.

The Maryland Department of Forests and Parks and the Northeastern Forest Experiment Station began a study of row thinning in 1954. Details of the study and the first 5-year results already have been described.[1] This note summarizes the 10-year effects.

The Study

The study was made in four similar adjoining stands of 3.0 to 5.2 acres each, all on Pocomoke sandy loam soil in the Wicomico State Forest. The four treatments were cutting (1) every other row of trees, (2) every third row, (3) every fourth row, and (4) every fifth row. A single treatment was applied in each of the four stands, and to about half of the area. The remaining half of each stand served as a check. None of the stumps was treated to reduce infection by *Fomes annosus*.

We studied treatment effects by (1) individual tree measurements and (2) stand measurements. In each stand, 20 trees of each of three crown classes (dominant, codominant, and intermediate) were selected and tagged in the check area and among the released stems of the treated area. Where every fourth or fifth row was cut, 20 additional trees were selected in each crown class from the center one or two rows that were not released. Thus, in all, 600 trees were selected and tagged, of which 512 were still living after 10 years. Measurements of tagged trees included diameter (b.h.) to the nearest 1/10 inch, total height, and length of live crown.

For stand data, five 0.5-acre plots were established, one in each treatment and one in a check area. Here all stems were tallied by 1-inch diameter classes and by species. In addition, 75 crop trees in each plot were selected, marked with paint, and tallied separately.

In 1961, Station pathologists examined all eight study areas to estimate damage caused by *Fomes annosus*. In six of the areas (three thinned and three unthinned), they made diagrams showing trees, stumps, snags, and the locations of *F. annosus* fruiting bodies.

Mortality

Row thinning hardly affected the mortality of upper-canopy stems in the first 10 years. None of the tagged dominant or codominant trees died in the every-other-row treatment and in two of the check areas; in the

[1]Little, S., and J. J. Mohr. FIVE-YEAR EFFECTS FROM ROW THINNINGS IN LOBOLLY PINE PLANTATIONS OF EASTERN MARYLAND. U. S. Forest Serv. Res. Paper NE-12, 15 pp., illus. NE. Forest Exp. Sta., Upper Darby, Pa. 1963.

other treated and check stands the mortality of similar stems did not exceed 2.5 percent. None of the marked crop trees died in the every-other-row treatment; 4 or 5 percent died in the other treatments and in the check plot.

Row thinning did reduce the mortality of intermediate and overtopped trees. Of the tagged intermediate trees, 5 percent died in the every-other-row treatment; 15 percent in the every-third-row treatment; 35 or 50 percent in the other two treatments; and 56 percent in the check areas. In the 0.5-acre plots, mortality among the non-crop pines, which included some upper crown class trees as well as many intermediate and overtopped ones, was 36 percent in the every-other-row treatment, 48 to 57 percent in the other treatments, and 55 percent in the control.

Diameter and Basal-Area Growth

Tagged-tree data.—Among the tagged trees in all crown classes, cutting every other row caused the greatest stimulation in diameter growth as compared to unthinned controls. The increased increment in the 10-year period under this treatment was 0.8 to 0.9 inch. It was 0.4 to 0.6 inch where every third row was cut, and still less, even for the outside released trees, where every fourth or every fifth row was cut (table 1).

In the unthinned and lightly thinned areas, diameter growth tended to decline during the second of the two 5-year periods. In contrast, growth

Table 1.—*Average 10-year diameter growth per tree, by crown classes, according to thinning treatment*[1]

Treatment (row cut)	Area	Dominant trees	Codominant trees	Intermediate trees
		Inches	*Inches*	*Inches*
Every other row	Treated	2.8 (1.4-1.4)	2.4 (1.2-1.2)	1.3 (0.6-0.7)
	Check	1.9 (1.0-0.9)	1.5 (0.9-0.6)	0.5 (0.4-0.1)
Every third row	Treated	2.6 (1.3-1.3)	2.0 (1.0-1.0)	1.1 (0.6-0.5)
	Check	2.1 (1.1-1.0)	1.6 (0.8-0.8)	0.5 (0.4-0.1)
Every fourth row	Treated: released	2.2 (1.2-1.0)	1.4 (0.7-0.7)	0.9 (0.5-0.4)
	Treated: unreleased[2]	2.1 (1.0-1.1)	1.2 (0.6-0.6)	0.5 (0.3-0.2)
	Check	1.8 (0.9-0.9)	1.1 (0.6-0.5)	0.2 (0.2-0.0)
Every fifth row	Treated: released	2.3 (1.2-1.1)	1.6 (0.9-0.7)	0.5 (0.4-0.1)
	Treated: unreleased[2]	2.1 (1.1-1.0)	1.5 (0.7-0.8)	0.4 (0.2-0.2)
	Check	1.9 (1.1-0.8)	1.3 (0.7-0.6)	0.6 (0.4-0.2)

[1] Limited to trees living in 1964. Values in parentheses are for the two 5-year periods, the first for 1954-59, the second for 1959-64. Crown classes are those before thinning.

[2] Trees in center of uncut strips, not usually released.

rates were maintained through the second 5 years in the two heavier treatments (table 1).

Because growth in tree diameter is reflected in proportionally much greater basal-area values, increased increment of basal area was considerably greater in the larger dominant trees than in the smaller codominants and intermediates. Where every other row had been cut, dominant, codominant, and intermediate trees gained an average of 0.292, 0.203, and 0.084 square feet of basal area respectively, or 0.111, 0.076, and 0.057 square feet more than comparable check trees. Basal-area increment was usually slightly more in the second 5 years for two groups: dominant stems in all study areas, and codominants in the two heavier thinnings.

In the strips left after cutting every fourth or fifth row, the interior unreleased trees showed little, if any, response to thinning.

Stand data.—Cutting every other row produced by far the greatest net gain (33 square feet) in basal area per acre, almost three times that from cutting every third row. The every fourth- or every fifth-row treatments gained only about 2.5 square feet, while the check plot lost 10 square feet from its high 1954 value of 171 square feet per acre.

When mortality and the slow growth of smaller pines are ignored, differences among treatments are much less. For example, the marked crop trees in the every-other-row treatment did grow fastest, but their gain in basal area was only 25 percent more than in the every-third-row cutting and 47 percent more than in the check. Diameter growth varied from the 2.4 inches per stem for crop trees in the heaviest thinning to 1.6 inches for those in the lightly thinned areas.

Although diameter growth of the crop trees increased with increasing intensity of thinning, the treatments had little effect on the overall average 10-year changes in diameter of all trees (except ingrowth). Four of the treatment values for average change were 1.9 or 2.0 inches; the other (every fourth row cut) was 1.6 inches. These values tended to be equalized by mortality among the smaller trees.

Crown Lengths and Ratios

During the 10 years, live crown lengths increased more than twice as much under the heaviest thinning as in the check areas. Under the other treatments, crown lengths increased, but little more than in the controls.

Treatment	Dominants (feet)	Codominants (feet)	Intermediates (feet)
Released:			
By cutting every other row	+11	+8	+5
By other cuttings	+ 6	+4	+2
Unreleased:			
In cutting every fourth or fifth row	+ 6	+4	+1
In check areas	+ 5	+4	−1

Crown ratios also increased only under the heaviest thinning; gains ranged from 7 percentage points for dominants to 2 points for intermediates. Under the other treatments, crown ratio changes varied from none for released dominants to a loss of 8 percentage points for intermediates in the check areas.

Crown Class

Between 1954 and 1964 about 25 percent of the surviving trees changed crown class. The changes are summarized in table 2.

Compared to no treatment, release resulted in fewer dominants dropping to the codominant class and in more codominants moving up to a dominant position. The heavier thinnings also reduced the proportion of codominants dropping in crown class and increased the probability of intermediates becoming codominant. Any degree of release decreased the proportion of intermediates falling to an overtopped category. Crown-class changes among unreleased trees in the centers of lanes left after cutting every fourth or fifth row were similar to those observed in the check plots.

Table 2. — *Percent of surviving 1954 trees that had changed class by 1964, by treatment and crown class*

Change	Treatment — rows cut			
		Fourth or fifth		
	Second or third	Trees released	Trees not released	No thinning
	Percent	*Percent*	*Percent*	*Percent*
Dominant to codominant	10	5	18	20
Codominant to dominant	18	25	5	8
Codominant to intermediate	2	15	20	19
Codominant to overtopped	0	2	2	0
Intermediate to codominant	19	8	0	3
Intermediate to overtopped	12	17	45	34

Volume and Volume Growth

During the 10 years, the volume of the *check* stand increased by 13.3 cords per acre, which was more net growth than in the three lighter thinning treatments. The every-other-row treatment had the greatest net growth per acre, 14.9 cords, and also the greatest 5-year growth, 8.4 cords between 1959 and 1964. However, total stand volume was still far below that of the *unthinned* stand (28 versus 44 cords per acre).

The percent of growth on residual volume also was the highest in the every-other-row treatment—114 percent. Other values were 66 percent in the every-third-row treatment, 47 and 49 percent in the other two treatments, and 43 percent in the check.

The peak in cordwood growth apparently had already occurred in the unthinned stand. Its mean annual net growth was 1.8 cords per acre in the first 17 years, 1.7 cords in 22 years, and 1.6 cords in 27 years. These figures indicate that such stands, if grown for pulpwood alone, should be managed on a 20- to 25-year rotation.

Row thinning cannot be recommended in such a short rotation. Unless the thinning is very heavy, subsequent net growth in cords will be less in thinned stands than in unthinned. Furthermore, yield in the final cut of thinned stands will be markedly less, and rotation yields (that from thinning plus the final cut) will usually be less than in unthinned stands.

For landowners managing for sawtimber and piling, thinning may be beneficial—partly by increasing growth of the final crop trees and partly by providing income through salvaging fiber for pulpwood. In our unthinned stand, 406 trees containing 9 cords of pulpwood per acre died between 1954 and 1964. We estimate that 250 more stems containing 20 cords per acre may die by the time the stand is 50 years old. In such stands, removal of every third row at 17 years and a stemwise thinning 10 to 13 years later would harvest many of these trees before they die. Together the cuts might produce 20 to 22 cords per acre, the second thinning yielding somewhat more than the first.

Infections by *Fomes annosus*

In 1961 fruiting bodies of *Fomes annosus* were found on many of the stumps and dead trees or snags, and on some living trees in the thinned plots. In the check plots fruiting bodies were found only on an occasional snag (table 3).

Infection was detected in 64 and 66 percent of the stumps (from cutting live trees) in the every-third- and every-fourth-row treatments,

Table 3.—*Incidence of 1961 fruiting of Fomes annosus in three plots thinned in 1954 and in the companion unthinned checks*

Fruiting medium	Treatment			
	Every other row	Every third row	Every fourth row	No cutting
	Percent	*Percent*	*Percent*	*Percent*
Stumps from cut live trees	33	64	66	—
Stumps from cut dead trees	7	22	—	—
Living trees	6	28	20	0
Standing dead trees[1]	9	62	70	0
Snags[1]	15	66	55	1
Dead-and-down stems[1]	16	29	30	0

[1]Standing dead trees are trees that had died recently and still retained most of their small twigs and branches. Snags were trees that had been dead for some time, but in some cases still had up to half of their branches. Stubs broken off 2 feet or more above ground were included as snags. Dead-and-down stems were those broken off near the ground, the remaining bole usually in an advanced stage of rot.

but in only half as many stumps in the every-other-row treatment. There is no logical explanation for this difference. Production and survival of *annosus* spores are supposedly less in late July when the two lighter cuttings were made than at the time of the every-other-row cutting in October to early January. No intensive examination was made in the every-fifth-row treatment.

Although, in the thinned area, many living trees without evident fruiting bodies presumably were infected by 1961, the 1954-1964 data do not indicate that the infections appreciably affected mortality or growth. As shown in table 1, diameter growth in thinned areas almost always exceeded the growth of comparable stems in unthinned areas, and the growth responses to degrees of thinning varied in a seemingly normal way.

The only noticeable effect to date from *annosus* infections has been the death of occasional small clumps of trees. Such mortality has occurred both in the study areas and in other thinned plantations. Although typical loblolly plantations in eastern Maryland undoubtedly are highly susceptible to *annosus* infection, the damage appears to be low on the more productive sites in the first 10 years after thinning—even where no control measures have been applied.

As yet, the effect of these infections over a piling-and-sawtimber rotation is not known. But in the absence of more definite information, stump treatments such as Driver described[2] would seem advisable when doing

[2]Driver, Charles H. THE OCCURRENCE AND CONTROL OF ANNOSUS ROOT-ROT IN SOUTHERN PINE PLANTATIONS. Internat. Paper Co., Southlands Exp. Forest, Forest Res. Note 23. 7 pp., illus. 1965.

any row or stemwise thinning in plantations to be managed for these products. These stump treatments are especially important on the lighter, sandier soils where *annosus* damage seems more severe than on Pocomoke or similar soils.

SILAS LITTLE, JOHN J. MOHR, and PAUL V. MOOK[3]

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[3]The authors are respectively Principal Silviculturist, Northeastern Forest Experiment Station, Upper Darby, Pa.; District Director, Maryland Department of Forests and Parks, Salisbury, Md.; and formerly Pathologist, Northeastern Forest Experiment Station, Hamden, Conn.

I. S. FOREST SERVICE RESEARCH NOTE NE-78
1968

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RESPONSE OF CROWNVETCH PLANTED ON ANTHRACITE BREAKER REFUSE

Abstract. Lime applications were essential to establishment of crownvetch (*Coronilla varia* L.) on coal breaker refuse in the Pennsylvania Anthracite Region, and mulch treatments were highly beneficial. Fertilizer applications had only slight effect on either establishment or growth.

The 112,000 acres of Pennsylvania's anthracite coal-mine spoils create a complex of unsightly, barren, and nonproductive landscapes. Many people think that trees or other vegetative cover would greatly contribute to the aesthetics and economic growth of the area. And studies have shown that a number of forest trees, both native and exotic, will survive and grow on most strip-mine spoils.

However, some 27,000 acres of black, carbonaceous, highly acid, deep-mine spoils create unique problems in slope stability, air pollution, stream pollution, siltation, and aesthetics. Perhaps the most conspicuous type of deep-mine spoil consists of coal-breaker refuse. Here few experimental plantings of trees have succeeded. However, we have recent evidence that at least some of the breaker-refuse areas will support plant growth,[1] especially if properly treated.[2]

We made a study to determine whether crownvetch (*Coronilla varia* L.) could be established on coal-breaker refuse by seeding or by planting crowns and using several lime, fertilizer, and mulch treatments; and if

[1]Czapowskyj, Miroslaw. AN EXPERIMENTAL STUDY OF THE SURVIVAL OF FOREST TREE SPECIES PLANTED ON ANTHRACITE MINE SPOILS IN PENNSYLVANIA. Unpublished office report, Northeastern Forest Experiment Station, 1967.

Schramm, J. R. PLANT COLONIZATION STUDIES ON BLACK WASTES FROM ANTHRACITE MINING IN PENNSYLVANIA. Trans. Amer. Philos. Soc. New Series, Part 1, 56 pp., illus., 1966.

[2]Czapowskyj, Miroslaw. EARLY RESPONSE OF JAPANESE LARCH AND RED PINE PLANTED ON TREATED ANTHRACITE BREAKER REFUSE. Unpublished office report, Northeastern Forest Experiment Station, 1967.

Stand of crownvetch growing on lime-treated coal-breaker refuse 2 years after planting.

so, whether the plants would grow well enough to provide quick and effective cover.

Our field study was begun in the spring of 1965 on coal-breaker refuse deposited on land owned by the Greenwood Stripping Company in Tamaqua, Pennsylvania. The physical and chemical characteristics of this spoil are probably typical of most coal-breaker refuse banks in the Anthracite Region.

Site

This refuse consists of medium to small pieces of very dark to black, highly pyritic, carbonaceous shales, slates, siltstones, and coal fragments. The top of the refuse bank is level and somewhat compacted by truck traffic. An analysis of the refuse revealed pH values ranging from 2.7 to 4.0, extremely low fertility, negligible amounts of organic matter, and about 25 percent content of soil-sized particles (less than 2 mm. in diameter).

Study Design and Establishment

The field arrangement was a split-split-plot design with three replicates. Seeding and planting were set up separately. We had six blocks, three each for seeding and planting. Each block, 30 by 60 feet, was divided into three plots for lime treatments; each of these was divided into three subplots for fertilizer treatments; and each of these was split in two for mulch treatments. Thus, the ultimate units were 10 by 10 feet. Lime and fertilizer treatments were randomly assigned, but the mulch treatments were deliberately grouped to lessen the problem of holding the mulch in place.

The treatments consisted of all combinations of three levels of hydrated lime, three levels of 5-10-5 fertilizer, and two levels of straw mulch, as follows:

Lime—0, 2.5, and 5.0 tons per acre.

Fertilizer—0, 250, and 500 pounds per acre.

Mulch—0, and 1 bale of straw per block.

The liming rates were based on lime-requirement data; the 2.5- and 5.0-ton rates were calculated to raise the pH to about 6.0 and 6.5 respectively. Rates for fertilizer and mulch represented arbitrary judgments of reasonable amounts.

Lime and fertilizer were applied with a calibrated seed and fertilizer spreader shortly after the spring thaw. The mulch was spread by hand after the seeding and planting were done.

In the seeding, the seeds were broadcast by hand at a rate of 15 pounds per acre, and the inoculant of nodule-forming bacteria for this leguminous plant was added immediately after. In the planting, 25 two-year-old crowns, each including 8 to 10 inches of taproot, were hand planted with mattock at 2-by-2-foot spacing in each sub-subplot. Each block thus contained 450 crowns, and the entire planting in 1965 totaled 1,350 crowns.

It soon became obvious in 1965 that the seeding was a complete failure. So to provide a replicate in time and thereby strengthen the data on establishment by planting, the three originally seeded blocks were planted in the spring of 1966. This raised the total of crowns in the study to 2,700. No additional lime, fertilizer, or mulch were added for the 1966 planting.

Measurements

We measured survival and ground cover after each growing season. The number of living plants within each sub-subplot was counted and converted to percent survival. Ground cover was determined by randomly placing a 24-inch ruler on top of the somewhat circular spreading plant, measuring its diameter in three directions, and computing an average diameter. The ground-cover area of the plants was later calculated and converted to a percentage of the sub-subplot area. The computed survival and ground-cover data were then transformed into arcsine values that we analyzed statistically by analysis of variance.

Results and Discussions

The treatments produced distinct patterns and striking differences in survival and ground-cover percentages of the planted crownvetch (tables 1 and 2). Lime had by far the strongest effect. Both the 2.5- and 5.0-ton treatments increased survival and ground cover many-fold. The two treatments were about equally beneficial, so they are not shown separately in the summary of statistically significant effects (table 3). Because crownvetch, like most legumes, is known to require a relatively high pH and high available calcium for best growth, the strong response to lime was what we expected.

From the nearly equal responses to the 2.5- and 5.0-ton applications of lime, we infer that the smaller amount was ample for maximum benefits. Further, this suggests that less than 2.5 tons per acre might be adequate.

Table 1. — *Percent survival of crownvetch planted in 1965 and 1966*
(Average of three replications)

Fertilizer (lbs./acre)	Lime in tons/acre: 0		2.5		5.0	
	Mulch		Mulch		Mulch	
	None	Straw	None	Straw	None	Straw
			1965 PLANTING First Growing Season			
0	15	21	89	95	92	97
250	11	15	83	95	84	93
500	5	11	89	92	85	88
			1965 PLANTING Second Growing Season			
0	0	8	79	88	87	92
250	1	8	79	89	80	80
500	1	1	84	92	77	88
			1966 PLANTING First Growing Season			
0	8	1	48	52	65	61
250	3	0	60	53	56	52
500	3	0	55	56	68	60

Table 2. — *Percent of ground cover produced by crownvetch planted in 1965 and 1966*
(Average of three replications)

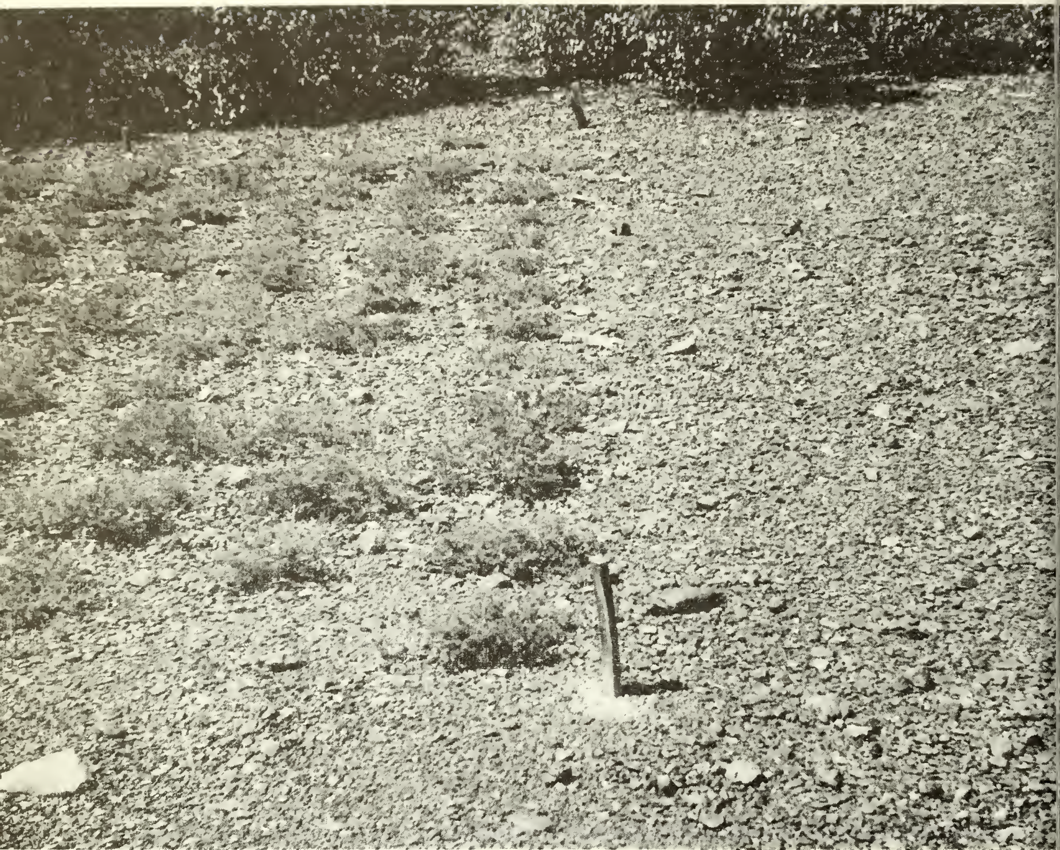
Fertilizer (lbs./acre)	Lime in tons/acre 0 — Mulch None	0 — Mulch Straw	2.5 — Mulch None	2.5 — Mulch Straw	5.0 — Mulch None	5.0 — Mulch Straw
			1965 PLANTING First Growing Season			
0	0.2	0.5	3.8	10.1	5.7	8.4
250	.2	.7	4.9	17.3	7.2	12.5
500	.1	.1	6.5	11.9	6.4	12.3
			1965 PLANTING Second Growing Season			
0	.0	.4	4.5	7.8	4.1	9.1
250	.0	.6	5.3	13.0	6.7	9.6
500	.1	.0	6.1	9.8	5.2	11.0
			1966 PLANTING First Growing Season			
0	.1	.1	1.6	3.1	1.6	3.0
250	.1	.0	1.5	2.0	1.3	2.2
500	.0	.0	1.5	2.5	1.8	3.0

Although lime was applied primarily to neutralize the acidity of the refuse, this treatment probably also supplied nutrient calcium and increased the availability of other nutrient elements in the spoil.

The lime effects reported here are short-term effects. We do not know how long the effects of lime will last. The high pyrite content of these spoils gives them an enormous potential for acid production, so the pH may revert to its former level within a few years.

Mulch, although not so essential to success as lime, did prove to have value in establishing crownvetch. Mulched plots produced almost twice as much ground cover as unmulched plots, and in the 1965 planting survival was about 10 percent higher on the mulched plots. In the 1966 planting, the effects of mulch on survival were somewhat inconsistent, apparently because the mulch was repeatedly blown off by wind.

Statistical analysis of data also revealed a significant effect of lime-mulch interaction on the percent of ground cover for both plantings during their first growing season (table 3). Although mulch increased ground cover both with and without the addition of lime, the increase was much smaller when no lime was applied. Lime was such an impor-



The area at left, treated with lime, shows a good stand of crownvetch. But on the untreated area at right, no crownvetch has survived.

Table 3.—*Factors significantly affecting the survival and ground cover of planted crownvetch*

Planting year	Variables				
	Dependent	Independent			
		Lime	Mulch	Lime x mulch	Fertilizer
	FIRST GROWING SEASON				
1965	Survival	*	*	—	—
	Ground cover	*	*	*	*
	SECOND GROWING SEASON				
1965	Ground cover	*	*	—	—
	Survival	*	*	—	—
	FIRST GROWING SEASON				
1966	Survival	*	—	—	—
	Ground cover	*	*	*	—

*Significant at 5-percent level.

tant factor that, when none was applied, the ground cover was practically zero whether or not mulch was present.

The fertilizer treatments produced so small an increase in percent of ground cover that it was scarcely evident. The fertilizer effect was statistically significant only during the first year of the 1965 planting (table 3). Since the natural fertility of the breaker refuse is known to be extremely low, fertilizer was expected to produce a substantial response. Probably the reason why this did not occur was that the plantings were established during a prolonged drought period. 1966 was especially dry, and this is reflected in poorer survival and growth during that year than in 1965 (tables 1 and 2).

In summary: Lime was highly beneficial—in fact essential—in establishing crownvetch on coal-breaker refuse ranging in acidity below pH 4.0. Mulch also was beneficial, but not so essential as lime. Mulch effects showed up more in growth than in survival. Fertilizer had little effect, probably because of drought, which caused moisture to be a limiting factor. The plants could reasonably be expected to show a greater response to fertilizer during years of more abundant rainfall.

—MIROSLAW M. CZAPOWSKYJ[3]
JOHN P. MIKULECKY
EDWARD A. SOWA

[3]The authors are respectively Soil Scientist, Northeastern Forest Experiment Station; Forester, Pennsylvania Power and Light Company; and Forestry Research Technician, Northeastern Forest Experiment Station.

ACKNOWLEDGMENT

APPRECIATION is owed to the Pennsylvania Power and Light Company for its interest in and financial support of the research reported in this note. The Company's efforts in mine-soil revegetation have been acclaimed throughout the Anthracite Region of Pennsylvania. Grateful acknowledgment is made to Joseph Larock and David Landis, who supplied planting materials, and to Steve Postupack, who supplied the necessary field assistance for the study.

U. S. FOREST SERVICE RESEARCH NOTE NE-79
1968

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APPLYING SITE-INDEX CURVES TO NORTHERN HARDWOODS IN NEW HAMPSHIRE

Abstract. Describes a new method for testing site-index curves. Study results indicate that Vermont site-index curves for yellow birch, paper birch, white ash, and sugar maple, and New York-Connecticut curves for red maple, can be applied satisfactorily in New Hampshire when used with certain precautions and corrections.

In both forest management and research, site index[1] has proved useful as a measure of site productivity. Site-index curves have been constructed for most of the commercial forest tree species. However, the shapes of these curves for a particular species may vary among geographic regions because of climatic, soil, or genetic differences. Therefore, available curves require testing before they can be applied outside the region where they were developed.

The study reported in this note was designed to determine the applicability of site-index curves developed for even-aged northern hardwood stands in Vermont (*Curtis and Post 1962*) to comparable stands in the White Mountains of New Hampshire. Curves developed by Hampf (*1965*), based on height-over-age data for red maple in New York and Connecticut, were also tested.

Field Methods

Height and age measurements were taken in even-aged northern hardwood stands 60 years or older throughout the White Mountain National Forest. These stands, selected over a range in elevation from 600 to 2,300 feet, showed no evidence of past cutting or any other drastic change that might have appreciably influenced stand development. From

[1] Height of dominant or codominant trees at a specified age—usually 50, 75, or 100 years.

one to three 1-acre plots were randomly located in each of 24 stands, providing a total of 40 plots.

One sample tree was selected for each of five species, as available, on each plot. This provided 34 yellow birch (*Betula alleghaniensis* Britton), 23 paper birch (*B. papyrifera* Marsh), 15 white ash (*Fraxinus americana* L.), 28 sugar maple (*Acer saccharum* Marsh), and 18 red maple (*A. rubrum* L.). The ages of the 118 trees sampled ranged from 60 to 159 years. The samples were restricted to trees that were dominant or codominant, free from injury and disease, and not visibly suppressed in past growth as evidenced by annual ring widths at breast height.

After felling, each stem was cut in cross section at breast height and six other points at roughly equal intervals up the stem. It was assumed that each cut would be made through the middle of the annual height growth; thus age at each section was found by counting the central ring as ½ year and the remaining rings as 1 year (ring count at the tip is zero). The number of years required to grow from breast height to each higher section point was determined by subtracting the age at a given section point from the age at breast height. Height measurements from the ground to each section point and to the top of the tree were taken to the nearest 1/10 foot.

Analysis

For each sample tree, total height (from the ground to the section point) was plotted over age (section age subtracted from breast-height age), and the points were connected by straight lines. This method of fitting a curve considerably reduces the bias associated with free-hand methods, and it also preserves much of the variation existing in the observed values that would have otherwise been lost by fitting a smooth curve with regression.

Observed site index for each sample tree was determined by using total height to the nearest foot at breast-height age 50 for paper birch and red maple, and breast-height age 75 for yellow birch, sugar maple, and white ash. The appropriate Vermont or New York curve (corrected from total age to age at breast height) of the same site index and species was plotted for each tree sampled. Then the observed height-growth curve for each sample tree could be compared with the corresponding established site-index curve.

Several methods of comparing site-index curves have been used in the past. Standard tests of differences between regression coefficients, as illustrated by Beck (*1962*), may be used, provided both the hypothesized and observed equations are of the same form and have been developed by standard regression techniques. Curtis (*1966*) used repeated measurements on sample plots to determine regression relationships between age and estimated site index. However, in addition to requiring that suitable remeasurement data covering an extended period of time be available, this method assumes that the repeated observations on the same plot are independent and thus amenable to analysis by standard regression techniques. Others have used a ratio of site index to average tree height for a given stand age, although this lacks the objectiveness of a statistical test (*Smith et al. 1960*).

In this study, the height differences between the sample tree height-over-age curve and the corresponding hypothesized Vermont or New York curve were taken at 20, 40, 60, and 80 years of age, and then expressed as a vector observation (D_1, D_2, D_3, D_4)—(more than four differences could have been taken if a closer expression of the form of the height curve were desired). Eighteen of the sample-tree curves had to be extrapolated a short distance to complete the vector observation at 80 years.

If the hypothesized site-index curves were similar to the sample-tree curves, the observed differences could be expected to approach a zero vector of (0, 0, 0, 0). Therefore, an appropriate test is the use of Hotelling's $T^2 = N\ (\overline{X} - \mu_0)'\ S^{-1}\ (\overline{X} - \mu_0)$, distributed as a non-central F with P and N — P degrees of freedom, where $\overline{X}$ is the mean vector of observed differences, μ_0 is the hypothesized (zero) vector, S is the sample covariance matrix, N is the number of samples (trees), and P is the number of measurements (4) per tree (*Anderson 1958*).

A separate comparison was made for each of the five species, including all trees (all site indices) for that species.

Results and Discussion

No significant differences were found between the Vermont curves and the sample-tree height relationships for yellow birch, paper birch, white ash, and sugar maple. However, a significant difference was revealed between the New York-Connecticut curves and the observed red maple heights.

Although all species except red maple showed non-significance, differences between the Vermont curves and observed tree heights were nearly significant for yellow birch. Mean height differences (table 1)

Table 1.—Mean height differences for five species found by subtracting site-index curve heights from the corresponding sample-tree curve heights

Site-index group (feet)	Trees	Mean age, years 20	40	60	80
	No.	*Feet*	*Feet*	*Feet*	*Feet*
			YELLOW BIRCH		
41-50	6	—4.57	—4.33	—1.58	0.72
51-60	11	—2.92	—2.12	—0.34	0.09
61-70	11	—2.64	—1.03	—1.19	0.65
71-80	6	—1.12	0.03	0.17	0.03
All	34	—2.80	—1.78	—0.75	0.37
			PAPER BIRCH		
41-60	9	—2.41	—0.84	0.87	2.06
61-80	14	—0.08	—0.06	0.34	0.63
All	23	—0.99	—0.37	0.55	1.19
			WHITE ASH		
61-80	6	—1.82	—1.95	—1.60	0.37
81-100	9	—0.54	—0.63	—0.03	0.26
All	15	—1.05	—1.16	—0.66	0.30
			SUGAR MAPLE		
41-50	5	—1.12	—0.96	—0.56	0.54
51-60	4	1.93	4.18	1.45	—0.58
61-70	6	—2.25	—0.85	—1.18	0.27
71-80	8	—3.67	—0.71	0.21	—0.40
81-90	5	1.40	3.44	1.66	—0.56
All	28	—1.20	0.65	0.21	—0.04
			RED MAPLE		
41-60	9	—4.90	—0.29	—0.99	—0.53
61-80	9	—2.37	1.07	—0.84	—0.51
All	18	—3.63	0.39	—0.92	—0.52

suggest that the Vermont site-index curves might appreciably underestimate site index when applied to young trees on poor sites. However, above 40 years of age on all sites, and above about 20 years of age on the better sites, the yellow birch curves appear to be reasonably accurate.

The major discrepancies between the observed heights of red maple and the corresponding site-index curves occurred at the 20-year age level. Although overall differences were significant for red maple, it appears that the New York-Connecticut curves can be used with acceptable accuracy at ages of 40 years or more.

When it is necessary to apply either the Vermont curves or the New York-Connecticut curves under situations described above where the accuracy of the curves is in question, table 1 can be used to correct observed tree heights. Subtract the values in table 1 from the observed sample tree heights. Then use this corrected height to estimate site-index from the appropriate site-index curve. For example, if we had an estimate of average sample-tree height for a 20-year-old stand of yellow birch on a poor site (site-index 40-50), we would add (— (—4.57)) about 4.6 feet to the average sample tree height and then use this corrected value to obtain a more precise estimate of site index from the appropriate curve.

The results of this study indicate that the Vermont site-index curves for yellow birch, paper birch, white ash, and sugar maple and the New York-Connecticut curves for red maple can be applied in New Hampshire when used with the precautions and corrections described above.

—DALE S. SOLOMON
Associate Mensurationist
Northeastern Forest Experiment Station
Forest Service, U. S. Dept. Agriculture
Durham, N. H.

Literature Cited

Anderson, T. W.
1958. An Introduction to Multivariate Statistical Analysis. 374 pp., illus. J. Wiley and Sons.

Beck, Donald E.
1962. Yellow-Poplar Site Index Curves. SE. Forest Exp. Sta. Res. Note 180, 2 pp., illus.

Curtis, Robert O.
1966. A Comparison of Site Curves for Douglas-fir. Pacific Northwest Forest and Range Exp. Res. Note PNW-37, 8 pp., illus.

Curtis, Robert O., and Boyd W. Post.
1962. Site-Index Curves for Even-Aged Northern Hardwoods in the Green Mountains of Vermont. Vt. Agr. Exp. Sta. Bull. 629, 11 pp., illus.

Hampf, Frederick E.
1965. Site Index Curves for Some Forest Species in the Eastern United States. (Rev.). 43 pp., illus. U. S. Forest Serv., Upper Darby, Pa.

Smith, J. Harry G., J. W. Ker, and L. Heger.
1960. Natural and Conventional Height-Age Curves for Douglas-fir and Some Limits to Their Refinement. Univ. Brit. Columbia, Fac. Forest Res. Paper 30, 6 pp.

J. S. FOREST SERVICE RESEARCH NOTE NE-80
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A COMPUTER PROGRAM FOR MAKING S-CONTRASTS INVOLVING LINEAR COMBINATIONS OF GROUP MEANS

Abstract. A description of a FORTRAN IV computer program that is used for making Scheffé's S-contrasts in one-way analyses.

Forestry research often involves experiments in which many treatments are tested. If the overall test of treatment equality results in a significant difference, it is usually necessary to make further tests involving linear combinations of the treatment responses. When many a *posteriori* comparisons are necessary and treatments have unequal sample sizes, the researcher often resorts to Scheffé's S-contrasts and finds himself involved in lengthy calculations.

Scheffé[1] describes the method of making contrasts for a one-way analysis. In short, the method results in the contrast $\sum_{1}^{I} c_i\beta_i$ with a confidence interval:

$$\sum_{1}^{I} c_i\beta_i \pm (I\text{-}1)(F_{\alpha;\ I-1,N-I})\ (s)\sqrt{\sum_{1}^{I} (c_i^2/J_i)}$$

Where:

c_i = a contrast multiplier for group i, and $\sum_{1}^{I} c_i = 0$.

β_i = arithmetic mean of group i.

---

[1] Scheffé, Henry. THE ANALYSIS OF VARIANCE. John Wiley, N. Y. 477 pp. 1959.

I = number of groups.
F = Fisher's F-value for I-l and N-I degrees of freedom at the chosen (α) level of significance.
N = total sample size (all groups combined).
s^2 = the error mean square.
J_i = sample size for group i.

By the same method, we may calculate an F-value for an individual contrast as:

$$F_{I-1,N-I} = \frac{\left(\sum_{1}^{I} c_i \beta_i\right)^2}{(I-1)s^2 \left(\sum_{1}^{I} c_i^2 \Big/ J_i\right)}$$

and we may check the F-value against a tabulated F at level of significance α.

The FORTRAN IV computer program described here is simply an automated method of making one-way analysis S-contrasts for linear combinations of group means with constant or varying sample sizes.

Description of Control Deck

The user must supply the following control deck as data to be operated on by the program:

Card No.	*Card Columns*	*Content*
1	1–4	Number of treatments or groups, right adjusted.
	5–8	Degrees of freedom for error, right adjusted.
	9–17	Error mean square, punched with decimal point.
	18–22	*MEANS* punched if individual treatment means are to be compared; blank otherwise.
2-I	1–10	Label for group.
(1 for each group)	11–13	Sample size, right adjusted
	14–20	Group total, punched with decimal point.
	21	Minus sign (—) if multiplier (c) for contrast is negative.

22–25	Multiplier (c) for contrast, punched with decimal point.
26–70	Repetition of format for columns 21–25 for each additional contrast to be made.

The program is limited to:

(1) A maximum of 10 contrasts (in addition to the contrasts of individual means).

(2) A maximum of 1,000 groups.

Example

If we assume that we have tested the effects of eight fertilizers on height growth of red pine seedlings and that the treatments are represented by unequal sample sizes, then the analysis might be:

Source	*df.*	*SS*	*M.S.*	*F.*
Fertilizer	7	94.0678	13.438	14.0
Error	134	128.7060	0.960	
Total	141	222.7738		

The treatment totals and their sample sizes are:

Treatment	J_i	*Total (growth in height)*
1	18	36.7
2	19	12.1
3	17	11.8
4	15	42.1
5	19	38.9
6	20	60.3
7	20	40.2
8	14	30.1

```
      8 134      0.960MEANS
TREAT. 1    18    36.7          .25   .25
TREAT. 2    19    12.1 .5     -.5
TREAT. 3    17    11.8 .5     -.5
TREAT. 4    15    42.1-.5             -.5
TREAT. 5    19    38.9          .25   .25
TREAT. 6    20    60.3-.5             -.5
TREAT. 7    20    40.2          .25   .25
TREAT. 8    14    30.1          .25   .25
```

Figure 1.—Control deck.

```
S CONTRASTS INVOLVING LINEAR COMBINATIONS OF ARITHMETIC MEANS -

EACH CONTRAST HAVING    7 AND  134 DEGREES OF FREEDOM

TREAT. 1   VS. TREAT. 2  , F= 0.2704E 01

TREAT. 1   VS. TREAT. 3  , F= 0.2353E 01

TREAT. 1   VS. TREAT. 4  , F= 0.7177E 00

TREAT. 1   VS. TREAT. 5  , F= 0.9890E-04

TREAT. 1   VS. TREAT. 6  , F= 0.1343E 01

TREAT. 1   VS. TREAT. 7  , F= 0.1177E-02

TREAT. 1   VS. TREAT. 8  , F= 0.1447E-01

TREAT. 2   VS. TREAT. 3  , F= 0.4380E-02

TREAT. 2   VS. TREAT. 4  , F= 0.5873E 01

TREAT. 2   VS. TREAT. 5  , F= 0.2813E 01

TREAT. 2   VS. TREAT. 6  , F= 0.8200E 01

TREAT. 2   VS. TREAT. 7  , F= 0.2734E 01

TREAT. 2   VS. TREAT. 8  , F= 0.2746E 01

TREAT. 3   VS. TREAT. 4  , F= 0.5292E 01

TREAT. 3   VS. TREAT. 5  , F= 0.2445E 01

TREAT. 3   VS. TREAT. 6  , F= 0.7366E 01

TREAT. 3   VS. TREAT. 7  , F= 0.2368E 01

TREAT. 3   VS. TREAT. 8  , F= 0.2422E 01

TREAT. 4   VS. TREAT. 5  , F= 0.7192E 00

TREAT. 4   VS. TREAT. 6  , F= 0.5536E-01

TREAT. 4   VS. TREAT. 7  , F= 0.8095E 00

TREAT. 4   VS. TREAT. 8  , F= 0.4647E 00

TREAT. 5   VS. TREAT. 6  , F= 0.1358E 01

TREAT. 5   VS. TREAT. 7  , F= 0.2025E-02

TREAT. 5   VS. TREAT. 8  , F= 0.1263E-01

TREAT. 6   VS. TREAT. 7  , F= 0.1503E 01

TREAT. 6   VS. TREAT. 8  , F= 0.9169E 00

TREAT. 7   VS. TREAT. 8  , F= 0.2402E-01

 0.5000E 00 X TREAT. 2
 0.5000E 00 X TREAT. 3
-0.5000E 00 X TREAT. 4
-0.5000E 00 X TREAT. 6
                     F= 0.1316E 02

 0.2500E 00 X TREAT. 1
-0.5000E 00 X TREAT. 2
-0.5000E 00 X TREAT. 3
 0.2500E 00 X TREAT. 5
 0.2500E 00 X TREAT. 7
 0.2500E 00 X TREAT. 8
                     F= 0.6871E 01

 0.2500E 00 X TREAT. 1
-0.5000E 00 X TREAT. 4
 0.2500E 00 X TREAT. 5
-0.5000E 00 X TREAT. 6
 0.2500E 00 X TREAT. 7
 0.2500E 00 X TREAT. 8
                     F= 0.2466E 01
```

Figure 2.—Program output.

```
$IBFTC STEST
      DIMENSION LABEL(1000,3),XJ(1000),TOT(1000),C(1000,10)
      READ(5.1)IGRPS,IDF,SQUARE,MEAN,S
  1   FORMAT(2I4,F9.0,A4,A1)
      DATA MEA.SN/4HMEAN,1HS/
      XGRPS=IGRPS
      DF=IDF
      IGRPDF=IGRPS-1
      DO 2 I=1,IGRPS
  2   READ(5,3)(LABEL(I,J),J=1,3),XJ(I),TOT(I),(C(I,J),J=1,10)
  3   FORMAT(2A4,A2,F3.0.F7.0,10F5.0)
      WRITE(6,4)IGRPDF,IDF
  4   FORMAT(85H1S CONTRASTS INVOLVING LINEAR COMBINATIONS OF ARITHMETIC
     1 MEANS - EACH CONTRAST HAVINGI5,4H ANDI5,20H DEGREES OF FREEDOM  )
      IF(MEA.NE.MEAN.OR.SN.NE.S)GO TO 7
      DO 5 I=1,IGRPDF
      IZ=I+1
      DO 5 K=IZ,IGRPS
      DIFF=TOT(I)/XJ(I)-TOT(K)/XJ(K)
      SUM=1./XJ(I)+1./XJ(K)
      F=(DIFF**2)/((XGRPS-1.)*SQUARE*SUM)
  5   WRITE(6,6)(LABEL(I,J),J=1,3),(LABEL(K,J),J=1,3),F
  6   FORMAT(2H0 2A4,A2,5H VS. 2A4,A2,4H, F=E11.4)
  7   DO 13 J=1,10
      WRITE(6.8)
  8   FORMAT(1H )
      DO 9 I=1,IGRPS
      IF(C(I,J).NE.0.0)GO TO 10
  9   CONTINUE
      GO TO 15
 10   DIFF=0.
      SUM=0.
      DO 12 I=1,IGRPS
      DIFF=DIFF+C(I,J)*(TOT(I)/XJ(I))
      IF(C(I,J).NE.0.)WRITE(6,11)C(I,J),(LABEL(I,K),K=1,3)
 11   FORMAT(1H E11.4,3H X 2A4,A2)
 12   SUM=SUM+(C(I,J)**2)/XJ(I)
      F=(DIFF**2)/((XGRPS-1.)*SQUARE*SUM)
 13   WRITE(6,14)F
 14   FORMAT(1H 21X,2HF=E11.4)
 15   STOP
      END
```

Figure 3.—Program listing.

Now, suppose that we want to make contrasts of:

(1) individual treatment response means.

(2) average of responses to treatments 2 and 3 versus average of 4 and 5.

(3) average of responses to treatments 1, 5, 7, and 8 versus average of 2 and 3.

(4) average of responses to treatments 1, 5, 7, and 8 versus average of 4 and 6.

Then the control deck for this job would be that shown in figure 1. The results are shown in figure 2. If we check the calculated F-values[2] against tabulated $F_{(.05)7,134} = 2.08$, we find the following contrasts to be significant:

(1) Treatments 2 and 3, taken separately, versus each of the remaining treatment means (1,4-8).

(2) Contrasts (2), (3), and (4), as stated above.

Figure 3 contains a program listing.

—WARREN E. FRAYER[3]

Assistant Professor of Forest Mensuration
Colorado State University
Fort Collins, Colorado

■

[2] Note that the floating-point multipliers and F-values contain a decimal value, and, after the E, the number of places to the left (—) or right that the decimal point must be moved.

[3] When this paper was prepared, Dr. Frayer was a research forester with the Northeastern Forest Experiment Station, Forest Service, U. S. Department of Agriculture, Upper Darby, Pa.

J. S. FOREST SERVICE RESEARCH NOTE NE-81
1968

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AMENDMENT TO "GUIDE TO HARDWOOD LOG GRADING" (REVISED 1965)*

Abstract. Amendment to "A guide to hardwood log gradings," a teaching aid and field reference first published in 1963 and revised in 1965. Amends only the section on epicormic or adventitious bud clusters.

Difficulties in interpreting the section in our *Guide to Hardwood Log Grading* that deals with the evaluation of epicormic branches and adventitious bud clusters (pages 17 and 18 in the revised edition) indicate the need for revising the original text. This revision will lead to easier interpretation and more uniform application of the information on surface abnormalities.

This note may be inserted in copies of the revised guide now in use, and is recommended along with descriptions and illustrations of the blemishes as presented on page 10 of *Grade Defects in Hardwood Timber and Logs.*** A new revision of the entire guide is planned for publication within the next year.

—MYRON D. OSTRANDER
Research Forester
Northeastern Forest Experiment Station
Forest Service, U. S. Dep. Agriculture
Upper Darby, Pa.

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*Ostrander, M. D. and others. A GUIDE TO HARDWOOD LOG GRADING (REVISED), U. S. Forest Serv. NE. Forest Exp. Sta., 50 pp., illus., Upper Darby, Pa. 1965.

**Lockard, C. R., J. A. Putnam, and R. D. Carpenter. GRADE DEFECTS IN HARDWOOD TIMBER AND LOGS. U. S. Dep. Agr. Handbook 244. 39 pp., illus. 1963.

SPECIAL INSTRUCTIONS FOR FACTORY LOGS

(Based on U. S. Forest Products Laboratory Report D-1737)

Surface Features

1. *Superficiality.*—A surface abnormality may indicate a grading defect depending on its depth. If the abnormality is estimated to extend into the log for a depth more than 1/5 the diameter at the point of occurrence it should be classed as a grading defect. Otherwise it should be classed as superficial and disregarded.

2. *Evaluation of defects.*—All log surface abnormalities judged to be defects are equal in effect, with the following exceptions in factory logs only:

a. Epicormic branches:

(1) Large (limbs more than 3/8 inch diameter at origin or bark surface): full defect on logs of all sizes, grades, and species.

(2) Small (limbs 3/8 inch diameter or less):

(a) All grades—hard hardwoods (except no defect for black cherry):[1] On logs less than 14 inches: full defect. On logs 14 inches and more: one-half defect; i.e., skip every other one.

(b) All grades—soft hardwoods:[2] Grades 1 and 2: full defect on logs less than 14 inches; one-half defect on logs more than 14 inches. Grade 3: no defect.

b. Dormant buds:

(1) Soft hardwoods: no defect in otherwise grade 3

(2) Other grades in soft hardwoods and all grades in hard hardwoods: no defect except where a raised or hard protuberance or burl in the wood is associated with buds.[3]

---

[1]Includes such species as sugar maple, beech, yellow birch, sycamore, hackberry, all oaks and ashes, and hickories.

[2]Includes such species as soft maples, basswood, yellow-poplar, gum, magnolia, willow, cottonwood, and elm.

[3]When grading black cherry, disregard all dormant buds as well as all light and medium bark distortions. Also disregard heavy bark distortions on butt logs 15 inches and larger.

U. S. FOREST SERVICE RESEARCH NOTE NE-82
1968

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AN ECONOMIC EVALUATION OF CULL-TREE REMOVAL IN MIXED HARDWOOD STANDS

Abstract. A comparison of inventories of six mixed hardwood compartments on the Kaskaskia Experimental Forest – made 12 years apart – shows that the three that received a cull-removal treatment as well as group-selection harvests were moving toward achieving sustained yields of medium to large sawtimber more rapidly than the three that had received only the group-selection harvests. Cull removal created value differences great enough to pay for the treatment two times out of three.

Before woodland owners invest their time and money in timber-stand-improvement (TSI) work, they want to know how TSI will affect their forest inventory and income. Our studies show that benefits can be derived from one kind of TSI work – cull removal. Our evaluation is based on data collected over 12 years on each of six comparable mixed hardwood compartments on the Kaskaskia Experimental Forest in southern Illinois.[1]

Three compartments were under extensive management – merchantable sawtimber trees were cut on an improvement and group-selection basis. Three compartments were under intensive management – merchantable sawtimber trees were cut on an improvement and group-selection basis, *and* cull trees were killed or removed. The objective on each compartment was to produce medium to large high-quality sawlogs from trees 18 to 24 inches d.b.h. Rotation is 80 to 100 years, and cutting cycle is 4 years. The six compartments reported are comparable and have the longest period of management.

---

[1]This report is based on a study of hardwood timber management practices conducted at the North Central Forest Experiment Station, Carbondale, Ill.

The authors acknowledge the contributions made to this publication by Leon S. Minckler, project leader of the forest-management research project located at Carbondale, who provided the field data. His patient counsel and careful reviews made this publication possible.

Inventory Changes

Cull removal favorably affected inventory. The three compartments that received a cull-removal treatment as well as group-selection cuts were moving toward sustained yields of medium to large sawtimber more rapidly than the three that had received only the group-selection cuts.

A comparison of physical data at the beginning of management with that after the last cut (table 1) shows the change in inventory over the 12 years. Some of these changes are:

- The proportion of total basal area in commercially sound trees increased on all three intensively managed compartments, while it decreased on two of the three extensively managed compartments.
- More effective regeneration area was generally provided by intensive management than by extensive management.
- The proportion of merchantable volume in high-value species (black walnut, white oak, and yellow-poplar) increased on all the intensive compartments, but decreased on two of the three extensive compartments.
- The proportion of merchantable volume in trees 18 inches d.b.h. and over increased on one intensive compartment, decreased on one, and remained constant on the third; while it decreased on all three extensive compartments.

Economic Evaluation

In addition to the favorable changes in inventory, the average value of standing timber increased on all the intensive compartments. But the average value decreased on two out of three of the extensive compartments. Average value was determined by applying a stumpage price to the merchantable volume in each species and by placing a premium on the merchantable timber in trees 18 inches and larger (see table 1, footnote 4). The values determined by this method were independently checked by other stumpage-appraisal relationships *(Worley 1962)* and found to be sound.

All possible comparisons of the change in average value for the intensive compartments and the extensive compartments show that the difference in stumpage value between paired compartments ranges from 0 to $2.50 per thousand board feet in favor of the intensive compartments (table 2). Per-acre value differences range from 0 to

Table 1. – Summary of selected data for extensively and intensively managed mixed hardwood compartments

Items for comparison	Units	Extensively managed			Intensively managed		
		A	B	C	A	B	C
At beginning of management:							
Average diameter breast high[1]	Inches	9.1	10.3	10.5	9.4	9.8	11.6
Basal area per acre, 5 inches and larger	Square feet	68	77	82	76	84	82
Proportion in commercially sound trees	Percent	92	76	80	85	86	86
Merchantable volume per acre	Feet board measure	4,600	4,600	6,400	3,700	5,500	7,600
Proportion in trees 18 inches and larger	Percent	42	41	51	26	46	57
Proportion in high-value species[2]	Percent	33	32	36	19	27	43
Average stumpage value[3]	Dollars per M feet board measure	17.60	18.80	19.60	16.30	17.40	20.70
Periodic cuts:							
Number of cuts	Number	4	4	4	4	4	3
Average volume removed per acre, per cut	Feet board measure	590	680	1,220	540	800	860
Diameter inches treated per acre, first cut	Diameter-inches	--	--	--	310	335	275
Average diameter inches treated per acre, other cuts	Diameter-inches	--	--	--	75	130	45
After last cut:							
Average diameter breast high	Inches	9.5	10.6	10.2	11.2	11.1	13.7
Basal area per acre, 5 inches and larger	Square feet	70	70	62	48	48	51
Proportion in commercially sound trees	Percent	71	75	81	100	100	100
Merchantable volume per acre	Feet board measure	4,500	4,800	4,900	3,700	4,600	6,700
Proportion in trees 18 inches and larger	Percent	28	34	39	29	38	57
Proportion in high-value species	Percent	46	30	28	20	42	52
Effective regeneration area per square foot of commercially sound trees harvested[4]	Milacres	13	4	6	8	13	18
Average stumpage value	Dollars per M feet board measure	18.50	17.80	18.20	17.20	18.60	21.80

[1] Live trees 5 inches and larger.
[2] Black walnut, white oak, yellow-poplar.
[3] Based on price ranges published in current Illinois and Ohio timber price reports. Assuming that larger timber produces higher-quality logs *(Trimble 1965b)* we applied the higher prices to volume in trees 18 inches and over, lower prices to trees 11 to 17 inches d.b.h.
[4] Area covered by enough free-growing desirable reproduction in openings of adequate size to produce a stand of desirable species.

Table 2. – All possible stumpage-value differences between extensive and intensive compartments in dollars per M board feet

Extensive compartments	12-year value change	Intensive compartments A (+ .90)	B (+1.20)	C (+1.10[1])
		Difference		
A	+ .90	$ 0.00	$+0.30	$+0.20
B	-1.00	+1.90	+2.20	+2.10
C	-1.40	+2.30	+2.60	+2.50

[1]The change in value over the 8-year management period is 75 cents per thousand board feet, or an annual change of around 9 cents. The 12-year change was obtained by multiplying 9 cents times 12.

$12.50, assuming an average volume per acre of 5 thousand board feet.

In most cases the increase in value was sufficient to pay for efficient cull removal. By dividing the per-acre value by the total amount of undesirable tree stems actually treated – 410 to 725 diameter-inches per acre – we find that in two out of three cases from 1 to 3 cents per diameter-inch could have been spent for this TSI work with a reasonable expectation of recovering this investment in the 12 years. Reasonable costs for efficient cull deadening (applying 2, 4, 5-T to ax frills) are estimated to be as low as 1 cent per diameter-inch *(Little and Mohr 1956, Plass 1956, Ryker and Minckler 1962,* and *Trimble and Wendel 1966).*

A Longer Look

A period longer than 10 to 15 years will find a much greater difference in the forest inventory on extensively and intensively managed properties. Over a longer time, the number of cull and other undesirable trees will increase on the extensively managed compartments, take up more and more growing space, and leave less and less space for desirable reproduction and growing stock. As a result, future inventory value on these extensive compartments will decrease. In addition to the constant increase in value differences between extensive and intensive compartments, the per-acre TSI cost on the intensive compartments will become lower as the number of undesirable trees to kill on these compartments steadily decreases (table 1) *(Trimble 1965a).*

If the woodland owner's objective is to grow high-value medium to large sawtimber using the group-selection management system, he will achieve that objective more quickly and more profitably by removing or killing cull trees in addition to making periodic commercial cuttings.

– DAVID P. WORLEY and HOYT A. WHEELAND[2]

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[2]David P. Worley is research forester at the Northeastern Forest Experiment Station's research unit at Columbus, Ohio. Hoyt A. Wheeland, formerly research forester at the Station's research unit in Columbus, is now with the Department of the Interior at Arlington, Va.

Literature Cited

Little, S. and J. J. Mohr. 1956. CHEMICAL CONTROL OF HARDWOODS ON PINE SITES OF MARYLAND'S EASTERN SHORE. U. S. Forest Serv. NE. Forest Exp. Sta. Res. Note 64, 4 pp. Upper Darby, Pa.

Plass, William T. 1956. KILLING HARDWOODS WITH HERBICIDES IN SOUTHEASTERN OHIO. U. S. Forest Serv. C. S. Forest Exp. Sta. Res. Note 98, 2 pp. Columbus, Ohio.

Ryker, Russell A. and Leon S. Minckler. 1962. METHODS AND COSTS OF KILLING HARDWOOD CULLS. U. S. Forest Serv. C. S. Forest Exp. Sta. Tech. Paper 191, 9 pp. Columbus, Ohio.

Trimble, George R., Jr. 1965a. IMPROVEMENT IN BUTT-LOG GRADE WITH INCREASE IN TREE SIZE FOR SIX HARDWOOD SPECIES. U. S. Forest Serv. Res. Paper NE-31, 15 pp., illus. NE, Forest Exp. Sta., Upper Darby, Pa.

Trimble, George R., Jr. 1965b. REDUCING THE PROPORTION OF CULL MATERIAL IN HARDWOOD STANDS. N. Logger 14(2):26-27, illus.

Trimble, George R., Jr. and George W. Wendel. 1966. A COST FIGURE FOR A CHEMICAL RELEASE IN APPALACHIAN HARDWOODS. N. Logger 14(7):24, 42.

Worley, David P. 1962. PREDICTING HARDWOOD STUMPAGE PRICES FROM SALES DATA. J. Forestry 60: 181-183, illus.

U. S. FOREST SERVICE RESEARCH NOTE NE-83
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HERBICIDE TREATMENTS OF JAPANESE HONEYSUCKLE FOR RELEASING DESIRABLE REPRODUCTION OR FOR SITE PREPARATION

Abstract. Various herbicides were used to release pine or hardwood seedlings from competition of Japanese honeysuckle, or to eliminate honeysuckle in areas being prepared for regeneration. Considering both the degree of honeysuckle control and the amount of damage to desired trees, we recommend 2,4-D emulsifiable acid with application in late fall for release of hardwoods and in late summer or early fall for release of pines. A mixture of 2,4-D—picolinic acid applied during spring or early summer is recommended as a conditioning treatment to prepare an area for new regeneration.

Certain herbicides have proved effective for controlling Japanese honeysuckle in woodlands (*4*); but before we can use them safely, we need to know how they affect other vegetation. In selective treatments, which herbicides can be applied to release desirable reproduction without injuring the reproduction appreciably? Are any special methods of application necessary? In preparing sites for desirable reproduction, is the overstory injured? And how lasting are any residual effects that delay the establishment or growth of desirable reproduction?

To answer these questions, the Maryland Department of Forests and Parks and the Northeastern Forest Experiment Station established a cooperative herbicide study on small plots in 1966.[1] This note presents results observed as of October 1967.

---

[1] The authors thank the Dow Chemical Company and Amchem Products, Inc., for supplying the herbicides tested.

Existing Information

Foliage treatments with herbicides are generally most effective in late spring or early summer, because this is the period of maximum downward translocation (*5*). However, desired reproduction and overstory trees are also damaged most seriously at this time. Little (3) found that the succulent growth of pines is more susceptible to damage at this time than terminals that are not actively elongating. Thus late summer or early-fall applications might be safest for selective release of pines, particularly for trees small enough that their foliage will be sprayed. Hardwoods may also be more resistant to damage late in the season when they are in a dormant state. In correspondence with the senior author, John H. Kirch of Amchem Products reported that dogwood, sumac, and locust were not damaged by a November spraying of 2,4-D, 2,4,5-T, or amitrole.

In previous honeysuckle control studies, 2,4-D (2,4-dichlorophenoxyacetic acid) was found to be more effective than amitrole (3-amino-1,2,4-triazole) and of the various 2,4-D formulations, the emulsifiable acid[2] was sometimes more effective than the esters (*4*). However, Bruner and Shearin (*2*) have recommended 2 gallons of amitrole in 100 gallons of water for releasing loblolly pine from honeysuckle. And for eliminating honeysuckle before establishing reproduction, Little and Somes (*4*) recommend a mixture of 2,4-D—picolinic acid (4-amino-3,5,6-trichloropicolinic acid).[3] Dicamba (3,6-dichloro-*o*-anisic acid) was somewhat less effective. They also found that both dicamba and picolinic acid may damage established trees if sprayed on honeysuckle growing under them.

Description of Study

Release treatments.—Release treatments were applied in three stands: a white pine plantation, a loblolly pine plantation, and a stand of natural hardwood reproduction—mostly yellow-poplar. The loblolly pines were 8 to 17 feet tall; the white pines were 1 to 7 feet tall (mostly about 3 feet); and the yellow-poplars were mostly 1 to 4 feet tall, but some as tall as 10 feet.

All treatments were made with a back-pack mistblower, usually in the late summer or early fall. White pine and hardwood areas were treated on October 6, 1966. The loblolly pine area was treated on September 13;

[2] Trade name is Weedone 638. Mention of trade names should not be construed as an endorsement of a particular commercial product by the Forest Service or the U. S. Department of Agriculture.

[3] Trade name is Tordon 101 Mixture.

but a heavy rainstorm nullified the treatment, so the loblolly pine plots were re-treated on June 6, 1967. Before mistblowing in each area, all climbing vines were cut or pulled down to a height of 3 to 4 feet; and in the treatment, an attempt was made to keep the spray below that height.

Herbicide applications on a per-acre basis were as follows:

- *In the white pine area* (a) 4 pounds active ingredient of the 2,4-D emulsifiable acid in 8 gallons of water, (b) 2 gallons of the commercial amitrole (21 percent of amitrole plus some ammonium thiocyanate) in 8 gallons of water, and (c) 3 gallons of the commercial amitrole in 8 gallons of water;
- *In the loblolly pine area* the same treatments as (a) and (b) above;
- *In yellow-poplar reproduction* (a) same as (a) above, (b) 4 pounds active of a 2,4-D ester (Esteron 44) in 8 gallons of water, (c) 2 gallons of the commercial mixture of picolinic acid—2,4-D (0.54 pound active of picolinic acid and 2 pounds active of 2,4-D per gallon) in 8 gallons of water.

All treatments were applied on 0.1-acre plots, except (b) and (c) in the yellow-poplar reproduction, which were applied to 0.05-acre plots.

Conditioning treatments.—Conditioning treatments were applied in one area where yellow-poplar reproduction was desired. Herbicide was applied with a back-pack mistblower on June 8, 1966. The stand was relatively mature. Some of the overstory yellow-poplar had been cut recently, and poorer overstory hardwoods had been injected with herbicide. However, a dense mat of honeysuckle was developing on the ground.

Herbicides used on a per-acre basis were as follows: (a) 2 gallons of the commercial mixture of picolinic acid—2,4-D in 4 gallons of water; (b) 3 gallons of the same commercial mixture in 3 gallons of water; and (c) three rates of a mixture of 2,4-D—dicamba (1.8 pounds active of 2,4-D and 0.2 pound active of dicamba per gallon), 1, 2, or 3 gallons in 5 gallons of water. The first two treatments were applied on 0.5-acre plots; the others on 0.1-acre plots. In June 1967, re-treatments were made on some spots in the first two treatments.

Results

Release treatments.—Both herbicides tried in the white pine area caused appreciable damage to the pines. Trees injured by amitrole had chlorotic old needles and a brownish color on new terminal growth in the following June. One year after treatment, about half of the pines were dead or dying in plots treated with the 2-gallon rate of amitrole, and about 75 percent were dead or dying where the 3-gallon rate had been used. The 2,4-D emulsifiable acid was less damaging. However, it greatly reduced the amount of new terminal growth, and killed some old needles, especially on the smaller pines. However, a year after treatment many of the damaged trees were recovering, and the mortality from the herbicide was estimated at 7 percent.

None of the three treatments in the white pine area eliminated honeysuckle, although the vines were usually killed back. A year later the honeysuckle had recovered its original density in both amitrole treatments, while the cover in the 2,4-D treatment was still about half of the original amount. The temporary effect of the treatments might still provide the freedom that trees need to dominate the site—if they are not also injured by the herbicide. The 2,4-D is most promising in this respect.

Even though the loblolly pines were appreciably taller than the white pines, the herbicide applications in June caused some damage. In the amitrole treatment, chlorotic foliage was noticeable on some trees by October. This included 25 to 85 percent of the needles on *upper* crowns of about 10 percent of the loblolly pines and a few needles on the lower branches of an additional 7 percent of the trees. Because affected trees were 10 to 20 feet tall, and those with upper-crown damage usually had unaffected foliage below, damage seemed to be due to translocation. In contrast, the 2,4-D treatment killed foliage on the lower branches (up to 6 or 8 feet), but left the upper crowns uninjured.

Bruner and Shearin (*2*) noted damage to loblolly pines where amitrole was used to control honeysuckle. They reported yellowing of needles and twisted leaders on the pines after applying 2 gallons of amitrole in 100 gallons of water, but stated that the damage usually disappeared within a year. They did not state the month of application.

In our loblolly pine area, both herbicides tended to kill back the honeysuckle cover, but left some spots with relatively unaffected vines.

In the hardwood area, the mixture of picolinic acid—2,4-D gave by far the best kill of honeysuckle. In that treatment no regrowth was noticed in June, and in October only one small clump of honeysuckle seedlings was found. However, the herbicide also killed all yellow-poplar reproduction, many sumacs, and all multiflora roses. Other vegetation, such as hickory and black walnut seedlings, was damaged; but the plants recovered. The 2,4-D treatments were less damaging to both hardwoods and honeysuckle. The 2,4-D ester reduced the honeysuckle cover only slightly, but damaged all the marked yellow-poplar seedlings (1 of 20 died). The 2,4-D emulsifiable acid produced a fair top-kill of honeysuckle, more than did the ester, but did not damage the yellow-poplars appreciably. Of 20 marked seedlings, 3 were unaffected, while the other 17 were injured but recovered.

Still less damage might have occurred if the 2,4-D treatments had been made 2 weeks or a month later. At the time of mistblowing most of the yellow-poplar leaves were yellow and a few were still green; only a few had fallen.

Conditioning treatments.—The mixtures of dicamba—2,4-D reduced the honeysuckle cover, but did not eliminate it. Survival varied with rate used, but in all treatments regrowth was appreciable after 1 year. However, the highest rate tried included only 0.6 pound of dicamba per acre, far less than the 4 pounds of dicamba (without 2,4-D) that eliminated much of the honeysuckle in a previous study (*4*).

In contrast, the mixtures of picolinic acid—2,4-D created a brown, barren appearance at the end of the 1966 growing season, even though there were a few spots with relatively unaffected honeysuckle. These spots were usually near tops or cull logs left after logging. By June 1967 very scattered sprouts of honeysuckle had appeared in other portions of these plots. On the basis of results in this study on plots where 8 gallons of water were used as the carrier (release treatment C in yellow-poplar reproduction) and results from a previous study (*4*) where high-volume sprays were applied, it seems probable that better distribution of the herbicide would have resulted in an almost complete kill. Hence, for similar conditioning treatments with a mistblower, the use of 8 gallons of water per acre is recommended.

Both rates of the 2,4-D—picolinic acid mixture were damaging to overstory yellow-poplar. The heavier rate was especially damaging. The damage was not very noticeable at the end of the 1966 growing season, but it became apparent in 1967. In June, 60 percent of the overstory yellow-poplar in the area treated with the 2-gallon rate showed light injury, mostly as cupped foliage, while the rest had severe injury (little foliage). In the area treated with the 3-gallon rate, 14 percent of the overstory yellow-poplar showed light injury in June, 72 percent were severely injured, and 14 percent seemed almost dead. However, none died during the summer. By fall all overstory yellow-poplar in both treatments appeared very sickly, having very thin crowns of deformed leaves.

Some of the vegetation was more resistant to the 2,4-D—picolinic acid herbicide. Some small oak and hickory seedlings lived. Catbrier resprouted, as did some perennial herbs, ferns, grasses, and sedges.

In June, a year after treatment, the ground cover was still very sparse, although close examination revealed the presence of many plants. These included new seedlings of black cherry, yellow-poplar, red maple, and pokeweed; and plants of false Solomon's-seal, May-apple, loosestrife, blackberry, strawberry, violets, and other herbs. By early October a new ground cover had developed, especially on the lower-rate plot. A dense cover of pokeweeds 3 to 4 feet tall mixed with scattered wild lettuce plants 6 to 9 feet tall dominated the site in the 2-gallon treatment, while in the 3-gallon treatment pokeweeds were much smaller and there were many spots with little herbaceous growth.

In contrast to the ground cover plants, the number and height of yellow-poplar seedlings in October 1967 seemed unaffected by the rate of 2,4-D—picolinic acid applied. All quadrats were stocked. The average number of yellow-poplar seedlings was 18,825 per acre, and the average height of the tallest seedlings on the 2-milacre quadrats was 0.4 foot.

In the southeastern United States, Bruner (*1*) found very rapid reinvasion of honeysuckle on bottomland sites, where honeysuckle seedlings grew so rapidly that in a year the vines reached the top of a yellow-poplar 14 feet tall. Such rapid regrowth has not occurred in our study areas, and the authors estimate that conditioning treatments such as outlined below would permit the dominance of yellow-poplar seedlings without later release from honeysuckle, under most conditions in the Northeast.

Tentative Recommendations

On the basis of the above results, tentative recommendations can be made for treating Japanese honeysuckle to release desirable reproduction or to prepare sites for reproduction.

FOR RELEASING REPRODUCTION FROM HONEYSUCKLE

White or Loblolly Pines 8 Feet or Taller

- Cut or pull down climbing vines so that spraying of pine foliage is not necessary.
- Use either mistblower or high-volume sprayer, but do not spray pine foliage.
- Use 4 pounds active ingredient of the 2,4-D emulsifiable acid per acre, in 8 gallons of water for mistblower applications or 100 gallons of water for high-volume sprays. Do not use amitrole.
- Treat during the summer or early fall, preferably after July.

White or Loblolly Pines Less Than 8 Feet Tall

- Cut or pull down climbing vines, and pull vines away from small trees where feasible.
- Use a high-volume sprayer.
- Use 4 pounds active ingredient of the 2,4-D emulsifiable acid in 100 gallons of water per acre. Do not use amitrole.
- Apply in late summer or early fall, being very careful *not* to spray pine foliage.

Yellow-Poplar Reproduction (2 to 12 Feet Tall)

- Cut or pull down climbing vines.
- Use either mistblower or high-volume sprayer. Mistblower seems preferable where drift is not a hazard.
- Use 4 pounds active ingredient of 2,4-D emulsifiable acid in 8 gallons of water per acre for mistblower applications.
- Treat in October or November after yellow-poplar leaves have become yellow or preferably have fallen. (When leaves are green, yellow-poplar seedlings are susceptible.)

FOR CONDITIONING YELLOW-POPLAR STANDS FOR REGENERATION

- Cut or pull down climbing vines more than 10 feet tall.
- Use mistblower where drift is not a problem, a high-volume sprayer where it is. Use extreme caution to avoid drift. Because a very small quantity of picolinic acid may injure tobacco, potatoes, or other crops at certain growth stages, the manufacturer does not recommend mistblower applications. So if there is any question of drift, use a high-volume spray.
- Apply 2 gallons of the 2,4-D—picolinic acid mixture per acre, in 8 gallons of water for mistblower treatments and 100 gallons of water for high-volume sprays. Be sure to wet all honeysuckle foliage if possible.
- Treat in late spring or early summer (May to early July) so residual effects will wear off enough that yellow-poplar seedlings can start the following year. But treat only if overstory trees will be harvested within

a year. If susceptible crops are growing nearby, a fall treatment seems preferable.

- Remove merchantable trees before the following growing season, and inject unmerchantable trees to provide desirable openings. Injection work might be delayed for a year because the spray treatment may make injection unnecessary on some trees.

Literature Cited

1. Bruner, Marlin H.
   1967. HONEYSUCKLE — A BOLD COMPETITOR ON BOTTOMLAND HARDWOOD SITES. Forest Farmer 26(12): 9, 17, illus.
2. Bruner, Marlin H., and A. T. Shearin.
   1964. PLANTING LOBLOLLY PINE ON SITES INFESTED WITH HONEYSUCKLE. S. C. Agr. Exp. Sta., Forest Res. Ser. 12. 8 pp.
3. Little, S.
   1963. MISTBLOWER TREATMENTS IN REGENERATING PREFERRED SPECIES IN THE FORESTS OF NEW JERSEY, EASTERN MARYLAND, AND EASTERN PENNSYLVANIA. NE. Weed Contr. Conf. Proc. 17: 517-526.
4. Little, Silas and Horace A. Somes.
   1967. RESULTS OF HERBICIDE TRIALS TO CONTROL JAPANESE HONEYSUCKLE. NE. Forest Exp. Sta., U. S. Forest Serv. Res. Note NE-62. 8 pp.
5. Romancier, Robert M.
   1965. 2,4-D, 2,4,5-T, AND RELATED CHEMICALS FOR WOODY PLANT CONTROL IN THE SOUTHEASTERN UNITED STATES. Ga. Forest Res. Council Rpt. 16. 46 pp., illus.

— SILAS LITTLE
Principal Silviculturist, and

HORACE A. SOMES
Research Technician

Northeastern Forest Experiment Station
Forest Service, U. S. Dep. Agriculture
Upper Darby, Pa.

U. S. FOREST SERVICE RESEARCH NOTE NE-84
1968

Northeastern Forest
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SAPSUCKERS AND FOMES IGNIARIUS VAR. POPULINUS

Abstract. In aspen trees infected by *Fomes igniarius* var. *populinus,* the thin shell of sound wood enclosing the central column of decayed wood offers an ideal place for sapsuckers to peck out nests.

Yellow-bellied sapsuckers *(Sphyrapicus varius)* usually select for nesting places aspen trees *(populus tremuloides* and *P. grandidentata)* that have been infected with the fungus *Fomes igniarius* var. *populinus.* By dissecting nest trees after the nesting season (fig. 1), we can suggest why woodpeckers select these trees, and what implications this has for silviculture.

The two aspen species pioneer in areas cleared by fire or logging operations. The trees require full sunlight for optimum growth. As other more tolerant tree species begin to compete with and shade the aspens, the latter lose vigor and are weakened further by insects and diseases. The species are very susceptible to decay *(1).*

The principal decay fungus that infects the aspen species is *Fomes igniarius* var. *populinus (5)* and the principal infection courts are branch stubs *(2).* When many branches die at approximately the same time, the processes that lead to discoloration and decay begin simultaneously in the stem from many points. The discoloration and decay processes proceed centripetally, and the wood that forms after the branches die is seldom infected *(7).* The result is an extensive decay column of large diameter surrounded by a thin cylinder of sound wood. Such long columns of decay are rare in other species of trees in the Northeast.

The thin cylinder of sound wood surrounding the large central column of firm decay presents what seems to be an ideal situation for pecking out nests. The sapsuckers need only to penetrate the narrow band of fairly soft sound wood, then the remainder of their task is easy.

Sapsuckers winter in the South and summer in the North, where they nest *(3).* They drill holes in living trees and drink the sap. These wounds initiate processes that result in discolorations or in ring shakes, a condition where cracks form between annual rings of wood *(6).* Sapsucker damage is concentrated near nesting areas where the birds first tap trees wounded or weakened by other agents *(4),* and then they attack other more vigorous trees. Forest managers should consider sapsucker nesting sites in their forest-management plans.

Figure 1. — A quaking aspen *(Populus tremuloides)* tree dissected to reveal a sapsucker nest in the decayed center of the tree.

Literature Cited

1. Basham, J. T.
   1958. DECAY OF TREMBLING ASPEN. Can. J. Bot. 36: 491-505.
2. Etheridge, D. E.
   1961. FACTORS AFFECTING BRANCH INFECTION IN ASPEN. Can. J. Bot. 39: 799-816.
3. Kilham, L.
   1962. BREEDING BEHAVIOR OF YELLOW-BELLIED SAPSUCKERS. Auk 79: 31-43.
4. Kilham, L.
   1964. THE RELATIONS OF BREEDING YELLOW-BELLIED SAPSUCKERS TO WOUNDED BIRCHES AND OTHER TREES. Auk 81: 520-527.
5. Riley, C. G.
   1952. STUDIES IN FOREST PATHOLOGY, IX. *FOMES IGNIARIUS* DECAY OF POPLAR. Can. J. Bot. 30: 710-734.
6. Shigo, A. L.
   1963. RING SHAKE ASSOCIATED WITH SAPSUCKER INJURY. U. S. Forest Serv. Res. Paper NE-8. 10 pp., illus. NE. Forest Exp. Sta., Upper Darby, Pa.
7. Shigo, A. L.
   1965. THE PATTERN OF DECAYS AND DISCOLORATIONS IN NORTHERN HARDWOODS. Phytopathol. 55: 648-652.

—ALEX L. SHIGO
and LAWRENCE KILHAM[1]

[1] Principal Mycologist, Northeastern Forest Experiment Station, Forest Service, United States Department of Agriculture, Durham, New Hampshire; and Microbiologist, Department of Microbiology, Dartmouth Medical School, Hanover, New Hampshire.

U. S. FOREST SERVICE RESEARCH NOTE NE-85
1968

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BIRCH REGENERATION: A STOCHASTIC MODEL

Abstract. The regeneration of a clearcutting with paper or yellow birch is expressed as an elementary stochastic (probabalistic) model that is computationally similar to an absorbing Markov chain. In the general case, the model contains 29 states beginning with the development of a flower (ament) and terminating with the abortion of a flower or seed, or the development of an acceptable stem, unacceptable stem, dead seedling, or nongerminate (the six absorbing states). Expressions are given for the expected mean number of occurrences of each state, and the probability of arriving at any absorbing state after the occurrence of any transient state.

Many biological phenomena in forestry are the result of a long series of related events. For example, the regeneration of a clearcut area may be considered a chain of events that begins with the initiation of flower buds on potential seed trees, continues through flowering, fertilization, fruiting, seed development, seed dispersal, germination, and survival; and finally terminates with the occurrence of established seedlings in the reproduction. Stochastic-process theory provides the basis for constructing a hypothetical probabalistic model that simulates the essential behavior of such a biological process.

A stochastic model may be constructed by specifying the probabilities of moving from each individual state to each succeeding event in the process. Thus, the probability of ending up with a particular result can be predicted from a given set of original circumstances. In the case of a regeneration process, this enables us to predict the number of established seedlings that will be obtained under various circumstances if the assumptions of the model are met. Such information is useful in determining the chances of obtaining successful regeneration in a particular situation or in evaluating the need for special measures to improve the chances of success.

A description of a stochastic model for the regeneration of paper birch or yellow birch is presented in this paper.

The Regeneration Process

The regeneration of a clearcutting with paper or yellow birch can be described conveniently as a series of five steps:

- *Flower development.* Conceptually, a tree or stand contains a given total number of potential flower buds, which contain a given number of potential ovules. These potential buds actually develop into flower buds, leaf buds, or dormant or aborted buds with probabilities that no doubt depend upon environmental and physiological conditions. For our purpose, we may consider flowers to be developed when the female ament[1] is fully formed and ready to receive pollen. Flowers that do not reach this stage will be considered aborted.
- *Seed development.* A female ament contains ovules that may or may not develop into mature seeds, depending upon pollination and upon environmental and physiological conditions. Seed will be considered developed when it has matured and is ready for dispersal. Seed that does not reach this stage will be considered aborted.
- *Seed dispersal.* After mature seed is produced, it may be dispersed varying distances into a clearcutting. We shall recognize eight different dispersal distances. (Under fall, winter, or early spring logging, seed dispersed before logging is also available in addition to seed subsequently dispersed from border trees.)
- *Microenvironment.* After dispersal, the seed might alight on any of several microenvironments[2] that affect germination, growth, and survival. Shade might be provided by border trees or any vegetation remaining on the clearcut area. Rainfall pattern and soil type would influence the amount of available moisture, which is particularly important during the germination stage. The amount of disturbance to the forest floor would affect the type of seedbed material. We shall recognize 13 microenvironments made up of various seedbed conditions, exposures, and moisture conditions.
- *Seed response.* Once a seed has been dispersed to a particular environment, it may: (1) fail to germinate, (2) germinate and then die,

[1] Birch aments generally are borne singly.
[2] See, for example: Marquis, David A., John C. Bjorkbom, and George Yelenosky. EFFECT OF SEEDBED CONDITION AND LIGHT EXPOSURE ON PAPER BIRCH REGENERATION. J. Forestry 62:876-881, illus. 1964.

(3) produce an unacceptable stem, or (4) produce an acceptable stem. The definition of acceptable may vary to suit the need.

With this arrangement, 29 possible states or conditions are represented in these five steps. The 29 states are:

1. Flower developed.
2. Seed developed.
3. Seed dispersed up to 1 tree height.
4. Seed dispersed to between 1-2 tree heights.
5. Seed dispersed to between 2-3 tree heights.
6. Seed dispersed to between 3-4 tree heights.
7. Seed dispersed to between 4-5 tree heights.
8. Seed dispersed to between 5-6 tree heights.
9. Seed dispersed to between 6-7 tree heights.
10. Seed dispersed to 7+ tree heights.
11. Microenvironment of damp, shaded, mineral soil.
12. Microenvironment of damp, sunny, mineral soil.
13. Microenvironment of dry, shaded, mineral soil.
14. Microenvironment of dry, sunny, mineral soil.
15. Microenvironment of damp, shaded, humus.
16. Microenvironment of damp, sunny, humus.
17. Microenvironment of dry, shaded, humus.
18. Microenvironment of dry, sunny, humus.
19. Microenvironment of damp, shaded, litter.
20. Microenvironment of damp, sunny, litter.
21. Microenvironment of dry, shaded, litter.
22. Microenvironment of dry, sunny, litter.
23. Micorenvironment of rock or other unproductive material.
24. Acceptable stem.
25. Unacceptable stem.
26. Dead seedling.
27. Nongerminate.
28. Flower aborted.
29. Seed aborted.

The Stochastic Model

The 29 events can be expressed as an elementary type of stochastic model that is computationally equivalent to an absorbing Markov chain[3]

[3] Reviewers have pointed out that the process described here can be represented in other forms, e.g. as a branching "tree" of probabilities. Also, this process differs in some respects from certain classical examples of Markov chains. Thus we are describing the process as computationally equivalent to an absorbing Markov chain.

Table 1.—Symbolic initial vector and transition matrix for the 29-state birch regeneration process, showing positive (+) probabilities for the possible transitions from transient states and certainties (p = 1) for the "transitions" from absorbing states. The 4 computational submatrices—Q, R, O, and S—of the transition matrix are shown

States	States[1]																												
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
Initial vector:	+																											+	
Transition matrix:																													
1. Flower developed		+																											+
2. Seed developed			+	+	+	+	+	+	+	+																			
3. Dispersal — 1 tree height											+	+	+	+	+	+	+	+	+	+	+	+	+						
4. 1-2 tree heights											+	+	+	+	+	+	+	+	+	+	+	+	+						
5. 2-3 tree heights											+	+	+	+	+	+	+	+	+	+	+	+	+						
6. 3-4 tree heights											+	+	+	+	+	+	+	+	+	+	+	+	+						
7. 4-5 tree heights											+	+	+	+	+	+	+	+	+	+	+	+	+						
8. 5-6 tree heights											+	+	+	+	+	+	+	+	+	+	+	+	+				R		
9. 6-7 tree heights											+	+	+	+	+	+	+	+	+	+	+	+	+						
10. 7+ tree heights											+	+	+	+	+	+	+	+	+	+	+	+	+						
11. Seedbed—shaded, damp, mineral																								+	+	+	+		
12. sunny, damp, mineral																								+	+	+	+		
13. shaded, dry, mineral																								+	+	+	+		
14. sunny, dry, mineral																								+	+	+	+		
15. shaded, damp, humus												Q												+	+	+	+		
16. sunny, damp, humus																								+	+	+	+		
17. shaded, dry, humus																								+	+	+	+		
18. sunny, dry, humus																								+	+	+	+		
19. shaded, damp, litter																								+	+	+	+		
20. sunny, damp, litter																								+	+	+	+		
21. shaded, dry, litter																								+	+	+	+		
22. sunny, dry, litter																								+	+	+	+		
23. unproductive																								+	+	+	+		
24. Acceptable stem																								1					
25. Unacceptable stem																									1				
26. Dead seedling																										1			
27. Nongerminate																											1		
28. Flower aborted																									S			1	
29. Seed aborted												O																	1

[1] The states listed under *Transition matrix* represent the present states. The colum numbers across the top represent the future states. For example, reading across the row from state 1, "flowers developed", we find a + under states 2 and 29; this indicates that in one step, an ovule in a developed flower may either develop into a mature seed (state 2) or abort (state 29).

with stationary (constant) transition probabilities. In general, an absorbing Markov chain consists of an array of possible states that are occupied in a series of succeeding steps (a change of state). The outcome of each step in the process is dependent upon (conditional upon) the outcome of the one previous step. The possible outcomes at each step in the process have probabilities that sum to 1. The process consists of a series of transient states—states that are never permanently occupied. Finally, the process reaches an absorbing state—a state that is never left once it is occupied. This terminates the process. States 1 to 23 are transient states, while states 24 to 29 are absorbing states.

A Markov chain is completely defined by a matrix of transition probabilities P and an initial vector A (a (1), a (2) . . .), which gives the probability distribution for the states (1, 2 . . .) at time zero. The matrix P contains the conditional probabilities of moving in one step from each state in the process to each other state.

The locations of positive entries in the initial vector and transition matrix (table 1) illustrate the specific course followed by the process. It begins with the development (state 1) or abortion (state 28) of a female ament. After nondevelopment of the ament, the process remains (is absorbed) in this state. If the ament develops, the process moves to the development of any given ovule into a ripe seed (state 2) or the abortion of the seed (state 29). Seed abortion is considered an absorbing state, and thus the process never leaves this condition. If the seed develops, the process moves to the dispersal of the seed to various distances (states 3 to 10). For each dispersal distance, any of several seedbed conditions (states 11 to 23) might be encountered with given probabilities. For each seedbed condition, the process moves to the development of any of various classes of seedlings or a nongerminate (states 24 to 27). These last four states also are considered absorbing states, which terminate the process.

Properties and Applications[4]

It is convenient to divide the transition matrix P into four submatrices:

$$(1)\quad P = \begin{array}{ccc} \text{1-23} & \text{24-29} & \\ Q & R & \text{1-23} \\ O & S & \text{24-29} \end{array}$$

Submatrix S covers the behavior of the process after it enters one of the absorbing states. Submatrix O is all zeros. Submatrix Q concerns the

[4] Kemeny, John G., and J. Laurie Snell. FINITE MARKOV CHAINS. 210 pp. D. Van Nostrand Co., Inc., New York. 1960.

process while it remains in transient states. Submatrix R covers the transition from transient to absorbing states.

Many of the properties of an absorbing chain are developed through use of the so-called fundamental matrix, which is defined as:

$$(2)\ N = (I - Q)^{-1}$$

where I is the 23 x 23 identity matrix (matrix with a diagonal of 1-values, and zeroes elsewhere).

Beginning with any present state i, the expected number of times that the process is in a given transient state equals:

$$M_i\ (n_j) = N$$

where $M_i\ (n_j)$ is a 23 x 23 matrix. For example, if we assume that a flower has developed, the ratio between the average number (number < 1 in this application) of seeds developed before the process reaches an absorbing state and the average number of seeds reaching shaded, damp, mineral soil would equal $M_1\ (n_2)\ /\ M_1\ (n_{11})$.

For any given initial probability vector A (excluding the absorbing states):

$$M_A\ (n_j) = AN$$

where $M_A\ (n_j)$ is a 1 x 23 vector.

Of particular interest is the probability of arriving at a given absorbing state if the process currently is in a given transient state. This matrix of probabilities is given by:

$$B = b_{ij} = N\ R$$

where B or b_{ij} is a 23 x 6 matrix, where i refers to the initial or current state and j refers to the six absorbing states.

For example, the probability that a developed seed will produce an acceptable stem is given by: $b_{2,1}$. For a given number of seeds = S, the expected number of acceptable stems would be $b_{2,1}$ x S. Furthermore, assuming that a given number of seeds or potential seeds are independently distributed into the absorbing classes with constant probabilities, we could estimate the probabilities of various numbers of occurrences of each absorbing state by using the ordinary multinominal distribution.

The probabilities provided by matrix B can also be developed by taking the original transition matrix P to successive powers. In the classical absorbing chain, $P^{n \to \infty}$ approaches a limit. In the present example, P^4 has reached a limit so that $P^4 \times P^n = P^4$.

For any given initial probability vector of transient states, the probability of arriving at any absorbing state would be:

$$B_A = A\ N\ R$$

where B_A is a 1 x 6 matrix.

Discussion

A number of silvicultural considerations can be incorporated into this theoretical model of the birch regeneration process. Silvicultural operations like scarification of the seedbed can be reflected simply by revising the estimated probabilities of encountering various seedbed conditions. Clearcutting in winter, which provides both a before-logging seed source during the first spring and an after-logging seed source in ensuing years, could be handled by a change in dispersal probabilities. Regeneration after small clearcuttings, patch cuttings, or strip cuttings requires the summation of expected numbers from more than one seed production source, as well as consideration of the effects of small cuttings on seedbed conditions. Finally, new biological information on the birch regeneration process would be reflected by greater accuracy in estimated probabilities and by new or refined definitions of the states in the process. As our knowledge of the process increases, we may find a need for incorporating additional states, recycling the process through certain states more than one time, and perhaps breaking the process into subprocesses.

The use of stochastic models appears to be a promising means not only for theoretically representing the birch regeneration process, but also for knitting together isolated available information into useful estimates of both regeneration probabilities and expected numbers. Based on the theory presented in this paper, further work is underway on the development and testing of numerical models and on the generation of practical estimates covering a range of natural and manmade regeneration conditions.

— WILLIAM B. LEAK
Principal Silviculturist
Northeastern Forest Experiment Station
Durham, New Hampshire

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U.S. FOREST SERVICE RESEARCH NOTE NE-86
1968

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RELIABILITY OF TREE-HEIGHT MEASUREMENTS IN NORTHERN HARDWOOD STANDS

Abstract. No significant differences were found between the heights of standing hardwood trees estimated with a Haga altimeter and actual heights measured after the trees had been felled. Differences ranged from +10 feet to —12 feet, and the mean difference for all trees was 0.1 foot.

Accurate height measurements of standing trees are required of foresters in many phases of their work. One problem is: what instruments will provide the accuracy required? Another is that heights of standing hardwood trees are difficult to estimate because their crowns are so irregular that one cannot easily determine what actually is the highest point of the tree. For this reason, measurements of hardwood tree height are often taken during the leafless season when the highest point of the crown is easier to see.

The accuracy of various height-measuring instruments has been reported by Warren (*1958*); he found that most discrepancies were not caused by the instruments. However, most comparisons of tree height have been made on softwoods, which have an easily discernible tip. Gibbs (*1964*) has demonstrated the accuracy of the Spiegel-Relascope for measuring heights of oaks and other hardwoods under leafless conditions. And Hunt (*1959*) has reported that the Haga altimeter is faster to use, is easier to handle, and is graduated more precisely than most other instruments.

A recent study of site index in the White Mountains of New Hampshire provided information for determining the accuracy of height estimates of standing northern hardwood trees under full foliage conditions. Heights of 70 standing trees (12 paper birch, 17 yellow birch, 20 sugar maple, 11 red maple, and 10 white ash) were estimated in mid-summer 1966 with a Haga altimeter. Then each tree was felled and actual height was measured with a 100-foot tape.

The actual tree heights ranged from 47.7 feet up to 92.7 feet, and differences between the estimated and actual heights ranged from +10.0 feet to −12.0 feet. The average difference between the two sets of measurements was less than 0.1 foot for all trees combined, and no discernible variation among species was found.

Some differences between estimated and actual heights were due to the scale of the altimeter not facilitating measurement closer than 0.5 foot. However, 28 percent of the trees had differences greater than ±5 feet. These larger differences may have been caused by trees leaning toward or away from the observer, or by the observer's not using the same tip for both measurements. The following tabulation shows the proportion of height estimates that were within a given number of feet of the actual measured height:

Feet	*Percent*
1.0	26
2.0	37
3.0	47
4.0	60
5.0	72

Mean height of the 70 trees as estimated with the Haga altimeter was compared with actual mean height, using a paired "t" test. No significant difference was found at the 95-percent level. Also, the measurement error was not significantly different among tree-height classes. Using the variance among individual differences calculated for this test (24.25) and using a $t_{.05}$ of 2, we could estimate the measurement error associated with the calculated mean height of a given number of sample trees measured with a Haga altimeter:

$$n = \frac{S^2t^2}{(M.E.)^2} \qquad (1)$$

Using formula (1) with the above variance (24.25) based on 70 degrees of freedom, we found that the following numbers of trees are required to be within the given measurement errors with 95-percent probability:

Measurement error (± *feet*)	*Trees* (*number*)
1	97
2	25
3	11
4	7
5	4

For example, on a small plot, if four trees qualify as site-index trees and all are measured with a Haga altimeter, the above tabulation indicates that the calculated mean height would be within 5 feet of the true mean height of those four trees. If greater precision is desired, additional measurements could be taken on the same trees to reduce measurement error. Note, however, that the error in the tabulation above is measurement error only and does not include sampling error. To estimate mean stand height (as opposed to mean height of the sampled trees alone) when all qualifying trees cannot be measured, it would be necessary to use more trees than indicated above to account for sampling variation.

Literature Cited

Gibbs, Carter B.
1964. Spiegel-Relascope reliable for measuring total heights of standing hardwoods. J. Forestry 62: 580.

Hunt, E. V., Jr.
1959. A time and accuracy test of some hypsometers. J. Forestry 57: 641-643.

Warren, W. G.
1958. Tests of some instruments for measuring tree height. New Zeal. Res. Note 12, 18 pp.

—DALE S. SOLOMON and RICHARD J. NOLET[1]
Forest Service, U.S. Department of Agriculture

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[1] Mr. Solomon is associate mensurationist at the Northeastern Forest Experiment Station's research unit at Durham, New Hampshire; Mr. Nolet is forester on the White Mountain National Forest, Gorham, New Hampshire.

U. S. FOREST SERVICE RESEARCH NOTE NE-87

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SPREAD OF *FOMES ANNOSUS* ROOT ROT IN THINNED SHORTLEAF PINE PLANTATIONS

Abstract.—Plots were established in thinned shortleaf pine plantations in Missouri to determine the rate of spread of *Fomes annosus* root rot over a 5-year period. On these plots mortality from *F. annosus* was about 5 trees per acre per year.

Foresters, pulpwood and timber operators, and forest landowners are becoming increasingly concerned about losses from a widely distributed fungus, *Fomes annosus* (Fr.) Cke., that has already caused much mortality of pines and other conifers, both in this country and abroad.

F. annosus frequently becomes established in healthy stands during thinning operations. Airborne spores land on freshly cut stump surfaces and the fungus grows down into the roots and infects roots of adjacent trees at points of contact. Once roots become infected, the fungus may survive below ground for 50 years or more. The rate of growth of the fungus in roots averages about 3 feet a year, so at least 2 to 3 years elapse after thinning before mortality from *F. annosus* begins to show up. As more and more trees become diseased, the infection center gradually enlarges.

The fungus produces fruit bodies or conks at the root collar or on roots of living infected trees as well as on stumps, dead trees, and slash. These conks, which are perennial, range in size from small button-shaped pustules up to brackets several inches across. Since they are usually produced at or below the ground line, it is often necessary to remove needle duff from around the base of a tree or stump to see them.

Figure 1.—A *Fomes annosus* infection center in a shortleaf pine plantation. The plantation, which was 26 years old when the photograph was taken, had been thinned 5 years previously.

In 1961 a survey of shortleaf pine areas in southern Missouri revealed that *F. annosus* root rot was widely distributed.[1] Damage was much more severe in plantations than in natural stands. All the infected plantations had been thinned in the past. Since all our native conifers are probably susceptible to *F. annosus,* the many old-field plantations that have been established in this country are threatened (fig. 1).

To follow more closely the progress of *F. annosus* root rot in thinned pine plantations and learn what losses are to be expected, a number of permanent study plots were established. The following criteria were used in selecting locations for these plots:

1. The plantation should not have been thinned more than 6 years earlier.

2. The plantation should not have been thinned more than once.

[1] Berry, F. H., and O. J. Dooling. *Fomes annosus* on shortleaf pine in Missouri. U.S.D.A. Plant Dis. Rep. 46: 521. 1962.

3. The plantation should be on an area uniform in topography and site.

4. The plot should be only lightly infected with *F. annosus*, preferably with only one infection center of 1 to 6 dead or definitely infected trees.

In the spring of 1963, nine 1/5-acre plots that met the above criteria were established in thinned shortleaf pine plantations in southern Missouri. Each plot was surrounded by a 1-chain-wide isolation strip. Each

Table 1.—*Shortleaf pine mortality in* Fomes annosus *spread plots in southern Missouri*

Plot no.	Location	Trees in plot	Trees killed by *Fomes annosus*[1]						
			1963		1965		1968		5-year increase
		No.	*No.*	*Percent*	*No.*	*Percent*	*No.*	*Percent*	*No.*
1	Meramec State Forest	86	2	2.3	6	7.0	13	15.1	11
2	Deer Run State Forest	63	5	7.9	10	15.9	10	15.9	5
3	Deer Run State Forest	70	2	2.9	2	2.9	2	2.9	0
4	Mark Twain National Forest	118	4	3.4	12	10.2	15	12.7	11
5	Mark Twain National Forest	117	6	5.1	11	9.4	14	12.0	8
6	Clark National Forest	41	1	2.4	3	7.3	3	7.3	2
7	Clark National Forest	46	2	4.3	2	4.3	2	4.3	0
8	Clark National Forest	128	1	.8	4	3.1	5	3.9	4
9	Clark National Forest	118	2	1.7	4	3.4	4	3.4	2
	Total	787	25	3.2	54	6.9	68	8.6	43

[1] Based on the presence of *F. annosus* fruiting bodies on the dead trees.

tree on the plot was given a permanent number, and data on site index, soil type, topography, aspect, and pH were collected.

The spread of *F. annosus* root rot in these plots over a 5-year period was traced (table 1). From 1963 to 65, mortality from *F. annosus* increased in seven of the nine plots. The average number of trees killed during this period was 3.2 trees per plot, varying from 8 trees on one plot to none on two others. Rate of *F. annosus* spread was considerably less in 1965 to 68. An average of only 1.6 trees per plot were killed by *F. annosus* during this period. On two plots no additional trees were killed by *F. annosus* after 1963. Over the entire 5-year period, *F. annosus* killed a total of 43 trees. From these plots we estimate that mortality from *F. annosus* would be about 5 trees per acre per year in thinned shortleaf pine plantations in Missouri.

During the re-examination of these plots, *F. annosus* sporophores were found on trees that from their crowns appeared to be perfectly healthy. In fact, some of these trees had sporophores in 1963. It appears that at least under some conditions, *F. annosus* root rot develops rather slowly or that the fungus may live in and fruit on the outer bark before invading other portions of the root or stem.

It is still too early to determine what effect, if any, ecological factors may have had on the spread of the root rot. We plan to re-examine these plots again in 1970.

—FREDERICK H. BERRY
Principal Plant Pathologist
Northeastern Forest Experiment Station
Forest Insect and Disease Laboratory
Delaware, Ohio

■

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SOME MANAGERS' VIEWPOINTS ON CAMPERS AND CAMPGROUND OPERATION

Abstract.—Nine managers of public campgrounds comment on their relations with their campers and some of the management problems they have. Topics include camping fees, reactions to survey interviews, registration procedures, campers' pets, and maintenance of facilities.

WHAT would you say if someone woke you at 2 a.m. and asked: "Will you please organize a search party to find my cat?" This request may seem a bit unusual to most of us, but not to a campground manager. After many contacts with campers, the experienced campground manager becomes well educated in camper behavior and attitudes.

Recently nine public-campground managers in New York State were asked to give their impressions about campers, and to describe their campground-management problems. Their replies may be useful to both public and private campground operators in successfully meeting the demand for camping.

Problems involving people and public relations were the main concern of managers at campgrounds near metropolitan centers, which served non-campers as well as campers. Preservation and maintenance of the natural environment were the principal management problems at campgrounds that had secluded surroundings located a day's drive or more from urban centers. This difference in management problems occurred even when the two different types of campgrounds accommodated approximately the same number of campers. The managers generally felt that each campground has its own unique set of conditions that attracts a particular type of camper.

Agreement between our results and those of past studies suggests that certain kinds of planning and research information may be more easily obtained from managers than from campers.

Managers' Observations

Why people camp.—When asked to give the most important reason why people camp, managers of campgrounds located near tourist attractions said "to avoid the expenses of hotels and motels during vacation." Managers of the more secluded out-of-the-way campgrounds said "enjoyment of the outdoor environment." Responses to this question agree roughly with those of a camper-interview survey at some of the same campgrounds.[1]

We also asked each manager if there was anything that attracted campers to his particular campground. Seven managers said that campers like the way each site is separated from surrounding sites by a vegetative screen. Four managers said that campers are impressed by campground cleanliness. Another important feature mentioned was that campers enjoy campsites located near water. In this the managers' answers agreed favorably with results from interviews with campers.[1]

Camping fees.—In reply to a question about camping fees, all the managers said that campers do not feel that present fees are too high. Four managers indicated that most campers probably would be willing to pay $2 to $3 per party when facilities such as electricity and hot showers are available. In this too, the managers' opinions agreed with results of a recent study of campers in New Hampshire.[2]

Interviewing campers.—Because recreation research studies sometimes use personal-interview techniques, we asked managers how they think campers react to such surveys. All nine managers felt that campers usually do not object to interviews that last less than 30 minutes, if the interview is conducted when the camper is relaxing. Three managers felt strongly that campers welcome the opportunity to discuss their camping experiences. One manager said that no more than 5 percent of his campers considered personal interviews to be a nuisance. This response also agrees

[1] Shafer, E. L., Jr. EFFECTS OF SAMPLING LOCATION, PERIOD, AND METHOD ON CAMPER SURVEY RESULTS. Unpublished Ph.D. dissertation on file at New York State University College of Forestry, Syracuse, N.Y. 245 pp. 1966.

[2] LaPage, Wilbur F. THE ROLE OF FEES IN CAMPERS' DECISIONS. In press, Northeastern Forest Experiment Station. 1968.

very closely with independent research on the subject.[3] In fact, fewer than 1 percent of the campers asked in recent surveys by the Northeastern Station refused to be interviewed.[4]

One manager mentioned that campers may be indifferent to interviews because they never see the results of the survey. In this respect, camper interest and cooperation may be stimulated if articles about recreation research results are occasionally distributed at campgrounds.

Management Problems

The managers briefly discussed several rules that some public campground users complain about. In this respect, private campground owners might consider avoiding or eliminating some of these rules at their campgrounds.

Registration procedures.—A big management problem dealt with registration and check-out procedures. Incoming campers are anxious to find a spot to set up camp, but some campers who plan to leave are reluctant to vacate their sites before noon—the required check-out time. Many campers would like to stay until 3 or 4 o'clock in the afternoon. However, if this practice were permitted, it would be impossible for managers to efficiently reassign sites to incoming campers. To avoid the confusion that would undoubtedly result, the managers interviewed were in favor of maintaining the earlier check-out deadline. An alternative might be to require the departing camper to vacate the site by 1 p.m., but still allow him to have complete access to the picnic area, swimming beach, and other day-use facilities until some later hour.

Another problem related to registration and check-out procedure is the no-reservation policy. In the campgrounds we visited, campers are not allowed to reserve sites before arrival. Managers reported that some campers feel they should be allowed to register in person, pay for 2 or 3 days use of a site, but not occupy it until the weekend. If a large number of campers did this, it is possible that all the campsites would be reserved for a weekend. Consequently, campers who arrive during a weekday and plan to stay through the weekend could not do so because of the pre-registered campers. Thus a first-come, first-serve procedure seems equitable in a public campground.

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[3] Cannell, C., and M. Axelrod. THE RESPONDENT REPORTS ON THE INTERVIEW. Amer. J. Sociol. 62(2): 177-181. 1956.

[4] LaPage, Wilbur F. THE CAMPER VIEWS THE INTERVIEW. In press, Northeastern Forest Experiment Station.

Campers are usually allowed to select their own sites, but when the campground becomes nearly full, incoming campers are usually assigned sites. A problem arises because the manager does not always know which sites are vacant. An inexpensive intercom system throughout the campground might help alleviate this problem. By phoning the site number they select, campers would not need to drive back to the registration booth for this purpose. Also, such a system could be used to let managers know when a campsite had been vacated and thus avoid the possibility of assigning an occupied site to an incoming camper. In addition, emergencies could be reported to the manager without delay.

Several managers suggested the need for an alphabetical file or bulletin board listing the name and location of each camping party. Visitors would then have much less trouble locating camping friends. At present managers must search the entire registration file of sites to find a specific name.

Other related regulations that campers find objectionable are the length-of-stay limit and the rules that limit use of a tentsite to either one family or six people.

This badly worn path illustrates one of the major problems in campgrounds located far from urban centers.

Pets.—Certain states permit pets in their campgrounds as long as they are tied. However, the presence of pets, usually dogs, in the campground causes much work for managers. Many campers who bring dogs want to let them run, whereas those campers who have no pets approve of the present rule of tying pets. But tied dogs create a disturbance by barking and by littering the sites. Untied, wandering dogs can cause endless disturbance and safety hazards. The fact that some states exclude dogs from their campgrounds probably has helped increase campground use-intensity in states that permit pets.

We suggest that the presence of a pet in the modern American family may significantly affect that family's vacation plans. In this respect, one manager mentioned a situation where a married couple left their children at home with a babysitter and took their dog with them on a camping trip! The private campground manager may be able to capitalize on this aspect of family camping by providing special facilities for dogs—such as large fenced-in areas where dogs can run free but not disturb other campers.

Facilities.—The managers generally approved of campground design; however several suggestions for improvement were made. One manager said that his picnic area is located too close to the camping area, and that picnickers sometimes annoy campers. Another manager thought that every campground should have a large parking area near the registration booth to avoid traffic at the park entrance. All managers felt it was necessary to provide more sites with electrical outlets to accommodate use of modern camping equipment.

Several managers suggested that an indoor play area was needed for children to use during inclement weather. All managers felt that flush toilets were needed, and one manager suggested that attendants, stationed in centralized sanitation facilities, would help reduce vandalism.

Managers varied in their opinions about how to preserve vegetation and prevent soil compaction, but the general consensus seemed to be that campsites should be built initially to withstand the wear and tear of heavy use. (In this too our results agree with those of others who have discussed campground design in more detail.)[5] As a result, construction costs might be higher but subsequent maintenance costs would be lower. Information-and-education programs that point out the effect of vandalism on aesthetics were also suggested as a means to preserve the natural beauty of a camp-

[5] Bohart, C. V. GOOD RECREATION AREA DESIGN HELPS PREVENT SITE DETERIORATION. J. Soil and Water Conserv. 23(1): 21-22. 1968.

One of the major problems in campgrounds located near urban centers is public relations. Here a manager listens as a camper tells him how to run his campground.

ground. One manager suggested that campers be given a brochure that would help them understand and preserve the natural environment.

Finally, all nine managers felt that a successful campground manager must be able to communicate well with people as well as to manage the facilities under his control. Managing people and coping with the recreation equipment explosion will pose the greatest challenge for the campground manager of tomorrow.

—HERBERT E. ECHELBERGER[6]
and ELWOOD L. SHAFER, JR.

[6] The authors are respectively Research Forester and Project Leader, Northeastern Forest Experiment Station, Forest Service, U.S. Department of Agriculture, Syracuse, N.Y.

U.S. FOREST SERVICE RESEARCH NOTE NE-89
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FORM RECOVERY BY UNDERSTORY SUGAR MAPLE UNDER UNEVEN-AGED MANAGEMENT

Abstract.—A study of advanced sugar maple reproduction on a good site in West Virginia indicated that considerable improvement of stem form takes place after selection cutting in the overstory. The study stems were 1 to 6 inches in d.b.h. and many of them were over 50 years old. To an appreciable extent, flat tops and minor crooks were overcome after partial release.

In many unmanaged forest stands on good sites in the northern Appalachians, sugar maple *(Acer saccharum* Marsh.) is a strong component in the understory. This occurs often in the so-called cove hardwoods as well as in the northern hardwood types. Sugar maple is tolerant and aggressive: even after years of suppression it can respond to partial release with increased growth *(Godman 1957; Tubbs 1968).* Trimble *(1965)* found that this species tends to increasingly dominate the stand after the initiation of uneven-aged management and individual tree selection cuttings.

In uncut stands, small (1- to 6-inch diameter) understory stems of sugar maple are generally present, and most of them appear to have poor form. Crooks and flat tops are common among these saplings (fig. 1). It is often assumed that these stems are old and defective, and that they have no potential as crop trees. How realistic is this observation?

For a number of years the author has been observing understory sugar maples and has been impressed by the *good* form of many 6- to 10-inch trees that started as understory stems in well-stocked unmanaged stands

Figure 1. — A flat-topped understory sugar maple that grew suppressed all its life.

and have grown into the intermediate crown class after selection cutting (fig. 2). These observations led to a small study of understory sugar maple in an attempt to learn whether or not the apparently poor stems have the ability to develop into satisfactory crop trees after release.

Ten 1/5-acre plots were established in good-site stands of 60-year-old second-growth sawtimber that had received either two or three individual tree selection cuts. Stand volumes in trees over 11.0 inches d.b.h. ranged from 8 to 12 thousand board feet per acre. Species composition of the overstory ran heavily to yellow-poplar *(Liriodendron tulipifera* L.), black cherry *(Prunus serotina* Ehrh.), red oak *(Quercus rubra* L.), and sugar maple. Site indexes determined for oak were in the 80-foot class (75 to 84 feet at 50 years of age); these are considered very good sites.

On each plot, all sugar maple stems between 1 and 6 inches d.b.h. were tallied by 1-inch classes. The form of each stem was rated as *good,* *medium, fair,* or *poor* according to a rating system we devised (appendix) for trying to determine which trees had good sawtimber potential. Some of the stems were cut to determine age: ages varied from 17 to 55 years, but all stems examined were older than the 15-year period since the first managed cut was made in the area.

Analysis of these data revealed a strong trend toward a higher portion of good stems as diameter increased (table 1). Though only 4 percent of the 1- to 2-inch stems were rated *good,* 11 percent of the 3- to 4-inch stems and 35 percent of the 5- to 6-inch stems rated *good.* This is a great increase in the proportion of good stems going from the 1- to 2-inch d.b.h. class to the 5- to 6-inch class. Conversely, the percentage of *poor* stems dropped from about 69 percent for the 1- to 2-inch class to 17 percent for the 5- to 6-inch class. Though the trend by plots was more erratic than the trend for the total, it was in the same direction in all cases.

Still another trend was evident in the data: a drastic reduction in the number of stems going from the 1-inch class to consecutively larger diameter classes (table 1). This is in accord with the usual stem distri-

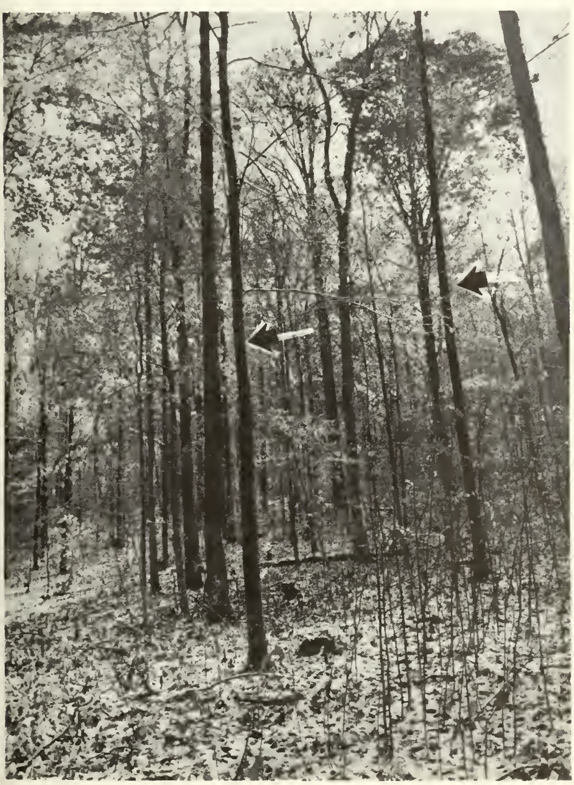

Figure 2. — Arrows mark two 7-inch understory sugar maple trees of good form. Both were suppressed until 17 years ago. Since then three individual tree selection cuts have been made in the area.

Table 1.—*Stem form rating of understory maple saplings*

Diameter class (inches)	Stem form	Portion in each class	Trees in sample
			No.
1 to 2	Good	4	201
	Medium	10	
	Fair	17	
	Poor	69	
2 to 3	Good	5	113
	Medium	13	
	Fair	30	
	Poor	52	
3 to 4	Good	11	65
	Medium	23	
	Fair	40	
	Poor	26	
4 to 5	Good	21	39
	Medium	28	
	Fair	23	
	Poor	28	
5 to 6	Good	35	23
	Medium	26	
	Fair	22	
	Poor	17	

bution in an all-aged stand as illustrated by the typical inverted J-shaped curve.

These results suggest either that: (1) form improves appreciably as the stems grow into the larger size classes; or (2) most of the small and poorly formed stems die while the well-formed small stems live and grow. Because the poorly formed small stems did not appear to be any less vigorous than the well-formed stems of the same size, the second theory seemed to be a poor one.

We decided that a comparison of growth data among form classes for small understory stems in an uncut stand would clarify this situation. If growth rates proved to be unaffected by stem-form class, then we could assume that mortality was the same for each form class and that the increasing proportion of better formed trees in the larger d.b.h. classes was due to form improvement of trees responding to openings in the crown canopy.

A 60-to-65-year-old well-stocked second-growth cove hardwood stand on an excellent site was chosen for this comparison. No cutting had disturbed this stand. A moderately heavy understory of sugar maple stems was present. Ten stems in each form class were chosen at random within the 2-to-3-inch d.b.h. class; stem wafers were cut from each of these at a 1-foot stump height and stem ages were determined (table 2).

The poor stems, slightly younger and slightly smaller in d.b.h., grew a little faster than the others. The good stems grew next fastest, with the medium and fair stems in the middle. But these growth differences were very small and unimportant. Thus it does not appear that increases in the proportion of good stems among the larger trees is due to higher survival among the stems of good form. It is more likely that some trees of poor form develop better form after release. Carvell *(1967)*, working with oak in West Virginia, found that understory seedlings recovered form after a single-tree selection cutting. While these stems were smaller than the sugar maple, they developed after release in the same way: flat-topped stems developed new straight leaders and many straightened crooks in the bole.

It is interesting to speculate about how this form recovery takes place. In flat-headed trees it appears that, as release stimulates height growth, a new vigorous terminal shoots up through the flat head (fig. 3). The flat head becomes just a dense whorl of branches, which eventually are shaded out and drop off.

Table 2.—*Growth rate and related data for 2- to 3-inch understory sugar maple stems*
(Based on 10 stems in each form class)

Stem form class	D.b.h. of 2-3-inch trees		Age at 1.0-foot stump		Rings per inch at 1.0-foot stump	
	Average	Confidence interval[1]	Average	Confidence interval[1]	Average	Confidence interval[1]
	Inches	*Inches*	*Years*	*Years*	*Number*	*Number*
Good	2.68	2.43-2.93	51	45-57	19.3	16.5-22.1
Medium	2.46	2.26-2.66	51	46-56	20.7	18.7-22.7
Fair	2.51	2.35-2.67	51	48-54	20.4	18.5-22.3
Poor	2.39	2.19-2.59	44	39-49	18.5	16.4-20.6

[1] At 5-percent level.

Figure 3. — A previously flat-headed understory sugar maple that developed a new vigorous terminal after release through an individual tree selection cut. (This tree was cut and moved into an opening so this photo could be taken.)

For crooked trees the mode of recovery is less obvious. A slight to moderate crook may recover completely or to the extent that it necessitates only a small scaling deduction in the log volume; an extreme crook will persist and must be cut out when the tree is harvested. Presumably the trees outgrow the crooks gradually because a greater portion of the diameter growth that occurs in the crooked section is laid on in the concave side of the curve. Sorensen and Wilson *(1964)*, in a study of red oak on the Harvard Forest, found that maximum radial increment occurred on the lower sides of naturally leaning trees. Engler *(1918)* found that the maximum increment in S-shaped ash and birch stems was always on the concave side of the curve. On the Fernow Experimental Forest, cross-sections were cut out of curves of five sapling understory sugar maples that had been partially released, and wider growth rings were found on the concave side. Other processes may also be at work. Jacobs *(1945)* stresses the role of strain gradients found in leaning hardwood stems, which cause the leaning stem to tend to attain or regain an erect habit.

Literature Cited

Carvell, Kenneth L.
1967. THE RESPONSE OF UNDERSTORY OAK SEEDLINGS TO RELEASE AFTER PARTIAL CUTTING. W. Va. Univ. Agr. Exp. Sta. Bull. 553, 19 pp., illus.

Engler, A.
1918. TROPISMEN AND EXCENTRISCHES DICKENWACHSTUM DER BÄUME. 106 pp. Beer and Co., Zurich.

Godman, R. M.
1957. SILVICAL CHARACTERISTICS OF SUGAR MAPLE. U. S. Forest Serv., Lake States Forest Exp. Sta., Sta. Paper 50, 24 pp., illus.

Jacobs, M. R.
1945. THE GROWTH STRESSES OF WOODY STEMS. Austral. Forestry Bur. Bull. 28, 67 pp., illus.

Sorensen, Ronald W., and Brayton, F. Wilson.
1964. THE POSITION OF ECCENTRIC STEM GROWTH AND TENSION WOOD IN LEANING RED OAK TREES. Harvard Forest Paper 12, 10 pp., illus.

Trimble, George R., Jr.
1965. SPECIES COMPOSITION CHANGES UNDER INDIVIDUAL TREE SELECTION CUTTING IN COVE HARDWOODS. U. S. Forest Serv. Res. Note NE-30, 6 pp. NE. Forest Exp. Sta., Upper Darby, Pa.

Tubbs, Carl H.
1968. THE INFLUENCE OF RESIDUAL STAND DENSITIES ON REGENERATION IN SUGAR MAPLE STANDS. U. S. Forest Serv. N. Cent. Forest Exp. Sta., St. Paul, Minn. Res. Note NC-47, 4 pp., illus.

—GEORGE R. TRIMBLE, JR.
Principal Silviculturist
Northeastern Forest Experiment Station
Forest Service, U. S. Dept. Agriculture
Parsons, West Virginia

APPENDIX
Sampling Rating System

Good Stem

(1) No main fork in first 32 feet above a 1-foot stump or to total height, if total height, is less than 32 feet. Stem may be forked below stump height.
(2) No stag head.
(3) No flat head.
(4) Butt-log alinement (first 17 feet) no more than 10-percent from vertical.
(5) No crooks that must be cut out below 17 feet.
(6) Stem has potential of at least 32 feet in merchantable log length with no log less than 8 feet and with one log at least 12 feet.
(7) Defect none or slight. *Definition of defect:* rot, crack, canker, potential rot entry from large low limb with weak connection.
(8) Seedling or seedling sprout origin.

Medium Stem

(1) No main fork in first 24 feet above 1-foot stump height or to total height, if total height is less than 24 feet. Stem may be forked below stump height.
(2) No stag head.
(3) May have evidence of previous flat head if it has well-recovered straight tip.
(4) Butt-log alinement no more than 20-percent from the vertical.
(5) No crooks that must be cut out below 9 feet.
(6) Stem has potential of at least 24 feet in merchantable log length with no log less than 8 feet.
(7) Defect none or slight.
(8) Seedling or seedling sprout or well-anchored single-stem sprout from stump less than 8 inches in diameter. Stem shows no evidence of rot having entered from stump.

Fair Stem

(1) No main fork in first 8 feet above 1-foot stump height. Stem may be forked below stump height.
(2) No stag head.
(3) May have evidence of flat head if it has well-recovered straight tip.
(4) Butt-log alinement no more than 30 percent from the vertical.
(5) No crooks that must be cut out below 9 feet.
(6) Stem has potential of at least 16 feet in merchantable log length with no log less than 8 feet.
(7) Defect none, slight, or moderate.
(8) Seedling or seedling sprout or well-anchored single-stem sprout from stump less than 8 inches in diameter. Stem shows no evidence of rot having entered from stump.

Poor Stem

All stems that are alive and fail to meet the requirements of the above three classes.

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J.S. FOREST SERVICE RESEARCH NOTE NE-90
1968

Northeastern Forest
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Experiment Station

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TREE SURVIVAL AND GROWTH ON FESCUE-COVERED SPOIL BANKS

Abstract.—In spoil-bank revegetation the emphasis today is on site protection. Quick cover crops overplanted to trees or shrubs are recommended on many sites. In this study we tried to determine how an established fescue cover affects tree survival and growth. We found the ground cover did not affect survival but did reduce the height growth of sycamore and sweetgum. It had little effect on growth of white pine and loblolly pine.

Recommended practices for revegetating coal mine spoil banks reflect an increasing concern for aesthetics and the quality of the water in our streams and rivers. Establishment of young tree plantations is no longer considered adequate treatment for spoils. Today the emphasis is on quick cover crops of grasses and legumes to cover the site and to minimize the amount and duration of off-site influences from open-pit mining disturbance. Overplanting the grasses and legumes with trees is also recommended to achieve permanent site protection.

However, the quick cover crops may affect tree growth. This causes particular concern when timber production is one of the revegetation objectives. Therefore we need to know how herbaceous ground covers affect tree survival and growth.

In this study, an established ground cover of K-31 tall fescue did not affect the survival of four tree species. But the grass cover did reduce the height growth of sycamore and sweet gum during the first four growing seasons after planting. No effect on the growth of white pine or loblolly pine was demonstrated.

Methods

This study was located on spoil from the Hindman coal seam in eastern Kentucky. The coal outcrops at an elevation of 2,200 feet; and the spoil is a mixture of sandstone and shale, with pH ranging from 4.5 to 5.5. Tall fescue had been seeded when mining was completed 2 years before this study was begun. The ground cover at the time was of light to moderate density, composed primarily of tall fescue. Other volunteer herbaceous species were present in varying densities.

Three plots with essentially uniform ground-cover density were located on the outslope of the spoil. Aspect was north to east. Before planting, all vegetation was grubbed out on half of each plot. Sycamore, sweet gum, white pine, and loblolly pine seedings were planted on each half of the plot, in two rows, with 10 trees to a row.

Once or twice during each of the next four growing seasons, all volunteer vegetation was grubbed out of those areas that had been cleared previously. Results are based on survival and height measurements at the end of the fourth growing season.

Results

Survival not affected.—The ground cover did not appreciably affect survival of the trees, as determined at the end of the fourth growing season (table 1). Survival for sycamore, sweet gum, and white pine was 75 percent or more on all but one plot. The low survival for loblolly pine could be attributed to environmental factors, seed source, or stock condition at the time of planting.

Table 1.—*Surival at the end of the fourth growing season, in percent*

Species	Treatment	Survival			
		Plot 1	Plot 2	Plot 3	Mean
Sycamore	Grass	95	90	95	93
	No grass	85	85	85	85
Sweet gum	Grass	95	90	85	90
	No grass	90	100	80	90
White pine	Grass	65	80	75	73
	No grass	90	90	80	87
Loblolly pine	Grass	5	30	30	22
	No grass	30	20	45	32

Table 2.—*Average total height at the end of the fourth growing season, in feet*

Species	Treatment	Tree height			
		Plot 1	Plot 2	Plot 3	Mean
Sycamore	Grass	3.9	2.2	2.2	2.4
	No grass	6.2	3.6	2.7	4.2
Sweet gum	Grass	3.3	1.5	1.8	2.2
	No grass	5.3	2.5	2.2	3.3
White pine	Grass	1.6	1.3	1.3	1.4
	No grass	1.9	1.5	1.7	1.7
Loblolly pine	Grass	5.4	2.4	2.0	3.3
	No grass	3.8	2.9	1.8	2.8

The spoil itself probably was not a limiting factor, because the other tree species and the tall fescue grew well. Some differences between survival on treated and untreated plots do show in table 1; however, statistical analysis indicates that these are not significant.

Effect on height growth. — On all three plots, the total height for sycamore and sweetgum at the end of the fourth growing season was greater where the grass had been removed (table 2). Statistical analysis showed that the difference was significant on all but one of the plots.

White pines at the end of four seasons were higher on the plots without grass. However, the differences in height between grassy and cleared plots were much smaller than differences for the hardwoods, and on only one of the three plots was the difference judged significant by the statistical analysis employed. No analysis was made of height growth of the loblolly pine because of the low survival achieved.

Conclusions

A fescue ground cover did not affect tree survival. Survival for all species was not appreciably better on plots where the ground cover had been removed.

Height growth of hardwood species was reduced by the established fescue cover. Sycamore and sweet gum were more sensitive than white or loblolly pine to competition from the fescue ground cover.

Since the results differ between species, species selection may be an important consideration when planting in a fescue ground cover. In this study, the fescue had a head start over the trees; the adverse effect might be less if ground-cover seeding and tree planting were done in the same season. This alternative is suggested because many of the perennial herbaceous cover crops require 2 to 3 years to mature, and the planted trees might have an opportunity to become well established during this period. They could then compete more effectively for water and nutrients when the ground cover matures.

Another possibility is to use grasses and legumes other than fescue, which puts on most of its growth early in the season. Some warm-season herbaceous species make most of their growth during the summer months after completion of the spring flush of tree growth.

Further research is needed to determine which tree species should be planted in specific ground covers for a minimum effect on tree growth. Also, we need to know whether growth differences are permanent or temporary. As the trees grow and crowns close, comparative height growth may differ from that in the early stages.

— WILLIAM T. PLASS
Plant Ecologist
Northeastern Forest Experiment Station
Forest Service, U. S. Dept. Agriculture
Berea, Kentucky

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U. S. FOREST SERVICE RESEARCH NOTE NE-91
1969

Northeastern Forest Experiment Station
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VACUUM PUMPING DOUBLES MAPLE SAP YIELD ON FLAT LAND

Abstract.—Vacuum pumping more than doubled maple sap yield from tubing installations on nearly level land during the 1968 season. Increased yields were greatest when sap had to move slightly uphill.

A Problem on Flat Land

Vacuum pumping of maple sap, first used in 1960, overcomes some of the problems normally associated with plastic tubing networks used to collect sap from sugar maple trees *(Morrow 1963a)*. The presence of vacuum in the tubing helps to overcome friction, to eliminate airlocks, and to reduce losses due to freezing, vent leaks, and reabsorption. It may also increase the amount of sap released from the tree.

Even the natural vacuum that develops in unvented tubing systems can increase sap flow. Blum *(1967)* found an increase of 43 percent in sap yield from unvented suspended tubing over that from vented tubing. He measured vacuums as high as 18 inches of mercury in these installations, which were located on moderately steep slopes.

Blum and Koelling *(1968)* found even greater yields when a vacuum pump was attached to the closed system. The increased yield from pumping, which averaged over 300 percent, was especially notable during weeping flows; but more sap was also obtained during good flow periods. Laing *et al (1962)* have also reported several-fold increases in sap flow as a result of vacuum pumping. Both of the above studies were made under carefully controlled and possibly optimum conditions. Other experiments made under near-commercial conditions have shown somewhat less increase, ranging from about 20 percent in Vermont and New York

(Laing et al 1962; Morrow 1963a) to nearly 100 percent during one poor season in southern Canada *(Macdonald College 1965)*. It is possible that some of the early vacuum systems were not operated efficiently, and better results may be possible. Several commercial producers have also reported substantial gains from vacuum pumping, and interest in this means of increasing sap flow is spreading.

Sap flow through tubing on flat land was recognized early as a special problem *(Morrow 1958)*. Water flow tables show that friction increases rapidly as pipe size decreases and slope decreases. For example, 1/4-inch pipe on a 20-percent slope would produce a flow rate of about 1 gallon per minute (to accommodate a flow of 1 quart per tap per hour for a 240-tap area). To obtain that same flow rate on a 2-percent slope, a 3/4-inch pipe would be required.

Sap flow on flat land can be aided by careful layout of the tubing to create an artificial slope. However, vacuum pumping would appear to be the best way to overcome tubing problems on such land. Accordingly, an investigation of the influence of vacuum pumping on sap flow on nearly level land was made in 1968 at Cornell's Arnot Forest in southern New York.

The Experiment

The experiment was designed to compare vacuum pumping with no pumping in closed suspended tubing networks on nearly level ground. The area selected was along a stream bottom that fanned out into a small valley terrace. Equipment was located in the center of the area so that sap from both downstream (area I) and upstream (area II) could be measured. Fifty trees in each area were each tapped twice in identical fashion to permit accurate pairing of pumped and unpumped tubing lines.

All tapholes were drilled 2 inches deep, excluding bark, and a paraformaldehyde pellet was placed in each. The two tapholes on each tree were made 6 inches apart, and treatments were alternated between taps of each successive tree to eliminate directional effects. The tubing was suspended and supported with wooden props where necessary, and unvented 18-inch drop lines were used. All tubing was 5/16 inch and a constant slope was maintained on both the main lines and the side lines. The only difference between the two groups of 100 tapholes was in direction of slope (down or up) and, within each slope, the presence or absence of applied vacuum. One small single-piston compressor was used as a vacuum source to activate two dumping units, one for each area (fig. 1).

Figure 1.—Vacuum pump and dumping unit of the type used in this study.

The ground slope was 1.7 percent over the entire area. Area I had about 1,000 feet of tubing at an upslope of 1.5 percent, while area II had about 1,500 feet of tubing at a downslope of 1.3 percent. The length of line for the area II unpumped trees was reduced to 900 feet on March 20 because yields were so low.

Trees are about the same size and quality in each area, but sap yield in area II above the pump may be potentially less because of moderate shading by conifers and higher surrounding hills. Except for the possible reduction in early-season flow by this shading, the only important difference between the two areas appears to be the difference in slope percent.

Since the experimental areas consisted of only 50 taps per treatment, considerably less than might be used on a commercial installation, an adjacent area containing a total of 300 taps was also fitted with a suspended tubing installation and subjected to vacuum pumping. Yields from the 300-tap area were then compared with the yields from pumped systems on the experimental areas. The 300-tap area was located on a northwest-facing slope of about 5 percent.

Results

In the area that had a very small downslope, twice as much sap was collected from vacuum-pumped tapholes as from unpumped tapholes (table 1). Vacuum pumping was even more effective in the area where sap moved slightly uphill. Vacuum pumping usually showed the best advantage on days of low tree pressure.

The amount of vacuum was measured on March 22, during a day of negligible sap flow, on March 28 during a weeping flow, and on April 5 when there was no sap flow. At these times it was found that the vacuum measured approximately 20 inches of mercury at the dumping unit, about 12 inches in the middle of the tapping areas, and 4 to 10 inches at the tree farthest from the pump. Even this little vacuum moved sap from the end of the tubing line during the weeping flow while sap in lines not pumped remained motionless.

It seems clear that vacuum pumping increased yield by helping to overcome the friction in the tubing network. How much it may have increased actual production at the tree was not determined. For the unpumped network, it can be speculated that much of the seasonal sap yield came from the nearest trees, and the farthest trees may have contributed little because of network friction.

Table 1.—*Sap yield from pumped and unpumped tubing networks*
(In quarts per taphole)

Date	Area I—up slope		Area II—down slope		300-taphole area
	Pumped	Not pumped	Pumped	Not pumped	Pumped
March					
15-20[1]	8.1	4.3	7.5	1.2	12.0
25-26	7.5	4.0	8.4	4.5	25.5
27-31	12.3	3.6	10.3	7.0	
April					
6-8, 12[2]	15.8	4.5	14.0	5.5	—
Total	43.7	16.4	40.2	18.2	—

[1]Very low yield for the area II unpumped line. The collecting tank was moved so that 600 feet of tubing could be removed from this line on March 20.

[2]This sap was buddy and without commercial value because of the extreme warm spell in late March. In normal years, commercial yields are obtained in early April.

On comparable days, the 300-taphole area produced even more sap per taphole than the experimental area (table 1). Possibly this was because some trees had only one taphole *(Morrow 1963b)*. It is also possible that the steeper slopes of the larger area made a more effective vacuum and helped produce more sap. This suggests that vacuum pumping can increase yields on relatively steep slopes even though the percentage increase in yield is likely to be less than that demonstrated on flat land.

Uphill pulls and air leaks reduce vacuum and limit the number of taps that can be effectively handled by a single vacuum pump. The number that can be operated efficiently with a given pump and tubing size is not known, but the small compressor used in this study made vacuum available to 100 tapholes and substantially increased seasonal yield.

Literature Cited

Blum, Barton M.
1967. PLASTIC TUBING FOR COLLECTING MAPLE SAP — A COMPARISON OF SUSPENDED VENTED AND UNVENTED INSTALLATIONS. U. S. Forest Serv. Res. Paper NE-90, 13 pp., illus. NE. Forest Exp. Sta., Upper Darby, Pa.

Blum, Barton M., and Koelling, Melvin R.
1968. VACUUM PUMPING INCREASES SAP YIELDS FROM SUGAR MAPLE TREES. U. S. Forest Serv. Res. Paper NE-106, 14 pp., illus. NE. Forest Exp. Sta., Upper Darby, Pa.

Laing, F. M., Lighthall, M. T. G., and Marvin, J. W.
1962. STUDIES ON PIPELINE SYSTEMS FOR GATHERING MAPLE SAP. Univ. Vt. Agr. Exp. Sta. Misc. Pub. 17, 5 pp.

Macdonald College.
1965. ANNUAL REPORT. Macdonald College and The Morgan Arboretum, Dep. Woodlot Manage.: 9-10.

Morrow, Robert R.
1958. PLASTIC TUBING TESTED FOR MAPLE SAP PRODUCTION. Farm Res. 24(3): 4-5.

Morrow, Robert R.
1963a. VACUUM PUMPING AND TUBING GATHER MAPLE SAP. Farm Res. 29(3): 14.

Morrow, Robert R.
1963b. INFLUENCE OF NUMBER AND DEPTH OF TAPHOLES ON MAPLE SAP FLOW. Cornell Univ. Agr. Exp. Sta. Bull. 982, 12 pp.

— ROBERT R. MORROW and CARTER B. GIBBS[1]

This note is the result of research conducted by the Cornell University Agricultural Experiment Station, Ithaca, New York, financed in part by cooperative aid funds of the Northeastern Forest Experiment Station, Forest Service, U. S. Department of Agriculture. The authors thank Fred Fontana for his technical work in laying out the experiment and gathering data.

[1]Dr. Morrow is associate professor of forestry in the Department of Conservation, New York State College of Agriculture at Cornell University, Ithaca, New York. Mr. Gibbs is silviculturist in the Northeastern Forest Experiment Station, Forest Service, U. S. Department of Agriculture, Burlington, Vermont.

D.A. FOREST SERVICE RESEARCH NOTE NE-92

1969

Northeastern Forest
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Experiment Station

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AN IMPROVED TECHNIQUE FOR TAKING HYDRAULIC CONDUCTIVITY CORES FROM FOREST SOILS

Abstract.—Describes a large-diameter, heavy-duty soil sampler that makes it possible to obtain long, relatively undisturbed sample columns from stony, root-filled forest soils. The resultant samples include the roots, root channels, stones, and macro-voids common to forested soils.

Spaces in forested soils caused by animal passageways and old root channels can transmit a tremendous amount of water. So these spaces —macro-voids—must be included in samples whenever hydraulic conductivity in forested soils is to be studied.

However, obtaining undisturbed forest-soil samples that contain macro-voids is difficult. The commonly-used soil samplers either are too small or they do not obtain undisturbed samples.

So we designed a sampler that obtains relatively undisturbed samples that *include* roots, small stones, old root channels, animal passageways, and other macro-voids. The sampler takes cores 6 inches in diameter and up to 18 inches deep. The larger cross-sectional area of the 6-inch cores reduces the relative proportion of the cross-sectional area occupied by an open channel; i.e. the influence of a channel on total conductivity is reduced.

Construction

The body of the sampler is constructed from standard 6¼-inch O.D. seamless steel tubing, ⅛-inch thick. The cutting edge, case-hardened for sharpness and durability, is constructed from 6¾-inch O.D. seamless mild carbon-steel tubing, ½-inch thick. The cutting edge is sweat-fitted and welded to the sampler body (fig. 1). Although we experienced no difficulty with damage to the cutting edge, there would be some merit in constructing a removable cutting edge that could be attached to the main body of the sampler by screw-on or lug fittings. The driving head is machined from 6¾-inch O.D. seamless steel tubing, ⅜-inch thick, and is sweat-fitted onto the body and spot-welded.

The body of the sampler and the upper part of the cutting edge are machined so they freely accept the removable sample cylinders. The inside of the cutting edge is machined so its diameter coincides with the inside diameter of the sample cylinders. Thus these cylinders rest on a flange slightly wider than the width of the cylinder wall. Coarse threads are cut into the upper portion of the sampler body for the retainer ring that holds the sample cylinders in place.

Sample cylinders and spacer ring are made from standard 6-inch O.D. aluminum tubing 1/16-inch thick. For forested soils, 3- and 6-inch lengths of cylinder are the most useful. The complete sampler weighs about 20 pounds and has a total length of about 21 inches (fig. 2).

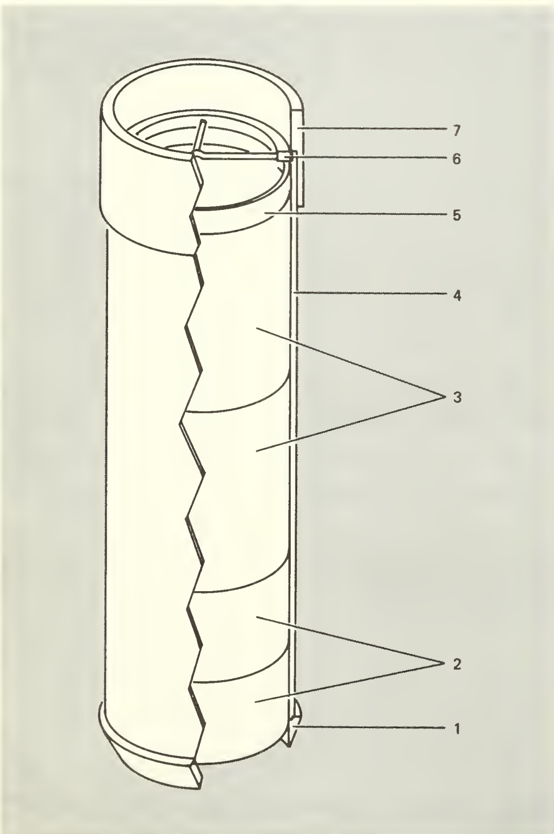

Figure 1.—Plan of the soil sampler. (1) Cutting edge, (2) 3-inch sample cylinders, (3) 6-inch sample cylinders, (4) body of sampler, (5) 1-inch spacer ring, (6) retainer ring, and (7) driving head.

Figure 2. — Sampler, 3-inch and 6-inch sample rings, 1-inch spacer ring, and retainer ring.

Procedure

Combinations of 3- or 6-inch sample cylinders are inserted into the sampler; a 1-inch spacer ring is inserted; and the retaining ring is screwed down snugly but not too tightly. The assembled sampler is then driven into the soil to the desired depth. A heavy hardwood block about 4 x 10 x 24 inches is placed upon the steel driving head to absorb part of the shock of impact. One man holds the block and sampler vertical and steady while a second man drives the sampler into the soil with a sledge or heavy mallet.

After being driven to the desired soil depth, the sampler is dug free and carefully removed. We find it is helpful to place the tip of a shovel under the bottom of the sampler and then pry upward slightly while the sampler is tipped forward. Supporting the bottom of the sample with one hand while handling the sampler prevents portions of the bottom of the sample from falling off. The sample and sample cylinders are best removed from the sampler by gently placing the bottom of the sample on a 4x4x24-inch section of wood and then carefully allowing the sampler to slide downward.

Any multiple of 3-inch deep samples between 3 and 18 inches may be obtained by combinations of sample cylinders. The entire sample is ordinarily rigid enough so that it can easily be removed from the sampler and held upright until the separate cylinders can be taped together with two wraps of 2-inch wide masking tape. However, the sampler or cylinders must not move in any manner that will cause samples to crack or separate where the separate sample cylinders join. After removal, the top and bottom are trimmed flush with the cylinder wall and then covered with a double layer of cheesecloth held in place by rubber bands.

Figure 3. — Transportation-storage box containing 3-, 6-, and 18-inch samples.

A hacksaw blade with one end broken to provide a sharp point is a most useful tool for trimming and separating samples. Samples prepared in the field are shown in figure 3.

Where 3-inch deep samples of the surface soil or other friable layers are desired, two 3-inch cylinders are placed in the sampler first and the remaining space is filled with either 3- or 6-inch cylinders. The sampler is then driven into the soil until the top of the soil sample is flush with the top of the second 3-inch ring. After the soil samples and cylinders are removed from the sampler, the lower cylinder and soil sample are carefully separated from the cylinder and sample above.

The sampler readily cuts through small woody roots up to 1 inch in diameter and even through thin, flat sandstone fragments an inch or more thick with a minimum of soil disturbance. However, each sample should be carefully examined for evidence of disturbance, both in the field and after laboratory hydraulic conductivity determinations. Occasionally roots or stones are encountered that may cause sample disturbance. Some of these disturbances may be observable only after the sample is removed from the cylinder.

To carry and store the samples, we used plywood boxes with hinged top and front (fig. 3). The boxes hold three sets of cylinders up to 18 inches in length and are constructed so that, when closed, the cylinders do not move.

— GERALD M. AUBERTIN
Research Soil Scientist
Northeastern Forest Experiment Station
Forest Service, U. S. Dept. of Agriculture
Columbus, Ohio

)A FOREST SERVICE RESEARCH NOTE NE-93
1969

Northeastern Forest
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CAMPGROUND MARKETING: THE HEAVY-HALF STRATEGY

Abstract. — When we arrayed camping frequencies in order from the lowest to the highest number of days spent camping per year we found that half of the campers do much more than half of the camping. Campers in this heavy half consistently camp more, year after year, and are increasing their annual participation as well. Heavy-half campers have larger investments in camping equipment; and their annual camping expenditures are nearly three times that of the light half. Heavy-half campers are not strongly bound by preferences or "brand" loyalties for specific types of campgrounds; and therefore, they are a good focus for promotional campaigns.

An advertising budget is most effective when it is concentrated on the specific segments of a market that have the best potential for responding. This is the underlying rationale for product differentiation. That is, different varieties of a single product are marketed; and each variety is keyed to the needs of a specific class of buyers. This is why, for example, automobile makers market a variety of models each year.

But, in the field of family camping, although distinct differences among campgrounds (in services, facilities, activities, and so forth) are becoming increasingly apparent, most campground owners still find they have to appeal to a full range of camper interests if they are to achieve financial success. So, campground owners must find other ways of segmenting the camping market to get the most return from their promotional efforts.

One of the most promising alternatives to product differentiation is the idea of appealing to the heavy user rather than to the average user or to the non-user of camping facilities. Market analysts often find that the distribution of total purchases among persons in a market is sharply skewed: some people buy much more of a product than others do (*Sizzors 1966* and *Twedt 1964*).

An analysis of a *Chicago Tribune* consumer panel (*Twedt 1964*) revealed that of 18 common household products purchased by the panel in 1962 the heavy user half of the panel accounted for 74 to 91 percent of the total reported purchases of every product. The pattern was the same whether the product had a specialized appeal, like bourbon, or more universal usage, like bathroom tissue, soaps, and shampoo. Detailed analysis of the users of these 18 products revealed that their different purchasing patterns *were not* due to pricing practices, nor were they the result of such obvious factors as family income, family size, or living near the store.

That the heavy user buys in greater quantity, with greater frequency, and from a wider array of brands suggests that he is a most promising target for sales promotion programs despite the difficulty in demographically identifying him.

The Camping Market's "Heavy Half"

In a recent cross section survey of New Hampshire state park campers (*LaPage 1968b*) we arrayed the camping families in order of their 1967 camping volume and split the sample at the median, which happened to be 20 days. This procedure revealed that 354 campers (half of the sample) accounted for only one-fourth of the reported 16,500 camping-days; the remaining campers — *the heavy half* — camped three times as much in 1967.

The heavy-half campers, in 1967, also were responsible for the majority of reported camping days in each of the preceding 3 years:

Year	*Reported camping-days*	*Percent done by heavy half*
1964	7,520	68
1965	9,689	67
1966	11,980	72

Not only do the heavy-half campers average more days of camping each year, but their participation is on the increase while that of the light half has remained practically unchanged over the 4-year period studied:

	Average Days Camped	
Year	*Light half*	*Heavy half*
1964	13	26
1965	14	28
1966	12	30
1967	12	34

Table 1. — Predicted average days of camping per year by heavy and light campers at daily fees of $1 to $5

Daily fees	Heavy-half campers	Light-half campers
	Days	*Days*
$1	39	14
2	34	12
3	28	7
4	18	7
5	10	4

Although the average daily expenditures by each group, when on a camping trip, are not greatly different ($11.94 for the light half, and $11.23 for the heavy half), their different participation rates result in a far greater dollar expenditure by heavy-half campers. The average annual expenditure for camping (exclusive of equipment) by light-half campers in 1967 was $143.28; for heavy-half campers it was $381.82.

We found no significant differences in the length of trips taken by heavy and light campers, but the heavy camper averaged 3 times as many camping trips (6 versus 2) during the 1967 camping season. Fifty-three-percent of the light campers went on only one trip during the year, while 61-percent of the heavy campers went on a minimum of five trips.

Because they take more frequent trips and they are exposed to many more campgrounds, heavy campers should be expected to be more sensitive to increasing camping fees. If the daily fee for a campsite were to be increased to $4, heavy campers predicted a 47-percent reduction in their visits to the park system at the same suggested fee level, the light campers predicted a 25-percent reduction. With daily fees as high as $5, both groups would reduce their camping by nearly 75 percent (table 1).

Reaching the Heavy-Half Camper

Like the analysts of the *Tribune's* consumer panel, we found no socio-economic or residential distinctions between light and heavy campers. At this point, the most that we can say about the heavy camper is that, on the average, he has more money invested in camping equipment, he has been camping longer, and he has decidedly less loyalty for specific kinds of campgrounds (tables 2-4).

The question of whether the heavy-half camper is a market segment worth focusing on is clearly answered in the observations that:

- One camping family in the heavy half is equal in purchasing power to three families in the light half.
- Heavy-half campers are less constrained in their campground selections by considerations of "brand" loyalty for specific campgrounds or types of campgrounds.
- Heavy-half campers are more sensitive to fee increases; and, therefore, they may be more responsive to attendance incentives that are based on discount fees (*LaPage 1968b*).

The question of how to reach the heavy-half camper segment is less easily answered. Whether heavy campers are any more likely to buy (and read) camping magazines and guidebooks (and which ones) is a subject well worth further study. Although our study did not focus on camper's sources of information, it did collect some preliminary data on camper decision-making. These data seem to indicate that the heavy-half campers are less likely to consciously deliberate between alternative campgrounds when selecting a place to camp, and they are more spontaneous in their selections. Two-thirds of the light-half campers had decided where to

Table 2. — The distribution of equipment investments by heavy and light campers

Campers	Investment in camping equipment: Under $150	$150 to $500	Over $500
	Percent	*Percent*	*Percent*
Heavy half	7	25	68
Light half	30	44	26

Table 3. — The distribution of years of camping experience by heavy and light campers

Campers	Years of camping experience: 0-2	3-5	Over 5
	Percent	*Percent*	*Percent*
Heavy half	30	27	43
Light half	47	19	34

Table 4. — The distribution of transient visitors, frequent visitors, and exclusive visitors in the New Hampshire state park system, by heavy and light campers

Campers	Transients	Regulars	Loyalists[1]	Total
	Percent	*Percent*	*Percent*	*Percent*
Heavy half	26	57	17	100
Light half	11	41	48	100

[1] In this study, transients were defined as campers who spent less than 15 percent of their 1967 camping at New Hampshire state parks; regular visitors spent between 15 and 89 percent; and loyalists camped almost exclusively (90 percent or more) within the state park system.

camp at least 2 weeks in advance; only 21-percent of the heavy-half campers decided this far in advance.

These findings suggest four possibilities for focusing a promotional campaign on the heavy-half of the camping market. (1) Check the readership surveys of camping magazines to find out what portion of their readers camp more than 20 days per year. Look also at their circulation figures for your part of the country. Generally, the magazines with the highest circulation and the largest proportion of heavy campers will be your best advertising buy. (2) Because the heavy-half camper has a big investment in equipment, he can be reached by campground brochures distributed at outdoor shows and through equipment dealers. (3) Ask your campers, when registering, how many days they camp per year. Then keep a separate mailing list for those who camp 21 days or more. Send these campers extra flyers during the year, particularly during the summer. And, (4) finally, because of the importance of word-of-mouth advertising in camping (*LaPage 1968a*), promotional schemes that are directed towards increasing camper satisfaction may prove to be the best advertising. The heavy-half camper, because he contacts 3 times as many campers per year, can be your most influential advertisement.

Before a fully developed strategy for reaching the heavy half of the camping market can be drafted, we will need to learn more about camping behavior. For example, is light camping a transitional stage to heavier equipment purchases and more frequent camping? Also, how long does the period of heavy camping last and does the frequent camper eventually stop camping abruptly or does he gradually return to a light camping stage?

To answer these and similar questions, the Northeastern Forest Experiment Station is now conducting its own long-term panel study of camper behavior. This panel survey is now entering its last year, and some of its findings should soon be available to campground owners.

Literature Cited

LaPage, W. F. 1968a. THE ROLE OF CUSTOMER SATISFACTION IN MANAGING COMMERCIAL CAMPGROUNDS. U. S. Forest Serv. Res. Paper NE-105, 23 pp., illus. NE. Forest Exp. Sta., Upper Darby, Pa.

LaPage, W. F. 1968b. THE ROLE OF FEES IN CAMPER'S DECISIONS. U. S. Forest Serv. Res. Paper NE-118, 24 pp., illus. NE. Forest Exp. Sta., Upper Darby, Pa.

Sizzors, J. Z. 1966. "WHAT IS A MARKET?" J. Marketing 30: 17-21.

Twedt, D. W. 1964. "HOW IMPORTANT TO MARKETING STRATEGY IS THE HEAVY USER?" J. Marketing 28: 71-72.

— WILBUR F. LA PAGE
Principal Social Scientist
Northeastern Forest Experiment Station
Forest Service, U. S. Dep. Agriculture
Durham, New Hampshire

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)A FOREST SERVICE RESEARCH NOTE NE-94

1969

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A DEVICE FOR MEASURING SOIL FROST

Abstract.—A water-filled plastic tube buried vertically in the soil in a copper casing permitted repeated observation of frost depth without damaging the sampling site. The device is simple and inexpensive and provides data on soil freezing at least as accurate as direct observation by digging through frozen soil.

Recent research reports about frost penetration in forest soils have relied on some admittedly unsatisfactory measurement techniques. Patric *(1967)* used direct observation: holes dug through frozen to unfrozen soil, a method recognized as accurate but laborious and destructive to the sampling site. Sartz *(1967)* tested three indirect measurement methods: electrical resistance blocks, a penetrometer, and a stack of buried water bottles. The older literature records yet other devices for indirect frost measurement, the most successful of which employed water-filled capillary tubes buried in the soil *(Gailleux and Thellier 1947)*.

A method was needed to combine the ease of indirect measurement and the accuracy of direct measurement with the capability for a statistically adequate sampling frequency.

A device was envisioned in which ice present in a buried water column would accurately reflect the advance and retreat of freezing temperature in the soil. Its ability to reflect advance of freezing temperature would rely on water's property of maximum density at 39°F. Water cooler than 39°F. would rise to the top of the column, then freeze when the temperature falls to 32°F. Warming of soil around the buried column would convert the ice back to water. A device was needed that would:

- React to soil freezing and thawing with reasonable speed and accuracy.
- Withstand expansion pressures during change from water to ice.
- Cause minimum alteration or damage to the sampling site.
- Be economical in construction and operation to permit frequent and replicated observation.

The Instrument

The frost tube finally developed consists of two basic parts: a 1/2-inch copper tube to serve as a well casing; and a transparent plastic 3/8-inch tube containing colored water (fig. 1). The copper casing was made watertight by capping the bottom end to preclude ice formation inside, which would prevent withdrawing the plastic tube for taking readings from it.

To install a frost tube, we forced a length of rigid copper tubing into unfrozen soil, then pushed the frost tube into the pilot hole. In stony soils a slender soil auger or a steel drive pin may be needed to make snug-fitting pilot holes.

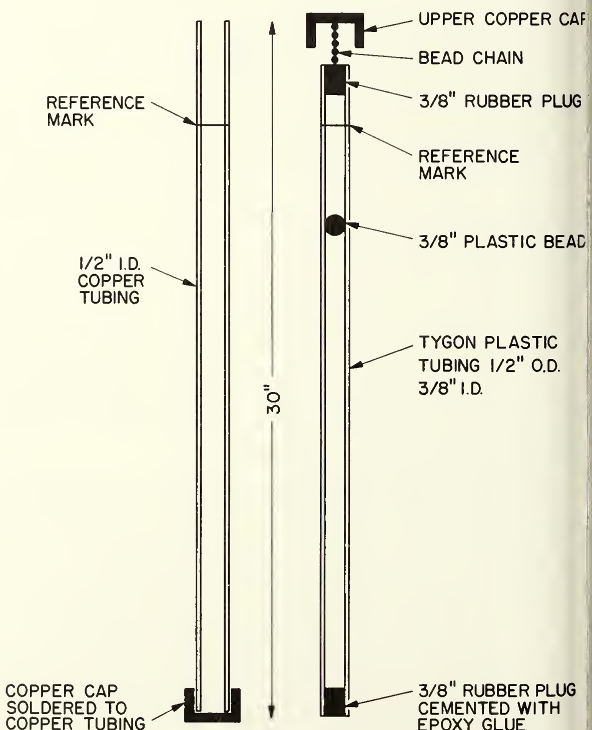

Figure 1.—Diagram of a frost tube. Not to exact scale.

For taking frost observations, the plastic tube is withdrawn by the chain connecting it to the upper cap. For proper reinsertion, this chain needs sufficient slack to permit reseating the plastic tube firmly against the bottom of the copper tube, before replacing the cap. The space partially occupied by the slack chain was intended to provide for expansion during freezing. However, the plastic tube was not observed to expand in any direction throughout the winter. We did dust all of the plastic tubes with graphite to make them easier to withdraw and reinsert.

It was necessary to insert in the tube a bead, of plastic or some other water-insoluble material, to prevent water overturn at the onset of freezing weather. At this time, even though surface soil froze, ice did not form within frost tubes without beads when subsoil temperature exceeded 39°F. Failure to freeze stemmed from water's unique property of maximum density at 7° above its freezing temperature. Placing the bead about 6 inches below the reference lines prevented this early-winter water overturn and provided more certain results on shallow freezing. The bead must of course be moved down as frost moves more deeply into the soil.

Reference marks can be inked or painted on both the copper and the plastic tubes. The frost tubes are inserted to the depth of the exterior reference mark, usually about 6 inches below the upper copper cap for easy relocation in snow and to forestall ice formation on the cover cap. Though exact placement of the exterior reference mark is unimportant, it and the interior reference mark must be at the same level. When the exterior reference mark is at the soil surface, frost measurements are made from the interior reference mark to the lowest ice dendrite visible inside the plastic tube.

Supercooling occasionally delayed ice formation when the frost tubes were being developed. A small quantity of finely dispersed silver iodide was mixed into the water to provide nucleating surfaces for ice-crystal formation. Although nearly insoluble, silver iodide was chosen for this purpose because its crystalline structure resembles that of ice.

Kool-Aid at 50 percent above drinking strength (3/4 package of Kool-Aid per quart of water) also was used in the frost tubes.[1] It contains a dye which tends to move away from ice and to concentrate in water (fig. 2). The contrasting pale ice and darker colored water greatly helps to determine the lowermost ice formation on dark winter days.

[1] The authors are indebted to Dr. Charles Stroh of the Chemistry Department, West Virginia University, for providing silver iodide and for pointing out the contrasting colors of frozen and liquid solutions of Kool-Aid. Mention of a commercial product should not be taken as an endorsement by the Forest Service.

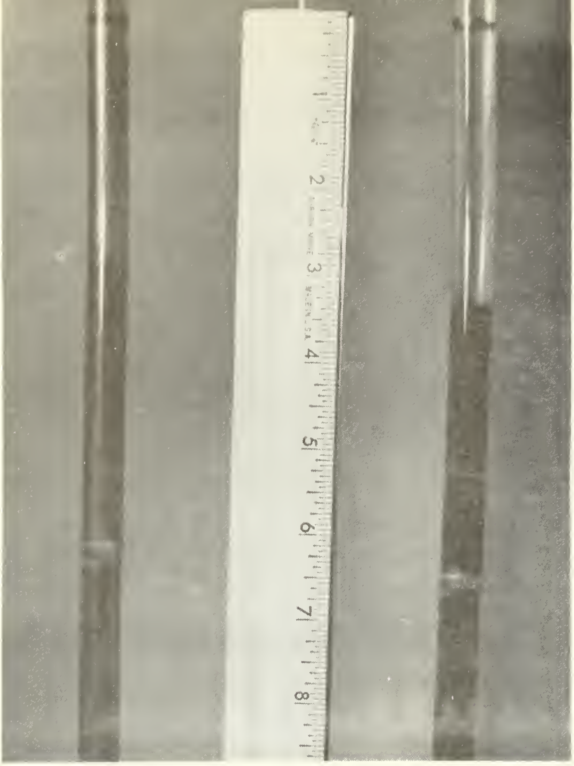

Figure 2. — The plastic tubes in course of development. Note the reference marks at top, and the plastic beads at 6½ inches. In the tube at right, coloring material in the water helps to mark the depth of freezing 3 inches below the reference line.

Test Results

The frost tubes were checked for ice whenever air temperatures fell below freezing. Ice never was observed in tubes when soil was unfrozen, regardless of air temperature. The soil froze first as a disc about 1 inch in radius and 1/2 inch deep around the tubes. This preliminary formation of frozen soil around the tubes suggests that the copper tubing initially conducts some heat from soil to atmosphere. At this stage of soil freezing, some but not all of the tubes contained ice in the uppermost portions. After continuous freezing more than 1 inch deep, ice will form in all properly constructed frost tubes .

During the period 17 January to 14 March 1968 we obtained 78 comparisons of frozen soil depths with the lengths of ice columns in frost tubes. These data, measured to the nearest 1/4 inch, are plotted in figure 3. The regression line expresses virtually a 1:1 relationship between ice-column length and frozen soil depth.

Late in the morning of 29 January, the soil thawed rapidly after being frozen about 8 inches deep. The following tabulation compares depths of freshly thawed soil to meltwater in frost tubes and depth of yet-frozen soil to ice remaining in frost tubes. These data suggest that water and ice in frost tubes reflect thawed and frozen soil fairly accurately, but with some time lag. Unfortunately no other observations were obtained under thaw conditions.

Tube No.	Newly thawed: Soil (inches)	Newly thawed: Water in tube (inches)	Still frozen: Soil (inches)	Still frozen: Ice in tube (inches)
3	4.0	2.50	4.5	6.50
6	3.5	2.75	4.0	2.25
11	4.0	2.75	.5	1.50
12	4.0	3.75	2.0	2.50

Five frost tubes were excavated on 28 February and the ice-frozen soil comparisons tabulated below illustrate the consistency of these data. Only the last comparison differed by more than 1/2 inch. Although differences as large as 2 inches were rare, they did occur. Errors even of this magnitude will decrease in consequence as frost depth increases.

Length of ice column (inches)	*Depth of frozen soil (inches)*
8.0	8.0
8.0	8.5
8.5	8.5
10.0	9.5
10.0	8.0

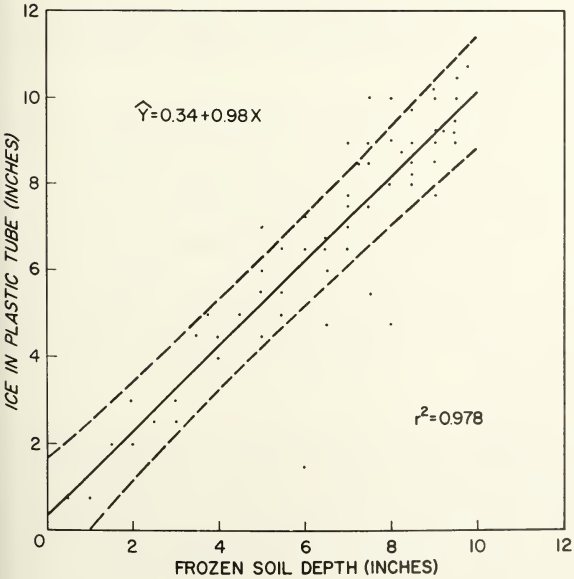

Figure 3. — The relationship of frozen soil to ice-column length on the frost tubes.

Discussion

Our study suggests that frost tubes provide strong evidence of depth of freezing temperature in the soil. However, Sartz's *(1967)* literature review, corroborated by results from his study in Wisconsin, led him to conclude that soil temperature is not a good indicator of soil freezing. This inexact relation of soil freezing to temperature may explain much of the point scatter around the regression line in figure 3 and the wild reading in the last text tabulation.

Possibly frost tubes can provide more accurate measurement of frozen soil depth than does excavation. The frost tube was held at eye-level in good light, assuring accurate measurement from the interior reference mark to the lowest ice dendrite in the plastic tube. To obtain a frozen soil measurement, frost tubes were excavated with a pick, crowbar, shovel or any other usable tool. The soil surface was not uniform and the exterior reference mark sometimes was 1/2 inch over or under the general soil level. Sometimes invisible, the probable bottom of the frozen layer was located by probing with a pocket knife, usually near the bottom of a very rough, small hole through the frozen soil. Soil easily penetrated by the knife blade was assumed to be unfrozen; yet sometimes small ice crystals were found in soft soil.

Thus, though frost tubes probably provide accurate indices of soil temperature, measurement of frozen soil combines personal judgment, imprecise boundaries, and awkward conditions for obtaining measurements. These error sources in direct measurement of frozen soil probably increase with increasing frost depth.

Although the available evidence suggests that frost tubes provide reasonably accurate estimates of frozen soil depth, further testing may be needed. For example, frost depths greater than 10 inches rarely occur in our relatively mild winters. Only one observation of thawing was obtained. Measurements both of deeper freezing and of thawing are being made in the severer climates of Wisconsin and Alaska. On the other hand, for frost depths of less than 2 inches, it is more accurate, less expensive, and easier to measure the frozen soil directly.

Frost tubes are simple, completely safe devices that permit us to estimate depth of soil freezing inexpensively, accurately, and in replicated installations. Most important, the frost tubes are non-destructive to the sampling site. They seem to provide a better method for measuring both freezing and thawing than any of the methods listed by Sartz *(1967)*. They should prove particularly useful for measuring the depths of active layers in permafrost regions.

Literature Cited

Gailleux, André and Emile Thellier.
1947. Sur La Determination De La Couche De Sol Geli. Acad. des Sci. Paris Compt. Rend. 224 16: 1174-1175. (Translated by Mrs. Severine Britt, U.S. Geological Survey, January 1948.)

Patric, J. H.
1967. Frost Depth In Forest Soils Near Juneau, Alaska. U.S. Forest Serv. Res. Note PNW-60. 7 pp. Portland, Oregon.

Sartz, Richard S.
1967. A Test of Three Indirect Methods of Measuring Depths of Frost. Soil Sci. 104: 273-278.

—JAMES H. PATRIC and BURLEY D. FRIDLEY

Timber and Watershed Laboratory
Northeastern Forest Experiment Station
Forest Service, U.S. Dep. Agriculture
Parsons, W. Va.

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)A FOREST SERVICE RESEARCH NOTE NE-95
1969

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A GLIMPSE AT NEW YORK'S CURRENT TIMBER RESOURCE

Abstract.—Data from the recent Forest Survey of New York reveal a 13-percent increase in commercial forest land area, a 12-percent increase in the cubic-foot volume of growing stock, and a 4-percent decrease in the board-foot volume of growing stock during the 18-year period between surveys.

In November, 1968, the second Forest Survey of the timber resources of New York was completed. Preliminary data for the Southwestern and Northern Regions already have been released and a similar release for the Southeastern Region will be available in 1969. A comprehensive statistical-analytical report containing data for 8 geographic units and 55 counties is being prepared for publication late in 1969.

This interim release is intended to provide a glimpse at the current statewide totals and to note some of the more important changes that have occurred since the initial Forest Survey was completed in 1950.

The total area of commercial forest land in New York has increased 13 percent since 1950. This increase has not been uniform over the State. The Southeastern Region actually decreased 3 percent in commercial forest area whereas the Southwestern Region had a 23-percent increase.

The increase in commercial forest area and a surplus of growth over cut combined to produce a 12-percent increase in the net cubic-foot volume of growing-stock trees. Some species did not follow this general trend. Yellow birch has been hit by the dieback complex, resulting in a loss of inventory volume since 1950. High mortality also has occurred in cedar and the elms.

The regions of New York used in reporting the findings of the Forest Survey.

The board-foot inventory volume has decreased 4 percent since 1950. Many factors have contributed to this loss. These include heavier removals of sawtimber, mortality, and a general decline in quality.

— JOSEPH E. BARNARD, Research Forester
TERESA M. BOWERS, Statistical Assistant
Northeastern Forest Experiment Station
Forest Service, U. S. Dep. Agriculture
Upper Darby, Pa.

Table 1.—*Commercial forest land area by geographic region and forest type, 1968*

Forest type	Thousands of acres			Sampling error in percent of cell total		
	Southwestern Region	Northern Region	Southeastern Region	Southwestern Region	Northern Region	Southeastern Region
White-red pine-hemlock	331.9	463.6	490.3	13	10	10
Spruce-balsam fir	48.5	599.6	10.5	39	10	73
Oak-pine	50.4	57.9	142.6	35	30	19
Oak-hickory	387.3	100.6	788.7	12	24	8
Elm-ash-red maple	1,492.6	929.2	859.9	6	8	7
Maple-beech-birch	2,711.3	2,353.6	775.9	4	5	8
Aspen-birch	364.0	646.2	112.4	13	13	22
Plantation	312.0	136.9	115.2	15	21	23
All types	5,698.0	5,287.6	3,295.5	1	1	2

Table 2.—*Net cubic-foot volume of growing-stock trees by geographic region and species, 1968*

Species	Millions of cubic feet			Sampling error in percent of cell total		
	Southwestern Region	Northern Region	Southeastern Region	Southwestern Region	Northern Region	Southeastern Region
White-red pine	352.8	467.5	457.6	14	10	10
Spruce and fir	16.4	600.3	20.8	44	7	37
Hemlock	399.9	372.2	309.9	9	10	9
Other softwoods	33.9	114.0	35.4	33	17	31
All softwoods	803.0	1,554.0	823.7	8	4	6
Beech-birch-maple	1,404.9	1,334.1	435.2	5	4	6
Oaks	489.6	133.7	808.0	8	14	6
Other hardwoods	2,118.5	1,280.8	1,014.3	3	4	4
All hardwoods	4,013.0	2,748.6	2,257.5	2	3	3
All species	4,816.0	4,302.6	3,081.2	2	1	2

Table 3.—*Net board-foot volume of growing-stock trees by geographic region and species, 1968*

Species	Millions of board feet			Sampling error in percent of cell total		
	Southwestern Region	Northern Region	Southeastern Region	Southwestern Region	Northern Region	Southeastern Region
White-red pine	619.0	1,246.3	1,140.9	15	10	10
Spruce and fir	6.2	1,077.5	34.6	50	8	40
Hemlock	850.1	1,026.0	730.5	10	11	11
Other softwoods	35.5	165.1	67.1	45	20	32
All softwoods	1,510.8	3,514.9	1,973.1	9	5	7
Beech-birch-maple	2,473.3	3,404.2	744.1	6	4	8
Oaks	1,162.4	314.5	1,915.6	9	16	6
Other hardwoods	3,396.6	2,501.3	1,497.6	4	5	6
All hardwoods	7,032.3	6,220.0	4,157.3	3	3	4
All species	8,543.1	9,734.9	6,130.4	2	2	2

Table 4.—*Average net annual growth by geographic region and species group, 1950-68*

Region	Thousands of cubic feet		Thousands of board feet	
	Softwoods	Hardwoods	Softwoods	Hardwoods
Southwestern	21,009	87,096	56,616	173,460
Northern	30,989	47,048	70,370	130,866
Southeastern	17,502	41,856	57,014	118,174
Total	69,500	176,000	184,000	422,500

Table 5.—*Average annual removals by geographic region and species group, 1950-68*

Region	Thousands of cubic feet		Thousands of board feet	
	Softwoods	Hardwoods	Softwoods	Hardwoods
Southwestern	4,692	50,369	14,951	195,129
Northern	28,043	31,880	90,508	124,236
Southeastern	7,965	10,851	32,641	15,635
Total	40,700	93,100	138,100	335,000

Table 6.—*Average annual mortality by geographic region and species group, 1950-68*

Region	Thousands of cubic feet		Thousands of board feet	
	Softwoods	Hardwoods	Softwoods	Hardwoods
Southwestern	6,389	31,457	8,134	39,233
Northern	14,474	27,903	24,596	35,511
Southeastern	6,437	18,240	10,270	13,756
Total	27,300	77,600	43,000	88,500

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HEIGHT GROWTH AND FOLIAGE COLOR IN A SCOTCH PINE PROVENANCE STUDY IN NORTHERN MICHIGAN

Abstract.—A Scotch pine provenance study conducted in northern Michigan revealed important differences in height growth and foliage color among seedlings from 83 European sources. Seed from southern European sources produced seedlings with the best fall foliage coloration. Height growth was fastest among seedlings from sources with latitudes like that of the Michigan planting site.

One of the first studies of racial variation in forest trees was conducted on Scotch pine (*Pinus sylvestris* L.) by DeVelmorin (*1862*). His plantings at Les Barres, France, proved that seedlings obtained from different countries varied in several important growth characteristics. Researchers did not fully appreciate the importance of this finding until they discovered that Scotch pine seed from certain geographic regions produced crooked, slow-growing, and virtually worthless trees when planted in the United States; whereas seed from other areas produced more desirable trees.

To determine the best region or regions from which Scotch pine seed should be obtained for plantings in the North Central Region of the United States, a provenance study was established in northern Michigan in 1958. This report describes the results after 5 growing seasons.

Study Methods

Seed was collected from natural stands in 18 European countries. Seed trees within each stand were spaced far enough apart so that the chance of progeny from different trees sharing a common pollen parent was remote. One hundred six seed sources of Scotch pine were collected, and

Table 1.—*Data on origin of seed sources.*

Number	Country	North Latitude	Longitude	Elevation
				Meters
201	Norway	60.5	3.2 E	33
202	Germany	53.0	10.6 E	100
203	Germany	48.2	8.3 E	—
206	Germany	50.2	8.8 E	—
208	Germany	50.6	9.8 E	—
209	Germany	50.3	12.2 E	600
210	Germany	53.2	14.3 E	—
211	East Prussia	53.8	12.2 E	—
213	Turkey	40.5	32.7 E	1,600
218	Spain	40.3	5.2 W	1,200
219	Spain	40.8	4.0 W	1,600
220	Turkey	40.0	31.3 E	1,500
221	Turkey	40.5	32.7 E	1,600
222	Sweden	60.2	15.0 E	250
223	Latvia	57.5	25.8 E	—
224	Latvia	57.7	26.3 E	—
227	Siberia	54 0	94.0 E	200
228	Finland	60.4	25.4 E	40
229	Finland	65.2	25.5 E	10
230	Finland	60.5	22.4 E	45
233	Finland	61.5	26.0 E	—
234	Russia	56.0	95.0 E	200
235	France	48.2	9.2 E	720
241	France	49.1	7.4 E	250
242	Yugoslavia	43.9	19.4 E	1,000
243	Greece	41.5	24.3 E	1,800
245	Spain	40.7	4.2 W	1,500
246	Spain	41.8	2.8 W	1,200
247	Spain	41.8	2.7 W	1,100
248	Germany	48.5	9.8 E	—
249	Austria	[1]	[1]	400
250	Germany	49.4	7.6 E	400
251	Germany	49.1	8.1 E	150
253	Germany	49.1	7.8 E	400
254	Russia	60.8	131.6 E	750
255	Russia	52.4	117.7 E	600
256	Russia	56.7	96.3 E	350
257	Russia	56.8	65.0 E	150
258	Russia	58.8	60.8 E	50
263	Russia	41.8	43.4 E	1,120
265	Scotland	57.1	4.9 W	200
266	Scotland	57.2	3.7 W	250
267	Scotland	57.2	4.8 W	300
268	Scotland	57.2	3.8 W	200
271	Greece	41.5	24.3 E	1,550
273	Norway	59.7	9.5 E	200
274	Norway	60.3	9.9 E	200
275	Norway	59.8	11.6 E	220

CONTINUED

Table 1—Continued

Number	Country	North Latitude	Longitude	Elevation
				Meters
276	Norway	59.8	11.5 E	220
305	Czechoslovakia	49.0	14.7 E	400
306	Czechoslovakia	49.2	14.0 E	450
307	Czechoslovakia	49.9	17.9 E	250
308	Czechoslovakia	50.2	15.5 E	200
309	Czechoslovakia	49.8	13.3 E	680
310	Czechoslovakia	48.7	14.9 E	550
311	Czechoslovakia	50.5	.6 E	300
312	Czechoslovakia	50.9	15.8 E	600
315	Czechoslovakia	49.1	16.2 E	300
316	France	45.1	3.5 E	1,000
317*	France	53.7	20.5 E	200
318**	France	51.2	5.5 E	—
319	Austria	—	—	500
521	Sweden	59.8	18.0 E	20
522	Sweden	60.9	16.5 E	225
523	Sweden	61.3	15.9 E	270
524	Sweden	61.3	17.9 E	30
525	Germany	50.4	12.2 E	465
526	Germany	50.4	12.2 E	510
527	Germany	50.9	13.7 E	540
530	Belgium	50.0	5.0 E	330
541	Sweden	57.7	15.5 E	150
542	Sweden	58.8	14.3 E	125
543	Sweden	59.9	12.9 E	200
544	Sweden	60.4	14.9 E	250
545	Sweden	60.4	12.9 E	250
546	Sweden	60.9	13.4 E	450
550	Sweden	55.9	14.1 E	20
551	Greece	41.3	23.2 E	—
552	Hungary	47.3	17.8 E	250
553	Hungary	47.7	16.6 E	328

[1] Commercial seedlot.

* Source 317 var. *rigensis* (Kluger).

**Source 318 "Belgium Long-needle" (Raeymaekers).

83 sources were included in this outplanting (table 1). Stock was grown in a nursery at East Lansing, Mich., and distributed for outplanting as 2-0 stock in the spring of 1961.

Eight replications of four-tree-line plots in a randomized complete block design were planted near Houghton, Mich. (Lat. 47° 20′ N. Long. 88° 50′ W). An 8-x-8-foot spacing was used, and trees were planted in an old field furrowed in both directions to reduce early sod competition.

Survival was checked in the fall of 1961, and replacements were made with 3-0 stock in the spring of 1962.

The data for this report were collected in November 1963, and represented 5 complete growing seasons—two in the nursery and three in the field. Only total height, survival, and foliage color were recorded although some observations were made on needle length and diameter. Analysis of variance was used to test differences in tree height among sources. Missing plot values were supplied using the technique described by Cochran and Cox (*1950*).

Results and Discussion

Highly significant differences were found in height growth between seed sources. No differences were observed between blocks. The tallest seedlings were from sources similar in latitude to the outplanting site (Lat. 47° N), and the shortest trees were from sources between 55° and 65° N latitude. Height growth also tended to decrease in seedlings from the southern sources (figs. 1 and 2).

Figure 1.—Latitude of seed source plotted over height of seedlings after 3 growing seasons in field.

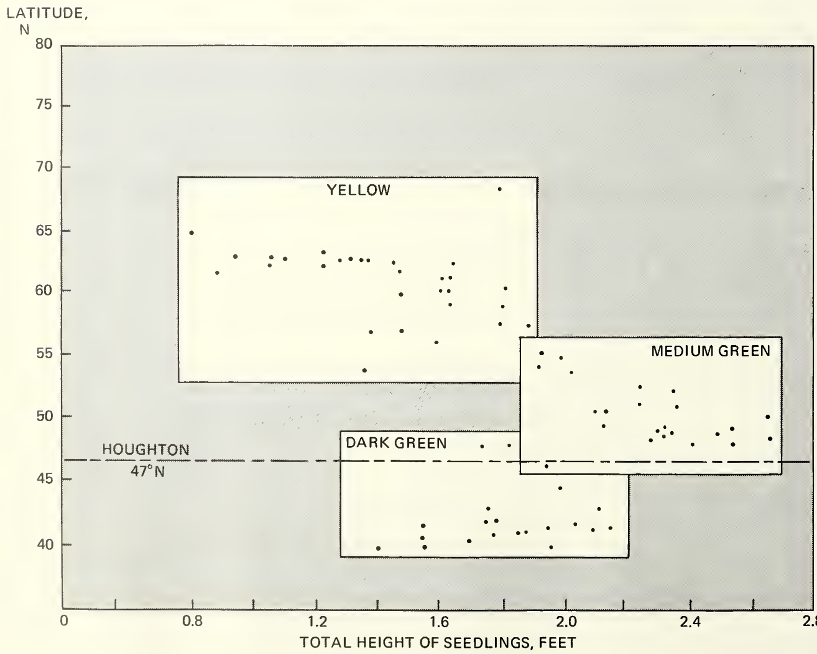
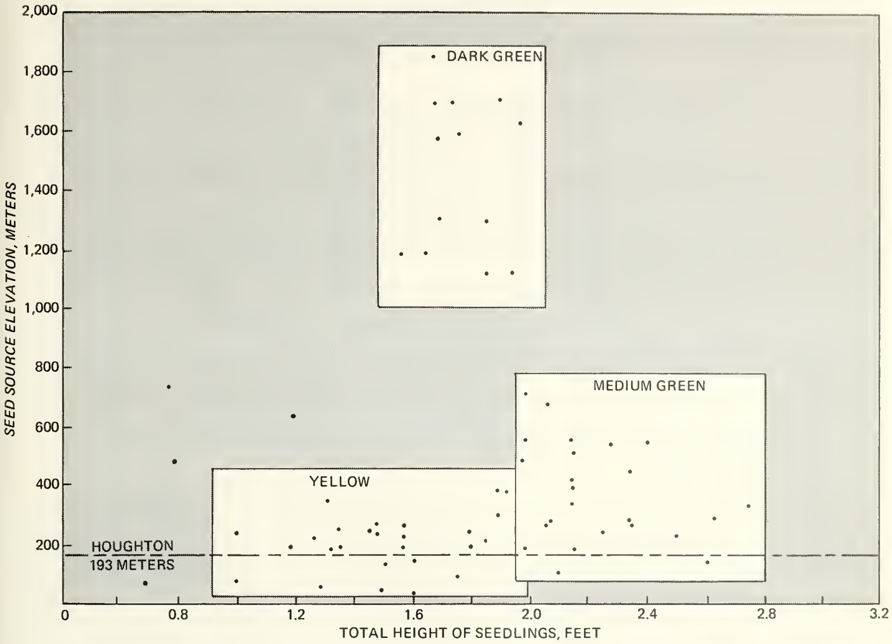


Figure 2.—Altitude of seed source above sea level plotted over height of seedlings after 3 growing seasons in field.



Fall foliage color also appeared to follow a definite geographic pattern. The darkest green foliage was found on seedlings from sources south of latitude 45° N, and the yellowest foliage was found on seedlings from sources north of latitude 55° N (fig. 1). Elevation of the seed source was also related to foliage color. The darkest foliage was found on seedlings from sources on the highest elevations (above 1,000 meters), and the yellowest foliage was found on seedlings from sources on the lower elevations (below 300 meters) (fig. 2).

Other morphological features observed were:

- Seedlings from sources 220 (Turkey) and 263 (Russia) had longer needles than seedlings from the other sources.
- Seedlings from source 316 (France) had more lateral branches per whorl than seedlings from the other sources.
- Seedlings from source 206 (Germany) had fine-textured needles similar to white pine and unlike the characteristic thick needles of Scotch pine.

- Seedlings from sources 241 (France), 242 (Yugoslavia), and 553 (Hungary) displayed some prolepsis (late-season development of lateral buds at the base of the terminal bud).

With the exception of slight needle damage to seedlings from source 224 (Latvia), no insect damage was observed in this outplanting area. Snow damage causing deformed and prostrate main stems is quite prevalent throughout the plantation, probably because seedlings were planted in deep furrows and the accumulations of snow are heavy in this area.

Our results seem to reinforce earlier observations about growth rate and foliar color of Scotch pine from various geographic seed sources. Wright *et al* (*1966*) found that trees from the extreme northern provenances were shortest; trees from central Europe were tallest; trees from western Europe were a darker blue; and trees from Siberia had the yellowest foliage.

Several writers (*Wright and Bull, 1963; Wright and Baldwin, 1957; Wright, et al., 1966*) have suggested that Scotch pine is composed of a number of distinct ecotypes. However, Langlet (*1959*) challenged this conclusion. He suggested that the data presented by Wright and Baldwin indicate that variability is continuous and that geographic ecotypes are not present. Our results seem to agree more closely with the clinal variation concept because no well defined breaks in height or foliage color separate one population from another.

Conclusions

Final judgments about mature tree form and other features such as wood quality of trees from the various sources will be made later. However, from what we have learned from this study so far, we can now make some tentative recommendations. Persons interested in growing Scotch pine for sawtimber in the Upper Lake States area and primarily interested in fast growth rates probably should select seed from central European sources.

If the future crop is to be Christmas trees and fall foliage color is the important consideration, then seed from southern European sources should be used. Source 316 (France) should be investigated further for this purpose because trees from this source have most of the characteristics desired in a good Christmas tree—dark green foliage late in the fall, moderately fast growth rate, and more lateral branches per whorl than trees from other sources.

Literature Cited

Cochran, W. G., and G. M. Cox.
1950. Experimental designs. 611 pp. John Wiley and Sons, Inc., N.Y.

DeVilmorin, Louis.
1862. Expose historique et descriptif de l'ecole forestiere des Barres. Mem. d'Agriculture. 332 pp. Paris.

Langlet, O.
1959. A cline or not a cline—a question of Scots pine. Silvae Genet. 8: 13-22.

Wright, J. W., and H. I. Baldwin.
1957. The International Union Scotch pine provenance test in New Hampshire. Silvae Genet. 6: 2-14.

Wright, J. W., and W. I. Bull.
1963. Genetic variation in Scotch pine—results of a 3-year Michigan study. Silvae Genet. 12: 1-25.

Wright, J. W., S. S. Pauley, and others.
1966. Performance of Scotch pine varieties in the North Central Region. Silvae Genet. 15: 101-110.

—PETER W. GARRETT[1]
Research Geneticist
Northeastern Forest Experiment Station
Durham, New Hampshire

[1] Data for this paper were collected while the author was assistant professor of forestry at Michigan Technological University, Houghton, Mich.

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USDA FOREST SERVICE RESEARCH NOTE NE-97
1969

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A PREVIEW OF OHIO'S FOREST RESOURCE

Abstract. The recent Forest Survey reveals that there has been a 933,000-acre increase in commercial forest land, a 32-percent increase in the cubic-foot volume of growing stock, a 30-percent increase in the board-foot volume of sawtimber, and an excess of net growth over removal since the 1952 inventory.

The recently completed re-inventory of the timber resource of Ohio indicates that several noteworthy changes have occurred since the initial inventory in 1952. Statistical-analytical reports for the Hill Country and for the State, presenting in detail the current forest situation and the apparent trends since 1952, are being prepared for publication. These comprehensive reports will contain detailed data for 5 geographical units and area and volume data for all 88 counties.

One notable change for the State is the 933,-000-acre increase in commercial forest land area. The current total of 6.3 million acres of commercial forest land is 24 percent of the total land area of Ohio. The change in forest land area was not uniform throughout the State. The Hill Country region increased 32 percent, to 4.4 million acres. The Glaciated region decreased slightly, to 1.9 million acres.

The timber-volume data[1] reveal a 32-percent increase in cubic-foot volume of growing stock and a 30-percent increase in the board-foot volume of sawtimber during the 16-year period between inventories. The current cubic-foot volume of 4.2 billion cubic feet is over 95 percent hardwood. Hardwood comprises more than 95 percent of the 14.6 billion board feet of sawtimber. The oaks and hickory comprise a major portion of the hardwood volume in both cubic feet and board feet.

[1] The 1952 inventory volume data have been adjusted to conform with 1968 standards in order to make the two inventories directly comparable.

Data on average annual growth, removal, and mortality reveal that the current net growth exceeds removal. The average annual cubic-foot net growth is 132.8 million cubic feet, and the average annual removal is 70.5 million cubic feet (almost a 2 to 1 ratio). The average annual board-foot net growth is 422.0 million board feet, and the average annual removal is 209.5 million board feet. For softwoods alone, the net annual growth is 14.0 million board feet and the removal is 12.5 million board feet.

—JOSEPH E. BARNARD, and TERESA M. BOWERS[2]

[2] Mr. Barnard is a research forester and Miss Bowers a statistical assistant in the Forest Survey unit of the Northeastern Forest Experiment Station, Forest Service, U. S. Dep. Agriculture, Upper Darby, Pa.

Table 1. Area of commercial forest land by ownership classes and geographic regions, Ohio, 1968

Ownership	Thousands of acres		Sampling error in percent of cell total[1]	
	Hill Country	Glaciated Region	Hill Country	Glaciated Region
National Forest	112.3	—	—	—
Other Federal	—	8.7	—	—
State	191.6	31.1	—	—
County and municipal	—	4.0	—	—
Total public	303.9	43.8	—	—
Forest industry	126.8	—	16	—
Farmer-owned	1,673.0	1,014.9	4	8
Miscellaneous private	2,277.6	889.2	3	9
Total private	4,077.4	1,904.1	1	4
All ownership	4,381.3	1,947.9	1	4

[1] There are no sampling errors for areas in public ownership. Acreages were obtained from public records.

Table 2. Net volume of growing stock on commercial forest land by species and geographic regions, Ohio, 1968

Species	Millions of cubic feet		Sampling error in percent of cell total	
	Hill Country	Glaciated Region	Hill Country	Glaciated Region
Softwoods	110.1	5.8	14	*
Select white oaks	444.3	148.7	4	16
Select red oaks	197.4	115.5	6	16
Other white oaks	245.0	7.0	7	**
Other red oaks	357.0	75.2	5	22
Hickory	304.1	178.4	5	15
Hard maple	124.5	115.4	8	19
Soft maple	90.8	136.6	9	16
Ash	127.1	142.3	7	10
Yellow-poplar	250.0	15.8	8	30
Elm	159.9	84.0	8	16
Other hardwoods	476.6	269.4	4	11
All species	2,886.8	1,294.1	1	4

* Sampling error of 50 to 99 percent.
** Sampling error of 100 percent or more.

Table 3. Net volume of sawtimber on commercial forest land by species and geographic regions, Ohio, 1968

Species	Millions of board feet[1]		Sampling error in percent of cell total	
	Hill Country	Glaciated Region	Hill Country	Glaciated Region
Softwoods	338.2	11.3	15	**
Select white oaks	1,661.4	698.2	5	17
Select red oaks	804.2	435.4	6	17
Other white oaks	811.4	35.0	8	**
Other red oaks	1,433.8	301.2	5	24
Hickory	804.7	440.4	6	18
Hard maple	373.8	436.5	10	22
Soft maple	262.2	520.2	12	18
Ash	389.2	468.5	9	13
Yellow-poplar	1,017.5	81.6	9	30
Elm	425.9	314.6	10	19
Other hardwoods	1,477.6	1,008.8	5	13
All species	9,799.9	4,751.7	2	5

[1] International ¼-inch rule.
** Sampling error of 100 percent or more.

Table 4. Average annual change on commercial forest land by species group, Ohio, 1951-67

Major components	Thousands of cubic feet		Thousands of board feet[1]	
	Softwoods	Hardwoods	Softwoods	Hardwoods
Mortality	1,300	25,700	4,000	69,000
Net growth	4,200	128,600	14,000	408,000
Removals	2,700	67,800	12,500	197,000

[1] International ¼-inch rule.

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USDA FOREST SERVICE RESEARCH NOTE NE-98
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DETERMINING pH OF STRIP-MINE SPOILS

Abstract.—Results with the LaMotte-Morgan method for determining soil pH—or the solution modification of this method—usually agreed fairly well with the results from using a pH meter, the recognized standard. Results obtained with the Soiltex and Hellige-Truog methods often deviated somewhat from the pH meter readings; and the Hydrion papers and the Kelway pH tester often gave results that were considerably different.

Success in establishing various types of vegetation on strip-mine spoils in the Eastern and Central States is often limited by spoil acidity. Thus, for planning revegetation programs on strip-mined areas, a knowledge of the relative spoil acidity is essential. This note contains brief descriptions and evaluations of several methods of determining spoil acidity.

The degree of acidity is measured by the hydrogen ion concentration in solution. If concentrations were given in conventional units, this would result in large unwieldy numbers; however, this can be avoided by using the logarithmic term pH. On the pH scale a value of 7 is neutral: values less than 7 are acid, and acidity increases as the pH value decreases; values greater than 7 are alkaline, and alkalinity increases as the pH value increases.

Certain pines and birches may grow on spoil with pH as low as 3.5; other trees and weeping lovegrass may grow on spoil with pH as low as 4.0. Most commonly used herbaceous species will not grow satisfactorily unless the pH is 4.5 or above. High pH is seldom a problem, but pines may do poorly on alkaline spoils.

Sampling Spoils

Before starting to sample, take a good look at all the spoils on a job. Areas that are obviously different in color or composition should be sampled as separate units if they are big enough to be handled separately in the revegetation program.

The number of samples to take on an area will depend on the homogeneity of the spoils and the objectives of revegetation. Our experience has been that 10 samples are about the minimum needed for revegetation interpretations on several acres of spoil that are uniform in appearance. Heterogeneous spoils and larger areas require more samples, but the question of how many needs further study. Since pH determinations are inexpensive in relation to total revegetation costs, and often inexpensive in relation to travel time to a site, it is better to take too many samples than too few.

When planning revegetation for a spoil area, your first concern should be the proportion of the area that falls into various acidity classes. Therefore, do not combine samples.

A tile spade with a round cutting edge usually works well for sampling. First make a vertical cut to a depth of about 4 inches, and discard the spoil. Then make a second cut, 2 or 3 inches behind the first, to obtain the sample; discard rock fragments larger than about 1/2 inch.

Small paper sacks can be used to hold samples and record information about spoil type and area. However, wet samples should be put in moisture-resistant liners or commercially available soil-test bags.

Several months of exposure after the mining operation are usually required before spoils containing acid-producing materials (sulfides) develop their lowest pH. Thus, in addition to pH measurements, a sulfide test may be desirable on some spoils. Details for making sulfide tests are contained in an article by Neckers and Walker.[1]

Methods Used to Determine pH

A pH meter is the standard device for determining soil pH. However, because of the purchase and maintenance costs of these meters, plus the requirements for containers, distilled water, and buffers, other methods are often used to determine spoil pH.

[1] Neckers, J. W., and C. R. Walker. FIELD TEST FOR ACTIVE SULFIDES IN SOIL. Soil Sci. 74: 467-470. 1952.

In contacts with revegetation specialists and strip-mine inspectors, we noted that some of the methods did not give results consistent with those that we obtained with a pH meter. To check the methods, we determined pH on 100 representative Kentucky spoils. The samples included spoils from all the major Kentucky strip-mined coal seams. The spoils were air-dried, screened to remove rocks larger than 1/2-inch diameter, and then mixed. The methods used to determine pH were as follows.

pH Meter.—The instrument used was a line-operated Fisher Accumet[2] pH meter equipped with glass and reference electrodes. The meter was checked with buffer at pH 4.0 and 7.0. Forty milliliters of distilled water were added to 20 grams of spoil. The spoil was allowed to slake in the water a few minutes; next it was mixed and allowed to equilibrate 1 hour; then it was mixed again; finally, the electrodes were inserted into the liquid and the pH was read.

LaMotte-Morgan.—This is a kit that contains several pH indicator dyes. Each dye has a range of about 1.6 pH units. If the color resulting from contact with soil was on either extreme of the range, the next higher or lower range indicator was used. Colors were compared to standard color charts. Directions given by the manufacturer were followed. Because Bromphenol Blue (pH range 3.0 to 4.6) and Meta Cresol Purple (pH range 1.2 to 2.8) were not included in the standard kit, they were ordered extra.

LaMotte-Morgan modification.—This was our modification, using the LaMotte-Morgan pH indicator dyes on the solution from the spoil-distilled water mixtures made up for the pH meter tests. Four drops of the solution were put into the LaMotte-Morgan porcelain test plate, and one drop of indicator was added. The color was read in the shallow groove rather than in the well of the plate.

Soiltex.—The Soiltex kit contains a single liquid-dye indicator that is added to the soil in a small wax-paper "boat". The color of the liquid after reacting with soil is compared to a color chart. We followed the directions given by the manufacturer.

Hellige-Truog.—This kit contains a single liquid-dye indicator solution that is placed in the cavity of a porcelain test-block; soil is added to absorb all the indicator. The indicator and soil are mixed; then a white powder is sprinkled over the surface. The powder absorbs the

[2] Mention of product names does not imply endorsement by the U. S. Department of Agriculture or the Forest Service.

color of the indicator, which is then compared to a color chart. The manufacturer's directions were followed.

Hydrion Papers.—These are narrow strips of paper impregnated with pH indicator dyes. The papers are sometimes used on soils and spoils, although they are not made nor advertised for this purpose. The manufacturer recommends that these test papers be used on buffered solutions (buffered solutions have a strong resistance to a change in pH). We dipped these papers into the solution from the spoil-distilled water mixtures made up for the pH meter tests. We also made up a paste of spoil and distilled water; then we pressed one side of the indicator paper against the paste and read the color resulting from the absorbed solution on the other side of the paper. Results of the latter method were nearly the same as the solution method. Wide range (pH 3.0 to 7.5) and short range (pH 3.0 to 5.5) papers were used.

Kelway pH Tester.—This is a probe that is made to be pushed into moist soil, after which the pH is read on a dial at the top of the probe. However, for dry soils the soil can be placed in a container; distilled water is added; and then the probe is inserted into the mixture for a reading. On the test spoils we used this latter procedure, following the manufacturer's directions.

Results and Discussion

Results obtained with the LaMotte-Morgan method, or with our solution modification of the LaMotte-Morgan method, usually agreed fairly well with results from using the pH meter (table 1). Results obtained with the Soiltex and Hellige-Truog methods often deviated more than 0.5 pH unit from the pH meter reading. Hydrion paper and the Kelway pH tester often gave results that were considerably different from those with the pH meter.

Although not strictly comparable because of differences in electrodes and soil materials, the deviations for the LaMotte-Morgan and Soiltex methods were similar but slightly greater than the deviations reported for these methods on soils.[3]

A pH meter is easy to operate, and battery-operated pH meters can be used readily in the field. However, when many samples are required, the most convenient method is usually to collect the samples and bring them into the laboratory for pH readings (fig. 1).

[3] Mason, D. D., and S. S. Obenshain. A COMPARISON OF METHODS FOR THE DETERMINATION OF SOIL REACTION. Soil Sci. Soc. Amer. Proc. 3: 129-137. 1939.

Table 1.—Percentage of readings from six pH determination methods falling within a given deviation of pH meter readings

Method and pH range*	Deviation, in pH units of—				
	0.2	0.5	1.0	2.0	3.0
LaMotte-Morgan:					
2.7-4.5	58	92	100	--	--
4.6-6.0	49	87	100	--	--
6.1-8.3	44	80	100	--	--
LaMotte-Morgan modification:					
2.7-4.5	44	100	--	--	--
4.6-6.0	51	80	100	--	--
6.1-8.3	52	88	100	--	--
Soiltex:					
2.7-4.5	44	83	97	100	--
4.6-6.0	33	59	92	100	--
6.1-8.3	16	44	84	100	--
Hellige-Truog:					
2.7-4.5	42	75	97	100	--
4.6-6.0	23	62	97	100	--
6.1-8.3	12	44	72	100	--
Hydrion Papers:					
2.7-4.5	56	97	100	--	--
4.6-6.0	8	31	77	100	--
6.1-8.3	0	0	0	48	100
Kelway pH Tester:					
2.7-4.5	6	33	50	92	100
4.6-6.0	0	3	10	87	100
6.1-8.3	44	68	80	100	--

*Number of spoil samples within the ranges, as determined by pH meter: 2.7 to 4.5—36; 4.6 to 6.0—39; 6.1 to 8.3—25.

The exact ratio of spoil to distilled water makes little difference in routine pH measurements on spoils. Thus the procedure can be simplified by filling small paper cups half full of spoil, then adding distilled water until the cups are nearly full. On more acid spoils (pH 3.5 to 5.0), the time allowed for equilibrium makes little difference (a few minutes will do). To obtain consistent readings on spoils of higher pH, especially in the 6.5 to 8 range, it may be necessary to let the mixture stand an hour or even overnight.

Figure 1.—Determining pH of spoils with a pH meter. Because of its general reliability and ease of operation, the pH meter is the recognized standard for soil pH measurements.

For most spoil materials, about the same readings are obtained with the electrodes in the solution above the settled spoil material as in the material itself. However, in some spoils (and in acid soils) a lower pH is recorded when the electrodes are inserted into the mass of settled particles. This is termed "suspension effect". The proper electrode placement for best results is still in question. Since electrodes can be broken by sharp contact with coarse particles, we prefer to insert them only into the liquid. The important point is consistency in the technique used.

The LaMotte-Morgan method should give satisfactory results for revegetation interpretations on spoils. The kit is less costly and can take rougher treatment than a pH meter. However, the procedure is more time-consuming because two or more indicators often have to be tried. Advantages of the solution modification method over the normal LaMotte-Morgan method are that spoil does not have to be cleaned from the spot plate, wet sticky spoils are manageable, and coarse fragments (up to about 1/2 inch in diameter) do not have to be removed from the sample. Some spoils will not give a clear solution, but reasonably good results are still obtained by using the slightly cloudy suspension.

The Soiltex and Hellige-Truog methods employ one mixed indicator solution for the pH range 4 to 8.5 or 9. Both of these methods have the disadvantages that readings below 4 cannot be made and that readings in the pH 4 to 5 range, critical for plant species, cannot be made closer than 0.5 pH unit. An advantage of these methods is that the kits are small and inexpensive. And if carefully used, the Hellige-Truog method can detect components that have different pH levels in a spoil sample. An example is a spoil sample that consists of small gray shale particles (pH 7.0) in a brown loamy matrix (pH 5.0).

The Hydrion papers method is recommended for use only with solutions naturally buffered to resist change in pH. The papers themselves are more strongly buffered than some spoils; thus spoils with a pH of 7 will often read 5.0 or 5.5. Extremely acid spoils are well buffered; therefore, the papers can be used to indicate spoils that have a pH of 4 or less.

The Kelway pH tester usually identified extremely acid spoils (below pH 4), but with spoils in the pH range 4 to 5 this tester often indicated a pH of 7. Thus reliable information on spoil acidity could not be obtained with this device. The Kelway pH tester did not give correct readings when inserted into buffers of pH 4 and 7.

How to Use pH Data

Use a map to delineate spoil types and record pH readings. Recommendations as to species for planting or seeding on spoils are made on the basis of dominant pH range, if that is representative of a large portion of the spoil. If a wide pH range occurs in spoil samples from a given area, and spoil types cannot be delineated by color or texture, select species on the basis of the lower pH readings.

—W. A. BERG[4]
Research Soil Scientist
Northeastern Forest Experiment Station
Forest Service, U. S. Dep. Agriculture
Berea, Kentucky

[4] The author is assistant professor of agronomy at Colorado State University, Fort Collins. When this study was conducted he was a research soil scientist with the Northeastern Forest Experiment Station's strip-mine restoration project at Berea, Kentucky.

SDA FOREST SERVICE RESEARCH NOTE NE-99
1969

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SPECIFIC GRAVITY AND WOOD MOISTURE VARIATION OF WHITE PINE

Abstract.—A report on results of a study to develop a means for estimating specific gravity and wood moisture content of white pine. No strong relationships were found by using either the single or combined factors of age and dimensional stem characteristics. Inconsistent patterns of specific gravity and moisture over height in tree are graphically illustrated.

The measurements most commonly employed in forestry to describe standing timber are tree age, diameter, merchantable height, and form class. If these measurements could be used to estimate specific gravity and moisture in the standing tree, then forestry cruise data could easily be transposed into quality and weight estimates for a given unit of area.

Results from a study of white pine (*Pinus strobus* L.) near Durham, New Hampshire, indicated that the use of age and stem dimensions as an expression of whole-tree properties accounts for too small a portion of the total variation to be seriously considered in prediction equations.

Methods

The procedure consisted of measuring age and diameter at breast height (d.b.h.), merchantable height (3-inch top), and Girard form class for a sample of 75 trees.[1] Trees were felled and cut into 8-foot sawlogs and 4-foot pulp bolts. A 1-inch cross-sectional disk was cut from the base of each section and at the top merchantable limit.

[1] Field data were collected by the author as part of Hatch 149 Project of the New Hampshire Agriculture Experiment Station.

Table 1.—Range and average of sample trees

Variable	Range	Average
Specific gravity	0.278–0.398	0.338
Moisture percent	78–187	137
Tree age, years	19–80	46
Tree diameter, inches	3.9–21.4	12.2
Merchantable height, feet	14–76	48
Form class	49–88	78

Specific gravity of the cross-section disks was computed on a green-volume[2] ovendry weight basis. Moisture content was determined as the difference between green and ovendry weight expressed as a percentage of ovendry weight. Specific gravity and moisture values presented on a tree basis were weighted in proportion to the bolt volumes making up the tree. Sample tree data are summarized in table 1.

The data were analyzed by a full-screen regression program, whereby tree specific gravity and moisture content were expressed as a function of all possible combinations of the independent variables listed in table 2.[3] All regressions were tested for significance at the 10-percent level, using the Scheffé conservative "S" test.[4] This test was used to assess significance on the basis of the buildup in the coefficient of determination as the number of regression components were increased.

Specific gravity and moisture determined from the cross-section disks were investigated graphically according to height in tree.

Results

Output from the full-screen program involved only the coefficients of determination. Table 2 gives the r-squares for specific gravity and moisture for the independent variables taken singly.

Specific gravity.—The most important single tree characteristic related to differences in specific gravity was found to be $1/A^2$. (r^2 = 0.282). Although significance is shown for most of the variables studied, it is obvious that no single factor is strongly related to the

[2] United States Forest Products Laboratory. METHODS OF DETERMINING THE SPECIFIC GRAVITY OF WOOD. USDA Forest Prod. Lab. Tech. Note B-14, 6 pp., 1956.

[3] Furnival, G. N. MORE ON THE ELUSIVE FORMULA OF BEST FIT. Soc. Amer. Foresters Proc. 1964: 7 pp.

[4] Scheffé, H. THE ANALYSIS OF VARIANCE. 447 pp. John Wiley and Sons, New York, 1959.

Table 2.—Coefficients of determination (r^2) for specific gravity and moisture content for each independent variable taken singly

	Independent variable	r^2 Specific gravity	r^2 Moisture content
X_1	Tree age (A)	0.228**	0.162
X_2	Tree diameter (DBH)	.157	.050
X_3	Merchantable height (MH)	.217**	.206**
X_4	Form class (FC)	.254**	.131
X_5	MH/A	.019	.019
X_6	DBH/A	.001	.027
X_7	$1/A^2$	.282***	.117
X_8	$1/MH^2$	.254**	.047
X_9	$FC^6 \times 10^{-8}$	.193*	.146
X^{10}	$[(FC)^6 \text{ Log } (A\text{-}19)]$	.242**	.196**

***Significant at 1 percent level.
**Significant at 5 percent level.
*Significant at 10 percent level.

specific gravity of white pine. On the basis of a significant improvement in explainable variability, none of the multiple regressions was superior to $1/A^2$. In fact, this variable alone accounted for 80 percent of the total variation in specific gravity explained by the maximum 10-variable model ($R^2 = 0.353$).

Moisture content.—Merchantable height was found to be the most important measurement in explaining tree-to-tree variability in percentage of moisture. ($r^2 = 0.206$). The only other significant factor was a model derived by combining a power transformation with a scaled transformation (X_{10}). However, in neither case is the coefficient of determination large enough to provide a reasonable expression of tree moisture. Beyond merchantable height, the additive effects of the other nine variables did not statistically improve estimating precision.

Height in tree.—Specific gravity and percentage moisture over height within the tree were plotted for three merchantable height classes (fig. 1 and 2). Specific gravity decreases from top of stump up to 8 feet, but fluctuates in the upper sections. Conversely, moisture increases in the basal section, but the pattern is inconsistent for the 64-foot height class. Above 8 feet, the average line for the three height classes levels off, then increases sharply in the top segments.

Figure 1.—The average (solid line) and range in specific gravity at successive heights above stump, for three height classes.

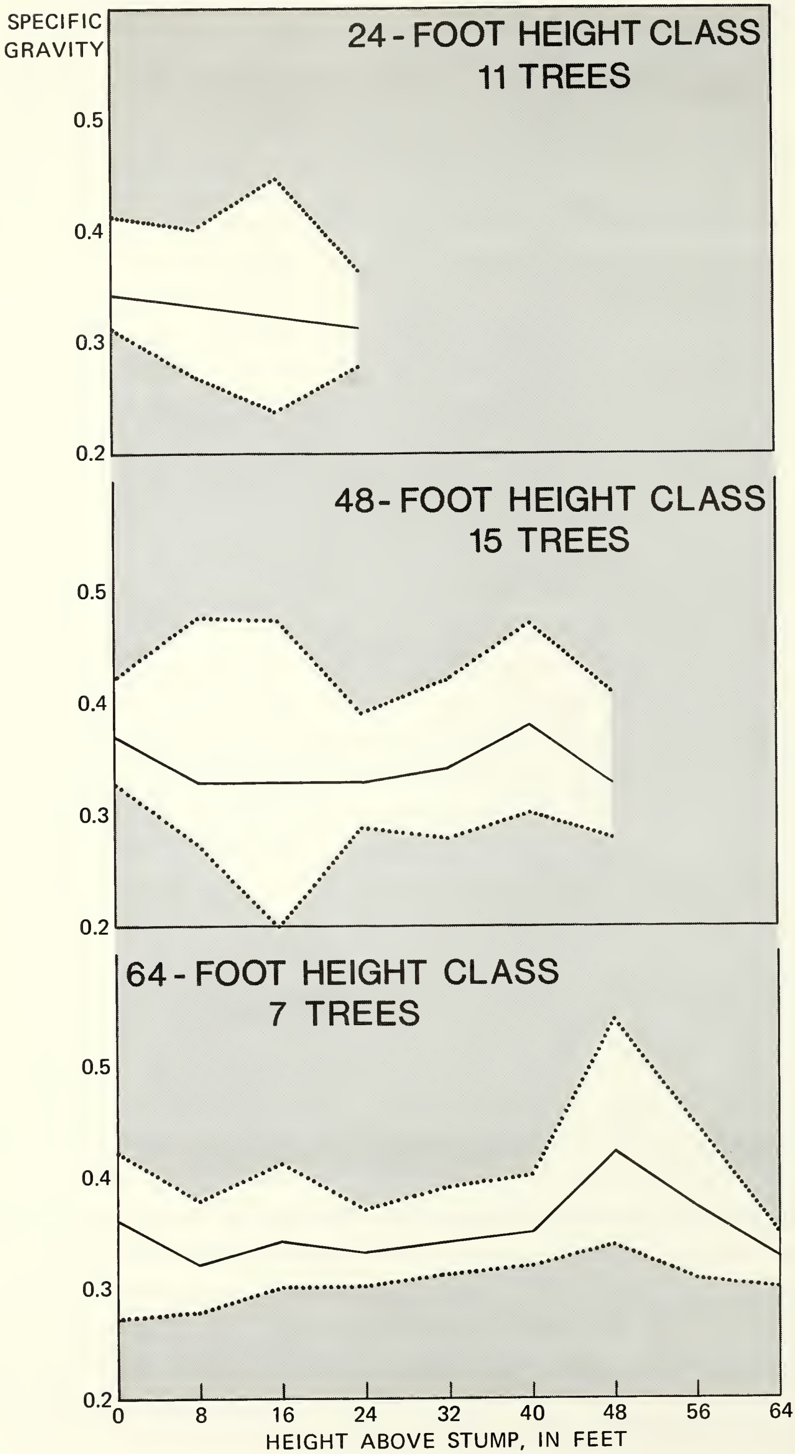
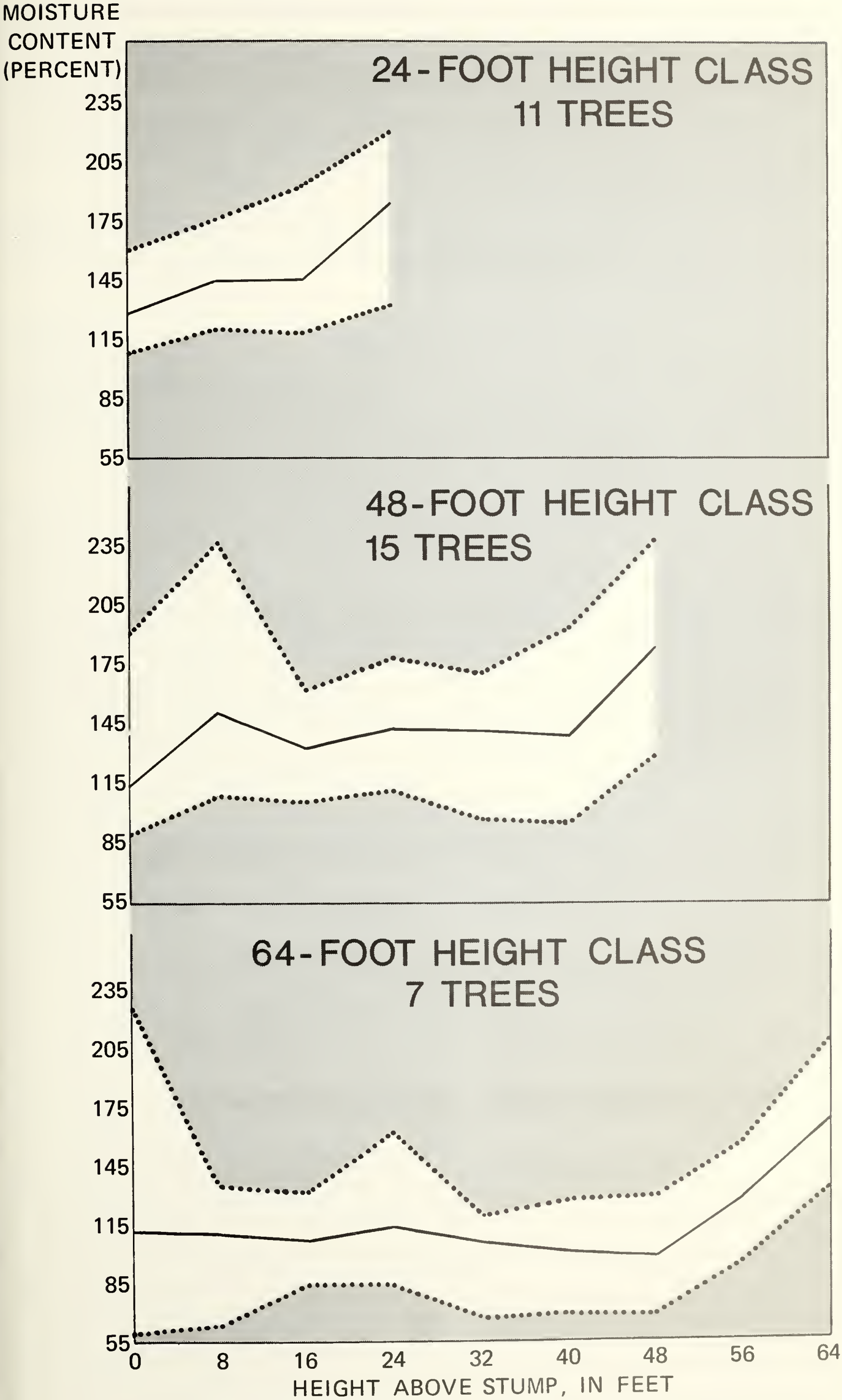


Figure 2.—The average (solid line) and range in moisture content at successive heights above stump, for three height classes.



Discussion

Results from this study have provided evidence of a wide range of variability in specific gravity and wood moisture of white pine. The rather small coefficients of determination illustrate that the forms selected to represent the relations may not have been appropriate. Or, there may be little or no relation of specific gravity and moisture to the independent variables chosen.

Before volume data can be transposed into quality and weight estimates, further basic research is needed to determine the roles of essential characters.

—GLENN L. GAMMON

Forest Products Technologist
Forest Service, U. S. Dep. Agriculture
Columbus, Ohio

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SDA FOREST SERVICE RESEARCH NOTE NE-100
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SAWMILL SIMULATION: CONCEPTS AND COMPUTER USE

Abstract. Product specifications were fed into a computer so that the yield of products from the same sample of logs could be determined for simulated sawing methods. Since different sawing patterns were tested on the same sample, variation among log samples was eliminated; hence, the statistical conclusions are very precise.

What is the best way to saw a log into boards for selected products or product parts? Until now, answers to this question have been approximations because of limited research techniques. Many different sawing patterns can be used, and researchers have had difficulty deciding which pattern will give the highest yield. The reason for this indecision is simple: once a sample of logs was sawed, it could not be reassembled and sawed again. Different log samples had to be used for each method. Because of the natural variation from log to log, and therefore from sample to sample, there has always been a question whether differences in product yields were caused by sawing pattern or by sample variation.

In the course of a study to determine the best way to convert low-grade hardwood logs into pallet parts, we developed a technique to solve the problem of variations between samples. Using computer simulation, we were able to compare the predicted yields of any number of sawing patterns from only one log sample. Because only one sample is used, the technique is very precise.

This paper gives a general description of the computer simulation technique. Detailed instructions and computer programs for researchers, production managers, and others who may wish to use this technique are found in a companion research paper by Reynolds.[1]

General Procedure

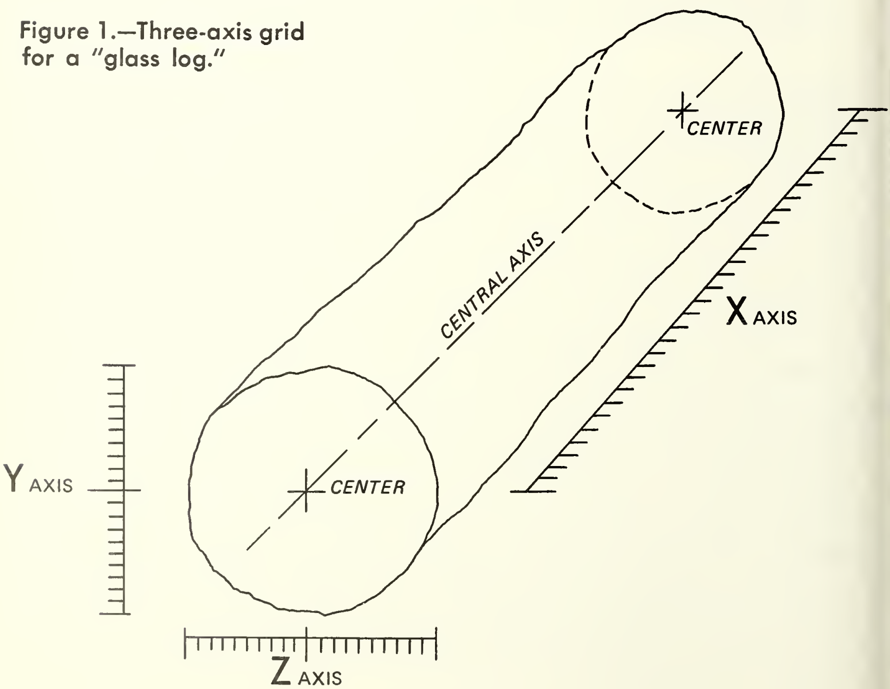
Computer simulation of a sawmill operation requires two basic computer programs: DEFECT and YIELD. Program DEFECT is used to simulate the conversion of a log sample into boards by using any sawing pattern. Program YIELD, developed by the USDA Forest Service's Forest Products Laboratory in Madison, Wisconsin, is used to examine the DEFECT-produced boards and to indicate the yield of preselected product parts.

Sawmill simulation by program DEFECT follows these steps:

1. Select enough sample logs to properly represent the quality of raw material normally used.

[1] Reynolds, Hugh W. SAWMILL SIMULATION: DATA INSTRUCTIONS AND COMPUTER PROGRAMS. U.S.D.A. Forest Serv. Res. Paper. In press. NE. Forest Exp. Sta., Upper Darby, Pa.

Figure 1.—Three-axis grid for a "glass log."



2. Live saw these logs into boards, identifying the boards so that they can be oriented to their proper place in the log.
3. Identify all defects on the boards by class, size, and location; and encode both the boards and the defects into a three-dimensional grid system (fig. 1).
4. Within the computer, reassemble the boards into their respective logs.
5. Prepare sawing instructions for each of the chosen sawing patterns to show the sequence and plane of the boards to be generated. Computer program DEFECT allows boards to be produced in any sequence, horizontally or vertically. And the program displays defects as they appear in each new board.

The output of program DEFECT is then used as the input for program YIELD. Program YIELD simulates the ripping and trimming of the boards and provides cutting yields by thickness, length, and width according to the product specifications used. The grade of these cuttings is determined by the grade of the boards produced in program DEFECT.

Program DEFECT

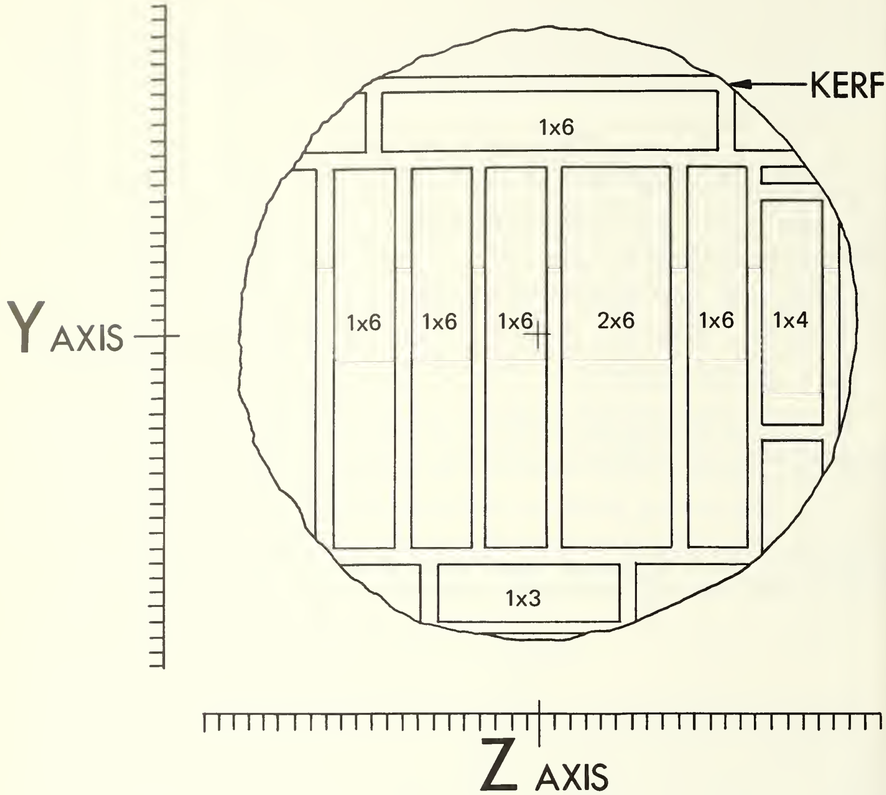
Constructing the log model.— The central axis of each log in the sample is located by marking the center of both ends of the log (fig. 1). Boards are then sawed parallel to the Y axis. Using the central axis as a reference, each board surface is identified by the Z-axis location it held before sawing. Similarly, the board width is identified by Y-axis values and the board length by X-axis values.

Defects in each board are grouped into classes that depend upon the products being considered. Each class includes those defects that would cause rejection of the piece for a particular use. For example, if the yield of parts for pallets, flooring, or dimension stock is to be determined, then three classes of defects can be used. When the yield of pallet parts is being computed, program DEFECT will ignore the flooring and dimension classes of defects.

Program DEFECT provides for reassembly of the boards into their original log form. Because board outline and defect location have been converted to numerical data, they are "visible" to the computer; therefore, the reassembled log can be considered a "glass log."

Specifying the sawing patterns.— The glass logs are sawed into boards according to predetermined sawing patterns (fig. 2). It is necessary

Figure 2.—Typical sawing pattern.



to draw a pattern for each diameter class to be studied. The computer sawing instructions are based on the Y-axis and Z-axis coordinates of each board. The sawing pattern predetermines the thickness and width of the boards to be produced.

Program YIELD

As stated above, the output of program DEFECT is used as the input for program YIELD. This output consists of boards of log length and of predetermined width, thickness, and quality. Program YIELD is used to simulate the conversion of these boards into cuttings. Product specifications are written for program YIELD that include length, width, thickness, and quality of desired cuttings. Program YIELD determines the optimum combination of product sizes that can be made from each board, and gives the best method for crosscutting and ripping each board to get these cuttings.

After the yield of product cuttings from each board is obtained, the yield from all boards in each log and for each sawing pattern can be compiled. In this way, the best method for sawing logs, based on yield of product parts, can then be determined.

Use of Sawmill Simulation

The potential value of sawmill simulation will depend upon the initial decisions of the research or production manager. Value of the technique will depend mainly on the adequacy of the sample, the extent to which defects are classified, the sawing patterns chosen for study, and the specifications of the product or component parts.

Users of program DEFECT should keep in mind that sawmill simulation has these limitations:

- The logs are sawed according to a prearranged pattern.
- Horizontally and vertically sawed boards are made according to the orientation of each log at the time it was converted into the three-dimensional grid "glass log." Rotation of the log between sawing techniques is not possible at the present stage of development of program DEFECT.
- The boards are sawed parallel to the central axis of each log. As written, the program does not allow for taper sawing.

Our work is a continuation of other Forest Service research. Peter and Bamping[2] used a partially automated simulation technique. The development of program YIELD[3] at the Forest Products Laboratory preceded our sawmill simulation work, and program DEFECT was written to be compatible with program YIELD. Future simulation developments by the Forest Products Laboratory will enable the board output of program DEFECT to be graded and tallied in terms of standard hardwood lumber.

—HUGH W. REYNOLDS and CHARLES J. GATCHELL
Forest Products Marketing Laboratory
Northeastern Forest Experiment Station
Forest Service, U.S. Department of Agriculture
Princeton, W. Va.

[2] Peter, Ralph, and James H. Bamping. THEORETICAL SAWING OF PINE LOGS—A NEW TECHNIQUE FOR EVALUATING SAWING METHODS. Forest Prod. J. 12 (11):549-557. 1962.

[3] Wodzinski, Claudia, and Eldona Hahn. A COMPUTER PROGRAM TO DETERMINE YIELDS OF LUMBER. U.S.D.A. Forest Prod. Lab. Misc. Pub., 33 pp. Forest Prod. Lab., Madison, Wis. 1966.

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SURVIVAL AND GROWTH OF YELLOW-POPLAR SEEDLINGS DEPEND ON DATE OF GERMINATION[1]

Abstract. A study of yellow-poplar seedlings showed that early survival and growth were best among stems that originated in May and early June. Few, if any, seedlings that emerged after 1 July were in favorable competitive condition 3 years later. This indicates that clearcuttings made for maximum natural regeneration of yellow-poplar should be carried out in fall and winter to permit early germination in the spring.

On good sites in the Appalachians, vegetation develops rapidly after clearcutting. After a year or two, the ground is so occupied that there is little space for additional seedlings to develop. Tree seedlings that do not get an early start have reduced chances of survival. This situation may be especially important in the case of yellow-poplar (*Liriodendron tulipifera* L.). Yellow-poplar seed germinates from spring to early fall,[2] but small seedlings do not appear to survive well after the first growing season.[3] Yellow-poplar is intolerant and does not develop well unless it gets a jump on the competition.

To determine whether or not time of germination affects initial development and early survival of yellow-poplar seedlings, a 3-year study was carried out on the Fernow Experimental Forest near Parsons, West Virginia. The study was begun early in the spring of 1966 in a number of openings that had been made the previous fall in a 65-year-old stand.

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[1] Published with the approval of the West Virginia University Agricultural Experiment Station as Scientific Paper No. 1055.

[2] Tryon, E. H., and K. L. Carvell. ENVIRONMENTAL FACTORS AFFECTING YELLOW-POPLAR SURVIVAL UNDER A YOUNG STAND. Castanea 25: 69-73, illus., 1960.

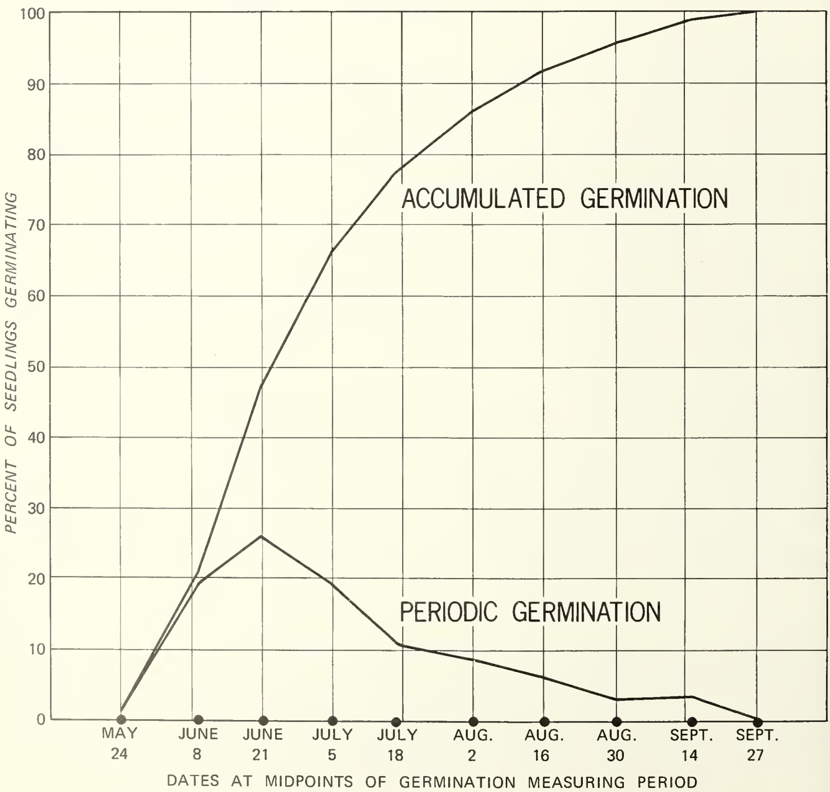
[3] Phillips, J. J. SOME EFFECTS OF COMPETITION ON THE SURVIVAL OF YELLOW-POPLAR. USDA Forest Serv. NE. Forest Exp. Sta. Res. Note 134, 4 pp., 1962.

The study area has an annual rainfall of 55 to 60 inches and an annual temperature of 48 to 50° F. Site quality is excellent: site index for yellow-poplar is 90 to 100 feet.

In the center of each of five of the openings, a 4-milacre plot was laid out. Light measurements were made in each plot in the first and second growing seasons. Light intensities were averages of readings taken throughout the day. Readings in the three sunniest plots averaged 45 percent sunlight; in the two most shaded plots, they averaged 25 percent.

Seedling tallies and height measurements were made of yellow-poplar stems at 2-week intervals from May to mid-October during the first growing season following logging. At each measurement new seedlings were identified by a small wire stake stuck into the ground nearby; different colored wires were used for each measurement period. During the second and third growing seasons, only spring and fall tallies were taken. The study was terminated in October 1968.

Figure 1.—Accumulated and periodic germination curves.



Results

Germination. — Germination started about 24 May and was completed by 21 September—a 4-month span. Some variation in starting dates existed between plots; germination began 1 to 2 weeks earlier on the three sunniest plots than it did on the two shadiest ones. The peak of germination came about 21 June (fig. 1) by which date about 50 percent of germination had taken place. Sixty percent of the seedlings had appeared by 1 July and 85 percent by 1 August. In all, 35 yellow-poplar seeds germinated per milacre the first season. This represents a rate of 35,000 per acre. More seedlings appeared on the shady plots than on the sunny plots. A few seedlings came up the second year, but none of them survived. We observed no germination the third year.

Survival. — In all, 40 percent of the seedlings that germinated the first year survived to the end of the third growing season. A higher proportion —49 percent—survived on the three sunnier plots. On the shady plots, only 33 percent survived. Mortality varied by seasons on all plots (fig. 2). It was heaviest during the growing seasons; 34 percent the third summer

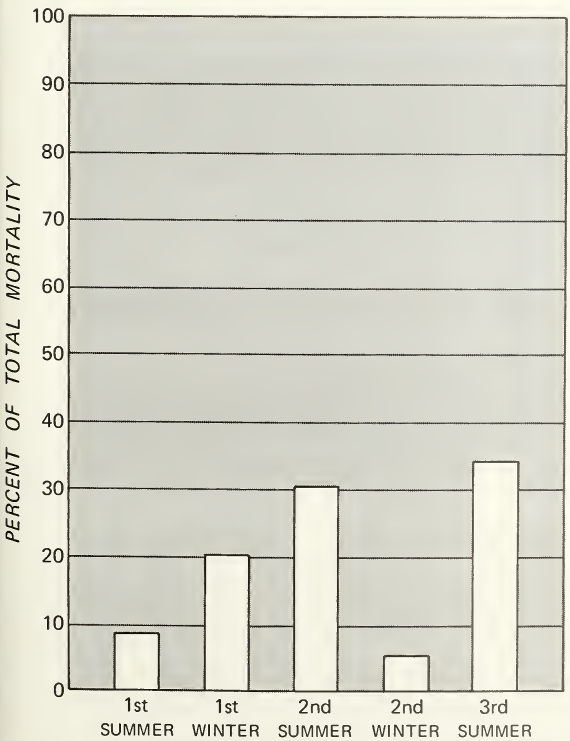


Figure 2.—Seedling mortality, by seasons.

and 30 percent the second. Mortality was 20 percent the first winter and 6 percent the second.

Seedlings from early-germinating seeds survived better than seedlings originating late in the season (fig. 3). At the end of the third growing season, between 65 and 70 percent of the seedlings that appeared in May of the first year after winter cutting, were still alive; between 40 and 45 percent of those that had come up during the last half of June survived; while less than 20 percent of those appearing after 1 August survived.

Summer mortality appeared to result largely from competition, plus some killing the first growing season by damping-off. Winter mortality was due mostly to unidentified causes, but some specific instances of frost heaving and smothering by litter were noted.

Height growth. — Height growth on the three sunniest plots appeared to approach height growth in large clearcuttings; but after the first

Figure 3.—Survival after 3 years, by germination.

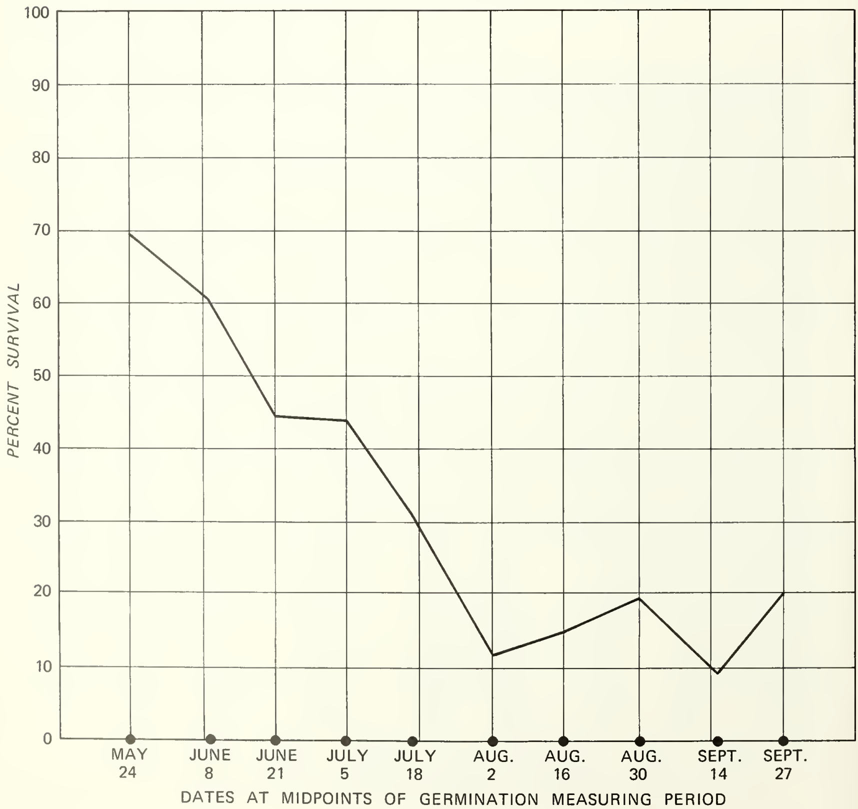
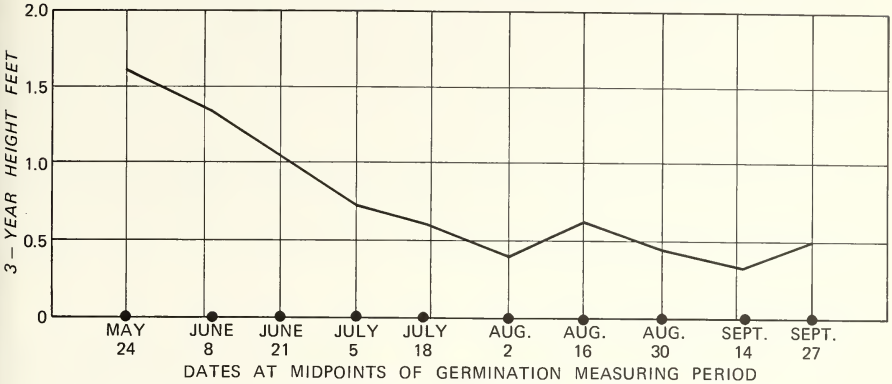


Figure 4.—Average 3-year height of seedlings by germination period.



year, height growth on the two shadiest plots definitely showed the effect of shading. However, on all plots, 3-year height of seedlings was strongly related to the date they originated (fig. 4). At the end of the third growing season, surviving seedlings that resulted from seed germinating the first week in June were 70 to 75 percent taller than those that came up the last week in June, and they were 210 percent taller than those that originated the last week in July.

At the 3-year measurement, utilizing only the three sunny plots, we estimated that those seedlings that were over 2.0 feet tall were in a good competitive position and would have a chance to survive to maturity. Fifty-six percent of those that came up during May were in this class (417 per acre) while only 14 percent of the stems originating in June were over 2.0 feet tall (1,833 per acre). None of those that appeared after 1 July had attained this height.

Summary and Discussion

The results of this study indicate that survival and height growth of yellow-poplar seedlings, in competition with other vegetation that develops simultaneously in newly clearcut areas, are dependent on time of germination. A high proportion of those seedlings that appeared before mid-June competed well with the flush of new vegetation. Most seedlings that came up after 1 July lost out in the race for growing space.

The practical implication of these findings is that the old stand should be logged between the end of the growing season (preferably after yellow-poplar seeds ripen) and 1 May of the following year to favor yellow-poplar reproduction. This would promote maximum germination and some development of yellow-poplar seedlings early in the growing season before strong competition from other plants develops. Logging in the spring and early summer results in late summer seedlings, which do not survive well, and competing vegetation is able to get a head start on seedlings originating the following year.

This restriction on time of logging becomes less important in areas where the yellow-poplar seed source is extremely plentiful and where site conditions are ideal for this species. However, where the situation is not so favorable for yellow-poplar, control of time of logging might provide the needed advantage.

—GEORGE R. TRIMBLE, JR.
Project Leader, Timber and Watershed Laboratory
Northeastern Forest Experiment Station
Forest Service, U.S. Department of Agriculture
Parsons, W. Va.

—E. H. TRYON
Professor of Silviculture
West Virginia University
Morgantown, West Virginia

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ARTIFICIAL REARING OF 10 SPECIES OF WOOD-BORING INSECTS

Abstract.—Small numbers of 10 species of wood-boring insects were reared from newly hatched larvae to adults on artificial media with good survival. Species with life cycles of up to 2 years in nature were reared on the media in less than 1 year. Although all of the adults appeared normal physically, some were sterile. One species was reared artificially for three generations. Survival figures and the developmental periods of the larval stages are given.

Lack of suitable rearing techniques has hampered research on the biology and control of many species of wood-boring insects injurious to forest and shade trees. This is especially true for those species with extended life cycles that appear as adults only briefly in the field annually, biannually, or less often.

Recent work has shown that some wood-boring insects can be continuously reared artificially. Wollerman, Adams, and Heaton (*1969*) reared the locust borer, *Megacyllene robiniae* (Forster), continuously on artificial media for several generations. Smith (*1965*) reported rearing the peach tree borer, *Sanninoidea exitiosa* (Say), on immature apples. Solomon (*1966*) was able to successfully rear the carpenterworm, *Prionoxystus robiniae* (Peck), on artificial media; and Harley and Willson (*1968*) reported artificial rearing of a cerambycid borer, *Plagiohammus spinipennis* Thomson.

This note is a report on artificially rearing small numbers of 10 species of insects that breed in the inner bark or wood of dead, dying, or living trees.

Materials and Methods

Adult beetles used for oviposition were obtained in the following manner. *Neoclytus caprea* Say, which were overwintering as adults just beneath the bark of white ash logs (*Fraxinus americana* L.) were carefully pulled from their tunnels with forceps. The rustic borer, *Xylotrechus colonus* (F.); red-headed ash borer, *Neoclytus acuminatus* (F.); painted hickory borer, *Megacyllene caryae* (Gahan); hackberry engraver, *Scolytus muticus* Say; and *Chion cinctus* (Drury) were collected during the summer months from outdoor emergence cages containing logs of *Ulmus americana* L., *Gleditsia tricanthos* L., and *Carya* species. Locust borer adults, *Megacyllene robiniae* (Forster), were collected in late summer on goldenrod flowers.

Adults of the cerambycid species, with the exception of *C. cinctus,* readily mated and oviposited eggs under ½-inch black bias type wrapped in a spiral around fresh 1 by 8 inch bolts of wood of their host species. *C. cinctus* produced only a small number of eggs. This technique was reported previously by Wollerman *et al. (1969).* After oviposition occurred, the bias tape was removed and placed along with the bolts of wood in uncovered ½-gallon ice cream cartons until the eggs hatched and the larvae dropped to the bottom of the carton.

Adults of *S. muticus* were placed on freshly-cut honeylocust bolts approximately 5 by 12 inches. At the end of nine days, the eggs were carefully dissected from the egg galleries and held in a petri dish until they hatched.

Orthotomicus caelatus (Eichhoff) beetles were found attacking dying white pine (*Pinus strobus* L.), and *Leperisinus aculeatus* Say were found in late spring attacking logs and branches of freshly cut white ash. Eggs of these species were dissected from field-collected wood and were held on moistened filter paper in a petri dish sealed with masking tape until hatched.

Eggs of *Romaleum rufulum* (Hold.) were provided by C. John Hay, insect ecologist at our Laboratory at Delaware, Ohio.

Newly hatched larvae of the various species were placed in one of two artificial media, except *M. robiniae* larvae, which were reared in both media. The number of newly hatched larvae placed in the media, number of days to adult emergence, and number of adult yield were recorded (table 1).

Table 1.—Species reared and rearing data

Species	Number of newly hatched larvae introduced to media		Number and days to adult emergence			Number and percent of adult yield	
	Medium A	*Medium B*	*Min.*	*Max.*	*Aver.*	*No.*	*Pct.*
Neoclytus caprea Say	40	—	78	103	92	32	80
N. acuminatus (F.)	36	—	37	53	49	34	94
Megacyllene caryae (Gahan)	45	—	52	81	68	40	89
M. robiniae (Forster)	25	—	51	78	60	20	80
M. robiniae (Forster)	—	31	52	63	59	28	90
Orthotomicus caelatus (Eichh.)	14	—	18	24	20	8	57
Romaleum rufulum (Hold.)	—	5	129	249	205	4	80
Scolytus muticus Say	29	—	25	37	29	21	72
Leperisinus aculeatus Say	19	—	21	32	25	11	58
Chion cinctus (Drury)	2	—	214	([1])	—	1	50
Xylotrechus colonus (F.)	—	44	38	57	47	41	93

[1] 1 larva died without establishing in the medium, so data are for 1 larva only.

The artificial media (table 2), media preparation, rearing containers, and techniques used in this study were similar to those reported by Galford (1967 and 1969[1]). The media had been pressed to a moisture content of 50 to 55 percent. Holes just large enough to accommodate the larvae were made in the media with a dissecting needle, and the larvae were transferred with a small brush.

Scolytid species were reared to adults in the glass plate rearing devices, while larvae of the cerambycid species were started in the glass plate rearing devices and transferred to 60 x 15-mm plastic petri dishes full of unpressed media at the end of 3 to 4 weeks. The ceramycid larvae were transferred to fresh media at monthly intervals until they pupated. All rearing was conducted in darkened cabinets at 30±2°C and 50±20 percent relative humidity.

[1] Galford, Jimmy R. A LARVAL AND OVIPOSITIONAL MEDIUM FOR SCOLYTUS MULTISTRIATUS. (Accepted for publication in the J. Econ. Entomol.)

Table 2.—Artificial media formulas

Constituent	Medium A	Medium B
	Grams	*Grams*
Agar	32.00	32
Sucrose	16.00	—
Fructose	8.00	—
Glucose	8.00	—
Vitamin diet fortification mixture	12.00	—
Brewer's yeast[1]	40.00	—
Soybean protein	16.00	—
Wesson's salt mixture	20.00	—
Cholesterol	.80	—
Kretschmer wheat germ[1]	20.00	120
Vegetable lecithin	.80	—
Vitamin Bt	.08	—
Sorbic acid	2.00	2.00
Methylparaben	1.00	1.00
Alphacel (hydrolyzed)[1]	320.00	280
	ml.	*ml.*
Wheat germ oil	4.00	—
Water	800.00	800.00

[1] Mention of specific brand products does not imply their endorsement by the USDA.

Results and Discussion

In some cases very small numbers of newly hatched larvae were reared because of the lack of eggs (table 1). The large amounts of media consumed by some of the cerambycids in the later instars, and necessity of transferring some larvae several times, prevented rearing more than a few larvae of each species. It is noteworthy, however, that survival was excellent, especially for the cerambycid species. The very small and easily injured nature of scolytid larvae probably accounted for their lower survival figures. In all cases the adults that emerged from the media were normal in physical appearances and capable of flight. The *M. robiniae* adults reared on medium B were slightly smaller than the average field-collected beetle, but were otherwise physically normal.

The scolytid adults produced normal egg galleries and offspring when confined with bolts of wood of their host trees. However, only two species of cerambycids, *X. colonus* and *M. robiniae,* laid viable eggs. The cause of infertility of some of the cerambycids was not investigated, but the medium-reared females of *M. caryae* produced many viable eggs when mated with field-collected males, which suggests that the males of *M. caryae* reared on the artificial medium were sterile. Three generations of *M. robiniae* were reared on medium B without any apparent decline in the vigor of the beetles.

To sum up: Many species of wood-boring insects can be reared artificially with good survival. Species with life cycles of up to 2 years in nature can be reared on the media in less than 1 year. Although the artificially reared adults appear physically normal, the infertility of many of the species must be investigated before continuous rearing can be successful.

■

Literature Cited

Galford, Jimmy R.
1967. A technique for rearing larvae of the smaller European elm bark beetle on an artificial medium. J. Econ. Entomol. 60(4): 1192.

Harley, K. L. S., and B. W. Willson.
1968. Propagation of a cerambycid borer on a meridic diet. Canad. J. Zoology 46:1265-1266.

Smith, E. H.
1965. Laboratory rearing of the peach tree borer and notes on its biology. J. Econ. Entomol. 58(2): 228-326.

Solomon, J. D.
1966. Artificial rearing of the carpenterworm, *Prionoxystus robiniae* (Lepidoptera: Cossidae), and observations of its development. Ann. Entomol. Soc. Amer. 59:1197-1200.

Wollerman, Edward H., Carol Adams, and George C. Heaton.
1969. Continuous laboratory culture of the locust borer, *Megacyllene robiniae*. Ann. Entomol. Soc. Amer. 62(3): 647-649.

—JIMMY R. GALFORD
Research Entomologist
Forest Insect and Disease Laboratory
Northeastern Forest Experiment Station
Forest Service, U.S. Dep. Agriculture
Delaware, Ohio

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PINE SEEDLINGS RESPOND TO LIMING OF ACID STRIP-MINE SPOIL

Abstract.—A greenhouse trial was made to determine the effect of three rates of liming on the growth of five species of pine seedlings in an extremely acid strip-mine spoil. Liming at the rate of 5 tons per acre-foot significantly increased the growth of four of the species. Tissue analysis indicated the growth rate may be related to a reduction in the concentration of the metallic ions of manganese, iron, copper, and zinc.

Extremely acid strip-mine spoils present a difficult reforestation problem. A few species of trees and shrubs may survive on spoils with pH values between 3.5 and 4.0, but growth is generally very slow. Below pH 3.5, few species will survive. Therefore, species selection is not the complete answer to this revegetation problem. Spoil treatment to modify the acid condition appears necessary.

Since liming is a widely accepted treatment for acid agricultural soils, lime appears to be a logical material to use. However, there is little information about herbaceous response to liming acid strip-mine spoils and even less about the use of lime with tree and shrub species. Therefore, a greenhouse test was made to determine the effect of three rates of liming on the growth of five pine species in an extremely acid strip-mine spoil.

Methods

We used the following species of pine: loblolly (*Pinus taeda* L.), shortleaf (*Pinus echinata* Mill.), pitch (*Pinus rigida* Mill.), Virginia (*Pinus virginiana* Mill.), and a hybrid of pitch and loblolly pine grown from seed produced by the Republic of South Korea that is considered to be very acid-tolerant. Seedlings for each species were 1-0 stock of similar size and condition.

The treatments, equivalent to 2, 5, and 10 tons of lime per acre-foot of soil, were compared with an untreated check. The purpose was to bracket the extremes and have two intermediate treatments.

The spoil was a coarse mixture of sandstone and shale; it had a pH of about 3.4. Before potting, the spoil was sieved through a screen of ½-inch mesh, thoroughly mixed, and then treated with hydrated lime as required by the assigned treatment. Round containers, 12 inches in diameter and 12 inches deep, were lined with black polyethylene and filled with 35 pounds of spoil. Each pot was then brought to 20 percent moisture by weight and allowed to stand 1 week before planting.

One seedling of each species was planted in each of the four treatments. Before potting, top length, root length, and total green weight of each seedling were measured.

We placed the pots in a greenhouse for 6 months, adding distilled water weekly to bring the spoil to 20 percent moisture by weight. The weight of water added was recorded.

Before the first fall frost, the pots were moved outdoors to a lath house. Distilled water was added when the spoil surface appeared dry. After 3 months outdoors and exposure to several freezes, the pots were brought inside and placed on a light table. The light source consisted of 40-watt cool white fluorescent and 200-watt incandescent bulbs; light intensities ranged from 800 foot-candles at the top of the pots to 1,200 foot-candles at the tip of the tallest seedling. Day length was set at 16 hours. Distilled water was added at weekly intervals.

The study was terminated at the end of this second growth period (about 4 months). We determined pH and specific conductance on spoil samples from the top and bottom of each pot. Specific conductance was determined to document changes in total soluble salt concentration of the soil solution resulting directly or indirectly from the application of lime. After the spoil was washed from the roots, each seedling was remeasured. The new needles, old needles, stem, and roots of each seedling were separately oven-dried and ground in a Wiley mill for tissue analysis. Tissue nutrient concentrations for elements except nitrogen were determined spectrographically at a commercial laboratory; nitrogen was determined by the Kjeldahl method in our laboratory.

Results

Spoil chemical properties.—Analysis of the spoil showed a progressive increase in pH with increasing amounts of lime. There was no significant difference in pH between the top and bottom of the pots. The pH of the treatments at the top of the pots were as follows:

Treatment	*pH*
Check	3.5
2 tons lime/acre	3.9
5 tons lime/acre	6.6
10 tons lime/acre	7.6

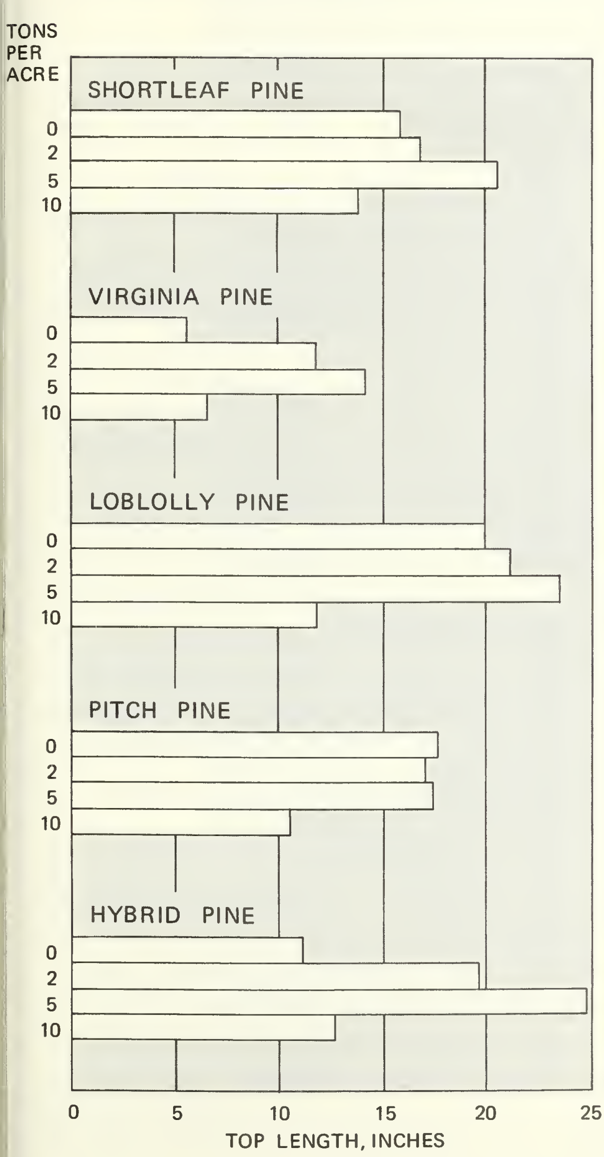

Figure 1.—Top length by species and treatment.

There was a significant increase in specific conductance in the pots with 2- and 5-ton treatments. A significant difference in specific conductance between the top and the bottom of individual pots was found only in the check. The bottom of the check pot had a specific conductance of 0.8 millimhos/cm. and the top was 1.3 millimhos/cm. The specific conductance at the top of the pots were as follows:

Treatment	*Specific conductance (millimhos/cm.)*
Check	1.3
2 tons lime/acre	1.7
5 tons lime/acre	1.6
10 tons lime/acre	1.2

Seedling size and growth.—Although only one seedling of each species was used with each level of liming, the consistency in response for all species, except pitch pine, is encouraging.

Differences in top length, root length, and total green weight, at the time of potting and after the second growth period, were used to compute growth. Average top length was the greatest on the 5-ton-per-acre treatment for all species except pitch pine (fig. 1). The top lengths on the 10-ton-per-acre treatment were as short or shorter than all other treatments for shortleaf, loblolly, and pitch pine.

For Virginia and loblolly pines, liming effect on root depth was similar to that on top growth (fig. 2). For the pitch x loblolly pine hybrid, root length increased with each lime increment; the reverse was true for shortleaf pine. Root length of pitch pine was erratic.

Green weights were less after the 10-ton treatment than after either the 2- or 5-ton treatments (fig. 3). Virginia pine and the hybrid responded dramatically to the 2- and 5-ton treatments while modest gains were made by loblolly and shortleaf. The green weight of pitch pine decreased with each increase in lime.

Water use.—We computed average weekly water use during the first 5-month growth period for each species under each treatment and found that from greatest to least water use, the treatments ranked as follows: 5 tons per acre, 2 tons per acre, check, and 10 tons per acre. Since each seedling was of similar size when potted, the differences in water use probably were related to growth response.

Nutrient content of plant tissue.—We first compared the concentrations of each of 12 nutrients in the roots, stems, new needles,[1] and old

[1] Those needles that developed during the second growth period.

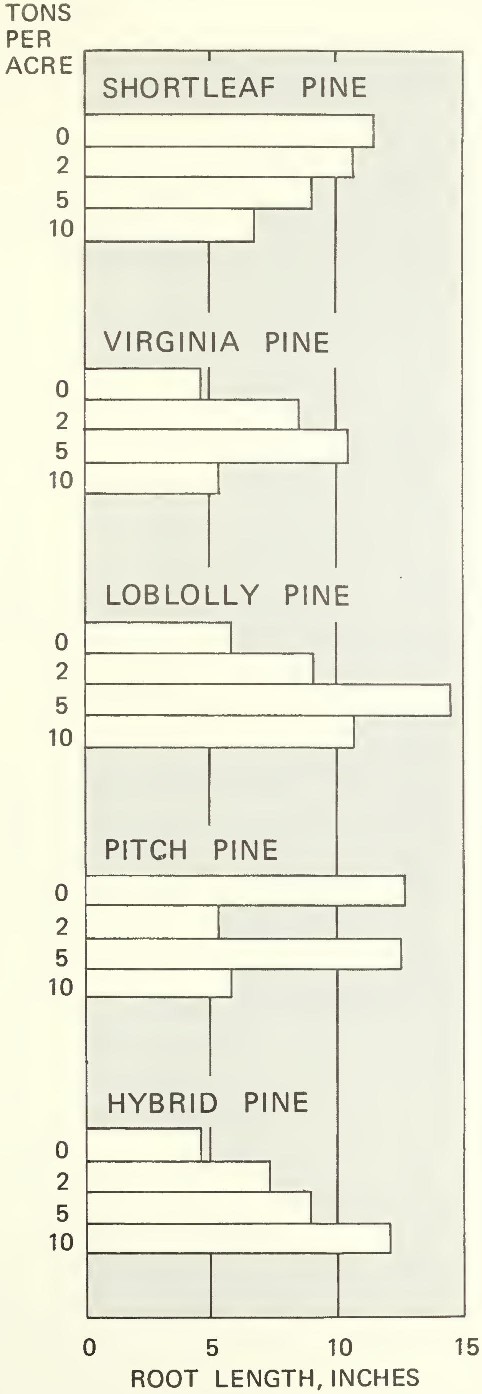

Figure 2.—Root length by species and treatment.

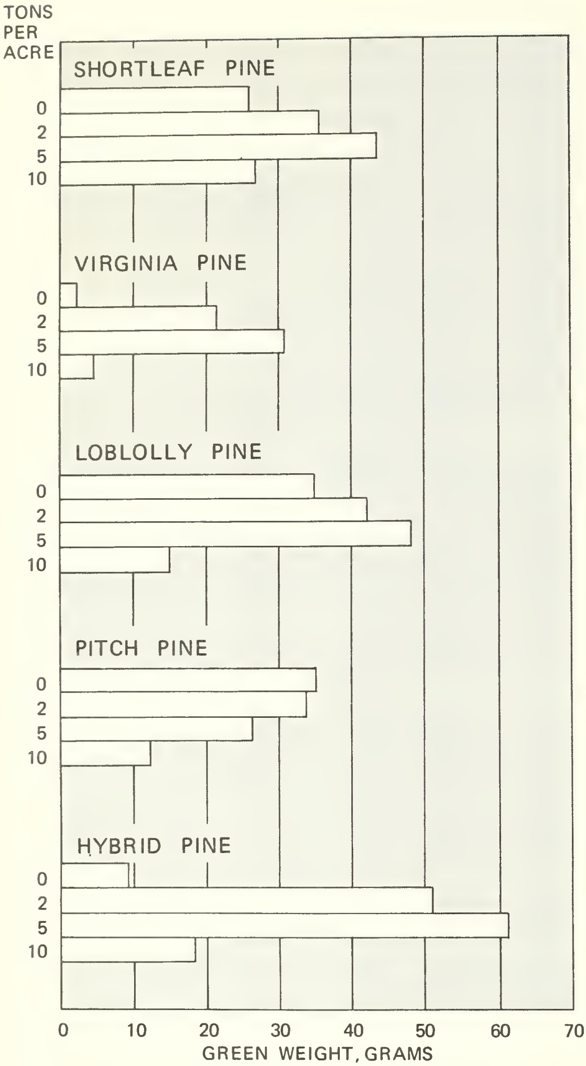

Figure 3.—Green weight of seedlings by species and treatment.

needles[2] of trees grown in the check pot to determine which part had the highest concentration.[3] The new needles had the highest concentration of potassium. Magnesium, manganese, and boron concentrations were highest in the old needles. Highest amounts of calcium, iron, copper, aluminum, and molybdenum were found in the roots. There was no significant difference between plant parts in the concentrations of phosphate or zinc, but their concentrations were assumed highest in the new

[2] Those needles on the seedling when potted or that developed during the first growth period.
[3] Statistically significant at the 1-percent level.

Table 1.—*Average nutrient content of tissue with the highest nutrient concentration for all species, by treatment*

Nutrient	At tons of lime per acre—				Differences between treatments were:
	0	2	5	10	
	Pct.	*Pct.*	*Pct.*	*Pct.*	
Nitrogen	1.56	1.22	1.36	1.43	Not determined.[1]
Phosphorus	.15	.15	.12	.09	Significant.[2]
Potassium	.53	.60	.59	.73	Not significant.
Calcium	1.28	.90	2.10	2.78	Highly significant.[3]
Magnesium	.33	.26	.18	.13	Highly significant.
	Ppm.	*Ppm.*	*Ppm.*	*Ppm.*	
Iron	1,998	1,150	818	871	Highly significant.
Manganese	750	798	421	218	Highly significant.
Aluminum	3,129	2,996	2,868	2,728	Not significant.
Copper	43	29	20	24	Highly significant.
Zinc	76	62	36	37	Highly significant.
Boron	38	44	38	21	Highly significant.
Molybdenum	5.06	4.22	2.82	3.22	Significant.

[1] Insufficient data.
[2] Statistically significant at the 5 percent level.
[3] Statistically significant at the 1 percent level.

needles and roots, respectively. There was insufficient data to statistically determine the highest concentration of nitrogen, but it was assumed to be in the new needles.

We compared nutrient content by treatment using values from the plant part with the highest concentration. Phosphorus, magnesium, molybdenum, zinc, copper, and boron decreased with increasing amounts of lime (table 1). Calcium was low on the check and 2-ton treatments, but increased with the 5- and 10-ton treatments. Concentrations of iron and manganese were reduced after the 5- and 10-ton treatments. Liming had no effect on the concentration in plant tissues of potassium, aluminum, or nitrogen.

Conclusions

We found that, under greenhouse conditions, liming at the rate of 5 tons per acre-foot can significantly improve the growth of loblolly, shortleaf, Virginia, and a hybrid of pitch-loblolly pine. Liming did not increase the growth of pitch pine. It was also apparent that 10 tons of lime per acre-foot reduced the growth of all species below that obtained with lesser amounts of lime.

Tissue analysis pointed out significant differences in nutrient content between treatments. In the tissues of the unlimed plants, all nutrients except calcium were as high or higher than those in the plants growing in the limed spoil. Growth, however, was best after the 5-ton-per-acre liming treatment. One explanation for the slow growth on the unlimed spoil could be toxic amounts of some elements. Since the 5-ton-per-acre treatment reduced the concentration of manganese, iron, copper, and zinc by almost half, it appears that one or more of these elements could have contributed to the reduction in growth.

Growth after the 10-ton-per-acre treatment was always less than after the other treatments. Also, the concentration of all elements except calcium, potassium, aluminum, and nitrogen was significantly reduced by this treatment. Therefore, heavy liming appears to have interfered with the absorption of essential nutrients.

The results indicate that liming can influence the growth of some pine species on extremely acid spoils; field research will be necessary to determine rates of application and duration of effect on extremely acid sites.

—WILLIAM T. PLASS
Principal Plant Ecologist
Northeastern Forest Experiment Station
Forest Service, U.S. Dep. Agriculture
Princeton, West Virginia

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DA FOREST SERVICE RESEARCH NOTE NE-104

1969

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DISTRIBUTING VALUE GAIN FROM THREE GROWTH FACTORS FOR YELLOW-POPLAR

Abstract.—A method of apportioning the maximum dollar value gain from tree growth into the amounts contributed by diameter growth, merchantable height increase, and quality improvement is described. The results of this method are presented for various sizes and qualities of yellow-poplar trees.

Many forest managers seek to enhance tree values by increasing diameter growth rates. In addition to the value increase by diameter growth, trees can increase in value by making gains in merchantable height and improving in quality as well. Thus, as a sawtimber tree grows, its gain in value for lumber can be apportioned to its d.b.h. growth, to its merchantable-height increase, and to its improvement in log grade. It is possible to determine how changes in each of these tree factors—diameter, height, and quality—add to the value increment resulting from a tree's growth, and to compare the relative contributions of each. This note describes a method for making such determinations by using yellow-poplar trees. The method described can be applied to other species by using their respective conversion values.

Procedure

Model trees were selected to represent various possible tree sizes and qualities. Measurements of these model trees ranged from 14 to 28 inches d.b.h. and from 16 to 48 feet of merchantable sawlog length. U. S. Forest Service hardwood log grades for standard factory lumber and construction and local-use classes were used.[1]

[1] Ostrander, M. D., and others. A GUIDE TO HARDWOOD LOG GRADING (revised). USDA Forest Serv., NE. Forest Exp. Sta., Upper Darby, Pa. 50 pp., illus. 1965.

Table 1.—Calculation of the percent of value increase contributed by diameter growth, height increase, grade improvement, and combination effect

Present measurements				Projected measurements			
D.b.h.	Merchantable sawlog height	Butt-log grade	Conversion value	D.b.h.	Merchantable sawlog height	Butt-log grade	Conversion value
Inches	*Feet*	*No.*	*Dollars*	*Inches*	*Feet*	*No.*	*Dollars*
14.0	24	2	3.98	16.0	24	2	6.34 (A)
—	—	—	—	16.0	40	2	7.55 (B)
—	—	—	—	16.0	24	1	7.69 (C)
—	—	—	—	16.0	40	1	10.87 (D)

To calculate the value added by each factor:

DIAMETER GROWTH: From the projected conversion value (A) subtract the present conversion value.

$6.34
−3.98

$2.36 (value added by diameter growth)

HEIGHT INCREASE. From the projected conversion value (B) subtract the present conversion value. From the remainder subtract the value added by diameter growth.

$7.55	$3.57
−3.98	−2.36
$3.57 (value added by diameter plus height)	$1.21 (value added by height increase)

GRADE IMPROVEMENT. From the projected conversion value (C) subtract the present conversion value. From the remainder subtract the value added by diameter growth.

$7.69	$3.71
−3.98	−2.36
$3.71 (value added by diameter plus grade)	$1.35 (value added by grade improvement)

ALL THREE FACTORS. From the projected conversion value (D) subtract the present conversion value.

$$\begin{array}{r} \$10.87 \\ -\ 3.98 \\ \hline \$\ 6.89 \end{array}$$ (maximum value gain from all three factors)

VALUE INCREMENT BY FACTOR:

D.b.h.	\$2.36
Height	1.21
Grade	1.35
	\$4.92

COMBINATION EFFECT. From the maximum value gain subtract the summation of the value gain by each factor.

$$\begin{array}{r} \$6.89 \\ -4.92 \\ \hline \$1.97 \end{array}$$ (value added by combination effect)

THE PERCENT OF MAXIMUM VALUE ADDED BY EACH FACTOR:

D.b.h.: $\frac{\$2.36}{\$6.89} \times 100 = 34.2$ percent

Height: $\frac{\$1.21}{\$6.89} \times 100 = 17.6$ percent

Grade: $\frac{\$1.35}{\$6.89} \times 100 = 19.6$ percent

Combination Effect: $\frac{\$1.97}{\$6.89} \times 100 = 28.6$ percent

Total = 100 percent

Changes in the model trees were projected to represent possible natural growth patterns. Diameter growth of 1, 2, or 3 inches was allowed for all trees. A maximum merchantable-height increase of 8, 16, or 24 feet was permitted for a 1, 2, or 3 inch d.b.h. growth respectively. No merchantable-height increase was allowed for trees with the following size combinations: d.b.h. 16 inches and 16 feet or less merchantable height; d.b.h. 18 inches and 24 feet or less merchantable height; d.b.h. 20 inches and 32 feet or less merchantable height; d.b.h 22 inches and 40 feet or less merchantable height; d.b.h. 24 inches and 48 feet or less merchantable height; d.b.h. 26 inches or greater and all merchantable heights. Maximum butt-log grade improvement was restricted to one grade class. No grade improvement was allowed for butt-log grade 3 trees over 22 inches d.b.h. or for butt-log grade 2 trees over 26 inches d.b.h.

The values used for all present and projected tree sizes and qualities are the conversion values developed by Mendel and Trimble in their work on the rate of value increase for yellow-poplar.[2] They used the quality-index concept, which is based on the expected 4/4 lumber grade recovery from hardwood logs, and lumber price relatives developed from current price reports. Costs of converting the standing trees into lumber were deducted to obtain the tree conversion values. Table 1 shows the conversion value of a yellow-poplar tree with present measurements of 14 inches d.b.h., 24 feet of merchantable height, and a grade 2 butt log.

The maximum dollar value gain resulting from improving all three growth factors simultaneously was calculated for each model tree and then was separated into the value gain due to (1) diameter growth, (2) merchantable-height increase, (3) quality improvement, and (4) the combined effect. The percent of value gain contributed by each of these factors to the total value gain resulting from a combination of all the factors was then determined. Sample calculations for one model tree are shown in table 1.

A combination-effect factor—the value gain resulting from combined merchantable-height increase and grade improvement — was necessary because the gain resulting from an improvement in all three factors did not consider any improvement in grade above the original merchantable length. For example, the sample calculation in table 1 shows that the value gain due to grade improvement was based on the original merchantable

[2] Mendel, Joseph J., and George R. Trimble, Jr. THE RATE OF VALUE INCREASE FOR YELLOW-POPLAR AND BEECH. *USDA* Forest Serv. Res. Paper NE-140. 27 pp. NE. Forest Exp. Sta., Upper Darby, Pa. 1969.

Table 2.—Distribution of the maximum dollar value increase contributed by diameter, merchantable height, and quality increase for yellow-poplar trees, in percent

Present measurements		Value increase contributed by—			
D.b.h. (inches)	Merchantable height (feet)	D.b.h. growth	Merchantable-height increase[1]	Grade improvement[2]	Combination effect
PROJECTED 1-INCH D.B.H., 8-FOOT MERCHANTABLE HEIGHT, AND 1-LOG GRADE INCREASE					
utt-log grade 1:					
16-22	16-48	55-100	0-45	—	—
24+	16-48	100	—	—	—
utt-log grade 2:					
14	16	20	30	10	40
	24	30	20	30	20
16	16	60	—	40	—
	24	30	20	30	20
	32	30	10	45	15
18	16	50	—	50	—
	24	40	—	60	—
	32	30	10	50	10
	40	25	5	55	15
20	16	45	—	55	—
	24	40	—	60	—
	32	30	—	70	—
	40	25	10	55	10
22-26	16	35	—	65	—
	24	30	—	70	—
	32	25	—	75	—
	40	25	—	75	—
	48	20	—	80	—
28+	16-48	100	—	—	—
utt-log grade 3:					
14	16-24	15	10	65	10
16-22	16-24	20	—	80	—
	32-48	25	5-10	65	0-5
24+	16-48	100	—	—	—
PROJECTED 2-INCH D.B.H., 16-FOOT MERCHANTABLE HEIGHT, AND 1 LOG GRADE INCREASE					
utt-log grade 1:					
16-22	16-48	55-100	0-45	—	—
24+	16-48	100	—	—	—
utt-log grade 2:					
14	16	30	40	10	20
	24	35	20	20	25

CONTINUED

Table 2.—Continued

Present measurements		Value increase contributed by—			
D.b.h. (inches)	Merchantable height (feet)	D.b.h. growth	Merchantable-height increase[1]	Grade improvement[2]	Combination effect
16	16	70	—	30	—
	24	35	20	20	25
	32	35	10	30	25
18	16	60	—	40	—
	24	60	—	40	—
	32	35	10	30	25
	40	40	5	55	—
20	16	60	—	40	—
	24	50	—	50	—
	32	45	—	55	—
	40	30	5	45	20
22-26	16	50	—	50	—
	24	40	—	60	—
	32	40	—	60	—
	40	35	—	65	—
28+	48	30	—	70	—
	16-48	100	—	—	—
Butt-log grade 3:					
14	16-24	20	15	45	20
16-22	16-24	30	5	60	5
	32-48	35	5	55	5
24+	16-48	100	—	—	—
PROJECTED 3-INCH D.B.H., 24-FOOT MERCHANTABLE HEIGHT, AND 1-LOG GRADE INCREASE					
Butt-log grade 1:					
16-22	16-48	60-100	0-40	—	—
24+	16-48	100	—	—	—
Butt-log grade 2:					
14	16	35	35	10	20
	24	40	20	20	20
16	16	70	—	30	—
	24	40	20	20	20
	32	40	10	30	20
18	16	70	—	30	—
	24	60	—	40	—
	32	40	10	30	20
	40	35	—	35	30
20	16	65	—	35	—
	24	60	—	40	—
	32	55	—	45	—
	40	40	5	40	15

CONTINUED

ɔle 2.—Continued

Present measurements		Value increase contributed by—			
D.b.h. (inches)	Merchantable height (feet)	D.b.h. growth	Merchantable-height increase[1]	Grade improvement[2]	Combination effect
22-26	16	50	—	50	—
	24	50	—	50	—
	32	45	—	55	—
	40	40	—	60	—
	48	35	—	65	—
28+	16-48	100	—	—	—
t-log grade 3:					
14	16-24	30	15	45	10
16-22	16-24	35	0-10	50	5-15
	32-48	40-50	5	40-50	0-5
24+	16-48	100	—	—	—

The following log-height-increase limitations were set for computation purposes:

ginal d.b.h. (inches)	*Merchantable height classes (feet) that will not increase*
16	16
18	16 and 24
20	16, 24 and 32
22	16, 24, 32 and 40
24	16, 24, 32, 40 and 48
26 and over	No increase in log height for any tree

[2] The maximum butt-log grade improvement is assumed to be one grade. No grade improvement ɔrojected for butt-log grade 2 stems over 26 inches d.b.h. No grade improvement projected for butt-og grade 3 stems over 22 inches d.b.h.

height of 24 feet. When merchantable height was increased to 40 feet, the value added by the grade factor was still based on a 24-foot merchantable length, in spite of the fact that grade improved throughout the 40 feet of merchantable length.

Results and Discussion

The distribution of the projected value gain attributable to diameter growth, merchantable-height increase, grade improvement, and the combination effect of all factors improving at once is shown in table 2 for different rates of diameter growth and merchantable-height increase.

For example, a yellow-poplar tree has a present d.b.h. of 14 inches, a merchantable height of 24 feet, and a butt-log grade 2. From the general appearance of the tree and its growing conditions it is anticipated that the tree will grow to 16 inches d.b.h., 40 feet merchantable height, and grade 1 butt log. In this case, with the projected diameter and height growth of 2 inches and 16 feet, table 2 shows that: (1) 35 percent of the total value gain will be due to diameter growth; (2) 20 percent will be due to merchantable-height increase; (3) 20 percent will be due to improvement in grade; and (4) 25 percent will be due to the combined effect of height increase and grade improvement.

If this same tree would not increase in merchantable height because of a fork at 27 feet, the conversion-value increase would have to come from the diameter and grade improvements. Increasing these two factors will yield 55 percent of the maximum total dollar value gain. If neither merchantable height nor quality improve, then the conversion value gain would be limited to that resulting from diameter growth. This would be only 35 percent of the maximum dollar value gain obtained when all factors are improved.

Understanding what each of the three factors contributes to the total conversion value of the tree—in combination with other economic, silvicultural, and forest management knowledge—can be helpful in reaching rational decisions about timber stand improvement.

—ROGER E. McCAY
Research Forester
Northeastern Forest Experiment Station
Forest Service, U.S. Dep. of Agriculture
Columbus, Ohio

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USDA FOREST SERVICE RESEARCH NOTE NE-105

1969

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HOW TWO TYPES OF FLUCTUATING TEMPERATURE AFFECT THE GROWTH OF *FUSARIUM SOLANI*

Abstract.—Growth of six isolates of *Fusarium solani* on potato dextrose agar was determined with (1) continually changing temperature programs, (2) programs consisting of two alternating constant temperatures, and (3) a constant temperature program. All programs had a mean of 70° F. Growth increased with an increase in temperature fluctuation of 10 or 20°F., but decreased with a fluctuation of 40° F. Significant differences were found in the growth rates of the isolates.

The change in the growth rate of a fungus with a change from a constant temperature to a fluctuating temperature has been reported by several authors. Smith (*4*) and Burgess and Griffin (*2*) used programs that approximated daily temperature changes. Jensen (*3*) used a program of two constant temperatures, each alternately maintained for 12 hours.

This study was established to determine if six isolates of *Fusarium solani* (Mart.) App. & Wr. emend Synd. & Hans. differ in their response to these two types of fluctuating temperature programs.

Materials and Methods

The effect of the two types of temperature programs on the growth of *F. solani* was determined in an incubator controlled by a cam-type temperature programmer. For each program type, three fluctuating temperature regimes, each with a mean of 70° F., were established. The three temperature regimes had fluctuation ranges of 10° (65 to 75° F.), 20° (60 to 80° F.), and 40° F. (50 to 90° F.). The effect of a constant temperature regime of 70° F. was also determined.

Six isolates of *F. solani* were grown with each temperature regime. Five of the isolates, F1M, F2P1, F3Y, F5P2, and F6P3, were isolated from cankers on hardwood trees. The sixth, F4S, was isolated from soil. All isolates were obtained from the U.S.D.A. Forest Service collection at Delaware, Ohio.

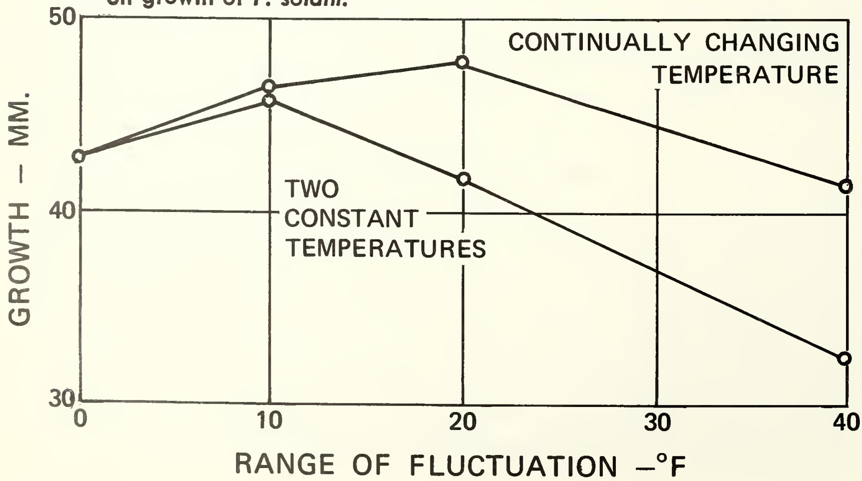
The fungi were grown on potato dextrose agar in disposable petri plates. The cultures were inoculated by cutting an agar plug from the edge of an actively growing culture with a No. 3 cork borer, and inverting the plug in the center of the petri plate. All isolates were placed in the incubator at the same time to insure uniform temperature treatment. After 5 days, the mean diameter of each culture was determined by measuring the culture diameter at two locations, at right angles to each other

The temperature regimes were replicated twice. Each replication contained four cultures of each isolate for each of the seven temperature regimes. The data were analyzed statistically in a split-plot design, and comparisons were made with Scheffé's test (*1*).

Results and Discussion

Growth of *F. solani* varied with the type of temperature program and with the temperature regime (fig. 1). Growth increased with an increase in the range of fluctuations up to 20° F. with the continually changing temperature program and decreased with a further increase in the range

Figure 1.—Effect of two types of fluctuating temperature programs on growth of *F. solani*.



of fluctuations to 40° F. With the program of two constant temperatures, growth increased with an increase in the range of fluctuation to 10° F. and decreased with an increase in the range of fluctuations to 20 or 40° F. Growth with the continually changing temperature program was greater than growth with the program of two constant temperatures, at all ranges of fluctuations tested.

The increased growth in the 65-75° F. regime suggests that the relationship between growth and temperature is not linear: that the increase in growth with an increase in temperature from 70 to 75° F. is greater than the decrease in growth with a decrease in temperature from 70 to 65° F.

At the upper and lower temperature extremes of the 60 to 80° F. and 50 to 90° F. regimes, growth was apparently slower than at temperatures nearer to 70° F. Hence, growth with the continually changing temperature program was greater because the environmental temperature was at the extreme temperatures only a very small part of the 24-hour period, whereas with the programs with two constant temperatures the temperature was at each extreme for 12 hours. Therefore, temperature programs that approximated the temperature variation in the natural environment caused the greatest changes in growth and probably most closely predict the response of the isolates studied to temperature in their natural environment.

Growth varied significantly among some of the isolates of *F. solani:* from 40.7 mm. for F5P2, a canker-causing isolate, to 44.7 mm. for F4S, the isolate from soil. However, growth of two of the canker-causing isolates was not significantly different from growth of the soil isolate.

The variation in growth between isolates of *F. solani* is probably due to genetic variation within the species and is not related to the source of the isolate. Even though the soil isolate grew significantly more than three of the canker-causing isolates, this relationship will have to be tested more thoroughly with many isolates before any conclusions can be made.

■

Literature Cited

1. Bancroft, T. A. 1968. Topics in Intermediate Statistical Methods. Vol. 1. 129 p. Iowa State Univ. Press, Ames, Iowa.
2. Burgess, L. W., and D. M. Griffin. 1968. The Influence of Diurnal Temperature Fluctuations on the Growth of Fungi. New Phytol. 67: 131-137.
3. Jensen, Keith F. 1969. Effect of Constant and Fluctuating Temperature on Growth of Four Wood-Decaying Fungi. Phytopathol. 59 (5): 645-647.
4. Smith, Richard S., Jr. 1964. Effect of Diurnal Temperature Fluctuations on Linear Growth Rate of Macrophomina Phaseoli in Culture. Phytopathol. 54: 849-852.

— KEITH F. JENSEN, Research Plant Physiologist
PHILLIP E. REYNOLDS, Research Associate
Northeastern Forest Experiment Station
Forest Service, U.S. Dep. of Agriculture
Delaware, Ohio

■

USDA FOREST SERVICE RESEARCH NOTE NE-106
1969

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

APR 14 1970
SCI., TECH. & AGR. DIV.

PITFALLS OF USING INTERNAL RATE OF RETURN TO RANK INVESTMENTS IN FORESTRY

Abstract.—Using the internal rate of return concept to rank the economic desirability of investment opportunities can lead to incorrect investment decisions. Present value provides a correct and unambiguous means of judging such investment alternatives.

Internal rate of return has received widespread acceptance as a means of evaluating and ranking the general economic effectiveness of timber-producing investments. Here we point to instances where rigid use of the internal rate of return concept provides incorrect guidance for investment decisions. The approach using present value provides a correct and unambiguous method for judging the financial merit of such investment alternatives.

The internal rate of return for a timber-management investment is the rate at which the investment grows toward the return it eventually generates. The general formula for computing the rate of return (i) for a single investment (C), yielding a single added value (R), in n years is:

$$C\ (1 + i)^n = R$$

C, n, and R are known; and we solve for i.

The procedure can be readily extended to projects having more than one cost and yielding more than one return during the investment period.

The i's (internal rates of return) generated by various alternative investment projects are customarily used to rank the economic desirability of the projects.

The internal rate of return is considered a valid device for judging whether an investment should be accepted or rejected. If the internal rate of return to a timber-management investment is greater than the investor's cost of borrowing capital (or the rate of return on his best alternative opportunity, whichever is appropriate) then the investment should be accepted.[1]

Consider for example a simple hypothetical project (A), with schedule of investments and net returns as follows:

Year	*Operation*	*Cost*	*Return*
1970	Precommercial thinning	$25/acre	——
1980	Commercial thinning	——	$29/acre
1990	Commercial thinning	——	$58/acre
2000	Harvest cut	——	$88/acre

The formula for computing internal rate of return for this project is:

$$25\ (1 + i)^{30} = 29\ (1 + i)^{20} + 58\ (1 + i)^{10} + 88$$

Solving for i yields a rate of about 10 percent. If our investor can borrow investment funds at a rate of 4 percent, this project is worth undertaking. He would accept it.

Now consider two similar investment alternatives (B) and (C) represented by the following income flows:

Investment	*1970*	*1980*	*1990*	*2000*
B	−$25	0	0	$250
C	−$25	$42	$42	$ 42

The internal rate of return to B is about 8 percent and to C about 10 percent. At a 4 percent borrowing rate, these investments would be worth undertaking too.

However, when the question asked is "Which of the projects is the better one?"; and not "Are the projects worth undertaking?"; the use of internal rate of return as a selection criterion can lead to an incorrect choice. If our investor ranks A, B, and C strictly in terms of internal rate of return values he will see no difference between investments A and C since both yield rates of 10 percent. And he will prefer either of these investments to B, because it yields a return of only 8 percent.

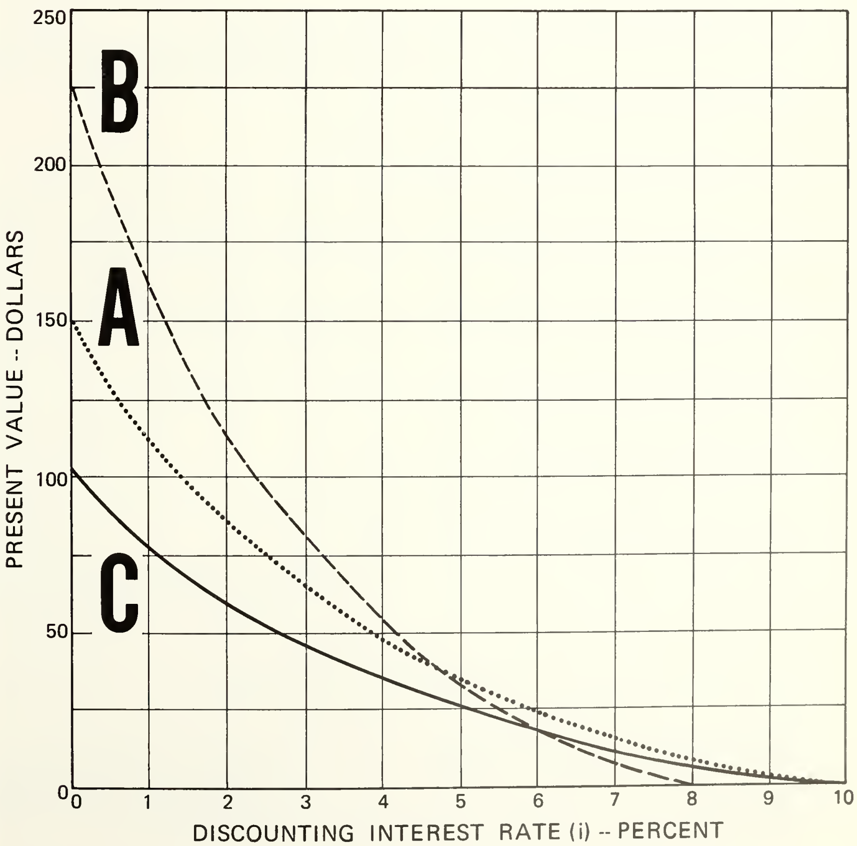
But the best financial alternative is the one yielding the greatest present value at the investors cost of capital. Discounting A, B and C at 4 percent yields present values of $48, $52, and $35, respectively. Clearly, investment B is the best alternative.

[1] Actually, investment is not an end in itself, but is a process of distributing consumption over time. The investment decision must take in to account the income preferences of investors over time. It must also consider problems of uncertainty, opportunities for reinvesting incremental cash flows, and choices of discounting rates. Such difficulties are beyond the scope of this paper and are not discussed.

We can use graphics to fully clarify this point. The chart in figure 1 plots the present values of options A, B and C as a function of discounting interest rates (fig. 1).

Internal rate of return for any multiperiod investment is that discounting rate of interest which makes the present value of the cash-flow stream equal to zero. The internal rates of return to A, B, and C are 10 percent, 8 percent, and 10 percent, respectively. Ranking in terms of internal rate of return would leave the investor indifferent between investments A and C, and he would prefer either A or C to B. However, the chart clearly shows that the choice between A, B, and C will depend on the rate of discount used. At discount rates of less than 4.6 percent, investment B is the best alternative. At rates greater than 4.6 percent, A is preferred.

Figure 1.—Present values of investments A, B, and C at varying discount rates.



C would never be preferred at any discount rate that yielded this investment a positive present value.

Thus, when we are deciding between mutually exclusive investment alternatives, the choice of the one with the highest internal rate of return is not, in general, correct. In fact, a decision between the alternatives cannot be made without knowing the appropriate discounting rate.

Another fundamental difficulty of using internal rate of return to evaluate investment alternatives is that some options may not yield a unique rate of return. Take for example a hypothetical project (D) having the following income flows:

1970	*1980*	*1990*	*2000*
−$25	$112.25	−$165.96	$80.78

Calculation of internal rate of return to this investment yields multiple values. The present value is zero at discounting rates of 2, 4, and 6 percent[2] (fig. 2).

[2] This is in accord with Descartes' rule of signs: The number of positive solutions for which present value equals zero is at most equal to the number of reversals of sign in the terms of the income flow sequence.

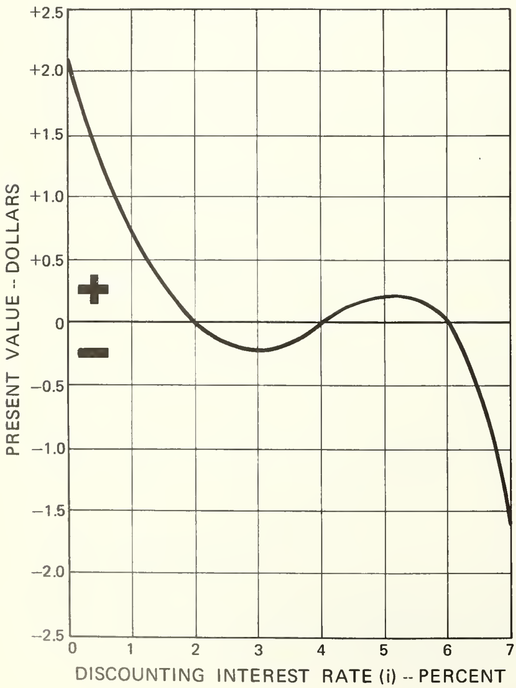


Figure 2.—Present value of investment D at varying discount rates.

Once again, the decision to invest will depend on the rate of discounting used. The present value of investment D is positive at discounting rates of 0 to 2 percent and 4 to 6 percent; and negative at rates of 2 to 4 percent and greater than 6 percent. Using the appropriate discounting rate the investor can calculate a correct and unambiguous present value which can be used to judge the financial merit of this investment.

Forest economists and others who use internal rate of return to rank the financial desirability of alternative investments in timber production must use this economic tool with care. If a particular investment yields a unique internal rate of return, the internal rate of return value is a sound index for determining whether or not the investment is worth undertaking.

But when the problem is to choose between mutually exclusive productive investment alternatives, the internal rates of return to these options will not rank them consistently with their present values. A choice cannot be made without knowning the appropriate discounting rate. Given this discounting rate, the options should be ranked in terms of their present values. This approach insures that the investment yielding the highest level of present worth will be chosen.

Bibliography

Alchian, Armen Albert.
1955. The Rate of Interest, Fisher's Rate of Return Over Costs and Keynes' Internal Rate of Return. Amer. Econ. Rev. 45: 938-943.

Herrick, Owen W. and J. Edwin Morse.
1968. Investment Analyses of Stand Improvement and Reforestration Opportunities in Appalachian Forests. U.S.D.A. Forest Serv. Res. Paper NE-111, 43 pp. NE. Forest Exp. Sta., Upper Darby, Pa.

Hirshleifer, Jack.
1958. On the Theory of Optimal Investment Decision. J. Polit. Econ. 66: 329-352.

Lorie, James H. and Leonard J. Savage.
1955. Three Problems in Capital Rationing. J. Bus. 28: 229-239.

Marty, Robert and David J. Neebe.
1966. Compound Interest Tables For Long Term Planning in Forestry. U. S. Dep. Agr. Handbook 311. 103 pp.

Marty, Robert, Charles Rindt, and John Fedkiw.
1966. A Guide For Evaluating Reforestration and Stand Improvement Projects. U. S. Dep. Agr. Handbook 304. 24 pp.

Renshaw, Edward F.
1957. A Note on the Arithmetic of Capital-Budgeting Decisions. J. Bus. 30: 193-201.

Solomon, E.
1956. The Arithmetic of Capital-Budgeting Decisions. J. Bus. 29: 124-129.

— DAVID A. GANSNER and DAVID N. LARSEN
Research Foresters
Northeastern Forest Experiment Station
Forest Service, U. S. Dep. Agriculture
Upper Darby, Pa.

;DA FOREST SERVICE RESEARCH NOTE NE-107
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BARK THICKNESS RELATED TO TREE DIAMETER IN SUGAR MAPLE (*ACER SACCHARUM* MARSH.)

Abstract.—Bark thickness for sugar maple trees in Vermont was found to be related to tree diameter at breast height (d.b.h.). The relationship was positive—as the diameter increased, the bark thickness increased.

Foresters using outside bark diameters to determine forest tree parameters should be aware that bark thickness not only varies by stem size and individual species, but also by site quality and tree age (*2*).[1]

The majority of published material shows bark thickness to be a linear function of tree diameter at breast height (d.b.h.). In conifers, Johnson (*1*) found this to be true with Douglas-fir (*Pseudotsuga taxifolia* (Poir.) Britt.) while Ostlin (*3*) reported that, in birch (*Betula* Sp.) and associated conifers, bark thickness increased from better to poorer sites and also increased with tree diameter and age class. However, no information has been available concerning the relationship of bark thickness to d.b.h. for sugar maple.

In 1967 our Sugar Maple Sap Production project at Burlington, Vermont, conducted a study to determine this relationship in sugar maple. It was found that bark thickness of sugar maple trees in Vermont is positively correlated with tree d.b.h.; that is, as d.b.h. increases, so does bark thickness.

Methods and Results

Measurements were taken on a total of 209 trees ranging in d.b.h. from 5.0 to 39.0 inches. These trees were located on glaciated, medium quality sites having slopes of 15 percent or less.

[1] Italic numbers in parentheses refer to Literature Cited, p. 4.

Two bark thickness measurements were recorded for each tree—one on the north side and one on the south side at 4½ feet above the ground—to the nearest 1/32 inch (fig. 1). Tree diameters were measured with a diameter tape to the nearest 0.1 inch after all loose bark was removed from the measurement area. These data were analyzed by linear regression techniques, using average bark thickness values for each tree. This provided a total of 209 observations.

Figure 1.—Bark thickness data were measured by using a depth gage.

The following regression equation was developed from the data:

$$Y = .135 + 0.020X_1$$

where: Y = average bark thickness

X_1 = tree d.b.h.

The coefficient of determination (R^2) was found to be .51 for the equation, indicating that 51 percent of the variation in bark thickness was associated with d.b.h.

An analysis of variance was computed, yielding an F-value for variation due to regression of 433.

This value is highly significant, indicating that the variation accounted for by fitting the regression line to the data was significantly greater than the remaining unexplained variation. Figure 2 is a graphic presentation of the regression equation.

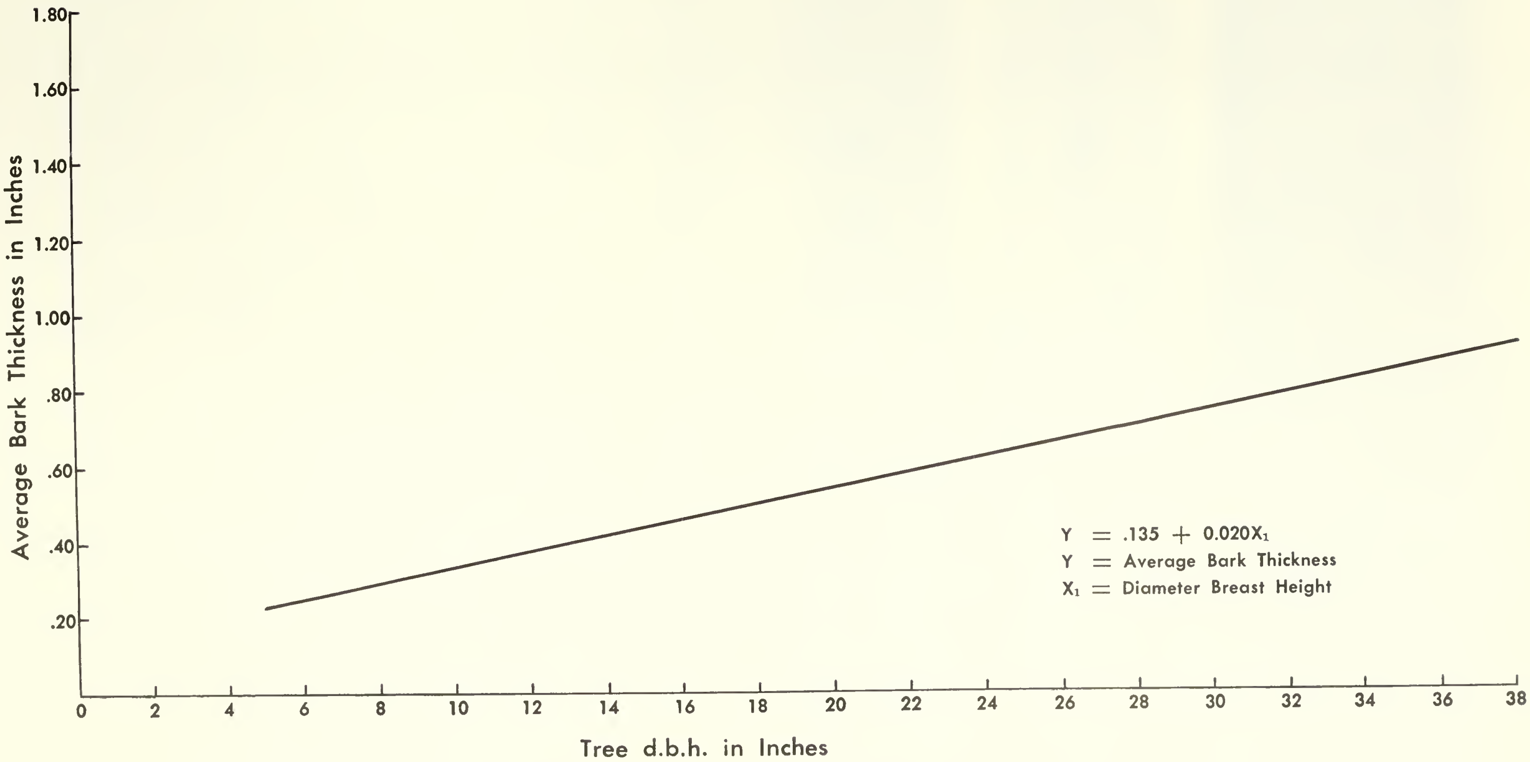

Figure 2.—Relationship between bark thickness and d.b.h. for average bark thickness of sugar maple in Vermont.

In summary, bark thickness for sugar maple trees in Vermont is strongly correlated with tree d.b.h.—and the relationship is positive. As the diameter increases, the average bark thickness increases. When radial inside bark parameters are desired, single bark thickness should be used. But when diameter inside bark measurements are desired, the bark thickness must be doubled.

Those desiring exact inside bark parameters should measure and compute the bark thickness, d.b.h. relationship, for the locale involved.

—H. CLAY SMITH, Research Forester
Northeastern Forest Experiment Station
Forest Service, U.S. Dept. Agriculture
Burlington, Vermont

Literature Cited

1. Johnson F. A.
ESTABLISHING PAST DIAMETERS OF DOUGLAS FIR TREES. U. S. Forest Serv., PNW. Forest and Range Exp. Sta. Res. Note No. 112, 3 pp. 1955.
2. Korsun, F.
BARK THICKNESS AS A FUNCTION OF STEM DIAMETER. Les, Bratislava 2: 51-54, 1955. (Rev. Forestry Abstract 4373, Vol. 16, 1955.)
3. Ostlin, E.
BARK DATA FOR PINE, SPRUCE, BIRCH, ETC. PART 2. BARK DATA FOR SITE AND AGE CLASSES AND FOR SAWLOGS AND PULPWOOD. Rapp. Uppsats. Instn. Stogstax., Skogskogsk., Stockh. No. 6: 67, 1963. (Rev. Forestry Abstract 1018: Vol. 26, 1965.)

;DA FOREST SERVICE RESEARCH NOTE NE-108
1970

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SOME PRELIMINARY ESTIMATES OF ENERGY UTILIZATION IN EVEN-AGED NORTHERN HARDWOODS

Abstract.—Estimates of energy utilization from various sources indicate that even-aged northern hardwood stands utilize less than 1/2 percent of net solar radiation for wood, leaf, and seed production, and only about 1/10 percent for production of merchantable wood. Forest managers should seek to understand and manipulate the remaining 99+ percent of solar energy, for improving the efficiency of merchantable wood production.

Both timber managers and ecologists are highly interested in the productivity of timber stands, but often from widely divergent points of view.

Timber managers are concerned with the ability of stands to produce useful primary products—veneer logs, sawlogs, bolts, and pulpwood. Production of non-merchantable material usually is of incidental interest.

Forest ecologists, on the other hand, are particularly interested in the total production of dry matter and the total energy flow within an entire forest ecosystem.

Each group has something valuable to learn from the other. Particularly in view of current trends in multiple forest land use and rapid advances in wood utilization, the timber manager needs a better appreciation of how the energy in a forest ecosystem is utilized—and wasted—in producing merchantable and potentially useful material, as well as in underwriting various other types of biological activity. Similarly, the forest ecologist should appreciate the need to direct part of his efforts toward developing a better understanding of how available energy can be harnessed in the production of useful products.

Recently developed estimates of growth and yield, coupled with available ecological information, enabled us to develop some preliminary estimates of energy utilization in even-aged northern hardwood stands of New England. Although approximate, these estimates provide some gross comparisons of energy utilization in the production of merchantable timber, leaves, and seeds. Implications of these findings for the management of northern hardwoods are discussed briefly.

Production Data

The available productivity information for even-aged northern hardwoods is shown in table 1. Cubic-foot volumes per acre were developed from yield tables for unmanaged even-aged stands (site index 60) published in *A Silvicultural Guide for Northern Hardwoods in New England (Leak et al 1969).* Volumes, which are taken to a minimum 4-inch d.i.b.

Table 1.—*Wood, seed, and leaf production per acre for even-aged northern hardwood stands in New England.*

Stand age (years)	Cumulative[1] merchantable wood		Annual[2] seed production		Annual[3] leaf productio
	Green	Oven-dry	Green	Oven-dry	Oven-dr
	Cu. ft.	*Kg.*	*No.*	*Kg.*	*Kg.*
0	—	—	—	—	—
10	—	—	—	—	—
20	—	—	—	—	—
25	—	—	2,838,660	15.809 — 41.352	—
30	—	—	—	—	—
40	—	—	—	—	—
50	1,900	28,514	—	—	1279.1
60	2,100	31,519	—	—	—
70	2,250	33,766	—	—	—
80	2,400	36,019	8,172,687	23.452 — 70.034	—
90	2,550	38,271	—	—	—
100	2,700	40,524	—	—	—
110	2,850	42,771	—	—	—
120	3,000	45,024	—	—	—
130	3,100	46,523	—	—	—
140	3,250	48,776	—	—	—
150	3,400	51,028	—	—	—
160	3,550	53,281	—	—	—
170	3,700	55,528	—	—	—
180	3,800	57,028	10,915,930	16.696 — 52.448	—

[1] Leak et al *(1969).*
[2] Leak et al *(1961).*
[3] Hart et al *(1962).*

Table 2.—*Some conversion factors and estimates used to determine energy flow in northern hardwood stands.*

Radiation:

1. Incoming solar radiation, Portland Maine = 439-550 langleys per day, averaging 506.2[1] during May-August.
2. Albedo of hardwood canopy, May-August = 0.17.[2]

Wood:

1. Average northern hardwood specific gravity = 0.53.[3]
2. Energy value = 4,267 to 4,679 gram calories per gram, averaging 4,473.[4]

Seeds:

1. Average moisture content 10 to 30 percent.[5]
2. Average energy value = 5,065 gram calories per gram.[6]
3. Number of seeds per pound:[5] beech 1,300 to 2,300; yellow birch 278,000 to 907,000; sugar maple 3,200 to 9,100; red maple 12,700 to 38,200; paper birch 610,000 to 4,120,000; white ash 5,500 to 18,200; pin cherry 11,900 to 21,800.

Leaves:

1. Energy value = 4,229 to 5,092 gram calories per gram, averaging 4,660.[4]

Physical conversions:

1. 1 kilogram calorie = 1,000 gram calories.
2. 1 pound = 0.453592 kilograms.
3. 1 langley = 1 gram calorie/square centimeter.
4. 1 joule = 0.0002388 kilogram calories.
5. 1 newton meter = 1 joule.
6. 1 kilogram (weight) = 9.8 newtons.
7. 1 acre = 40,468,564.224 square centimeters.

[1] U.S. Dep. Commerce *(1960, 1963, 1964, 1965, 1967).*
[2] Federer *(1968).*
[3] USDA Forest Service *(1955).*
[4] Golley *(1961)* and Ovington et al *(1967)*, respectively.
[5] USDA Forest Service *(1948).*
[6] Golley *(1961).*

top, represent total estimated cubic-foot yield in sawtimber and pulpwood. Estimated oven-dry weights are based on the conversions in table 2.

Annual numbers of seeds produced were taken from unpublished data for the Bartlett Experimental Forest *(Leak et al 1961).* Data from an old-growth uneven-aged stand were used for the 180-year class in table 1. Because of great variability in both seed production and the seed conversion factors in table 2, oven-dry seed production is expressed as a range of values.

The leaf production data were adapted directly from the oven-dry weights published by Hart et al *(1962).* These data, taken in a stand of hardwoods about 50 to 60 years old, also containing some old holdovers and saplings, probably hold true for a wide range in stand age *(Moller 1947)*.

Energy Flow Estimates

The first step in developing energy-flow estimates was to fill in a complete range of data for seed and leaf production to accompany the basic data in table 1. Assuming that leaf and seed production are 0.0 at stand age zero, and that leaf production remains constant after age 50, annual values for each 10-year class were filled in by straight-line interpolation.

Next, cumulative estimates of leaf and seed production were developed. Since leaf production rises rapidly as a young stand develops, we assumed that the annual leaf production estimate for each 10-year age class applied to each of the 10 *previous* years. Since seed production in hardwood stands develops more slowly, we assumed that each annual seed production estimate applied to each of the 10 *subsequent* years. By summing annual leaf and seed production rates, cumulative estimates were developed corresponding to the cumulative cubic-foot volumes of wood shown in table 1.

The gram-calories of chemical energy represented by given weights of woods, leaves, and seeds are fairly well documented in the literature (table 2). These energy conversions have not been worked out for northern hardwoods specifically. However, the range in conversions for other tree and plant species is not great. Thus we feel reasonably confident in applying these factors to produce the cumulative estimates of energy tied up in wood, leaf, and seed production shown in table 3.

Notice, first, that mean annual energy utilization at stand maturity (120 to 160 years) is about 6.7 to 7.0 million kilogram calories. Based on an average daily solar radiation of 506 langleys (table 2) over a 100-day growing season, with an albedo (reflection) of 0.17 *(Federer 1968)*, the net incoming solar radiation is estimated at 1,700 million kilogram calories per acre over the growing season. Thus energy utilization for wood, leaf, and seed production is a little less than ½ percent of the net solar radiation. Mean annual energy utilization for merchantable wood production alone is only about 1/10 percent. The remaining 99+ percent energy is accounted for by heat or radiation loss to the atmosphere, evapotranspiration, respiration, and the production of other organic materials within the forest ecosystem.

At stand maturity, the ratio of energy utilization for wood, leaf, and

Table 3.—*Cumulative and mean annual energy estimates for merchantable volume, leaves, and seeds by stand age, in millions of kilogram calories per acre.*

Stand age (years)	Merchantable wood		Leaves		Seeds		All	
	Total	Mean annual	Total	Mean annual	Total	Mean annual	Total	Mean annual
0	—	—	—	—	—	—	—	—
10	—	—	11.9	—	—	—	—	—
20	—	—	35.8	—	0.3-.8	—	—	—
30	—	—	71.5	—	1.0-2.5	—	—	—
40	—	—	119.2	—	1.8-4.7	—	—	—
50	127.5	2.5	178.8	3.6	2.7-7.2	0.1	309.0-313.5	6.2
60	141.0	2.3	238.4	4.0	3.7-10.0	.1-.2	383.1-389.4	6.4-6.5
70	151.0	2.2	298.0	4.2	4.7-13.0	.1-.2	453.7-462.0	6.5-6.6
80	161.0	2.0	357.6	4.5	5.8-16.3	.1-.2	524.5-535.0	6.6-6.7
90	171.2	1.9	417.2	4.6	7.0-19.8	.1-.2	595.4-608.2	6.6-6.7
100	181.3	1.8	476.2	4.8	8.2-23.3	.1-.2	666.3-681.4	6.7-6.8
110	191.3	1.7	536.4	4.9	9.3-26.7	.1-.3	737.0-754.4	6.7-6.9
120	201.4	1.7	596.0	4.9	10.4-29.9	.1-.3	807.8-827.3	6.7-6.9
130	208.1	1.6	655.6	5.0	11.4-33.1	.1-.3	875.1-896.8	6.7-6.9
140	218.2	1.6	715.2	5.1	12.4-36.2	.1-.3	945.8-969.6	6.7-6.9
150	228.2	1.5	774.8	5.2	13.4-39.2	.1-.3	1016.4-1042.2	6.7-6.9
160	238.3	1.5	834.4	5.2	14.4-42.2	.1-.3	1087.1-1114.9	6.8-7.0
170	248.4	1.5	894.0	5.2	15.3-45.0	.1-.3	1157.7-1187.4	6.8-7.0
180	255.1	1.4	953.6	5.3	16.2-47.8	.1-.3	1224.9-1256.5	6.8-7.0

seed production is in the neighborhood of 10:30:1. Under repeated thinnings, merchantable wood production might be doubled *(Leak and Filip 1969)*, which would (1) raise the energy utilization for wood production to perhaps two-thirds of that for leaf production, and (2) raise the percent utilization of net solar radiation for wood production to perhaps 1/5 percent. This latter percent utilization is, quite logically, considerably lower than the values calculated by Hellmers and Bonner *(1959)* of 1.4 to 2.5 percent for *total current annual dry matter production* in even-aged stands of European beech. Furthermore, these authors based their percentage on *visible* solar radiation, which comprises roughly half or a little less of the net solar radiation.

Another usage of energy considered in this analysis of energy flow was the potential mechanical energy represented by the standing trees—the energy released when a tree falls to the ground. Assuming that the center of gravity of the typical northern hardwood tree (the merchantable portion) is at 9 meters above ground, cumulative potential mechanical energy was estimated at only 200 to 400 kilogram calories per acre—negligible compared to the chemical energies.

Discussion

Although approximate, these figures emphasize that timber-growing accounts for a very minute proportion—1/10 to 1/5 percent—of the net solar energy that enters into a northern hardwood stand.[1] Furthermore, merchantable timber growth comprises only a small proportion of the energy utilized in the total production of dry matter. Apparently, more energy is tied up in leaf production than timber production.

No manufacturing system is perfectly efficient. However, northern hardwood timber production ranks very low in efficiency when compared, for example, with gasoline or diesel engines, which commonly attain efficiencies of 10 to 25 percent. In the laboratory, photosynthesis may attain efficiencies of up to about 35 percent *(Daniels 1956)* under optimum conditions.

These findings hold two important implications for timber-oriented foresters.

First, because of the relatively high efficiency of the photosynthetic process under optimum conditions, the possibilities for increasing the efficiency of northern hardwood timber production appear great; and ways must be sought to accomplish this end. In fact, I find it difficult to see how timber production can remain competitive with other forest land uses unless more efficient production ratios are obtained. Some of the known possibilities for increased production are fertilization, genetic improvement, optimum thinning programs, conversion to faster-growing species or species mixtures that more fully utilize the site, and improved wood utilization.

Second, forest managers in the past have been almost exclusively concerned with less than 1 percent of the solar energy entering the forest properties under their control. As land managers in the broadest sense, we should seek to understand and manipulate for human benefit the remaining 99+ percent.

[1] Note that these proportions would be roughly doubled if based on *visible* solar radiation instead of net solar radiation.

Literature Cited

Daniels, Farrington.
1956. ENERGY EFFICIENCY IN PHOTOSYNTHESIS. *In* RADIATION BIOLOGY, pp. 259-292. McGraw-Hill, N.Y., 765 pp.

Federer, C. A.
1968. SPATIAL VARIATION OF NET RADIATION, ALBEDO AND SURFACE TEMPERATURE OF FORESTS. J. App. Meteorol. 7 (5): 789-795, illus.

Golley, Frank B.
1961. ENERGY VALUES OF ECOLOGICAL MATERIALS. Ecol. 42(3): 581-584.

Hart, George, Raymond E. Leonard, and Robert S. Pierce.
1962. LEAF FALL, HUMUS DEPTH, AND SOIL FROST IN A NORTHERN HARDWOOD FOREST. USDA Forest Serv. NE. Exp. Sta. Forest Res. Note 131, 3 pp.

Hellmers, Henry, and James Bonner.
1959. PHOTOSYNTHETIC LIMITS OF FOREST TREE YIELDS. Soc. Amer. Foresters Proc. 1959: 32-35.

Leak, William B., George Yelenosky, and David A. Marquis.
1961. PROGRESS REPORT ON A PHENOLOGICAL STUDY OF NORTHERN HARDWOODS. 23 pp. USDA Forest Serv. NE. Forest Exp. Sta., Durham, N.H.

Leak, William B., Dale S. Solomon, and Stanley M. Filip.
1969. A SILVICULTURAL GUIDE FOR NORTHERN HARDWOODS IN THE NORTHEAST. USDA Forest Serv. Res. Paper NE-143, 34 pp., illus. NE. Forest Exp. Sta., Upper Darby, Pa.

Leak, William B., and Stanley M. Filip.
1969. SOME CUTTING STRATEGIES AND TIMBER YIELDS FOR UNBALANCED, EVEN-AGED NORTHERN HARDWOOD FORESTS. USDA Forest Serv. Res. Paper NE-153. (In press). NE. Forest Exp. Sta., Upper Darby, Pa.

Moller, Carl Mar.
1947. THE EFFECT OF THINNING, AGE, AND SITE ON FOLIAGE, INCREMENT, AND LOSS OF DRY MATTER. J. Forestry 45: 393-404.

Ovington, J. D., and D. B. Lawrence.
1967. COMPARATIVE CHLOROPHYLL AND ENERGY STUDIES OF PRAIRIE, SAVANNA, OAKWOOD, AND MAIZE FIELD ECOSYSTEMS. Ecol. 48(4): 515-524.

United States Forest Service.
1948. WOODY PLANT SEED MANUAL. U.S. Dep. Agr. Misc. Pub. 654, 416 pp., illus.

United States Forest Service.
1955. WOOD HANDBOOK. U.S. Dep. Agr. Handb. 528 pp., illus.

United States Department of Commerce.
1960, 1963, 1964, 1965, 1967. CLIMATOLOGICAL DATA 11(13), 13(13), 15(13), 16(13), 18(13). Annual national summaries.

—WILLIAM B. LEAK
Principal silviculturist
Northeastern Forest Experiment Station
Forest Service, U.S. Dep. Agriculture
Durham, N.H.

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ꞩDA FOREST SERVICE RESEARCH NOTE NE-109
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DOES BEDDING PROMOTE PINE SURVIVAL AND GROWTH ON DITCHED WET SANDS?

Abstract.—Results from a study of prepared beds for planting slash pine on a wet sandy flat in Florida were inconclusive. Early growth was improved, but survival was not; and differences between a bedded site and an unbedded site were slight.

A question frequently asked is: "Does bedding help pine tree establishment and early growth on a ditched, wet, sandy flat?"

Some foresters contend that bedding is not necessary where the drainage system lowers the water table enough for pine trees to survive and grow. Others contend that bedding is a desirable supplement to a well-designed water-management system: they say that better stocking, better survival, and better early growth all result from this treatment.

In an attempt to answer this question, a research study was made on the Apalachicola National Forest in northwestern Florida.

The site selected for the study was adjacent to a 4½-foot-deep main ditch of the Ft. Gadsden Creek drainage project. The land was nearly level. Soils were very fine sandy loam with slowly permeable, clayey subsoils. Predominant ground cover was a heavy stand of mixed grasses with a few palmetto, some scattered Hypericum spp., and an abundant supply of pitcher plant throughout. Drainage was provided by a main ditch adjacent to the bedding test site, a second ditch parallel and 15 chains away, and a third ditch on one end of the study area.

In August 1964, twenty 56 x 320-foot plots were laid out along one main ditch. A month later, in September, one-half of the plots were bedded with a fireplow. Later the unbedded plots were prescribe-burned; and in January 1965 all plots were hand-planted at an 8 x 8-foot spacing with ungraded 1-0 slash pine (*Pinus elliottii* var. *elliottii*) seedlings (fig. 1).

Figure 1.—Bedded and unbedded plots after planting with slash pine in January 1965. Edge of drainage ditch in foreground.

First-year survival of the unbedded and bedded plots was essentially the same: 93 and 92 percent, respectively. Growth likewise differed little: seedlings on the unbedded plots added 0.8 foot in height, and seedlings on the bedded plots added 0.7 foot.

After 4 years the picture changed. In that growing season, trees on

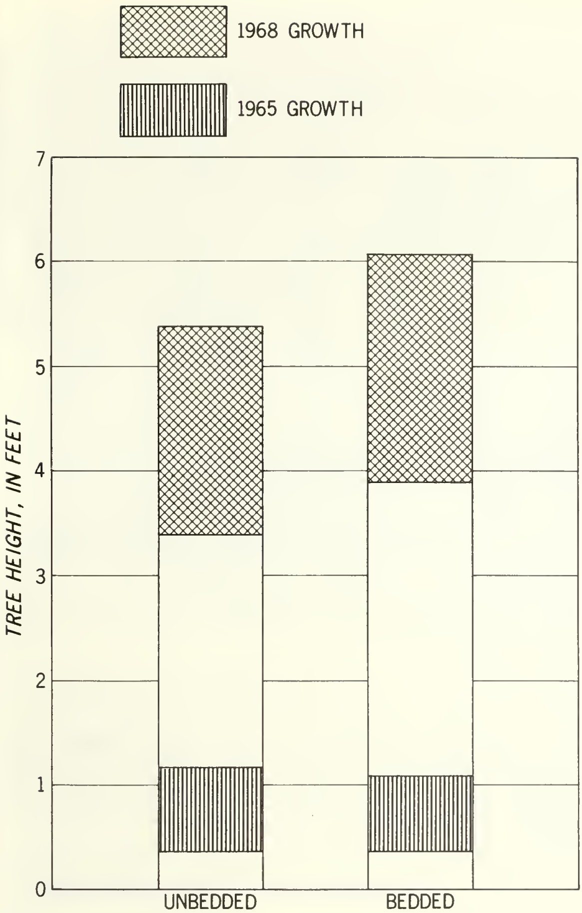

Figure 2.—Early height growth of bedded and unbedded slash pine trees, and total height after 4 years.

the bedded plots averaged 2.2 feet in height growth compared to 2.0 feet for those on the unbedded plot. Total height averaged 6.1 feet for the trees on the beds and 5.4 feet for those planted on the flats (fig. 2).

The ranking in survival remained the same as the first year: greater survival on the flats than on the beds, 89 percent versus 86 percent. Statistical analysis of the data showed that all differences—growth, total height, and survival—of the fourth-year measurement were significant.

Now we return to the original question, "Does bedding help pine tree establishment and early growth on a ditched, wet, sandy flat?"

Yes, and No, would be the answer. Early tree growth was improved significantly, while survival was not. However, the magnitude of the differences is not too great after 4 years: 0.7 foot in total height, 0.2 foot in growth, and 3 percent in survival (fig. 3).

Figure 3.—Bedded and unbedded plots at beginning of fifth growing season in May 1969. Same view as figure 1.

Another evaluation of the study is planned for the future. But for now, it looks as though foresters on both sides of the question will still have something to argue about.

—RALPH A. KLAWITTER*
Assistant Director
Insect and Disease Research
Northeastern Forest Experiment Station
Forest Service, U.S. Dep. Agriculture
Upper Darby, Pa.

*At the time this study was made, Dr. Klawitter was serving as principal silviculturist at the Southeastern Forest Experiment Station, Forest Service, U.S. Department of Agriculture, Charleston, South Carolina.

USDA FOREST SERVICE RESEARCH NOTE NE-110
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SURBAL: COMPUTERIZED METES AND BOUNDS SURVEYING

Abstract.—A computer program has been developed at West Virginia University for use in metes and bounds surveying. Stations, slope distances, slope angles, and bearings are primary information needed for this program. Other information needed may include magnetic deviation, acceptable closure error, desired map scale, and title designation. SURBAL prints out latitudes and departures, adjusted bearings and line lengths, closure error, acreage, and a plotting of the survey to any selected scale, all at a fraction of the costs for manual methods.

Some of the most tedious, time-consuming, and expensive work in land surveying occurs not in the field with transit and chain, but in the office with notes, mathematical tables, and endless pages of computations. Correcting distances from slope to horizontal, calculating latitudes and departures, determining closure error and acreage—these and other steps in converting field measurements to useful surveys are mathematical operations well suited to automatic processing.

The success enjoyed by other users of electronic equipment for digesting large amounts of data suggested to us the desirability of a computer program specially designed for metes and bounds surveys. Recent development of an electronic plotter capable of reproducing the adjusted survey made this a doubly desirous objective. Land surveyors, enigneers, foresters—anyone concerned with metes and bounds surveying—will find this a useful program—accurate, economical, and amazingly rapid.

What SURBAL[1] Does

SURBAL is a computer program designed to adjust a closed metes and bounds survey, calculate the area within the adjusted survey, and plot the adjusted survey. Any number of surveys, with up to 1,300 lines (calls) in each survey, may be submitted to the computer. The original program calculated latitudes and departures and provided adjusted bearings, adjusted line lengths, closure error, and acreage. It was developed for use on the IBM 7040/7044 computer.

In its present form, SURBAL provides all the preceding information in addition to a plotting of the adjusted survey complete with title, scale, border, and even a north arrow. Besides the computer, SURBAL requires an off-line Calcomp plotter and the Calcomp library subroutines. All this equipment is available at the West Virginia University computer center, where SURBAL was developed.

How to Submit Data

Figure 1 shows how survey data should be submitted to the computer center. Only four kinds of survey information are needed, and these may be submitted in various forms: (1) Station, identification by number, letter, or other convenient designation. (2) Slope distance between stations, in English or metric units (in figure 1 distance is expressed as chains, links, and tenths of links). (3) Slope between stations, expressed in degrees and minutes. (4) Bearing or azimuth between stations, expressed in degrees and minutes.

If the user desires, SURBAL can be modified to accept angle measurements (3) and (4) to seconds. Since these data are punched on cards for use by the computer, it is simplest to transcribe them from survey field notes to tabulation sheets having the same column arrangement as a computer card. These sheets are available from any computer center. In addition to the above survey data, information such as magnetic deviation from true north, the date, and a survey title are needed.

SURBAL users must also specify: (1) plotting scale desired and (2) acceptable error of closure. Plottings may be drawn to any specified scale (1 inch = 100 feet, 1 inch = 5 chains, 1 inch = 10 meters) but the chosen scale may describe a plotting larger than the Calcomp plotting paper (29 inches). In this case, the user may specify that the scale will

[1] Computer program No. 1 is on file at the Northeastern Forest Experiment Station, Biometrics Branch, 6816 Market Street, Upper Darby, Pa. 19082. Complete documentation and source decks also may be obtained from this address.

01	0472	0000	N8130W
02	1777	2830	N7930W
03	1471	2200	N7500W
04	2577	1630	N5445W
05	2232	1100	N4430W
06	1900	1000	N4845W
07	2089	0830	N5415W
08	2096	0800	N0130E
09	2540	0330	N5200E
10	2087	0600	N1200E
11	2602	0830	N0530W
12	2495	0645	N0300W
13	4439	0400	N1000E
14	3621	0130	N3000E
15	2668	0400	N1000E
16	1519	0430	N2530E
17	1545	0300	N7000E
18	1782	0230	N2545E
19	0633	0000	N2800E
20	1691	0200	S7930E
21	1958	0815	S7530E
22	1171	0515	S8430E
23	1611	0430	S7600E
24	1400	0145	S7100E
25	2146	0145	S6245E
26	0605	0230	S0930E
27	2748	0330	S0130W
28	2435	0245	S0900W
29	1405	0115	S2200W
30	2547	0230	S1730W
31	3211	0430	S0800W
32	2918	0700	S0330W
33	2298	1015	S0900W
34	3079	1545	S1600W
35	2332	0700	S0345E
36	1430	0800	S0030W
37	1000	0300	S0030W
38	2044	0830	S4530W
39	1169	1600	S5415W
40	2323	0000	S7450W

Figure 1.—Card-punching form for submitting field survey notes to computer. The columns are for station, slope distance, vertical angle, and bearing. The unit of slope-distance measurements must be specified because the SURBAL program accepts both English and metric units of length. In this example, chains and links were used for measurements of slope distance, and degrees and minutes for vertical angles and bearings.

be halved repetitively until the plot will fit the paper. Computer processing on a given survey is programmed to terminate if closure error exceeds 1:300. The user may state his preference that the program terminate on any other closure error, or he may prefer that the computer program proceed to conclusion regardless of closure error. The user's choice of alternatives among plotting scales and closure errors must be specified to the computer operator before processing begins.

Technical Information

Most users of SURBAL will want only to know, having submitted the previously specified data in proper form, that all subsequent mathematics and plotting are completed electronically at the computer center. Other users, however, may wish to delve into some of SURBAL'S inner workings. The program is based on commonly used rules of surveying found in any modern surveying text *(see Davis and Foote 1956)*.[2]

SURBAL uses the compass rule to balance all surveys; it corrects latitudes and departures in proportion to the length of the line. The adjusted length and adjusted azimuth are determined from the corrected latitude and corrected departure. The equation for determining corrected latitude is:

$$CL_i = L_i + \frac{M_i\,SF}{T} \qquad (1)$$

where:

CL_i = Corrected latitude of line i.
L_i = Uncorrected latitude of line i.
M_i = Length of line i.
S = Sum of uncorrected latitudes.
F = An algebraic correction factor (equal to $\pm$ 1) that will cause addition or subtraction of the correction as the data require.
T = Total traverse length.

The corrected departures are obtained in a similar manner.
The adjusted azimuth of each line is determined by the equation:

$$A_i = \text{Arc Tan } \frac{CL_i}{CD_i} \qquad (2)$$

[2] Davis, R. E., and F. S. Foote. Surveying—Theory and Practice. 1021 pp. McGraw-Hill Book Co., New York. 1956.

where:

A_i = Adjusted azimuth of line $_i$.

CD_i = Corrected departure of line $_i$.

The coordinates of each survey corner are determined by algebraically summing the corrected latitudes and corrected departures. The first station in the survey is considered to be the origin, and this is given the coordinates (0,0). SURBAL calculates the area of each survey by the method of coordinates, and area is determined by the equation:

$$\left[(X_2 Y_1 + X_3 Y_2 + \text{------} X_n Y_{n-1} + X_1 Y_n) - (X_1 Y_2 + X_2 Y_3 + \text{------} X_{n-1} Y_n + X_n Y_1) \right] \frac{S^2}{2} \qquad (3)$$

where:

X_i = X coordinate in inches.

Y_i = Y coordinate in inches.

S = Distance, in feet or other measure, represented by 1 inch on the map. (If S is in feet, area determined will be in square feet, etc.)

What Does SURBAL Print Out?

A sample of computer output for SURBAL is shown as figure 2. Experienced surveyors will recognize all the information needed to provide an area statement and to evaluate its accuracy. Surveys with more lines (calls) simply are printed on more pages. SURBAL also provides a plot of the adjusted survey data as shown in figure 3. All this printout, of course, becomes the property of the surveyor.

What Does SURBAL Cost?

The question finally must be answered: What does computer processing of survey data cost? The answer often comes as a pleasant surprise. It is impossible to predict exact costs because surveys vary in length and complexity. It should be noted, however, that costs vary with number of lines (calls), not with area of the surveyed tract.

For the purposes of cost estimation, survey data processing at the West Virginia University computer center will cost about $0.25 per line, providing computer outputs similar to figures 2 and 3. At this low cost, computer center personnel prefer to deal with problems of more than 100 lines. This $25.00 minimum may be met by submitting a single lengthy survey or by submitting several smaller surveys having a total of 100 or more lines.

Figure 2.—An example of SURBAL data compilation.

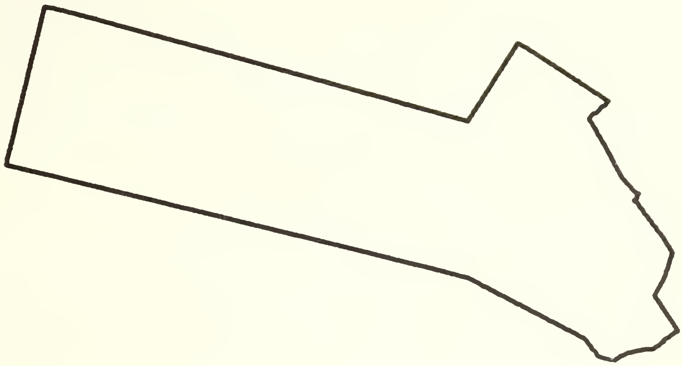
SAMPLE PROBLEM*

Trav. Sta.	Azimuth, degrees	Cnvrted length	Latitude North	Latitude South	Departure East	Departure West	Adj. latitude North	Adj. latitude South	Adj. depart. East	Adj. depart. West	Tot. latitude North	Tot. latitude South	Tot. depart. East	Tot. depart. West	Adjusted azimuth	Adjusted length
AB												0.00	—	0.00		
	0.0	500.0	500.0	—	0.0	—	501.4	—	3.2	—					0.37	501.4
BC											5.01	—	0.03	—		
	45.0	848.6	600.1	—	600.1	—	602.4	—	605.5	—					45.15	854.1
CD											11.04	—	6.09	—		
	110.6	854.4	—	299.4	800.0	—	—	297.6	805.5	—					110.27	858.7
DE											8.06	—	14.14	—		
	168.7	1019.0	—	999.2	200.0	—	—	996.4	206.5	—					168.29	1017.5
EF											—	1.90	16.21	—		
	259.7	1118.0	—	199.9	—	1100.0	—	196.81	—	1092.8					259.79	1110.4
FA											—	3.87	5.28	—		
	305.9	656.8	385.1	—	—	532.0	386.9	—	—	527.8					306.24	654.5

North latitude sum = 1485.18
South latitude sum = −1499.00
East departure sum = 1600.04
West departure sum = 1632.02
Lengths listed above are in feet.
Total latitudes and total departures are scaled to 1 inch = 100.0 feet for plotting.
Total latitudes and total departures are in reference to traverse station AB.
Reference rectangle required for plotting his vertices (0.00, 11.04), (16.21, 11.04), (16.21, −3.87), (0.00, −3.87).
Linear error of closure is 34.84 feet.
Total traverse length is 4996.8 feet: angular error of closure is 23.38 degrees.
Relative linear error of closure is 1/143..
Traverse encloses 1737062.05 square feet = 39.877 acres.

* Based on data from Davis and Foote (1956).

Figure 3.—A plat drawn by SURBAL computer.



TYGART VALLEY FOREST
DAILEY, WEST VIRGINIA
DIVISION OF FORESTRY
WEST VIRGINIA UNIVERSITY
MORGANTOWN, WEST VIRGINIA
DECLINATION 5.00′ W
1 INCH = 40 CHAINS   OCTOBER 1968
AREA = 497.06 ACRES

Processing at West Virginia University

Inquiries or requests for SURBAL processing should be addressed to Dr. D. L. Kulow, Division of Forestry, West Virginia University, Morgantown, W. Va. 26506. Perhaps the most satisfactory answers to questions about completeness of information, accuracy of results, and economy of computer processing are obtained by submitting one or more surveys of minimum cost to the SURBAL program.

— ROGER N. BAUGHMAN and JAMES H. PATRIC[3]

[3] Roger N. Baughman is a graduate assistant, Division of Forestry, West Virginia University, Morgantown, W. Va., now serving in the U. S. Army. James H. Patric is forest hydrologist, Timber and Watershed Laboratory, USDA Forest Service Northeastern Forest Experiment Station, Parsons, W. Va.

USDA FOREST SERVICE RESEARCH NOTE NE-111
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DEER PREFER PINE SEEDLINGS GROWING NEAR BLACK LOCUST

Abstract.—The presence of volunteer black locust seems to make some pine species on a bituminous coal spoil more palatable to white-tailed deer. Seedlings of jack pine, pitch pine, and Austrian pine were browsed more heavily when within 10 feet of a black locust than when farther away. The nitrogen produced by the black locust may have caused more succulent tissue in the pines. Proximity of black locust did not seem to strongly influence browsing of other pine species in the study area.

Deer browsing varied among several species of pine planted on bituminous coal-mine spoils. Some of the trees were browsed more heavily than others; some were not touched. So, we wondered why white-tailed deer (*Odocoileus virginianus*) preferred some pine species over others. This led us to investigate the browsing more closely, and our inspection of the pine planted on the spoils gave us the impression that browsing was more prevalent in pine growing close to black locust trees (*Robinia pseudoacacia* L.) that were invading the site. This made us think that perhaps black locust somehow affected deer browsing habits.

The study was originally established to compare the results of fall planting with spring planting. Trees and shrubs were planted in the fall of 1961 and 1962 and in the spring of 1962 and 1963 on bituminous coal-mine spoils in Clearfield County, Pa. Ten coniferous species were used in this study: red pine (*Pinus resinosa Ait.*), white pine (*P. strobus* L.), Scotch pine (*P. sylvestris* L.), pitch pine (*P. rigida Mill.*), jack pine (*P. banksiana* Lamb.), Austrian pine (*P. nigra* Arnold), European larch (*Larix decidua* Mill.), Japanese larch (*L. leptolepis* Sieb. and Zucc.), white spruce (*Picea glauca* (Moench) Yoss.), and Norway spruce (*P.*

abies L.). Each species was planted on two plots within the experimental area. Shortly after the final plantings were made, volunteer black locust began to invade the study area.

Light browse damage was first noted in December 1967 when the trees were 5 and 6 years old. In April 1968, the incidence of browsing was recorded, and its intensity was coded for all trees in the study area. Distance to the nearest black locust tree was also measured, so we could either substantiate or disprove our impression that the trees near black locusts were more heavily browsed.

Data obtained from the measurements show that 222 of the 2,403 conifers in the study area had been browsed to some degree (table 1). This is only 9 percent of the total; but among trees within 10 feet of a black locust tree, 39 percent had been browsed. The species most heavily browsed were: pitch pine, 24 percent browsed; Austrian pine, 21 percent browsed; and jack pine, 12 percent browsed.

Of the 222 browsed trees, 72 were more than 10 feet from a black locust tree; 57 of these were pitch pine. Thus, pitch pine seems to be the most acceptable pine species to deer. The data suggest that browsing on this species was also influenced by the proximity of black locust; 95 percent of the pitch pines within 10 feet of a locust were browsed.

Our impression that black locust influenced browsing was further substantiated: on one of the Austrian pine plots containing no locust, there was no browsing.

Browse damage to Scotch pine was intermediate but also appeared to be related to the proximity of black locust trees. Light browsing on red and white pine, regardless of the proximity of black locust, suggests that these species are the least acceptable pines in the area. Neither the spruces nor the larches were browsed, even though black locust trees were within the plots.

Black locust also influenced the severity of browsing damage on jack pine and especially on Austrian pine; the intensity of deer browsing increased dramatically near the black locusts. Heavy browse damage was recorded for 28 of the 54 browsed Austrian pines within 10 feet of a black locust. Damage was considered heavy when 67 to 100 percent of the branch tips, including the terminal bud of the tree, had been browsed. The increased severity of browsing near black locusts in addition to the higher incidence of browsing indicates that the presence of black locust does influence deer browsing.

Why did deer apparently prefer some pine seedlings growing near black locust in the study area? There are many possible reasons, some

Table 1. — *Deer browsing on trees within 10 feet of a black locust and over 10 feet from a black locust*

Pine species	Trees within 10 feet of locust			Trees over 10 feet from locust			All trees			Black locust on plots
	Total	Browsed		Total	Browsed		Total	Browsed		
	Number	*Number*	*Percent*	*Number*	*Number*	*Percent*	*Number*	*Number*	*Percent*	*Number*
White	67	4	6	329	0	0	396	4	1	7
Red	25	0	0	550	2	0	575	2	0	3
Scotch	40	13	32	274	1	0	314	14	4	15
Jack	99	41	41	362	12	3	461	53	11	15
Pitch	40	38	95	354	57	16	394	95	24	9
Austrian	112	54[1]	48	151	0	0	263	54	21	32
All	383	150	39	2,020	72	4	2,403	222	9	81

[1] Twenty-eight of the browsed Austrian pine within 10 feet of a black locust were heavily browsed; that is, 67 to 100 percent of the branch tips, including the terminal, had been browsed.

A heavily browsed Austrian pine 5 feet away from a black locust (background).

perhaps have not even occurred to us. One possibility is that differences in microsite affected both the establishment of black locust and the palatability of the pine; on strip-mine spoils this seems unlikely. A more likely reason is that the pines growing near locust—a legume that increases soil nitrogen—developed more succulent foliage.

—WALTER H. DAVIDSON
Research Forester
Northeastern Forest Experiment Station
Forest Service, U. S. Dep. of Agriculture
Kingston, Pennsylvania

JSDA FOREST SERVICE RESEARCH NOTE NE-112
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FACTORS THAT INFLUENCE CHRISTMAS TREE SALES

Abstract.—An analysis of the metropolitan Christmas tree market in Winston-Salem, N. C., shows that to sell more trees, Christmas tree retailers should locate their lots on heavily traveled streets in business areas, have adequate parking facilities, advertise, and have attractive displays of trees. Retailers who follow these practices can expect to receive higher prices for their trees.

Most Christmas tree retailers have little knowledge of marketing. Thus they are often left with piles of unsold trees on their lots after Christmas day. And this leads to a high turnover of disappointed retailers.

The result is a disorganized and unstable market. To insure that the market operates efficiently, Christmas tree retailers need information about effective marketing practices. They need to know about merchandising techniques, the best locations, realistic pricing and inventory policies, and the buying habits of tree users.

To provide this information, the Forest Products Marketing Laboratory at Princeton, W. Va., has made a detailed analysis of the Christmas tree retail market in Winston-Salem, N. C.

The Study

In the 1967 and 1968 Christmas seasons, a survey was made of all Christmas tree retailers in Winston-Salem (population 150,000). Each tree lot was visited and its operation was observed. After the selling season, each lot owner or operator was asked to provide information about his Christmas tree business. In this way, data were obtained on tree sales, prices, the types and locations of retail outlets, merchandising methods, and consumer buying habits. This information was used to evaluate existing marketing practices and to determine those that were the most effective.

The Market

Christmas tree retailers in Winston-Salem sold 9,227 trees in 1967 and 10,152 trees in 1968 (table 1). Balsam fir was by far the best seller each year, accounting for over 40 percent of all trees sold. In 1967, eastern red cedar and white pine were second and third in sales, respectively. But, in 1968 white pine and Scotch pine were the second and third best sellers. The decline in sales of cedar Christmas trees in 1968 was attributed to an increase in the supply of the better quality pines and firs. Scotch pine and Fraser fir showed the largest percentage of increase in sales from 1967 to 1968.

In 1967, 14.7 percent of the Christmas trees in stock were not sold, and in 1968, 9.7 percent were not sold. Eastern red cedar led the list of unsold trees in both years. Lot operators had to discard about one-fifth of their cedars each year.

Chain grocery stores, discount stores, and independent dealers (including civic and church groups) accounted for about two-thirds of the outlets and over 70 percent of the sales each year. In the 1967 season, 53 retailers sold Christmas trees in Winston-Salem. But only 46 retailers

Table 1. — Christmas tree sales in Winston-Salem, N. C., 1967 and 1968

Type	In stock		Sold			
	1967	1968	1967		1968	
	No.	*No.*	*No.*	*Pct.*	*No.*	*Pct.*
Balsam fir	4,200	4,912	3,762	89.6	4,529	92.2
Fraser fir	746	889	615	82.4	848	96.4
White pine	1,863	1,995	1,566	84.1	1,737	87.1
Scotch pine	1,025	1,400	976	95.2	1,305	93.2
Eastern red cedar	2,175	1,365	1,686	77.3	1,097	81.4
Norway spruce	16	20	16	100.0	3	15.0
White spruce	50	—	35	70.0	—	—
Arizona cypress	60	—	40	66.7	—	—
Halvorson [1]	683	662	531	77.8	633	95.6
Total	10,818	11,243	9,227	—	10,152	—

[1] A color-processed natural spruce.

Table 2. — Average retail price of Christmas trees in Winston-Salem, 1967 and 1968

Species	1967	1968
Balsam fir	$2.84	$3.10
Fraser fir	4.81	6.73
White pine	4.44	4.69
Scotch pine	4.55	4.76
Eastern red cedar	2.08	2.32
Norway spruce	3.25	—
White spruce	2.00	—
Arizona cypress	1.10	—
Halvorson	2.00	2.32
Average	3.21	3.75

sold trees in the city in 1968. Many retailers did not return to sell trees in 1968 because of the relatively large number of unsold trees in 1967.

The retail price of Christmas trees varied according to species (table 2), but Fraser fir brought the highest price both years. Prices of all species increased between 1967 and 1968, and Fraser fir also showed the largest gain—about 40 percent. Most of the Fraser firs were premium trees, and they were sold in high-income areas.

Lot Location

The study showed that retail prices of Christmas trees varied according to lot location. In 1967, the average price of trees sold at lots on major streets [1] was $3.49, or $0.51 higher than tree prices at lots on minor streets. In 1968, lots on major streets averaged $4.14 per tree—$1.12 more than lots on minor streets. And lots on major streets received over $1.40 more for a Fraser fir in 1967 than did lots on less traveled streets.

Trees were sold at higher prices in business areas than in residential areas. In 1968, the average price of trees sold in business areas was $3.99; the price in residential areas was $2.93. The average prices in 1967 were $3.35 in business areas and $2.83 in residential neighborhoods.

Christmas tree retailers in predominantly business areas and on major streets sold more trees and discarded fewer in both years than did other

[1] Average daily volume of over 10,000 vehicles.

retailers. In 1968, the average retailer sold 221 trees, but the typical retailer on a major street in a business area sold 352 trees. These retailers also had relatively few trees left over. But the typical retailer on a minor street in a residential area sold only 79 trees and had to discard one tree for every three trees sold. The data for 1967 are similar.

Parking

Most Christmas tree outlets in Winston-Salem had large and easily accessible parking lots in 1967 and 1968. It paid off! Generally, those outlets with parking lots that could accommodate more than 10 cars sold more trees and had fewer trees left over after Christmas than did those that had smaller parking areas or only street parking. In 1968, retailers with only street parking had to discard one tree for every two sold. Those outlets with large parking lots had very few unsold trees on Christmas day.

Merchandising

The study found that about one-half of all Christmas tree retailers in Winston-Salem advertised in 1967 and 1968. This advertising included newspaper, television, and radio ads; handbills; trading stamp specials; special displays; and direct mail campaigns. Newspaper advertising was the most common—in 1967 about 40 percent of the Christmas tree retailers advertised in newspapers, and in 1968 the number was almost 50 percent. This form of advertising was used heavily by chain grocery stores and discount establishments. The study also revealed that Christmas tree retailers made very little use of radio and television to reach the public.

Retailers who advertised in 1967 and 1968 sold more trees and had fewer trees unsold than those who did not advertise. In 1968, each retailer who advertised sold an average of 337 trees and had only 6.6 percent of his original supply of trees unsold on Christmas day. On the other hand, the typical retailer who did no advertising sold an average of only 105 trees and on Christmas day had almost one-fifth of his trees still unsold. The 1967 data are almost as striking.

Retailers who advertised also usually received a higher price for their trees than those who did not. It was found that the average prices received by retailers who advertised were consistently higher than the average prices of those who did not. In 1967, retailers who advertised received an average of $3.35 per tree, but those who did not advertise received only $3.00 per tree. And in 1968, those who advertised sold trees at an average of $4.00 apiece, compared to only $3.36 apiece received by those who did not advertise.

The study also showed that the way trees were displayed on the lot affected tree sales and prices. Generally, a retailer whose trees stood upright and separately sold over twice as many trees as a dealer who leaned his trees against a building or stacked them in piles on the ground. Dealers with good displays also received a higher price for their trees.

Conclusion

The business of selling Christmas trees is not unlike other businesses. Marketing practices long known to be successful in other retail businesses work for Christmas trees as well. To attract customers, lot owners and operators must choose a suitable location, provide adequate parking and shopping facilities, and let the public know about their wares. Better marketing practices are a solution to many of the industry's ills.

—THOMAS H. PENDLETON and LAWRENCE D. GARRETT
Associate Economists
Forest Products Marketing Laboratory
Northeastern Forest Experiment Station
Forest Service, U.S. Department of Agriculture
Princeton, W. Va.

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USDA FOREST SERVICE RESEARCH NOTE NE-113
1970

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WATERSHED MODELS FOR INSTRUCTIONAL FILMS

Abstract. — Watershed models, with a special sponge material that simulates soil drainage, were used to make an instructional film on subsurface flow and stream flow. Construction of the models and filming techniques are described.

Watershed models make it possible—through time-lapse photography—to study subsurface and stream flow. The models are covered with a special sponge material that simulates the drainage characteristics of soil, and are marked with dye traces and placed under a rainfall simulator. We will describe how the models were built and how they were used to make an educational film illustrating subsurface flow and stream flow.

The film, entitled "Subsurface and stream flow on watershed models," was produced by the State University of New York, College of Forestry; the USDA Forest Service; and the State University Water Resources Center. The film provides definitions, a discussion of advantages and limitations of the models in such studies, specific data recorded during the trials, and a description of the experimental apparatus.

Watershed Models

Five models were built to evaluate the effects of slope, drainage and density, and "soil" depth (fig. 1). Characteristics of the models are shown in table 1.

In designing the models, we tried first to hold land slope and stream gradient constant by using graphs of stream gradient (as a function of distance from the mouth) and land slope (as a function of distance from the stream). But this dictated that stream gradient and land slope were automatically confounded with drainage pattern; because, on the lower

Figure 1. — The watershed models were made from ½-inch styrofoam sheets and were covered with a special sponge material that simulates soil drainage.

drainage-density models with greater distances between streams, steeper slopes could be attained. The 17- and 62-percent palmate models were built to ascertain the effect of slope.

The graphs of slope and gradient were used to locate points of equal elevation on outline maps of the models, and these were connected to create contour maps of each model. Cut apart, these maps provided templates for marking and cutting impervious ½-inch styrofoam sheets to form the model base. The layers were glued together and then sanded to provide a smooth surface.

Each geometric facet of the model was carefully fitted with "soil" blankets of a special 3/8-inch polyurethane sponge material (obtained by special arrangement from a commercial firm: for further information, write the authors). This particular sponge was selected to represent soil because it had (1) interconnected pores, (2) a gradation of pore sizes all less than raindrop size, (3) uniformity and dimensional stability under extremes of water content, and (4) a large retention capacity (about 25 percent).

All the models were of the common pear-shape, with a horizontal area of 3 square feet. Each model could be completely covered by the rainfall simulator, so the trials shown and the conclusions drawn apply to models completely, continuously, and uniformly covered by the rain storms.

Rainfall Simulator

The simulator was constructed from plans developed by Chow and Harbaugh.[1] It consists of a plexiglas box 2 feet square and 1 inch deep, with an inlet for water at the top, and 576 capillary tubes (on 1-inch

[1] Chow, V. T., and T. E. Harbaugh. RAINDROP PRODUCTION FOR LABORATORY WATERSHED EXPERIMENT. J. Geophys. Res. 70(24):6111-6119. 1965.

Table 1. — Watershed model characteristics

Characteristic	Model drainage pattern				
	Wye	Palmate	Pinnate	Palmate	Palmate
Drainage density, in./in.^{2}	0.16	0.31	0.44	0.31	0.31
Maximum relief, inches	9.3	7.5	6.8	4.25	14.9
Mean slope, percent	38.8	31.2	28.3	17.7	62.1
Stream gradient, log S_g	*$1.23 + .05D_m$	$1.23 + .05D_m$	$1.23 + .05D_m$	$.93 + .05D_m$	$1.54 + .05D_m$
Land slope, log S_1	$1.35 + .57D_s$	$1.35 + .57D_s$	$1.35 + .57D_s$	$1.10 + .57D_s$	$1.65 + .57D_s$

*Where D_m equals distance from watershed mouth, in inches; and D_s equals distance from the stream, in inches.

centers) protruding from the base. When water is supplied to the unit, drops form and fall at random moments in time. A constant-head regulator and manual valve allowed adjustment of intensity (from about 2 to 12 inches per hour) and duration. All trials were run at the same intensity (6 inches per hour) and duration (2 minutes). Drops fall about 3 feet before hitting the model surface, and two small fans provide gentle turbulence that distributes the drops randomly over the models.

Water temperature affected the performance of the simulator and the models. To assure comparable results, all trials were conducted at the same water temperature.

Dye-Spot and Filming Technique

For testing the relationships between the selected geometric properties of the watershed models and runoff parameters, runoff and its temporal distribution (not a part of the film and not covered in this report) were measured directly. Water movement under various conditions was timed, using a dye-spot technique; and the events were filmed in time-lapse sequence. Nine of these sequences were employed in the film.

Ordinary vegetable food coloring was used because it did not permanently stain the "soil" or the model base, it is soluble in water, and the colors contrast well and blend well for easy observation.

Dye spots were applied about 0.1 inch downhill from points located by straight pins. All points were located with a ruler so as to be equidistant horizontally or vertically from the outlet along the stream or ridge. Generally, two drops of dye were placed as rapidly as possible at each location on the damp "soil" blanket; and rainfall, stopwatch, and camera were started immediately. The simulator was allowed to run for about 2 minutes (about 0.2 inch of water), by which time the dye had reached the outlet of the model.

Color sequences at the outlet were noted by stopwatch time on special data forms which were cross-referenced to the film by a scene board exposed before each run. Where a model with symmetrical branches was used, yellow and blue dye spots indicated the coincidence of side branches by blending and making a green dye at the outlet. Red dye was used in the main stem; it arrived more quickly at the outlet.

After each run, the remaining dye was flushed from the entire system. About 10 minutes of drainage was allowed between successive runs; this permitted planning of the next sequence, adjusting the lights and camera, and recording the data.

The camera used was a Bolex H16T[2] fitted with a 16-mm wide-angle lens. It was located about 5 feet from the model at an angle of about 60 degrees from the main axis of the stream.

A scene board—documenting data, trial number, model number, film roll, shutter speed and opening, and time factor—was exposed at the start of each trial. All filming data were also transcribed on the trial-data form to ensure proper identification.

A 4-foot cable release was used to trip the shutter twice each second for the duration of the run. Two 650-watt color-balanced flood lights were used to illuminate the model; this lighting required an opening of f.4 for a shutter speed of 1/30 second. All trials were filmed on Ektachrome Commercial Film with a type-A filter on the camera.

— PETER E. BLACK
and RAYMOND E. LEONARD

Associate Professor of Watershed Management
State University of New York, College of Forestry
and Project Leader
Northeastern Forest Experiment Station
Forest Service, U. S. Dep. Agriculture
Syracuse, New York

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

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GERMINATING POKEBERRY SEED (*Phytolacca americana* L.)

Abstract. The seeds of pokeberry (*Phytolacca americana* L.) can be germinated successfully by storing them dry over winter and then nicking them with a needle to break the seed coat, followed by germination treatment at about 75°F.

In northern Kentucky and southern Ohio, growers of pokeberry, which is used as a vegetable green and is canned commercially by several firms as "poke salet", have reported difficulty in getting the seeds to germinate.[1]

My studies have shown that the seedcoat of pokeberry (*Phytolacca americana* L.) is impermeable to water, and that germination will not occur until the hard seedcoat has been opened or softened to permit the entrance of moisture. When this occurs, germination is prompt and satisfactory.

Harvesting the Seeds

The pokeberry fruit—clusters of dark purplish berries (fig. 1) that begin to ripen in late August and September—are best harvested in September and October.

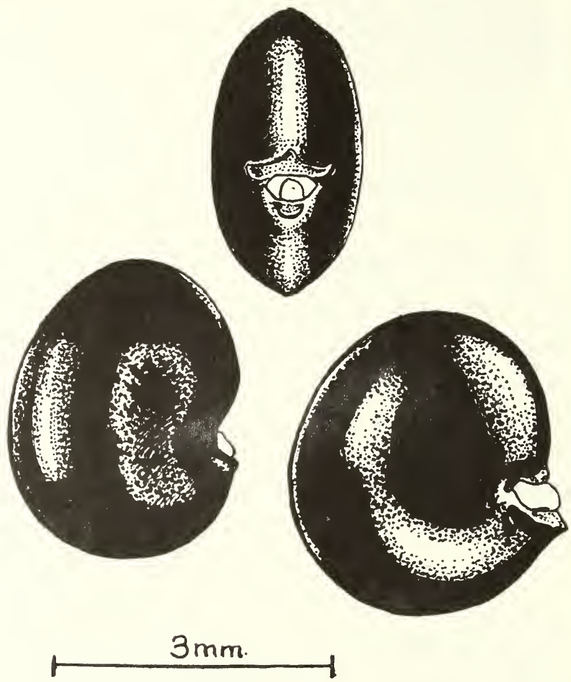
The seeds can be separated from the fruit inexpensively and rapidly by mashing in an ordinary hand-operated kitchen colander (fig. 2). After the seeds are fairly free of berry residues, the mash is poured into a bucket of cold water to float off the berry skins and pulp, which then can be poured off along with the water, leaving the heavier seeds on the bottom. The seeds are best dried at room temperature in shallow pans, stirring occasionally until dry.

[1] Barton, Lela V. SEED PRESERVATION AND LONGEVITY. 216 pp. Leonard Hill Books, Ltd., Interscience Publishers, Inc., New York. 1961.

Figure 1.—Ripe pokeberry fruit.

Figure 2.—An ordinary kitchen colander can be use separate the seeds from the fruit.

Figure 3.—Pokeberry seeds.



The seeds—dark, shiny, and blue-black, averaging about 2.7 mm. x 3.1 mm.—are disk-shaped and have a prominent hilum (fig. 3).

Experimental Procedure

Seeds were tested in lots of 100 on paper towelling, in darkness, in a seed germinator.

Initially, lots of freshly harvested seeds were dipped in concentrated sulfuric acid, boiling water, and 5-percent hydrogen peroxide. No germination resulted from these treatments.

Figure 4.—Nicking the seedcoat promotes germination.

Five lots of freshly harvested seeds were scratched with a needle (fig. 4), just enough to break the seed coat and show white color, and were placed in the germinator at two different temperatures. At 75°F., mean germination was 78.8 percent. At 60°F., germination was less than half —32 percent (table 1).

Four lots of year-old seed, scarified and germinated at 75°F., had germination of 79.2 percent (table 1), almost the same as fresh seed.

Table 1.—*Percent germination of 1968 and 1969 pokeberry seed after 10 days*

Seed lot no.	1968	1969	
	75°F	75°F	60°F
		SCARIFIED	
1	64	88	34
2	84	56	36
3	76	80	34
4	100	90	20
5	—	80	36
Mean	79.2	78.8	32.0
		NOT SCARIFIED	
Control	0[1]	2.0[2]	2.0[2]

[1] Three lots of seed.
[2] Two lots of seed.

Table 2—*Percent germination of unscarified pokeberry seed after 5 months storage under different conditions*

Storage treatment	Germination
At room temperature	8
At 42°F. for 5 months in air	0
At 42°F. for 5 months in wet sand	54
At 42°F. for 5 months in sphagnum moss	68

Earlier research has shown that pokeberry seeds retain viability for long periods of time.[2]

Unscarified seeds stored under different conditions at 42°F. (table 2) and then placed in the 75°F. germinator showed different germination: in wet sand 54 percent; in wet sphagnum moss 68 percent. Dry storage at room temperature and at 42°F. resulted in poor germination (table 2).

In an attempt to reproduce commercial scarifying conditions, a pint screw-top jar was lined with medium sandpaper and seed were shaken in it 25, 50, 100, and 200 times. No germination resulted from these seeds, which suggests that this type of scarification is inadequate.

Conclusion

This work shows quite clearly that pokeberry seeds have an impermeable seedcoat and that good germination can be achieved only when the seedcoat is made permeable.

Best germination can be achieved by storing seeds over winter in dry conditions at room temperature and then nicking or scarifying them with a needle, followed by germination treatment at about 75°F.

When germination occurs, the small seedlings can be transferred to a rich soil mix in a seed flat.

—ARNOLD KROCHMAL
Principal Economic Botanist
Northeastern Forest Experiment Station
Forest Service, U.S. Dep. Agriculture
Berea, Kentucky

[2] Personal communication from C. R. Roberts, Extension Horticulturist, University of Kentucky, Lexington.

ɪDA FOREST SERVICE RESEARCH NOTE NE-115

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MISTBLOWING A HARDWOOD UNDERSTORY IN WEST VIRGINIA WITH "D-T" HERBICIDE

Abstract.—A 40-pound ahg solution of 2,4-D and 2,4,5-T herbicide was successfully mistblown on an undesirable hardwood understory on a good site in West Virginia. After 2 years, many of the stems 1 to 15 feet tall had been killed or severely damaged. The possibilities of obtaining desirable shade-intolerant reproduction on the site were improved by the application of this "D-T" herbicide backpack mistblowing treatment.

Obtaining desirable reproduction after clearcutting harvest operations is one of the most important challenges in forestry. One research facet of this problem involves determining how a dense undesirable hardwood understory can be substantially deadened at reasonable cost so that desirable reproduction can get started.

Tierson[1] reported on work done over a period of several years in New York State that is applicable to the problem. He developed a means of reducing the effects of dense beech (*Fagus grandifolia* Ehrh.) understories in northern hardwood stands so that, after the clearcut harvesting of the overstory, desirable species such as sugar maple (*Acer saccharum* Marsh.), yellow birch (*Betula alleghaniensis* Britton), white ash (*Fraxinus americana* L.), and black cherry (*Prunus serotina* Ehrh.) had a better opportunity to become established and to develop as the future forest stand. Tierson had excellent success in killing the understories with 2,4,5-T in either oil or water, using both tractor-mounted and backpack mistblowers. With backpack mistblowers, he effectively deadened understory beech up to 20 feet in height at a cost of $6 to $7 per acre.

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[1]Tierson, William C. Controlling Understory Beech By Use of Mistblowers. Northern Logger 17(12): 24, 41. 1969.

To test Tierson's methodology under conditions in the mountains of West Virginia, we made a smaller-scale study on a high-quality site near Parsons, West Virginia. Here, in a well-stocked stand, we treated a dense understory composed mostly of sugar maple and beech. Under such conditions the forestry objective would call for striving to obtain a new stand of such light-requiring species as yellow-poplar *(Liriodendron tulipifera* L.), black cherry, and white ash after a clearcutting harvest. In this situation—frequently encountered in the northern Appalachian mountains —the desired species are usually present in the overstory, so a seed source is available.

The results of our study, although based on less work than Tierson did, demonstrated the general effectiveness of using backpack mistblowers for hardwood understory treatments in West Virginia.

The Study

In cooperation with the Monongahela National Forest, we established an understory-treatment study, employing a backpack mistblower and using a herbicide mixture of 2,4-D and 2,4,5-T.

The study area was a 5-acre plot on the Fernow Experimental Forest near Parsons, West Virginia. A 65-year-old, well-stocked stand of mixed hardwoods occupied the area. Species composition was typical for a good-quality site in this location: sugar maple, beech, yellow-poplar, black cherry, white ash, red maple *(Acer rubrum* L.), northern red oak *(Quercus rubra* L.), black locust *(Robinia pseudoacacia* L.), and cucumbertree *(Magnolia acuminata* L.). The sawtimber-size portion of the stand (trees larger than 11.0 inches d.b.h.) averaged 15,000 board feet (International 1/4-inch kerf scale) to the acre. The understory comprised all living stems between 1 foot tall and 5 inches d.b.h. There were about 11,000 of these stems per acre, of which approximately 75 percent were sugar maple and 13 percent were beech and hornbeam *(Carpinus caroliniana* Walt.). Most of the stems were of seedling origin and were less than 5 feet tall.

The prelogging mistblowing treatment was applied to the understory during the last week in June 1967. (Tierson found that this type of treatment has the best effect if begun after full leaf development and completed at least 2 weeks before the first killing frost.) A 5-horsepower mistblower was used to spray a 40-pound acid equivalent solution of "D-T", at a rate of 7-1/2 gallons per acre (fig. 1). Both the 2,4-D and 2,4,5-T were low volatile iso-octyl esters, each having an acid concentration of 6 pounds per gallon.

Figure 1. — Mistblowing undersirable reproduction established in a mature forest before cutting.

The exact mixture used, on the basis of a 100-gallon mix, was as follows: 6-2/3 gallons of 2,4-D and 2,4,5-T (half and half), 6-2/3 gallons of kerosene, and 86-2/3 gallons of water.

In applying the spray, the nozzle was elevated at about 45 degrees. Spray lines were about 20 feet apart, and the spacing of spray lines was easily maintained on this small area by the wet-glossy appearance of the foliage sprayed on the previously treated strip. No attempt was made to thoroughly soak the whole area—that is, all understory vegetation—because we recognized that the benefits from a complete kill would probably not compensate for the extra cost.

Results

The results, measured 2 years after treatment, generally supported the work done by Tierson. We killed or severely damaged (to the point where we judged their competitive potential was practically eliminated) 75 percent of the sugar maple, 94 percent of the beech, and between 85 and 100 percent of the other species, with the exception of white ash and black cherry. As in Tierson's work, beech proved more susceptible to treatment than sugar maple.

Table 1.—*Number of pretreatment stems and percent of stems severely damaged or killed as a result of mistblowing*

Species	Stem height class									
	1-5 feet tall		6-10 feet tall		11-15 feet tall		15+ feet tall to 5.0 inches d.b.h.		Total	
	No. per acre	Percent damaged or killed	No. per acre	Percent damaged or killed	No. per acre	Percent damaged or killed	No. per acre	Percent damaged or killed	No. per acre	Percent damaged or killed
Sugar maple	8,349	76	14	79	46	39	99	26	8,508	75
Beech	803	96	26	92	29	79	29	55	887	94
Hornbeam	546	89	4	100	2	100	35	57	587	87
Black cherry	333	59	—	—	—	—	—	—	333	59
Red maple	152	100	3	100	3	67	37	32	195	87
Striped maple	152	90	—	—	2	100	—	—	154	90
Hickory	136	88	—	—	—	—	2	100	138	88
White ash	136	44	—	—	2	0	6	0	144	42
Others	288	90	6	100	12	100	59	83	365	90
Total	10,895	78	53	91	96	61	267	47	11,311	77

The effectiveness of treatment decreased with increasing stem size: we killed or severely damaged only about half the stems in the class 15 feet tall to 5.0 inches d.b.h. (table 1). This was somewhat less effective than Tierson's work in New York State, where spray applied with back-pack mistblowers deadened beech up to 20 feet in height.

Using a labor cost of $2.00 an hour and the appropriate 1967 cost of materials, the total treatment cost per acre of applying 7-1/2 gallons of spray was $5.50 (travel time to and from the area not included). Though this cost was determined for only 5 acres, it compares closely to Tierson's cost of $6 to $7 per acre.

Of the species heavily represented in the understory, the following were especially susceptible to the spray treatment: beech, hornbeam, red maple, striped maple *(Acer pensylvanicum* L.), and hickory *(Carya* sp.).

Two years after treatment, the dense stand of small stems was almost leafless. Closer examination showed that the heavily damaged sugar maple stems were beginning to recover by putting out new shoots from the lower stem. The heavily damaged beech, on the other hand, appeared to be dying.

Discussion

Results of this work show that a mistblown understory spray will greatly reduce the density of the small stems beneath the main stand. Where this understory is composed of undesirable species, and where a seed source of the desired species is available, this treatment should greatly improve the chances of obtaining reproduction of the desired species.

The mistblowing should be done in the summer, one or two seasons before the harvest cutting. The big advantage of spraying 2 years before logging is to give new black cherry and yellow-poplar seedlings a chance to get started in the absence of dense forest-floor competition. Spraying earlier than two growing seasons before cutting would give many of the damaged understory sugar maples a chance to recover their competitive position; it would also provide time for other undesirable tolerant vegetation to build up.

This treatment is not applicable to all situations. Two particular examples come to mind. In oak stands where oak reproduction is the objective, this treatment, applied a couple of years before a clearcut harvest, would in most cases preclude obtaining a new oak stand. Oak reproduction is usually either on the ground when a stand is cut, or it is not obtained because of the erratic periodicity of oak seed crops. Another case where this treatment is not applicable is where the understory is composed mostly of saplings over 15 feet tall. Here a basal spray, or some other type of sapling treatment, is called for.

— H. CLAY SMITH and GEORGE R. TRIMBLE, JR.[2]
Northeastern Forest Experiment Station
Forest Service, U.S. Dept. Agriculture

[2]Mr. Smith, a research forester formerly on the staff of the Station's Timber and Watershed Laboratory at Parsons, West Virginia, is now at the Station's research unit at Burlington, Vermont. Mr. Trimble is project leader for timber-management research at the Parsons Laboratory.

Caution about Pesticides

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SEQUAN: A COMPUTER PROGRAM FOR SEQUENTIAL ANALYSIS

Abstract.—A description of a FORTRAN IV computer program for performing sequential analysis on four common distributions after the underlying probability distribution is known.

Decision-making and cost-reduction are key concepts in management research. Sequential hypothesis-testing procedures that were developed for quality control in industrial processes (*2, 3, 5*) have been applied in a limited way to biological problems. Forest entomologists have used the sequential probability ratio test of Sobel and Wald (2) to classify insect populations (*4*) and to evaluate the need for insect control (*1*). This note describes briefly a computer program that was developed to eliminate much of the computational work associated with sequential analysis.

Sequential analysis is popular with forest entomologists because, on the average, it requires fewer observations for fixed type-1 (α) and type-2 (β) errors than fixed-sample size plans require. The smaller the difference to be detected at a given type-1 (α) and type-2 (β) error, the larger the average sample size. In this method of analysis we assume that the observations are independent and the probability distribution is known beforehand.

To perform any sequential analysis, the following must be known:

1. A description of the underlying probability distribution.
2. A statement of the hypothesis that is to be tested.
3. The type-1 (α) and type-2 (β) errors.

The computer program was developed for the three-decision problem (light, medium, heavy) that is commonly encountered by forest entomologists. By repeating selected input data in certain columns of the second control card, the program can be used to obtain the required statistics for the two-decision problem (control *vs* no control).

The FORTRAN IV program was developed by the authors on a 7094 computer. The program will provide the following statistics for the binomial, negative binomial, poisson, and normal distributions:

1. Equations for the decision lines.
2. Table of decision boundaries.
3. Graph of decision lines.
4. List of selected points for the operating-characteristics (OC) curve.
5. List of selected points for the average-sample-number (ASN) curve.

For the normal and negative binomial distributions, it is assumed that the variance and k-value are known beforehand.

Description of Control Deck

The user must supply the following control cards when using the program. Two control cards are required for each analysis desired. The first control card contains the type-1 (α) and type-2 (β) errors, the distribution index, and the number of decision points to be printed.

Card 1	*Column*	*Format*	
	1 - 3	F3.2	Type-1 error, A
	4 - 6	F3.2	Type-2 error, B
	7 - 8	I2	Distribution index
		01 - Binomial	
		02 - Negative binomial	
		03 - Poisson	
		04 - Normal	
	9 - 11	I3	Number of decision points to be printed

The second control card contains the parameters needed for the analysis. The format of this control card depends upon the distribution.
Binomial distribution:

H_0: $P < P_1$

H_1: $P_2 \leq P \leq P_3$

H_2: $P > P_3$

Column	*Format*	*Description*
1 - 8	F8.4	P_1
9 - 16	F8.4	P_2
17 - 24	F8.4	P_3
25 - 32	F8.4	P_4

Negative binomial:

H_0: $M < M_1$
H_1: $M_2 \leq M \leq M_3$
H_2: $M > M_4$

Column	*Format*	*Description*
1 - 8	F8.4	M_1
9 - 16	F8.4	M_2
17 - 24	F8.4	M_3
25 - 32	F8.4	M_4
33 - 40	F8.4	K - "Index of aggregation"

Poisson:

H_0: $\lambda < \lambda_1$
H_1: $\lambda_2 \leq \lambda \leq \lambda_3$
H_2: $\lambda > \lambda_4$

Column	*Format*	*Description*
1 - 8	F8.4	λ_1
9 - 16	F8.4	λ_2
17 - 24	F8.4	λ_3
25 - 32	F8.4	λ_4

Normal:

H_0: $\mu < \mu_1$
H_1: $\mu_2 \leq \mu \leq \mu_3$
H_2: $\mu > \mu_4$

Column	*Format*	*Description*
1 - 8	F8.4	μ_1
9 - 16	F8.4	μ_2
17 - 24	F8.4	μ_3
25 - 32	F8.4	μ_4
33 - 42	F10.4	σ - standard deviation

Example

Suppose we wish to calculate the sequential plan described by Waters (4) for the spruce budworm. The basic data for this plan were fitted to the negative binomial distribution. Waters listed the following parameters for his plan:

$\alpha = 0.10$ $\qquad \beta = 0.10$
$M_1 = 3.00$ $\qquad M_2 = 6.00$
$M_3 = 9.00$ $\qquad M_4 = 12.00$

$k = 7.288$

Figure 1.—Program output of decision equations and sequential table.

SEQUAN ALPHA = 0.100 BETA = 0.100

NEG BIN P1 = 0.415 P2 = 0.830 P3 = 1.245 P4 = 1.660 K = 7.228

CASE 1 PO VS P1 PO .GT. P1 LOW VS MEDIUM

LOWER = -5.040+ 4.265 N

UPPER = 5.040+ 4.265 N

CASE 2 PO VS P2 P2 .GT. PO MEDIUM VS HIGH

LOWER = -18.612+ 10.386 N

UPPER = 18.612+ 10.386 N

	LOWER		UPPER	
	LOW VS MEDIUM		MEDIUM VS HIGH	
N	LOW	HIGH	LOW	HIGH
1	-0	9	-7	29
2	3	14	2	39
3	8	18	13	50
4	12	22	23	60
5	16	26	33	71
6	21	31	44	81
7	25	35	54	91
8	29	39	64	102
9	33	43	75	112
10	38	48	85	122
11	42	52	96	133
12	46	56	106	143
13	50	60	116	154
14	55	65	127	164
15	59	69	137	174
16	63	73	148	185
17	67	78	158	195
18	72	82	168	206
19	76	86	179	216
20	80	90	189	226
21	85	95	199	237
22	89	99	210	247
23	93	103	220	257
24	97	107	231	268
25	102	112	241	278

Figure 2.—Graph of decision line equations.

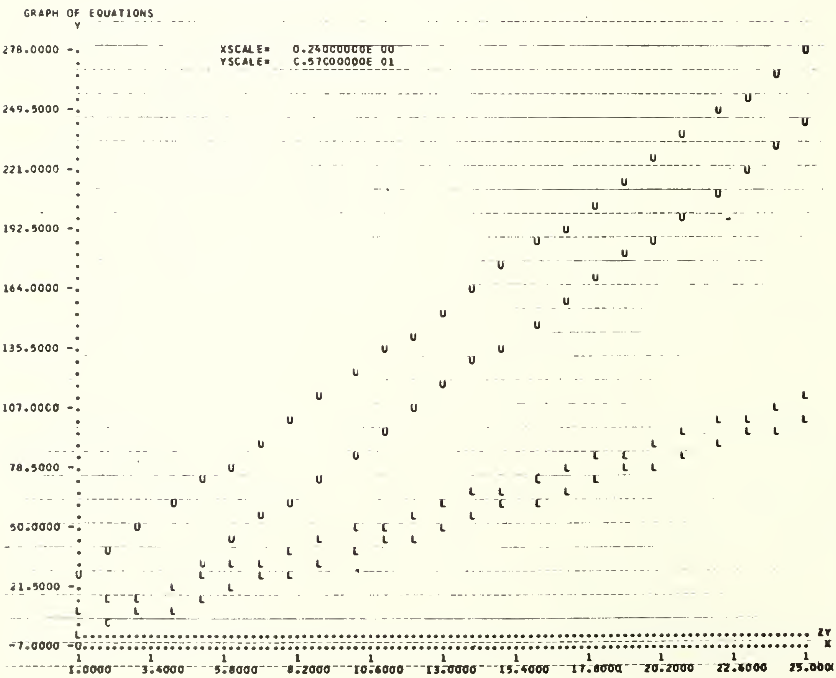

TABLE OF VALUES FOR THE OC AND ASN CURVES-- NEG BIN

CASE 1			CASE 2		
LOW VS MEDIUM			MEDIUM VS HIGH		
P	OC	ASN	P	OC	ASN
0.595	0.486	3.73C	1.432	0.514	13.7C7
C.600	0.473	3.713	1.427	0.527	13.726
0.606	0.459	3.694	1.421	0.541	13.734
C.611	0.445	3.673	1.416	0.555	13.736
0.621	0.418	3.626	1.406	0.582	13.720
C.632	0.392	3.572	1.396	0.608	13.678
0.643	0.366	3.513	1.386	0.634	13.609
C.654	0.341	3.448	1.376	0.659	13.516
0.666	0.317	3.379	1.366	0.683	13.401
0.677	0.293	3.305	1.357	0.707	13.265
0.7C1	0.250	3.149	1.337	0.750	12.939
0.725	0.211	2.984	1.318	0.789	12.554
0.750	0.177	2.815	1.300	0.823	12.128
0.776	0.147	2.647	1.281	0.853	11.675
0.803	0.122	2.482	1.263	0.878	11.210
C.830	0.100	2.323	1.245	C.900	1C.744
1.156	0.012	1.202	1.080	0.988	7.046
2.179	0.000	0.439	0.816	1.000	4.148

MEAN 1 = 3.0000 CC-VALUE = 0.900 MEAN 2 = 6.0000 OC-VALUE = 0.100
MEAN 3 = 9.0000 CC-VALUE = 0.900 MEAN 4 = 12.0000 OC-VALUE = 0.100

Figure 3.—Program output of OC and ASN values.

From this information the control deck would be prepared as follows:

COLUMN NO.

```
ird
o.  1 2 3 4 5 6 7 8 9¹ 0 1 2 3 4 5 6 7 8 9² 0 1 2 3 4 5 6 7 8 9³ 0 1 2 3 4 5 6 7 8 9⁴ 0
    0 1 0 0 1 0 0 2 0  2 5
    0 0 0 3 0 0 0 0 0  0 0 6 0 0 0 0 0 0 0  9 0 0 0 0 0 0 1 2 0  0 0 0 0 0 0 7 2 2 8  0
```

Figures 1, 2, and 3 show the sequential plan produced by this program. The decision-line equations produced by this program differ slightly from those published by Waters, but these differences are probably due to rounding errors. The occasional discrepancies between values in the sequential tables are also the results of rounding errors.

A program deck with examples can be obtained from the authors.

Literature Cited

1. Ives, W. G. H., and G. L. Warren. 1965. Sequential sampling for white grubs. Can. Entomol. 97: 596-604.

2. Sobel, M., and A. Wald. 1949. A sequential decision procedure for choosing one of three hypotheses concerning the unknown mean of a normal distribution. Ann. Math. Statist. 20: 502-522.

3. Wald, A. 1947. Sequential analysis. 212 pp. J. Wiley & Sons, Inc., New York.

4. Waters, W. E. 1955. Sequential sampling in forest insect surveys. Forest Sci. 1: 68-79.

5. Wetherill, G. B. 1966. Sequential methods in statistics. 218 pp. Methuen & Co., Ltd., London; J. Wiley & Sons, Inc., New York.

—ROBERT L. TALERICO and ROGER C. CHAPMAN[1]

[1] Mr. Talerico is a research entomologist at the Forest Insect and Disease Laboratory of the USDA Forest Service's Northeastern Forest Experiment Station, at Hamden, Conn. Mr. Chapman, formerly mathematical statistician on the staff of the Northeastern Station, Upper Darby, Pa., is now on the faculty of the School of Forestry at Duke University, Durham, N. C.

;DA FOREST SERVICE RESEARCH NOTE NE-117

1970

Northeastern Forest
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EARLY EVIDENCE OF WEEVIL RESISTANCE IN SOME CLONES AND HYBRIDS OF WHITE PINE

Abstract.—White pine species and hybrids are being tested for inherent resistance to the white-pine weevil. First-year results offer hopes of finding or developing resistance in this group. *Pinus monticola* had a low level of weeviling, while the hybrid between *P. strobus* X *P. wallichiana* was heavily weeviled. There is evidence that individual *P. strobus* with acceptable levels of weeviling can be located in natural populations.

Several approaches can be used to locate or develop plants that are resistant to pests. One can select resistant individual trees or provenances, use immune or resistant exotic species that have other properties similar to the native species, or develop hybrids between a well-adapted native species that has desirable growth properties but lacks resistance and a closely related species that may or may not have desirable growth properties but does have resistance to the particular pest. The success of any one of these methods depends on the combining ability of the resistant material, or the ability of the tree improver to mass-produce ramets from genetically resistant material by vegetative means.

This is a report on interim results from a study of white-pine weevil (*Pissodes strobi* Peck.) resistance in clones of *Pinus strobus* L., *P. monticola* Dougl., and some hybrids between *P. strobus* and *P. wallichiana* A. B. Jackson.[1] Although none of the hybrids showed resistance to weeviling, a number of clones of *P. monticola* had little or no damage, and one clone of *P. strobus* showed less than half the damage sustained by the rest. The wide variation in resistance found among clones during a year of large weevil populations makes documentation of these first-year results worthwhile as a base for future comparisons and as a guide for further research on weevil resistance.

[1] This species is also known as *P. griffithii* McClelland and *P. excelsa* Wall.

Methods

In the spring of 1967, scions of rust-resistant intraspecific hybrids of *P. monticola* were obtained from the Intermountain Forest and Range Experiment Station at Moscow, Idaho.[2] Additional material of this species was collected from a plantation in eastern New York State (origin of seed unknown). Scions of *P. strobus* were obtained from individual trees in a stand near Midhurst, Ontario.[3] The stand was relatively free of weeviling, though surrounding stands were weeviled considerably.

Scions of the hybrid *P. strobus* x *P. wallichiana* were selected from the best phenotypes in a 16-year-old experimental planting established by the Northeastern Forest Experiment Station at Washington Crossing, New Jersey.

All scions were side-grafted on main-stem terminal shoots of 6- to 8-foot plantation-grown *P. strobus* on the Massabesic Experimental Forest in southern Maine. The scions from each species group were grafted in separate plantations on the Experimental Forest, and scion material from a heavily weeviled native eastern white pine growing in the vicinity was grafted at the same time to serve as a check clone. No deliberate attempt was made to randomize the sources within the plantations, although the final stock selection resulted in a degree of randomization. This general region, being one of the most heavily weeviled in the northeastern United States, is one of the best locations available for studying weevil damage. Weevil populations are normally high, but they were extremely high in 1968 and again in 1969.

All trees were pruned to encourage scion growth and to prevent lateral branches from assuming a dominant position — a position favored by weevils for feeding and egg-laying. All trees were sprayed with an insecticide (Lindane) in the spring of 1967 and 1968. Observations of weevil damage were made in August 1969, when the grafts were large enough for weevil attack.

Results

Pinus monticola. — Of the *P. monticola* grafts, 60 survived and had reached a size suitable for attack by weevils in the spring of 1969. Successful attacks were made on only 22 percent of the scions from Idaho sources and on 18.2 percent of the scions from New York. The scions

[2] Scion material supplied by Dr. Richard T. Bingham.
[3] Scion material supplied by Dr. C. Heimburger, Ontario Department of Lands and Forests, Research Branch, Maple, Ontario.

from Idaho had an average length of 27.5 inches and those from New York 21.4 inches.

Because of the small number of surviving grafts from any one clone, the percent of weeviling varied considerably by clone. Ten of 18 clones received no weevil damage, 3 others were less than 20 percent weeviled, and only 5 were 50 percent or more weeviled.

The 34 *P. strobus* scions used as checks in this plantation averaged 22.8 inches and sustained almost 60 percent weevil damage.

Pinus strobus. — As in the *P. monticola* portion of this study, weeviling varied by clone. Only one (clone 1202) showed potential value for a resistance program.

Canadian clones	*Total (No.)*	*Weeviled (percent)*	*Unweeviled (percent)*	*Average length (inches)*
1200	32	66	34	38
1201	25	68	32	31
1202	19	32	68	29

The check scions of local *P. strobus,* averaging 24 inches in length and represented by 31 grafts, were weeviled more than any of the select clones (71 percent), although the difference between the two heavily weeviled clones and the check material was not significant.

Pinus strobus x *Pinus wallichiana.* — The weeviling in this material was remarkably uniform and severe. There was no difference in weeviling between the hybrids and the check material in this portion of the study.

Washington Crossing clones	*Total (No.)*	*Weeviled (percent)*	*Unweeviled (percent)*	*Average length (inches)*
2-11	13	69	31	21
2-24	18	67	33	17
6-14	21	67	33	13
6-19	24	71	29	21
8-12	14	71	29	16
P. strobus checks	26	77	23	28

Discussion of Results

Pinus monticola. — Although this species is reported to be slow-growing in the early years, it has not been grown in sufficient numbers in the Northeast to verify this. The scions used are from rust-resistant individuals, which could be an important bonus in the program. Because of the high percentage of weevil-free scions in this study, the species deserves, and will receive, further intensive investigation. *Pinus monticola* seedlings are being grown in our nursery and will be cage-tested in transplant beds during the 1970 and 1971 seasons. The hybrids between fast-growing *P. strobus* and *P. monticola* will be studied along with open-pollinated seedlings of both parents.

Pinus strobus. — Though only a few clones were investigated, there is evidence here and elsewhere that individual trees with a higher than normal degree of resistance will be located. More trees from this Canadian stand and individual selections from the entire natural range will be included in future work. Because of the large number of individual trees involved, a rapid method of prescreening candidates will have to be developed. We are investigating several possible techniques for this purpose.

Pinus strobus x *Pinus wallichiana.* — This combination of species is probably not too promising, although we want to study the same clones on root stocks of *P. wallichiana* when it becomes available. We will also obtain pollen of *P. wallichiana* to develop larger numbers of the *P. strobus* hybrid. This population will be tested for possible resistance to weevil attack.

These preliminary results suggest that more effort should be concentrated on *P. monticola* and possibly on hybrids between *P. strobus* x *P. monticola*. *P. wallichiana* does not appear to contain any more resistance than the local *P. strobus*. More attention should be given to selection of individual trees of *P. strobus*, and more effort should be devoted to techniques for vegetatively propagating large quantities of resistant material.

Because between 23 and 40 percent of the weevil-susceptible check scions of local *P. strobus* in these plantations remained unweeviled, there is reason to believe that some of the study material may also have escaped attack in this first season. Either low populations in these areas, resulting from two successive applications of Lindane, or a nonrandom distribution of weevils may account for the lack of attack on some susceptible clones. All trees will be observed in 1970 and again in 1971. If weeviling in the check scions does not approach 90 percent in all areas in 1970, the native populations of weevils will be supplemented by additional weevils before the 1971 season.

Finally, additional work will include Balkan pine (*P. peuce*), Korean pine (*P. koraiensis*), and other soft pines as individual species and in hybrid combination with both *P. strobus* and *P. monticola*.

— PETER W. GARRETT
Research Geneticist
Forest Service, U. S. Dep. of Agriculture
Durham Research Laboratory
Durham, N. H.

SDA FOREST SERVICE RESEARCH NOTE NE-118

1970

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PARAFORMALDEHYDE PELLET NOT NECESSARY IN VACUUM-PUMPED MAPLE SAP SYSTEM

Abstract. In a study of sugar maple sap collection through a vacuum-pumped plastic tubing system, yields were compared between tapholes in which paraformaldehyde pellets were used and tapholes without pellets. Use of the pellets did not increase yield.

Since the spring of 1967 our Sugar Maple Sap Production Project at Burlington, Vermont, has been conducting research on the use of vacuum pumping to collect sap yields from sugar maple trees (*Acer saccharum* Marsh.). In an earlier study Blum *(1967)* found that increased sap yields from closed tubing systems on sloping land were associated with a naturally produced vacuum. Subsequent research with applied vacuum by Blum and Koelling *(1968)* showed yield increases as high as 300 percent. On flat land, sap yield increases were doubled with vacuum pumping *(Morrow and Gibbs 1969).*

Many sugarmakers put a paraformaldehyde pellet into each taphole. This aspirin-size pellet is used as a means of increasing sap yields. A number of sugarmakers and researchers have noticed that, when vacuum pumping is used, pieces of the pellets get into the tubing. Thus, since the pellet does not always remain in the taphole, there is a serious question about the effectiveness of the pellet under these circumstances.

From a study completed during the 1969 sap season, we found that a paraformaldehyde pellet was not necessary when a vacuum pump is used to pump sap from sugar maple tapholes.

Methods

This study was made in northwestern Vermont to determine if the amount of sap collected from tapholes with paraformaldehyde pellets (fig. 1) was different from the amount of sap collected from tapholes without pellets. All sap yields were collected from a closed plastic-tubing installation, with a vacuum pump.

Figure 1.—Putting a paraformaldehyde pellet into a taphole. The pellet is pushed to the back of the taphole.

A total of 16 sugar maple trees, 20 to 30 inches in diameter, were used in this study. Two tapholes, 6 inches apart, were drilled into each sugar maple tree to a wood depth of 3 inches, excluding bark. A 250-milligram paraformaldehyde pellet was placed in one of the two tapholes at random. Spouts and plastic tubing were installed, and the sap yields from each taphole were collected in individual 55-gallon sealed drums.

A Venturi ½-horsepower jet-type vacuum pump was used to pump the sap from the trees (fig. 2). This pump provided a vacuum of 12 to 13 inches of mercury at each taphole.

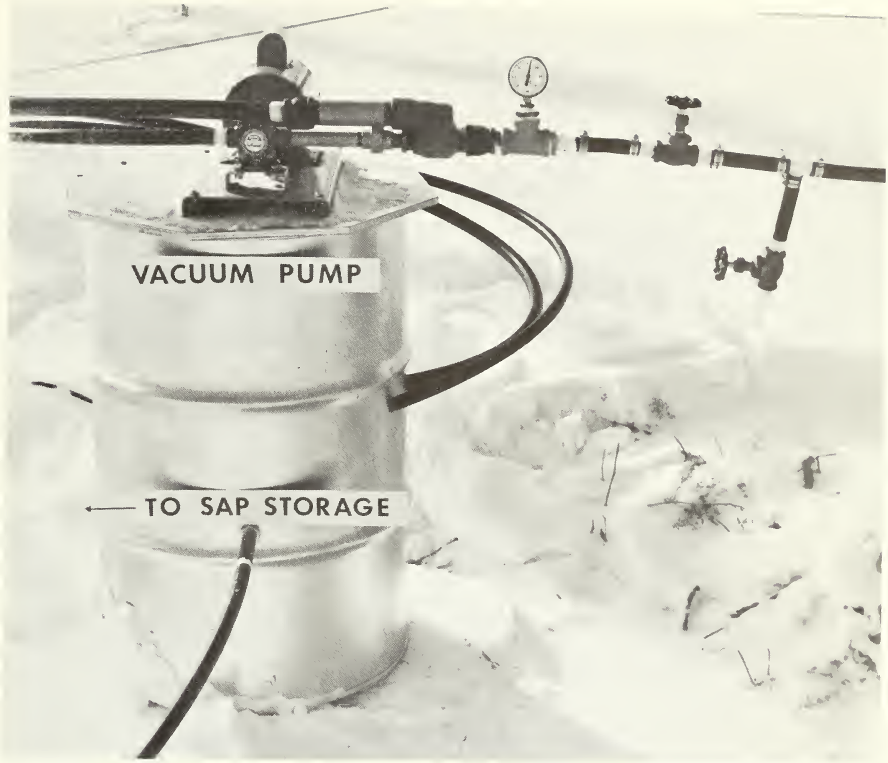

Figure 2.—A vacuum pump used to provide vacuum at the tapholes.

Results

On the average, a taphole without a pellet produced 5.2 liters more sap than one with a pellet (table 1). This increase was statistically significant, with a probability of less than 5 percent that this difference in sap yield was a chance occurrence.

We do not know why we got less sap from the tapholes with pellets. There is a possibility that the pellet, under the stress of vacuum, becomes lodged in the spout and impedes sap flow. Also, as the pellet disintegrates, it may leave the taphole and restrict flow in the tubing lines. When the spouts were removed from the trees, we did not observe any pellet fragments on the inside ends of the spouts. Pellet fragments have been observed in the tubing lines of this and other studies where high vacuum was applied.

We conclude from the results of this study that the paraformaldehyde pellet is not necessary when 12 inches of applied vacuum is used with a tubing installation.

Table 1.—*Sugar maple sap yields collected under applied vacuum from tapholes with and without pellets*

Tree number	Taphole treatment	
	Pellet	No pellet
	Liters	*Liters*
1	24	46
2	24	23
3	44	38
4	27	29
5	28	35
6	22	27
7	10	20
8	46	44
9	44	42
10	33	37
11	6	15
12	30	44
13	44	45
14	67	55
15	4	29
16	48	56
Total	501	585

t-value $= 2.20$; $t_{05,15df} = 2.13$

Literature Cited

Blum, Barton M.
1967. Plastic Tubing For Collecting Maple Sap—A Comparison Of Suspended Vented And Unvented Installations. USDA Forest Serv. Res. Paper NE-90, 13 pp., illus. NE. Forest Exp. Sta., Upper Darby, Pa.

Blum, Barton M., and Koelling, Melvin R.
1968. Vacuum Pumping Increases Sap Yields From Sugar Maple Trees. USDA Forest Serv. Res. Paper NE-106, 14 pp., illus. NE. Forest Exp. Sta., Upper Darby, Pa.

Morrow, Robert R., and Gibbs, Carter B.
1969. Vacuum Pumping Doubles Maple Sap Yield On Flat Land. USDA Forest Serv. Res. Note NE-91, 5 pp., illus. NE. Forest Exp. Sta., Upper Darby, Pa.

—H. CLAY SMITH and CARTER B. GIBBS

Northeastern Forest Experiment Station
Forest Service, U. S. Dept. Agriculture
Burlington, Vermont

SDA FOREST SERVICE RESEARCH NOTE NE-119
1970

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NATURAL SEED FALL IN WHITE PINE (*PINUS STROBUS* L.) STANDS OF VARYING DENSITY

Abstract.—Seed fall was observed in three stands of mature white pines at stand basal-area densities of 80, 120, and 187 square feet per acre. It was found that the intermediate-density stand produced nearly 50 percent more seed than the stands of other densities. During a good seed year this stand produced 59 pounds of dry sound seed per acre. Most of the seeds were dispersed during a 7-week period beginning about the middle of September. The seed crop was reduced by action of birds, animals, and insects.

A detailed knowledge of natural seedfall is of value to the forest manager, particularly when natural regeneration is planned. This information can also be useful in estimating seed crops and in scheduling seed-collection activities.

Little is known about the qualitative and quantitative aspects of eastern white pine seed production. Most of the meager knowledge available is in the very general source, *The Woody-Plant Seed Manual*.[1] The only detailed study of white pine seed fall was done by Messer[2] in Germany, and this is not readily available, even if it could be assumed to be applicable in Northeastern forests.

To gain some of the needed information about white pine seed fall, a study was made in southwestern Maine. We found that seed fall

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[1] United States Forest Service. WOODY-PLANT SEED MANUAL. U.S. Dep. Agr. Misc. Pub. 654, 416 pp., illus. 1948.

[2] Messer, H. Untersuchungen über das Fruchten der Weymouths Kiefer (*Pinus strobus* L.) und der grünen Douglasie (*Pseudotsuga taxifolia* var. *viridis*). Ztschr. Forstgenet. 5(2):33-40. 1956.

started by mid-September, peaked in late September and early October, and was 98 percent complete by the end of November. Seed production was influenced by stand density, an intermediate density producing far more seed than the uncut control stand or the heavily cut stand. The maximum seed fall per acre was 59 pounds (ovendry weight) of viable seed.

Methods and Materials

Seed fall was measured twice—during a good seed year 1965) and during a poor seed year (1968)—in a pure stand of white pine on the Massabesic Experimental Forest. This even-aged stand of pine was 80 years old in 1965. We used three 5-acre plots of different densities—80, 120, and 187 square feet of basal area per acre (table 1).

Table 1.—Average stand conditions in three white pine plots, 1965

Stand-density level	Basal area per acre	Average dominant tree measurements		
		Height	D.b.h.	Height in live crown
	Sq ft.	*Feet*	*Inches*	*Percent*
High	187	96	17.1	28
Intermediate	120	95	18.0	36
Low	80	101	18.4	40

Seed fall was sampled in nine rectangular (1-x-2-foot) seed traps randomly located in each of the three plots. The seed traps were emptied at weekly intervals in autumn and at longer and less regular intervals in winter. The collected seeds were cut longitudinally and examined. All well-filled seeds with fully developed embryos were classed as viable. Analysis of variance was used to evaluate the data, and orthogonal comparisons were made to locate significant differences among the three stand-density levels.

Additional observations were made in 1965 to provide an indication of total cone numbers and losses. Cone counts were made on 10 randomly selected dominant trees in the intermediate stand. The observer made binocular counts of mature normal cones and insect-infested cones in the trees. Squirrel-cut cones and insect-killed cones on the ground were also counted.

Results and Discussion

Total cone crop.—The cone counts made in 1965 provided an estimate of the number of cones per dominant tree. The mean number of mature undamaged cones per tree was 731. An average of 30 insect-killed cones remained in the crown, and an additional 14 insect-killed cones were recovered under the average tree. The primary insect infestation in all examined cones was caused by the white pine cone beetle (*Conophorus coniperda*) or the cone moth (*Dioryctria abietella*).

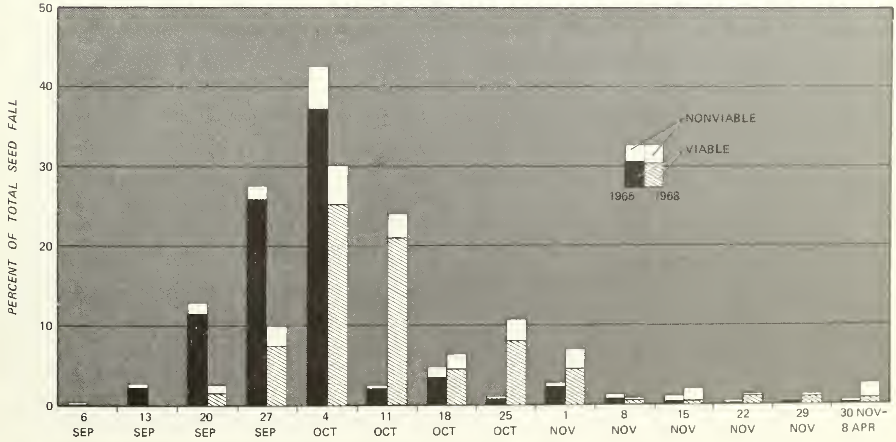
Squirrels cut and consumed or left lying on the forest floor an average of 29 cones per tree. The discarded cone cores were counted where consumption had occurred. The total cone potential per tree was 804 cones; and, of these, 91 percent (731) remained undamaged on the trees to release seed. The average number of viable seeds per cone was 32, resulting in a mean seed crop of 23,400 seeds per tree.

Time of seed fall.—Seed fall began on September 5 in 1965 and about 2 weeks later in 1968 (fig. 1). The maximum weekly seed fall occurred at the same time both years during the week ending October 4. In 1965 the seed fall diminished rapidly after October 4; in 1968 it tapered off more gradually. This difference probably reflects warm and dry weather in 1965 and cool and moist weather in 1968.

In both years seed fall after November was negligible. Only one viable seed fell in the seed traps after November 29, 1965.

From these data we conclude that cone collection for seed extraction should be completed by mid-September in this area. Also, site preparation

Figure 1.—Time of white pine seed fall in 1965 and 1968.



to increase natural regeneration should be complete by the same date to take full advantage of the natural seed supply.

Effects of stand density.—The periodic measurements of seed fall did not reveal any effect of stand density on time of seed dispersal (fig. 2); however, the total amount of seed fall was related to stand density (table 2). The total seed fall in the stand of intermediate density was significantly greater (1-percent level) than that in the other two stands in 1965. The much smaller seed crop of 1968 did not differ significantly among densities. This lack of a significant difference in 1968 was related to the light seed fall, which resulted in a high sample variability. In both seed years the ratio of seed fall in the intermediate-density stand to that in the other stand densities was similar.

The effects of stand density were logical. The uncut high-density stand with a basal area of 187 square feet was too crowded for maximum seed production; the crowns, though numerous, were small. In the intermediate-density stand, the trees were well-spaced and had larger crowns. In the low-density stand, crown development was slightly better still,

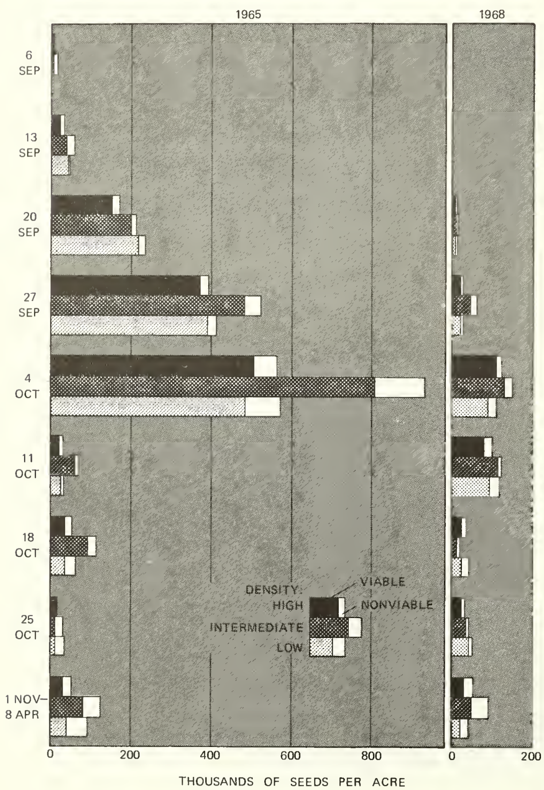


Figure 2.—Periodic seed fall as influenced by stand density.

Table 2.—Total viable seed fall per acre

Stand-density level	Viable seeds	
	1965	1968
High	1,139,820	297,660
Intermediate	1,793,220	408,980
Low	1,253,560	297,660

but too few trees remained to fully occupy the site; consequently potential seed production was limited by lack of sufficient crown area.

Cone production per tree was similar in both the intermediate- and low-density stands, but there were approximately 50 percent more trees in the intermediate stand. As a result, seed fall in the intermediate stand exceeded by about 40 percent that of the low-density stand.

Number of viable seeds per pound.—The number of ovendry viable seeds per pound was determined once in 1965 and weekly in 1968. In early October 1965 the average number of seeds per pound was 31,700. The weekly determination made in 1968 showed the heaviest seed (28,700 per pound) fell in late September. From this time on, the mean seed weight declined about 6 percent per week, causing the average number of seeds per pound to increase. By mid-November, the average number of seeds per pound had risen to 45,000. But, because most of the seeds had fallen by mid-October, the overall average for the season was 31,000 viable seeds per pound.

Seed viability.—The percentage of viable seeds was especially high in 1965, the heavy seed year. Viability averaged 86.7 percent in 1965 and 73.4 percent in 1968. Seed viability varied widely during the time of seed fall. The period of maximum seed fall coincided with the highest viability.

In 1965 the viability was 20 percent during the first week of September, peaked at 93.6 percent in the fourth week of September, and dropped to 10 percent by the end of November. Seed viability followed a similar trend in 1968.

Seed losses caused by birds and small mammals.—In late September and October 1965, during the period of maximum seed fall, many seeds were conspicuously exposed on the ground. At this time, roving flocks of 30 to 50 rusty blackbirds (*Euphagus carolinus*) were noted in the seed-bearing stands of pine. The flocks of blackbirds were observed on many occasions scratching and feeding in the pine litter. After these birds had worked through an area, very little seed could be found.

During the same period, white-winged crossbills (*Loxia leucoptera*) were observed in the tree-tops plucking seed from open cones. Many other species of birds, including white-throated sparrows (*Zonotrichia albicollis*), fox sparrows (*Passerella iliaca iliaca*), slate-colored juncos (Junco *hyemalis hyemalis*), black-capped chickadees (*Parus atricapillus atricapillus*), and red-breasted nuthatches (*Sitta canadensis*), were frequently sighted in the seed fall area. These birds are seed eaters, and very likely they were taking some seed.

Many small mammals were seen in the area, including red-backed voles (*Clethrionomys gapperi*), white-footed mice (*Peromyscus lecopus*), chipmunks (*Tamias striatus*), and red squirrels (*Tamiasciurus hudsonicus*). Only the red squirrels were actually observed eating seed, but the other animals listed are known to be voracious consumers of white pine seed.

No measure of the amount of seed eaten by birds or small mammals was made, but it is likely that a significant portion of the seeds was consumed.

Conclusions

Stand density can have a major influence on total seed production. An intermediate density in the mature stand studied here resulted in maximum seed production.

Total seed yields of well over a million seeds per acre can be expected in good seed years from mature pine stands such as these.

White pine differs from many other species in that nearly all the seeds are released during a relatively short period in the autumn, and virtually no seed is carried over in the cones to be released during the succeeding growing season.

The loss of cones caused by insect and animals was relatively unimportant in a good seed year, averaging less than 10 percent in 1965. However, it is likely that a similar number of cones would be destroyed in a poor seed year, raising the percentage lost to a much higher level.

—RAYMOND E. GRABER
Associate Plant Ecologist
Northeastern Forest Experiment Station
Forest Service, U.S. Dep. Agriculture
Durham, New Hampshire

SDA FOREST SERVICE RESEARCH NOTE NE-120

1970

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A COMPARISON OF SOIL-MOISTURE LOSS FROM FORESTED AND CLEARCUT AREAS IN WEST VIRGINIA

Abstract.—Soil-moisture losses from forested and clearcut areas were compared on the Fernow Experimental Forest. As expected, hardwood forest soils lost most moisture while revegetated clearcuttings, clearcuttings, and barren areas lost less, in that order. Soil-moisture losses from forested soils also correlated well with evapotranspiration and streamflow.

Since 1965, forest hydrologists at our Timber and Watershed Laboratory at Parsons, West Virginia, have made several studies of soil moisture. These studies were intended to develop proper techniques for use of the neutron probe for measuring soil moisture; and to learn how forest vegetation depletes soil moisture, and how altering the vegetation changes these depletion rates.

Changes in soil-moisture content over time are expected to provide a basis for correlating estimates of actual and potential evapotranspiration with streamflow. Knowledge of soil-moisture depletion rates for forested and cleared areas would then provide a better understanding of how forest management influences streamflow.

Methods

Three study areas were used. The first consisted of two circular openings (200-foot diameter) and the surrounding uncut forest. The openings were created in 1965, when all trees more than 5-inches d.b.h. were cut. Stumps and vegetation larger than 1 inch d.b.h. were killed with herbicides. Soil-moisture access tubes were installed along a transect through the openings and into the surrounding forest (fig. 1). Since 1966 these openings have revegetated naturally.

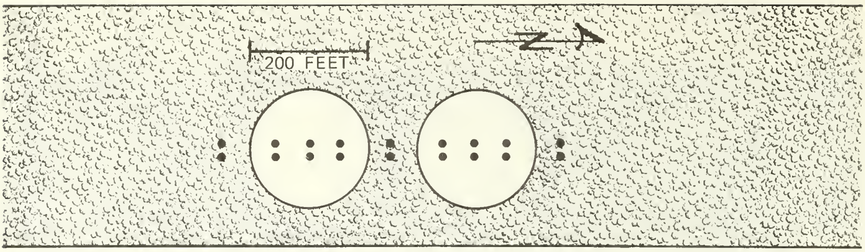


Figure 1.—Diagram of the access tube transect for comparing soil-moisture depletion in clearcut openings and in adjacent forest. The dots indicate positions of access tubes.

The other study areas were located on two experimental watersheds in which 30 acres were clearcut in 1964 and were kept barren with herbicides. In 1966 soil-moisture access tubes were installed above and below the boundary between the forested and barren areas (fig. 2).

Soil-moisture sampling was begun in May 1966 and was continued through the 1967 growing season. Sixteen access tubes were installed in the forest, 12 in the clearcut area, and 10 in the barren areas. Soil moisture was sampled with a Troxler[1] neutron moderation probe having an Amer-

[1] Use of trade names is for information only and does not imply endorsement by the U.S. Department of Agriculture or Forest Service.

Figure 2.—Aerial view of one of the forest-barren boundaries, showing the approximate locations of soil-moisture access tubes.

Table 1.—*Some physical properties of Calvin silt loam soil*

Horizon	Texture	Depth (inches)	Bulk density	Porosity (percent)	Observed Moisture Content (percent by volume)	
					Max.	Min.
A^1	Silt loam	0-2	—	—	—	—
A^3	Silt loam	2-8	1.22	54	32.5	18.0
B	Silt loam	8-16	1.45	45	35.0	24.0
C	Silty clay loam	16-25	1.65	38	32.5	25.0
R	Decomposed shale	25-32	1.90	28	28.0	24.0

ican source. The probe was positioned in the access tubes to sample soil moisture at 6-inch intervals, to depths ranging from 24 to 42 inches. We were not equipped to install access tubes deep into underlying shale and sandstone bedrock.

Some physical characteristics of Calvin silt loam, the predominant soil on all three study areas, are listed in table 1. Bulk density and porosity were calculated from "undisturbed" core samples. Soil-moisture measurements taken below 24 inches (the 21- to 27-inch horizon) are not emphasized in this report because the data indicated relatively small changes in water content below that level. Frequent observations to the depth of 24 inches suggest that the Calvin silt loam profile sampled (0 to 27 inches) contained close to 8 inches of water at full recharge or "field capacity" in early spring.

Results

Soil-moisture changes in clearcut openings were initially grouped by location as north, center, and south. Because there were no consistent differences due to location within openings, only mean values of moisture in clearcut and forest soil were used in this analysis.

Large differences in soil-moisture depletion between forest and clearcut openings occurred in 1966 (table 2). These differences, at least in the upper foot of soil, were erased in 1967 when soil moisture accumulated in clearcut openings was used by invading herbaceous plants, tree sprouts, and seedlings. In 1967 soil moisture in the forest also was depleted to a lower level than in the clearcut areas, but the contrast between the two was not so pronounced as in 1966. Soil-moisture loss per unit time was about the same for the forest during both 1966 and

Table 2.—*Moisture losses from forest and clearcut soils*

Year	Sampling depth (inches)	Moisture loss (percent by volume)		
		Forest[1]	Clearcut[2]	Difference
1966[3]	6	8.1	2.2	5.9**
	12	6.1	1.9	4.2**
	18	5.5	1.3	4.2**
	24	4.7	1.6	3.1**
1967[4]	6	5.4	5.2	0.2
	12	2.7	2.2	.5
	18	1.8	.6	1.2**
	24	1.3	.2	1.1**

[1] Mean of 6 observations.
[2] Mean of 4 observations.
[3] 26 May to 27 June.
[4] 26 May to 9 June; one year of regrowth had occurred.
** Significant at the 0.01 level.

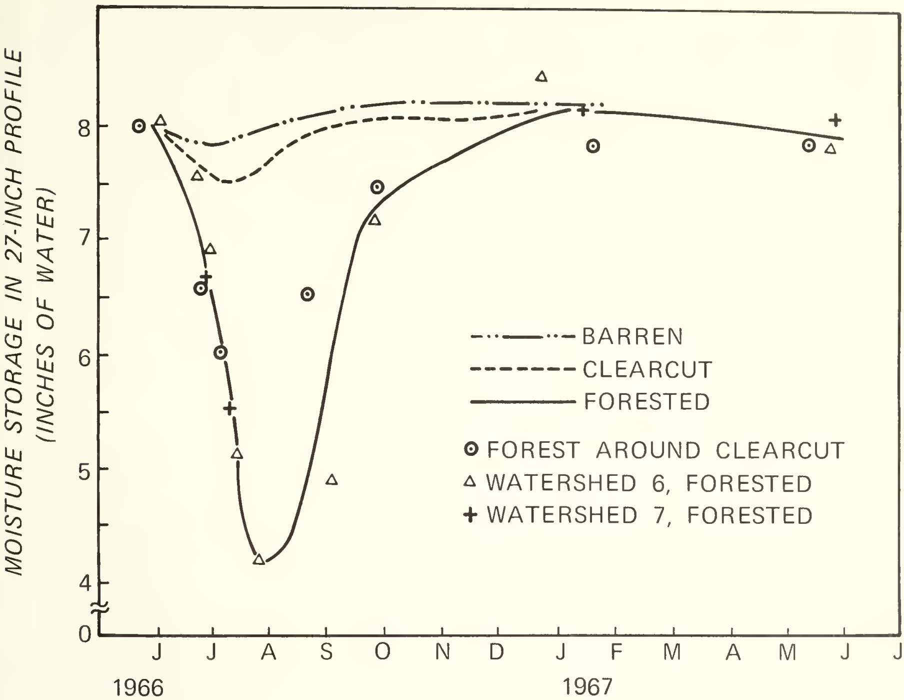
1967. Similarly contrasting moisture losses were observed between forest and barren soils on the other two study areas.

Soil-moisture depletion and recharge data from all sites, May 1966 to April 1967, are incorporated in figure 3. The depletion line for forest (June to mid-July) fits the data extremely well, indicating a similar depletion rate for all locations between May and mid-July. After mid-July, precipitation exceeded evapotranspiration, and soil-moisture recharge began. Not so many soil-moisture samples were taken during the recharge period, and the data are insufficient for plotting a closely defined line. Nevertheless, observed deficits for September and October (1.7 and 0.8 inches) agreed closely with potential soil-moisture deficits (1.5 and 1.0 inches) calculated by Hamon's (*1961*) procedure, using an assumed 8-inch storage capacity. All three forested areas were fully recharged by January and remained so until May. It was apparent, but not statistically tested, that moisture depletion was less in barren soil than in clearcut openings.

Actual evapotranspiration (ET) for one of the forest sites was compared with potential ET during the 1966 and 1967 growing seasons. Potential ET was estimated as 0.7 of average daily pan evaporation (*Kohler et al. 1955*) at Parsons. Actual ET was estimated by using equation 1:

$$\text{Mean daily ET} = \frac{\text{Precipitation} \pm \text{change in soil-moisture storage}}{\text{Length of period in days}} \qquad (1)$$

Figure 3—Composite of all change in soil-moisture storage. Curves were fitted to the data by eye.



When precipitation occurred as small storms, soil-moisture data provided close agreement between potential and actual ET (table 3). During periods with heavier rain, soil-moisture losses to deep seepage and streamflow caused overestimation of actual ET during the rainy periods.

In a humid climate, soil moisture saved by reducing evaporation can increase streamflow (*Wilm and Dunford 1948*). This principle was

Table 3.—*Daily actual and potential evapotranspiration from forest soils, in inches*

Period	Precipitation	Change in storage	Actual ET	Potential ET
5/26 - 6/27/66	3.12	(Loss) 1.47	0.14	0.14
6/27 - 7/7/66	.92	(Loss) .57	.15	.15
7/7 - 8/24/66	7.52	(Gain) .52	.15	.13
5/26 - 6/9/67	1.44	(Loss) .68	.15	.15
6/9 - 9/15/67	14.43	(Gain) 1.36	.16	.11

demonstrated in this study. Evapotranspiration from the forested half of the watershed was estimated by using equation 2:

$$ET = P - RO \pm \triangle s \tag{2}$$

in which

ET = Evapotranspiration.

P = Precipitation.

RO = Expected streamflow for watershed 6 estimated from the streamflow for the control watershed, using the calibration period relation.

$\triangle$s = Change in soil-moisture storage.

Substituting measured values into this equation provided an estimated ET loss of 15.2 inches for the months June to September. Since the watershed was half cut, this has the potential of increasing streamflow by 7.6 inches. Using the estimated streamflow plus one standard deviation in equation 2 still produced an estimated increase of 7.0 inches. Because clearcutting materially decreased but could not prevent all evaporative losses, the actual increase in streamflow was 3.3 inches, less than half the potential.

There was a close correlation between streamflow and moisture content in the upper 2 feet of soil (fig. 4). When soil moisture was high, streamflow was high and quite responsive to precipitation; when soil moisture was low, the reverse was true. Increasing streamflow lagged behind in-

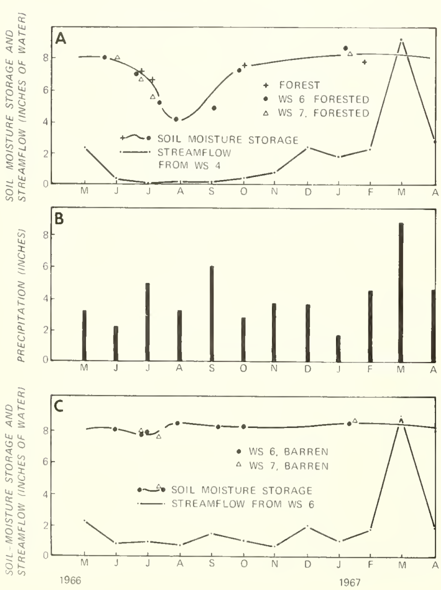


Figure 4.—Soil moisture-streamflow relationships. *A*, soil moisture in forest soil with discharge from a forested watershed. *B*, precipitation. *C*, soil moisture and streamflow from a barren watershed.

creased soil-moisture storage just as decreasing streamflow preceded early summer depletion. During the period of largest soil-moisture deficit (June to July), streamflow was lowest and did not respond to heavy precipitation during late July and August. Streamflow from the barren watershed, which maintained a high soil-moisture content, was much more responsive to precipitation than the forested and drier watershed.

Discussion

Several Fernow studies have suggested that increased streamflow accompanying forest cutting is related to decreased soil-moisture demand (*Reinhart et al. 1963*). My study explored some of the mechanisms involved, relating reduced forest vegetation to measured increases in soil moisture and streamflow. These observations compare well with those reported by Helvy and Hewlett (*1962*) for similar soil-moisture-streamflow observations in the southern Appalachians. Field capacity, seasonal soil-moisture loss, and shapes of the annual soil-moisture depletion-recharge curves are similar. In comparing data from both areas, it is apparent that moisture depletion in the upper 2 feet of soil is similar for both the southern and central Appalachians.

Large differences have been reported in soil depths from which trees draw water—from 18 inches (*Eschner 1960*) to 20 feet (*Patric et al. 1965*). Nevertheless, subsidiary information supports the assumption that most water used by the Appalachian forest is drawn from the upper 2 feet of soil:

- Actual and potential ET were comparable, based on moisture lost from this soil depth. This agreement was expected because the Fernow Forest receives about 30 inches of rain, well distributed over the growing season. Less rainfall probably would result in soil-moisture loss at less-than-potential rates and possibly to greater depths.

- Estimated streamflow increases agreed well with measured increases from treated watersheds. Under barren conditions, evapotranspiration occurred at substantially less than potential rates, and soil water saved from evaporative loss was diverted to streamflow.

- In Calvin soils, 75 to 90 percent of the tree roots are located in the upper 2 feet of soil.[2] These results also agree well with similar studies on agricultural land (*Dreibelbis 1962*).

[2] Personal communication, James N. Kochenderfer, Timber and Watershed Laboratory, Parsons, W. Va.

This preliminary study permits us to rank vegetative cover in order of decreasing soil-moisture use, much as in other studies in eastern hardwoods (*Lull and Axley 1958; Marston 1962; Fletcher and Lull 1963*):

1. Complete forest cover.
2. Revegetating clearcut forest land.
3. Newly clearcut forest land.
4. Barren land.

This ranking is based on gross differences in vegetative cover. Much refinement is needed. Well-documented comparisons of soil-moisture use among variously structured hardwood stands or comparisons between tree species are unavailable. As water becomes an increasingly valuable forest resource in the populous East, the neutron probe offers hope that such refinement may be possible.

Literature Cited

Dreibelbis, F. R.
1962. Some aspects of watershed hydrology as determined by soil moisture data. J. Geophys. Res. 67: 3425-3436.

Eschner, A. R.
1960. Effect of scrub oak and associated ground cover on soil moisture. NE. Forest Exp. Sta. Sta. Paper 133, 16 pp., illus. Upper Darby, Pa.

Fletcher, P. W., and H. W. Lull.
1963. Soil-moisture depletion by a hardwood forest during drouth years. Soil Sci. Soc. Amer. Proc. 27: 94-98.

Hamon, W. R.
1961. Estimation of potential evapotranspiration. J. Hydrol. Div. ASCE Proc. 87: (HY3).

Helvey, J. D., and John D. Hewlett.
1962. The annual range of soil moisture under high rainfall in the southern appalachians. J. Forestry 60: 485-486.

Kohler, M. A., T. J. Nordenson, and W. E. Fox.
1955. Evaporation from pans and lakes. U.S. Dep. Com. Res. Paper 38. 21 pp.

Lull, H. W., and John H. Axley.
1958. Forest soil-moisture relations in the coastal plain sands of southern New Jersey. Forest Sci. 4: 2-19, illus.

Marston, R. B.
1962. Influence of vegetation cover on soil moisture in southeastern Ohio. Soil Sci. Soc. Amer. Proc. 26: 605-608.

Patric, J. H., J. E. Douglass, and J. D. Hewlett.
1965. Water absorption by mountain and piedmont forests. Soil Sci. Soc. Amer. Proc. 29:303-308.

Reinhart, K. G., A. R. Eschner, and G. R. Trimble, Jr.
1963. Effect on streamflow of four forest practices in the mountains of West Virginia. USDA Forest Serv. Res. Paper NE-1. 79 pp., illus. NE Forest Exp. Sta., Upper Darby, Pa.

Wilm, H. G., and E. G. Dunford.
1948. Effect of timber cutting on water available for streamflow from a lodgepole pine forest. U.S. Dep. Agr. Tech. Bull. 968. 43 pp., illus.

—CHARLES A. TROENDLE
Research Forester
Northeastern Forest Experiment Station
Forest Service, U.S. Dep. Agriculture
Timber and Watershed Laboratory
Parsons, West Virginia

USDA FOREST SERVICE RESEARCH NOTE NE-121
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PHYSICAL SUITABILITY OF APPALACHIAN HARDWOOD SAWLOGS FOR SAWED TIMBERS

Abstract.—A study of the physical suitability of Appalachian hardwood sawlogs for manufacture of sawed timbers revealed that: most grade 1 logs can be used to saw timbers as large as 8 by 9 inches, end dimension; most grade 2 logs are suited for manufacture of timbers 6 by 8 inches and smaller; and most grade 3 logs are suited for manufacture of timbers 5 by 7 inches and smaller.

Little is known about the suitability of Appalachian hardwood logs for manufacturing timbers. A recent Forest Service study of the yield of timbers of various size from different grades of hardwood logs may help millowners more accurately match tie and timber orders with their log resource. Also, millowners not producing timbers could use this information in making decisions concerning entry into the tie and timber market.

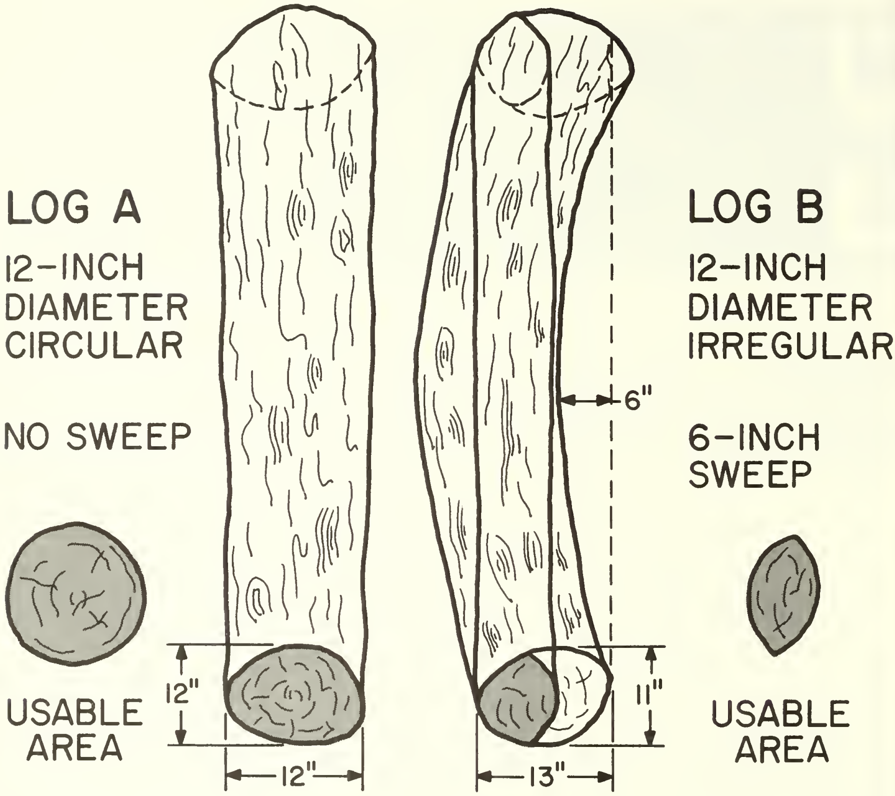
Study Methods

830 sample logs were selected at random from logs at three mills in southern and central West Virginia. Logs from three species groups—red oaks, white oaks, and hickories—were included in the sample. These species make up most of the growing stock in the Appalachian Region, and most timbers manufactured in the Appalachian Region are sawed from these species.

The logs were graded in accordance with the USDA Forest Service grading system,[1] which includes five grades: 1, 2, 3, tie and timber, and

[1] Ostrander, M.D., and Others. A Guide To Hardwood Log Grading. USDA Forest Serv. NE. Forest Exp. Sta., Upper Darby, Pa. 50 pp., illus. 1965.

Figure 1.—Effects of sweep and shape on the portion of the log usable for manufacture of timbers.



local-use. Logs that graded 3, tie and timber, or local-use were grouped and are referred to in this report as grade 3 logs.

Diameter, sweep, internal defect, and shape were judged to be the major factors that determine a log's potential for production of sawed timbers. A log must be sound and have sufficient diameter to offset the effects of sweep and shape before a timber can be sawed from it.

Because the sample was taken at the mill, length was not considered as affecting a log's usefulness for conversion to timbers. All logs sampled had been cut to satisfy random-length orders for both lumber and timbers. Therefore, we imposed the precondition that timbers would be cut to the entire length of each log.

Measurements of diameter, sweep, and shape were used to determine the portion of the log from which a timber could be sawed. This procedure is schematically illustrated in figure 1. Log A is straight, has a circular end shape, and is 12 inches in diameter at the small end. Log B is also 12 inches in diameter; however, it has irregular end shape and 6 inches of sweep. All of the surface area on the small end of log A represents the portion usable for manufacture of a log-length timber. Log B, because of irregular shape on its small end and sweep on one axis, has a smaller usable area. If sweep had occurred on both axes, an even smaller usable area would have resulted.

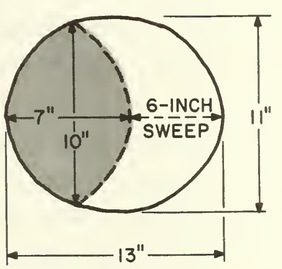
All 830 sample logs were tested for potential production of 10 timber sizes ranging from 4 by 6 inches to 10 by 10 inches, end dimension (fig. 2). Most timbers manufactured in the Appalachian Region fall within the limits of this range.

A pretest sample of 25 logs that were sawed revealed that the formula for an ellipse (fig. 2) adequately described the usable area projected onto the small end of the log. Measurements of the long and short axes of this area were used in defining the ellipse.

FORMULA TO DETERMINE RETRIEVABLE CANT SIZE FROM ELLIPSE:

$$\bar{Y} = B\sqrt{1 - \frac{X^2}{A^2}}$$

WHERE
A = MAJOR ELLIPSE AXIS (10")
B = MINOR ELLIPSE AXIS (7")
X = CANT WIDTH
$\bar{Y}$ = CANT HEIGHT



SOLUTION IF A 5-INCH-WIDE TIMBER IS DESIRED:

$$\bar{Y} = 7\sqrt{1 - \frac{25}{100}}$$

$$\bar{Y} = 7\sqrt{\frac{75}{100}}$$

$$\bar{Y} = 7 \times .87$$

$$\bar{Y} = 6$$

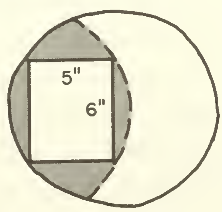


Figure 2.—Method for determining maximum retrievable timber size.

Results

Logs that have unsound internal defect will not yield an acceptable log-length timber. Thirteen percent of the grade 1, 11 percent of the grade 2, and 18 percent of the grade 3 sample logs were unsuited for sawing of timbers because of holes, decay, or shake. Grade 1 logs were predominantly butt cuts with typical butt flaws, so they were slightly more defective than grade 2 logs.

Diameter affects the utility of different log grades for the manufacture of timbers the most. Low-grade logs have smaller average diameters than high-grade logs, so fewer low-grade logs are suited for manufacture of larger timbers because of diameter alone. For example, all grade 1, 2, and 3 sawlogs[2] have sufficient diameter to produce 4- by 6-inch timbers provided they are not restricted by shape, sweep, or defect. And all grade 1 logs have sufficient diameter for 7- by 9-inch crossties, but many grade 3 logs have less than the 12-inch diameter necessary for crossties.

Logs that have sufficient end diameter for recovery of a timber of given size may not be suited for production of that timber because of sweep (fig. 1). The frequency of sweep was much greater in the smaller low-quality logs. Twenty-five percent of grade 3 logs had 2 inches or more sweep. Only 15 percent of the grade 2 logs and 12 percent of the grade 1 logs had this much sweep.

Irregular end shape was more common in grade 3 logs than in grade 2 or 1 logs. This irregular shape in low-quality logs was usually accentuated by the log being twisted.

Grade 3 logs.—Grade 3 logs are the most logical choice for tie and timber production as they yield mostly low-grade lumber that commands a low market price. Also, in the Appalachian hardwood region, low-grade logs make up over 60 percent of the growing-stock volume.[3] These physical characteristics make many grade 3 logs unsuitable for manufacture of larger size timbers; however, 72 percent of these logs will produce a 5- by 7-inch mine tie.

Sweep and unsound defect are more prevalent in grade 3 logs than in grades 1 and 2. Diameters of the grade 3 logs averaged only 13.0 inches. These factors restricted the number of grade 3 logs suitable for manufacture of timbers (table 1). Of the grade 3 logs studied, 76 percent

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[2] Sawlogs must be at least 8 inches in diameter inside bark at the small end.

[3] Ferguson, Roland H. The Timber Resources Of West Virginia. USDA Forest Serv. Resource Bull. NE-2. 121 pp., illus. NE. Forest Exp. Sta., Upper Darby, Pa. 1964.

Table 1.—Percent of sample logs suited for manufacture of sawed timbers, by grade

[Includes red oak, white oak, and hickory species groups.]

Timber size (end dimension)	Log grade		
	1	2	3*
Inches	*Pct.*	*Pct.*	*Pct.*
4 by 6	84	85	76
4 by 8	84	85	71
5 by 7	84	85	72
6 by 6	84	85	72
6 by 8	84	82	62
7 by 9	83	64	42
8 by 8	83	64	42
8 by 9	83	54	34
9 by 9	72	37	24
10 by 10	48	20	12

* Includes tie and timber and local-use grades.

could be used for sawing 4- by 6-inch timbers. As timber size increased, the percent of logs acceptable for manufacture of timbers decreased. For example, as timber size is increased to 7 by 9 inches, the percentage of suitable logs decreases to 42 percent. Only 34 percent of the logs could be used for production of 8- by 9-inch timbers.

Grade 2 logs.—Grade 2 logs contained less core defect than either grade 1 or grade 3 logs. Sweep and irregular shape occurred less frequently than in grade 3 logs, and the average diameter was 14.5 inches.

More than 80 percent of the grade 2 logs studied were suited for production of timbers up to 6 by 8 inches in end dimension (table 1). However, the utility of grade 2 logs for production of timbers decreased rapidly for timbers greater than 6 by 8 inches. One-half of the grade 2 logs could be converted to 8- by 9-inch timbers, and only 20 percent could be converted to 10- by 10-inch timbers.

Grade 1 logs.—Grade 1 logs were found to be the best physically suited for production of the timber sizes studied. The average diameter of grade 1 logs—16 inches—far exceeded the average for grade 3 logs. Sweep was not prominent in these logs, but internal defect did limit their utility for production of timbers. Because of this internal defect, grade 2 logs were equally well suited for conversion to timbers smaller than 7 by 9 inches.

Eighty-three percent of the grade 1 sample logs could be used to saw timbers as large as 8 by 9 inches. Approximately half of the samples met the requirements for conversion to 10- by 10-inch timbers.

—LAWRENCE D. GARRETT
Associate Economist
Northeastern Forest Experiment Station
Forest Service, U.S. Dep. Agriculture
Princeton, West Virginia

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USDA FOREST SERVICE RESEARCH NOTE NE-122

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COMPARISON OF VACUUM AND GRAVITY SAP FLOWS FROM PAIRED SUGAR MAPLE TREES

Abstract.—Paired sugar maple trees with single tapholes were used to compare sap yields from vacuum-pumping with sap yields from gravity flow. Results indicated that vacuum yields were approximately twice as great as gravity flows. These results support previous findings from studies in which vacuum and gravity were compared with two tapholes on the same tree.

At the Forest Service sap production research project at Burlington, Vermont, we have been studying the vacuum-pumping technique for the past four sugaring seasons. Our previous work indicated that, when two tapholes were drilled in each tree, and sap was collected from one taphole with vacuum-pumping and from the other taphole by gravity flow, total sap yields could be increased nearly four times with vacuum-pumping *(Blum and Koelling 1968)*.

Although dye and vacuum studies from the two-taphole trees revealed that sap moved only from above and below the taphole *(Blum and Koelling 1968)*, there was some question about the independence of taphole yields when one taphole was vacuum-pumped and the other was not.

During the 1968 sap season we compared vacuum-pumping with gravity flow on an individual-tree yield basis. The results supported our earlier findings that the use of a vacuum pump can increase sap volume yields appreciably.

The Study

Two sets of 15 trees each were paired on the basis of similar sap volume yields measured during the 1967 season. Earlier research had indicated that pairing on the basis of previous yields is a valid procedure *(Blum and Gibbs 1968)*. Each tree was tapped once, to a wood depth of

3 inches excluding bark; and all tapholes received a paraformaldehyde sanitation pellet.

Vacuum-pumping was assigned at random to one tree in each pair. The trees were pumped at controlled levels of 5 and 10 inches of mercury. At 5 inches of vacuum the trees were pumped for 16 hours; at 10 inches for 42 hours. The sap yields were collected through unvented plastic tubing into 55-gallon drums (fig. 1).

From the other tree in each pair, sap yield was collected in buckets, by gravity flow.

Sap volumes and sap-sugar percentages were measured on all trees and were recorded periodically throughout the sap season from 1 March to 15 April. Data were totaled for the sap season and were subjected to a "t" test for paired replicates.

Figure 1.—Sap yields from vacuum-pumped tapholes were collected in 55-gallon drums. The bucket in left background was used to collect sap flowing from a taphole by gravity.

Results and Conclusion

Study results indicated that trees pumped at 5 inches of mercury yielded twice (200 percent) as much sap as trees from which sap was collected by gravity flow (table 1). At the higher vacuum—10 inches of mercury—we found that the sap yields from the pumped trees were 2½ times (250 percent) greater than the sap yields from the other trees. Sap yield differences at both levels of vacuum were significant at the 5-percent level.

Sugar readings were recorded on the vacuum-pumped trees before and after pumping (6 sets of readings for 6 days of pumping). There was no significant difference in daily sap sweetness before or after pumping. This confirms results obtained in all our vacuum experiments in past years. Therefore, vacuum-pumping at 5 and 10 inches of mercury did not result in any change in sap-sugar concentration.

Results support our recent research findings that vacuum-pumping increases sap volume yields of sugar maple. This previous vacuum work was based on paired tapholes on the same trees. The paired one-taphole tree comparisons have strengthened the validity of taphole independence. We also observed that the sap-yield differences between vacuum-pumped and gravity-flow tapholes were greater at higher vacuum levels (table 1). Additional research is being done on the sap yield-vacuum level relationship.

Table 1.—*Sap yields collected from one-taphole trees paired for comparing vacuum-pumping and gravity flows*

Method of sap collection	Vacuum level	Sap yield
	Inches of mercury	*Gallons per hour*
Vacuum-pumping	5	1.4
Gravity flow	0	0.7
	(Difference—200 percent)	
Vacuum-pumping	10	3.0
Gravity flow	0	1.2
	(Difference—250 percent)	

Literature Cited

Blum, Barton M., and Carter B. Gibbs. 1968. VARIATION OF SUGAR MAPLE SAP YIELD AND ITS INFLUENCE ON EXPERIMENTAL DESIGN. USDA Forest Serv. Res. Paper NE-108, 8 pp. NE. Forest Exp. Sta., Upper Darby, Pa.

Blum, Barton M., and Melvin R. Koelling. 1968. EFFECT OF VACUUM PUMPING ON LATERAL MOVEMENT OF SAP IN THE MAPLE TREE BOLE. USDA Forest Serv. Res. Paper NE-107, 9 pp., illus. NE. Forest Exp. Sta., Upper Darby, Pa.

Blum, Barton M., and Melvin R. Koelling. 1968. VACUUM PUMPING INCREASES SAP YIELDS FROM SUGAR MAPLE TREES. USDA Forest Serv. Res. Paper NE-106, 14 pp., illus. NE. Forest Exp. Sta., Upper Darby, Pa.

— H. CLAY SMITH and CARTER B. GIBBS
Northeastern Forest Experiment Station
Forest Service, U. S. Dep. Agriculture
Burlington, Vermont

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MANUSCRIPT RECEIVED FOR PUBLICATION 4 MAY 1970.

USDA FOREST SERVICE RESEARCH NOTE NE-123

1970

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A DISPOSABLE INSULATED CONTAINER FOR REARING FALL WEBWORM LARVAE IN THE LABORATORY

Abstract.—Plastic-foam cups with plastic lids were found to be more suitable for rearing larvae of the fall webworm, *Hyphantria cunea* Drury, than other types of containers tested. These cups are inexpensive, lightweight, rigid, and translucent; and they protect the contents from rapid fluctuations in temperature.

Many types of containers have been tried for rearing larvae of various lepidopterous species. Glass vials *(Miskimen 1965),* polyethylene or polystyrene plastic containers and petri dishes, and plastic-coated or waxed-paper cups have been used *(Paschke 1964; Guerra and Ouye 1968).* The type and size of the rearing container have been found to affect the results of a rearing program *(Miskimen 1965).* We have found that plastic-foam cups can be used successfully for rearing larvae of the fall webworm, *Hyphantria cunea* Drury (Lepidoptera: Arctiidae).

Each of these types of containers was used in mass-rearing the fall webworm. They were tested to see if they would provide a micro-environment similar to the natural conditions described by Wellington *et al (1954),* who reported that feeding-stage larvae were more active in their natural habitat on warm, humid, overcast days. Feeding activity was observed to increase markedly during periods when direct sunlight was not present.

Transparent plastic containers, glass vials, and petri dishes did not provide optimum light conditions. It was also difficult to control the humidity in them. Plastic-coated paper containers are almost opaque, making it difficult to provide suitable light conditions for the larvae. Waxed-paper cups and plastic-foam cups with plastic lids provided the most suitable environmental conditions.

These two types of containers are inexpensive and disposable—a very desirable feature in any mass-rearing program *(Paschke 1964).* They are translucent and can be modified to maintain a satisfactory level of humidity. Moisture within the container is supplied by an artificial diet or by plant material used as food for the larvae. Adequate control of humidity is obtained by punching holes in the side or lid with a needle. The number of holes depends on the external environment, the number and size of the larvae, and the amount of food present in the container. If too many holes are punched, they can be covered with masking tape.

The plastic-foam cup[1] has more advantages than the waxed-paper cup. It is more rigid and will withstand frequent handling. Hot artificial-diet media can be poured directly into the cup—a practice that usually results in melting the wax of a waxed-paper cup. In addition, the insulating effect of the plastic-foam moderates the rapid temperature changes usually experienced when rearing containers are moved into and out of incubators (table 1). In other experimental situations, the plastic-foam cup allows a period of acclimation to temperature changes.

[1]Hot or cold insulated plastic cup, Dart Container Corporation, Mason, Michigan. Mention of a trade name should not be taken as endorsement of this product by the Forest Service or the U. S. Department of Agriculture.

Table 1.—*Comparison of the insulating value of 6-ounce plastic-foam cups and waxed-paper cups when removed from a 21.1° C. environment and placed in a 4.4° C. environment*

Elapsed time (seconds)	Air temperature differential[1]	
	Plastic foam	Waxed paper
	°C.	°C.
15	5.6	1.6
30	6.7	1.6
45	5.6	1.6
60	3.3	1.6
75	2.8	1.6
90	2.2	1.1
105[2]	1.1	1.1

[1]Difference between the air temperature measured at the outer surface and in the center of the container.

[2]Temperature at the outer surface reached 4.4° C. after 180 seconds.

Literature Cited

Guerra, A. A., and M. T. Ouye.
1968. Hatch, Larval Development, and Adult Longevity of Four Lepidopterous Species After Thermal Treatment of Eggs. J. Econ. Entomol. 61:14-16.

Miskimen, G. W.
1965. Nonaseptic Laboratory Rearing of the Sugarcane Borer, *Diatraea saccharalis*. Ann. Entomol. Soc. Amer. 58:820-823.

Paschke, J. D.
1964. Disposable Containers for Rearing Loopers. J. Insect Pathol. 6:248-251.

Wellington, W. G., C. R. Sullivan, and W. R. Henson.
1954. The Light Reactions of Larvae of the Spotless Fall Webworm, *Hyphantria textor* Harr. (Lepidoptera: Arctiidae). Can. Entomol. 86:529-542.

—WILLIAM N. CANNON, JR.
Research Entomologist
Northeastern Forest Experiment Station
USDA Forest Service
Delaware, Ohio

Manuscript received for publication 19 May 1969.

USDA FOREST SERVICE RESEARCH NOTE NE-124

1970

Northeastern Forest

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HYDROSEEDING ON ANTHRACITE COAL-MINE SPOILS

Abstract.—A study was made of the performance of selected species of legumes, grasses, and trees hydroseeded on anthracite coal-mine spoils in a slurry of lime, fertilizer, and mulch. Hydroseeding failed on coal-breaker refuse, but was partially successful on strip-mine spoils.

How can trees and herbaceous vegetation be established quickly on large areas of anthracite coal-mine spoils in Pennsylvania? It is extremely difficult to establish plants on these sites. Hand-planting works, but is slow. Conventional direct-seeding machinery cannot negotiate the steep slopes and rocky spoils that are typical of mine spoils. But in recent years, one method of direct seeding by machine—hydroseeding—has been used successfully to establish cover on some steep problem areas.

Until now, no formal studies have been made to evaluate the success of hydroseeding various tree and herbaceous species and seeding mixtures on coal-mine spoils, although hydroseeders have been used to revegetate mine spoils in Kentucky and West Virginia. This is a report on such a study conducted by the Forest Service in cooperation with the Pennsylvania Power and Light Co. on the anthracite coal-mine spoils of Pennsylvania.[1]

A hydroseeder consists of a tank, a pump, and a nozzle mounted like a gun. (fig. 1). Seed, fertilizer, lime, and mulch are mixed with water in the tank, and the entire mixture is sprayed directly from the nozzle

[1]Stephen Postupack provided necessary field assistance in this study.

Figure 1.—Hydroseeder in operation.

onto the area to be seeded. The hydroseeder can be mounted on a truck or on a trailer to be pulled by a tractor.

The Study

In April 1967, seeds of trees, grasses, and legumes — mixed in a slurry containing hydrated lime, fertilizer, and wood-fiber mulch — were hydroseeded on coal-mine spoils in the Anthracite Region of Pennsylvania. Two seed mixtures, each containing seeds of a coniferous and a hardwood tree species, a legume, and a grass, were hydroseeded on separate plots. The plot layout included two spoil materials, each with two grading conditions, and two seed mixtures, each replicated four times. Thus 32 plots were hydroseeded. Each plot was 33 by 33 feet square, plus a 3-foot buffer strip on each side.

The study sites were chosen in the southern coal field near Tamaqua and Lansford boroughs on lands owned by the Greenwood Stripping Company.

Site.—Two coal mine spoils, a strip-mine spoil and a coal-breaker refuse, each represented in the graded and ungraded condition, were

Table 1.—*Selected characteristics of experimental sites*

[Average of four replications]

Spoil type	Coarse fraction	Soil-size fraction			pH	Lime requirement
		Sand	Silt	Clay		
	Pct.	*Pct.*	*Pct.*	*Pct.*		*Tons/acre*
Strip-mine:						
Graded	46	23	16	15	4.8	2.9
Ungraded	66	15	10	9	4.5	3.2
Breaker refuse:						
Graded	63	24	11	2	3.8	3.8
Ungraded	70	20	8	2	3.7	3.8

selected as experimental sites. The ungraded sites included two aspects, northeastern and southwestern, and had slopes of about 40 degrees. The graded sites were on almost level ground, except two plots on a slope of about 7 degrees of northern aspect.

After the plots were delineated, bulk samples were taken to a depth of 6 inches for determination of the physical make up, pH values, and lime requirement (table 1).

The strip-mine spoils resembled the material described earlier[2] as sandstone and conglomerates, type III. The spoils consisted of sandstone rocks over 2 inches in diameter (discarded from analysis), fragments from 2 inches to 2 mm. in diameter, and particles less than 2 mm. (referred to here as the soil-size fraction). The graded sites had lower rock content and a much higher content of gray shales than the ungraded sites, thus the graded sites had more soil-size material (table 1).

The coal-breaker refuse — a black material separated from the coal during the process of coal cleaning — consisted of a loose mixture of fragments of carbonaceous slaty shale, medium-size coal pieces, and a soil-size fraction. Because of the oxidation of pyrites released from weathered shale fragments, the materials were highly acid. The characteristics of coal-breaker refuse as a plant growth media were described earlier.[3] The sites selected had high proportions of coarse fraction — 63 percent in graded sites and 70 percent in ungraded sites — and extremely

[2]Czapowskyj, Miroslaw M.—Experimental Planting of 14 Tree Species on Pennsylvania's Anthracite Strip-mine Spoils. USDA Forest Serv. Res. Paper NE-155, 18 pp., illus. NE. Forest Exp. Sta., Upper Darby, Pa. 1970.

[3]Czapowskyj, Miroslaw M.—Performance of Red Pine and Japanese Larch Planted on Anthracite Coal-breaker Refuse. Proc. Int. Symp. Drastically Disturbed Lands. Manuscript in preparation. NE. Forest Exp. Sta. 1969.

low amounts of clay-sized fraction — 2 percent in both (table 1). The acidity before hydroseeding was too high for plant survival and normal growth.

Hydroseeding.—The hydroseeder — manufactured by the Finn Co.[4] in Ohio — had a 500-gallon tank, an agitator, pumps, and spraying hoses and nozzles. In preparing the slurry, the tank was first partly filled with water. Then, with the agitator operating, the prescribed quantities of lime, fertilizer, and wood-fiber mulch[5] were added and mixed for at least 20 minutes. The tank was filled to capacity with water. The seed mixture (table 2) was added to the agitated slurry.

Lime was added in the amount necessary — based on the analysis of the spoil samples (table 1) — to bring pH on all plots to 6.0, or slightly above in the top 6 inches. Fertilizer was added at a level considered adequate for a site of low fertility. Wood-fiber mulch was applied at the rate recommended by the manufacturer.

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[4]Mention of a particular product should not be taken as endorsement by the Forest Service or the U. S. Department of Agriculture.
[5]Silva-Fiber (Weyerhaeuser Co.).

Table 2.—*Seed mixtures and amount of seeds used (in grams)*

Species	Per tank load	Per plot*	Per acre
		MIXTURE A	
Red pine *Pinus resinosa* L.	56	28	940
Gray birch *Betula populifolia* Marsh	56	28	940
Perennial ryegrass *Lolium perenne* L.	262	131	4,402
Sericea lespedeza *Lespedeza cuneata* (Dumont) G. Don	376	188	6,318
Total	750	375	12,600
		MIXTURE B	
Scotch pine *P. sylvestris* L.	56	28	940
Black locust *Robinia pseudocacia* L.	56	28	940
Tall fescue Ky. 31 *Festuca arundinacea* Schreb.	262	131	4,402
Penngift crownvetch *Coronilla varia* L.	376	188	6,318
Total	750	375	12,600

*Includes 3-foot buffer strip.

The composition of the slurry (in pounds) was as follows:

Amendment	*Per tank load*	*Per plot*	*Per acre*
Hydrated lime	312.0	156.0	5,250
Fertilizer (10-10-10)	25.0	12.5	420
Silva-Fiber Mulch	125.0	62.5	2,100

The data for the plots do not include the buffer strip. The hydrated lime data are 100 percent calcium carbonate equivalent.

Water for the slurry was from a public water supply at a nearby colliery. The slurry was agitated continuously during the trip to the plots.

One tank load of the slurry was used to hydroseed two plots. The slurry was sprayed as evenly as possible on each plot and buffer strip. About 8 minutes were needed to hydroseed one plot. Appropriate legume inoculant was spread manually immediately. About 1½ hours were needed from the start of slurry preparation to completion of a cycle.

After the first seed mixture was sprayed (eight loads), the tank was drained and washed of residues.

Collection of data.—After the first two growing seasons (1967 and 1968), the number of emerged plants on the graded spoils was determined as follows. A square frame, 2.2 feet on each side, was placed at 18 randomly selected points on each plot, and the emerged trees, legumes, and grasses were counted. The data were converted to number of plants by species per milacre (table 3).

This method could not be used on ungraded spoils, because walking

Table 3.—*Number of plants after the first and second growing seasons on 1-milacre plot on graded spoils*

[Average of four replications]

Species	Strip-mine spoil		Coal-breaker refuse	
	1967	1968	1967	1968
		MIXTURE A		
Red pine	1	2	<1	0
Gray birch	1	7	<1	1
Perennial ryegrass	176	38	7	<1
Sericea lespedeza	176	180	82	115
		MIXTURE B		
Scotch pine	2	1	0	<1
Black locust	1	0	0	0
Tall fescue Ky. 31	307	178	14	8
Penngift crownvetch	95	8	42	22

Table 4.—*Average numerical rating (from 0 to 4) of stand performance per plot on hydroseeded strip-mine spoils*

Species	Ungraded		Graded
	N.E. slope	S.W. slope	
		MIXTURE A	
Red pine	0.5	2.0	1.0
Gray birch	1.0	1.0	1.0
Perennial ryegrass	1.0	0	.5
Sericea lespedeza	4.0	1.0	1.0
		MIXTURE B	
Scotch pine	1.0	0	2.0
Black locust	0	.5	1.0
Tall fescue Ky. 31	3.5	1.5	2.5
Penngift crownvetch	2.5	.5	2.0

on the plots to collect the data would have caused rock sliding and damage to the plots. Germination and plant emergence were observed, but no estimates were attempted.

In the fall of 1969, after the third growing season, it became evident that the counting method would be unsuitable for making comparisons of the relative success of establishment between trees, legumes, and grasses. So, in order to have a more suitable basis for comparing the performance of each species on each spoil, a numerical rating system was used. Three experienced workers independently rated the performance of each species on each plot, and the ratings by all workers for all plants were averaged (table 4). The rating system — based on a set of criteria that took into account such factors as number of plants, plant vigor, and ground cover — was as follows:

Rating	*Number of trees*	*Criteria for legumes and grasses*
0	None	No plants
1	1 to 5	Individual plants, poor growth
2	6 to 12	Occasional clumps, stunted growth
3	13 to 20	Frequent clumps, acceptable growth
4	21 to 50	Adequate cover, good growth

Results and Discussion

Emergence and establishment varied widely between species and between spoils (tables 3 and 4). No plants became established on coal-breaker refuse.

Coal-breaker refuse.—Plots hydroseeded on ungraded breaker refuse showed negligible emergence, and all plants subsequently died.

Plots hydroseeded on graded breaker refuse showed only slightly better emergence. Considerable numbers of sericea lespedeza, Penngift crownvetch, and tall fescue Ky. 31 emerged during the first growing season. Except for sericea lespedeza, which increased in number, these species decreased in number during the second growing season. All species died by the end of the third growing season.

Previous attempts to direct-seed crownvetch on coal-breaker refuse also failed.[6] Attempts to direct-seed other species on these spoils have yielded variable results.[7]

Strip-mine spoils.—The plots hydroseeded on strip-mine spoils performed markedly better. Overall emergence and establishment varied considerably between graded and ungraded sites and between aspects. Some plots produced an adequate stand of at least one species (fig. 2).

Red and Scotch pines emerged poorly, but the seedlings that survived had good vigor. Gray birch and black locust had poor emergence and survival. Gray birch had slightly better emergence than black locust,

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[6]Czapowskyj, Miroslaw M., John P. Mikulecky, and Edward A. Sowa. RESPONSE OF CROWNVETCH ON ANTHRACITE BREAKER REFUSE. USDA Forest Serv. Res. Note NE-78, 7 pp., illus. NE. Forest Exp. Sta., Upper Darby, Pa. 1968.

[7]Schramm, J. R. PLANT COLONIZATION STUDIES ON BLACK WASTES FROM ANTHRACITE MINING IN PENNSYLVANIA. Trans. Amer. Philos. Soc. New Series, Part 1, 56 pp., illus. 1966.

Figure 2.—Series of hydroseeded plots on northeast aspect of ungraded spoil-type III (sandstone and conglomerate) after 3 years. The plots did not reach to the top of the slope and were separated by unhydroseeded strips. From foreground the plots are, crownvetch, lespedeza and lespedeza.

but gray birch occurred naturally in the area and it may have emerged partly from seed from natural sources.

Crownvetch emerged and grew only in clumps and performed about the same on both graded and ungraded sites. It grew slightly better than sericea lespedeza on graded sites. Only a few plants were found on southwestern slopes.

Sericea lespedeza — which performed best on northeastern slopes, where it produced a stand with adequate ground cover and good growth for the conditions — grew better than crownvetch on ungraded sites.

Tall fescue Ky. 31 performed about as well as sericea lespedeza. It performed better than perennial ryegrass and was healthy, but it provided only spotty ground cover.

Some volunteer plants, apparently from natural local seed sources, were noted on all the plots.

Recommendations and Conclusions

Although this study was limited in scope, and the results presented here apply only to the conditions under which the study was performed, general conclusions and recommendations are made as follows:

- Because neither the trees nor legumes and grasses became established on coal-breaker refuse, we do not recommend any revegetation programs by hydroseeding on similar sites until more research data are available.

- Hydroseeding strip-mine spoils may result only in partial success, but it may be recommended for certain sites. Spoil characteristics — especially slope, aspect, and physical make-up — in addition to species selection, have to be carefully weighed.

- The advantages of hydroseeding in establishing ground cover may be considerable. The results obtained in this study provide a basis for more research on hydroseeding as a direct-seeding method for rapid establishment of ground cover.

— MIROSLAW M. CZAPOWSKYJ
and ROSS WRITER
Soil Scientist and Forester
Forest Service, U. S. Dept. Agriculture
Northeastern Forest Experiment Station

MANUSCRIPT RECEIVED FOR PUBLICATION 8 JUNE 1970.

SDA FOREST SERVICE RESEARCH NOTE NE-125

1971

Northeastern Forest

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DECAY NOT SERIOUS IN NORTHERN RED OAK

Abstract. — A study of 114 northern red oak, *Quercus rubra,* indicated that decay is not serious during the time necessary to produce high-quality saw logs and veneer logs. Two heart-rot fungi, *Poria oleraceae* and *P. cocos,* accounted for almost 25 percent of the total decay volume in the study trees. Basal fire wounds, dead branch stubs, and open branch-stub scars were the most important means of entry for decay fungi.

Northern red oak is one of our most valuable hardwood species. Its wood is highly prized because of its strength and beauty and the many uses for which it is suited. More intensive management of northern red oak has pointed up the need for information on decay in this species. Therefore, we made a study to determine the heart rot fungi associated with decay in northern red oak and the relationship of decay losses to tree age and diameter.

Study Areas and Methods

The northern red oaks (*Quercus rubra* L.) sampled in this study were scattered from Virginia to Missouri. Altogether, 114 northern red oak trees 5.6 inches diameter breast height and over were felled and bucked into either bolts or logs. The nature, extent, and location of all defect indicators were recorded. The 41 trees from Virginia had been selected previously for a log- and tree-grade study on the George Washington National Forest. These trees were bucked into logs and the extent of decay was determined when the logs were milled. The remaining 73 trees were randomly selected from national and State forests in Ohio, Kentucky, Indiana, Illinois, and Missouri. They were cut into 4-foot bolts up to a 4-inch-top diameter inside bark, and critically examined for decay in the field. Where decay appeared, its extent and dimensions were determined by splitting the bolts longitudinally.

Gross volume and decay volume were calculated in cubic feet. No reduction in gross volume was made for trim, taper, long butting, or breakage.

Cultures were prepared from samples of decayed wood to determine the fungi responsible for decay. Sample blocks were taken to the laboratory and split to expose a fresh face of infected wood. Small cores of infected wood were removed with a sterilized increment hammer and placed in test tubes containing 2.5 percent Fleischmann's diamalt[1] with 2 percent agar. If no growth was observed after 2 weeks, reisolations were attempted.

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

Table 1. — *Fungi causing decay in living northern red oak trees and their relation to the portion of the tree bole affected*

Fungus (species)	Number of infections			Decay volume		
	In butt[1]	In trunk	Total	In butt[1]	In trunk	Total
	No.	*No.*	*No.*	*Cu. ft.*	*Cu. ft.*	*Cu. ft.*
Poria oleraceae Davidson & Lombard	1	2	3	8.38	0.67	9.05
Poria cocos (Schw.) Wolf	2	—	2	8.69	—	8.69
Polyporus compactus Overh.	—	8	8	—	2.85	2.85
Polyporus sulphureus Bull. ex. Fr.	1	2	3	.82	.89	1.71
Unknown H[2]	—	3	3	—	.92	.92
Stereum frustulatum (Pers. ex. Fr.) Fckl.	—	4	4	—	.81	.81
Stereum gausapatum (Fr.) Fr.	—	3	3	—	.62	.62
Polyporus versicolor L. ex. Fr.	—	1	1	—	.38	.38
Poria andersonii (Ell. & Ev.) Neuman	—	2	2	—	.20	.20
Irpex mollis Berk. & Curt.	—	1	1	—	.15	.15
Polyporus spraguei Berk. & Curt.	1	—	1	.14	—	.14
Unknown[3]						
White rots	8	34	42	5.83	19.05	24.88
Brown rots	4	4	8	16.90	.49	17.39
Undetermined rots	17	30	47	3.48	3.97	7.45
Total	34	94	128	44.24	31.00	75.24

[1] Decay originating at stump height or below was considered as butt rot.

[2] Misidentified as *Corticium lividum* Pers. ex. Fr. in U.S. Dep. Agr. Tech. Bull. 785, Fungi Causing Decay of Living Oaks in the Eastern United States and their Cultural Identification, by Ross W. Davidson, W. A. Campbell, and Dorothy B. Vaughn. 1942.

[3] Decay columns from which we were unable to isolate any heart rot fungi.

The Fungi that Caused Decay

Most of the 11 species of fungi recovered (table 1) are well established as organisms causing decay in other oak species (*1,2,3*). The two species of *Poria* — *P. oleraceae* Davidson & Lombard, and *P. cocos* (Schw.) Wolf — accounted for about one-fourth of the total decay volume (table 1). However, because of the small number of identified infections, we did not attempt to draw any conclusions on the relative importance of the various fungus species in causing decay in northern red oak. Many of the decay columns were inactive at the time the trees were dissected and we were unable to isolate a decay fungus from them. Some of these columns yielded bacteria and nondecay fungi while others were sterile. The close association of bacteria, nondecay fungi, and decay fungi in living trees suggests that all are important in the decay process (*4*).

As in other tree species, decays can be divided into butt rots and trunk rots, based on their position in the tree. Although trunk infections were almost triple the number of butt infections, the latter infections accounted for considerably more volume loss (table 1). All decay caused by *P. cocos* and most of that caused by *P. oleraceae* was found in the butt log.

How Fungi Gained Entry

Decay-causing fungi are unable to penetrate the protective bark on living trees except through wounds or dead branch stubs. Basal fire wounds were the most important means of entry for decay fungi

Table 2. — *Relationship between infection courts and decay in living northern red oak trees*

Infection court	Infections	Volume of decay	
	No.	*Cu. ft.*	*Pct.*
Closed fire scars	14	22.40	29.77
Open fire scars	3	17.26	22.94
Dead branch stubs	19	8.07	10.73
Open branch stub scars	5	8.06	10.71
Branch bumps	21	4.50	5.98
Insect wounds	15	3.52	4.68
Mechanical injuries	11	2.63	3.50
Parent stump	6	1.73	2.30
Woodpecker injuries	3	1.49	1.98
Unknown	31	5.58	7.41
Total	128	75.24	100.00

(table 2). Over 50 percent of the decay volume was associated with fire-scarred trees. And this decay was in the most valuable part of the tree — the butt log. Better fire protection and fewer fires should result in less decay from basal wounds in the future. Other important entry courts, based on decay volume, were dead branch stubs and open branch stub scars.

Decay vs. Tree Age and Diameter

Age-decay relationships demonstrate that relatively small decay volumes can be expected in northern red oak (table 3). Sixty-one of the 114 trees contained measurable amounts of decay. Decay losses were slightly over 1 percent of the gross volume for trees up to 90 years of age. Although decay volume increased in trees over 90 years old, the decay percent of

Table 3. — *Relationship between age and decay in living northern red oak trees*

Age class (years)	Trees	Trees with decay	Gross volume	Decay
	No.	*No.*	*Cu. ft.*	*Pct.*
30 to 70	64	22	1,921.92	1.13
71 to 90	32	26	1,564.23	1.02
91 to 130	18	13	1,125.15	3.32
Total	114	61	4,611.30	—
Average (all classes)	—	—	—	1.63

Table 4. — *Relationship between diameter and decay in living northern red oak trees*

Diameter class (inches)	Trees	Trees with decay	Gross volume	Decay
	No.	*No.*	*Cu. ft.*	*Pct.*
5.6 to 11.5	30	12	342.14	1.61
11.6 to 17.5	53	27	1,785.69	1.21
17.6 to 25.5	31	22	2,483.47	1.94
Total	114	61	4,611.30	—
Average (all classes)	—	—	—	1.63

3.32 was still quite nominal. And 4 of the 13 trees with decay in this age class contained 90 percent of the decay volume.

The relationship between decay and tree diameter was analyzed (table 4). There was relatively litlle decay loss even in the largest diameter class, which indicates that decay will not be serious during the time necessary to produce high-quality northern red oak saw logs and veneer logs.

Conclusion

From the decay standpoint, northern red oak should be an excellent tree to manage for lumber and veneer production. Its durable heartwood is affected by relatively few fungi that cause decay. Northern red oak grows rapidly, so these fungi do not have time to cause excessive cull before the trees reach merchantable size.

Literature Cited

1. Berry, Frederick H. 1969. Decay in the Upland Oak Stands of Kentucky. USDA Forest Serv. Res. Paper. NE-126, 16 pp. NE. Forest Exp. Sta., Upper Darby, Pa.
2. Hepting, George H., and George H. Hancock. 1937. Decay in Merchantable Oak, Yellow Poplar, and Basswood in the Appalachian Region. USDA Tech. Bull. 570, 29 pp.
3. Roth, Elmer R., and Bailey Sleeth. 1939. Butt Rot in Unburned Sprout Oak Stands. USDA Tech. Bull. 684, 43 pp.
4. Shigo, Alex L. 1967. Successions of Organisms in Discoloration and Decay of Wood. Int. Rev. Forest. Res. 2: 237-299.

— FREDERICK H. BERRY
Principal Plant Pathologist

JOHN A. BEATON
Biological Laboratory Technician

Northeastern Forest Experiment Station
Forest Service, U.S. Dep. of Agriculture
Delaware, Ohio

Manuscript received for publication 8 May 1970.

SDA FOREST SERVICE RESEARCH NOTE NE-126
1971

Northeastern Forest
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TAPPING NEAR OLD TAPHOLES IN SUGAR MAPLE TREES

Abstract.—A study of sugar maple tapping indicated that sugar producers can drill a new taphole within 1 inch of an old taphole in a horizontal direction and obtain normal sap and sap-sugar yields.

When a taphole is drilled into a sugar maple tree, the wood tissues above and below the taphole become stained. This stained wood is usually about as wide as the taphole. If a sugarmaker taps into stained wood, his sap yields are reduced. For this reason, producers seldom tap close to old tapholes.

Sugarmakers usually drill a new taphole at least 4 to 6 inches from an old taphole, horizontally around the tree. But as tapping is continued year after year, it may become difficult to find untapped wood 4 to 6 inches away from older tapholes.

How close to an old taphole can a sugarmaker tap? In a study in Vermont, we found that sugarmakers can get the same yield of sap from new tapholes 1 inch from older tapholes as they can from new tapholes 6 inches from older tapholes.

Methods

During the 1967 sugaring season, 15 trees having similar sap-yield patterns were selected for study. In late February, before the tapping season, two new tapholes were drilled into each tree to a depth of 3 inches, excluding the bark. The first new taphole was drilled 1 inch from a 1-year-old taphole. The second new taphole was drilled 6 inches from the old taphole, but on the other side of it (fig. 1).

Figure 1.— The taphole on the left (spout attached) is 1 inch from the older taphole (tip of pencil); the taphole on the right is 6 inches from the old taphole.

A paraformaldehyde sanitation pellet was placed in each new taphole. The purpose of the pellet is to keep the woody sap-producing tissue from clogging, thus prolonging the sap season and increasing yields.

Results

Yields from the tapholes 1 inch from older tapholes averaged 15.9 gallons, while yields from tapholes 6 inches from older tapholes averaged 15.1 gallons. The sap-sugar concentration differences between the 1- and 6-inch tapholes averaged only 0.1 percent. These data were analyzed using a pairing design with a t-test, and the sap yields were not statistically different at the 95-percent probability level (table 1).

Recommendations

When tapping, it is possible to tap within 1 inch of an older taphole without influencing the sap-volume and sap-sugar yields. To avoid overtapping, the following number of tapholes per tree should be used:[1]

[1]Willits, C. O. MAPLE SIRUP PRODUCERS MANUAL. USDA Agr. Handb. 134, 112 pp., illus., revised 1965.

Table 1.—*Summary of total seasonal sap and sap-sugar yields for new tapholes 1 and 6 inches from older tapholes*

Tree number	Sap yields		Sap-sugar yields	
	Distance from old taphole: 1 inch	6 inches	Distance from old taphole: 1 inch	6 inches
	Liters	*Liters*	*Percent*	*Percent*
1	50.7	40.1	3.0	4.0
2	32.6	13.2	4.0	4.0
3	29.0	35.1	3.5	3.4
4	89.3	89.0	3.2	3.2
5	72.6	65.4	4.0	4.3
6	64.6	86.6	3.2	3.0
7	47.4	46.5	2.4	2.4
8	71.5	52.5	4.8	3.4
9	29.5	28.4	4.0	4.0
10	89.2	78.8	3.0	3.0
11	72.8	69.4	3.2	3.0
12	49.4	62.5	3.2	3.2
13	60.8	40.8	3.4	3.7
14	89.5	92.9	3.0	2.8
15	55.9	56.8	2.8	2.8
Average	60.3	57.2	3.4	3.3

Tree diameter (inches)	*Tapholes per tree (number)*
<10	0
10-14	1
15-19	2
20-24	3
25+	4

Using this taphole guide, producers tapping previously untapped sugarbushes could systematically tap the tree from year to year and avoid tapping near old tapholes. However, many older sugarbushes have been overtapped. This creates problems in using the taphole guide and drilling new tapholes 4 to 6 inches from old tapholes.

We do not suggest that producers start tapping 1 inch from older tapholes, because problems in taphole healing may develop. But if it is impossible to leave 4 to 6 inches between the new and old tapholes, the new one can be as close as 1 inch from the old taphole without a reduction in sap and sugar yields.

—H. CLAY SMITH
Research Forester
Northeastern Forest Experiment Station
Forest Service, U. S. Dep. Agriculture
Burlington, Vermont

MANUSCRIPT RECEIVED FOR PUBLICATION 25 AUG. 1970.