U. S. FOREST SERVICE

RESEARCH NOTE LS-1

LAKE STATES FOREST EXPERIMENT STATION • U. S. DEPARTMENT OF AGRICULTURE

Flow Characteristics of Two Types of Springs in Southwestern Wisconsin[1]

Springflow in southwestern Wisconsin is of great interest because it has a stabilizing effect on streamflow. Permanent springs may furnish a supply of clear, cool water of special importance in trout streams and ponds. Throughout the area, springs are widely used as a source of water for livestock.

Streamflow records from Coon Creek show that, for the period April 1934 to March 1939, about three-fourths of the total flow was in the form of ground water discharge.[2] Springflow is ground water discharge. Until recently, little information was available concerning the behavior of flow from individual springs in this area.

[1] *Reported from the Station's field unit at La Crosse, Wis., where research is conducted in cooperation with the Wisconsin Conservation Department.*

[2] *Unpublished data in the files of the Lake States Forest Experiment Station.*

More than a dozen springs can be found on the Coulee Experimental Forest, an area of approximately 2,800 acres representative of much of the Driftless Area. The springs are of two distinct types and have been termed "lower" and "upper" in relation to their approximate elevational locations of 900 and 1,000 feet above sea level. Both types may be classified as gravity contact springs. The "lower" springs are near the Ironton-Goodenough contact within the Franconia formation in the geologic structure; the "upper" springs are in the Trempealeau formation at the contact of the Jordan sandstone and the Lodi siltstones.

Besides a difference in elevation, the springs differ in topographic position. The upper springs appear in natural channels, while the lower springs issue from sides of

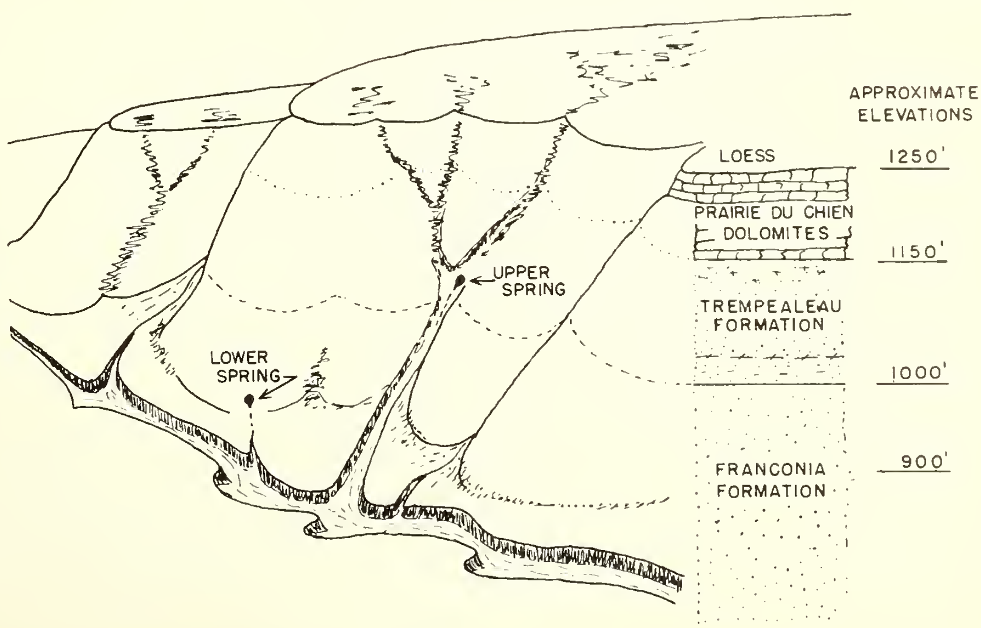

FIGURE 1. — Schematic diagram showing typical land forms on the Coulee Experimental Forest. Locations of "upper" and "lower" springs are shown in relation to topography, geology, and to each other.

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hills or from points of secondary ridges (fig. 1).

Three springs of each type were tested for pH, alkalinity, total hardness, calcium hardness, manganese, sulfate ion, and total iron. A difference in total hardness was expected because the upper springs appear nearer the dolomitic caprock than do the lower springs. However, no large differences were found in chemical quality of water.

Perhaps the most striking and important difference between the two types of springs is in their annual discharge pattern. Three springs of each type are being measured. Records collected over a 3-year period indicate that discharge from the upper springs was relatively constant, with little change throughout the year. During the same period, flow from the lower springs fluctuated widely by years, seasons, months, and even days, in relation to climatic variables (fig. 2). The discharge from lower springs has been observed to range from near zero in late winter to over 200 gallons per minute during early spring.

The reasons for the striking differences in flow characteristics between these two types of springs are under investigation. Although both types of springs are usually less than a half mile apart and subject to the same precipitation and climatic variables, the factors responsible for their difference in behavior are unknown. Further investigation will help determine whether manipulation of vegetative cover can modify the contribution of these two types of springs to the total water resources of the area.

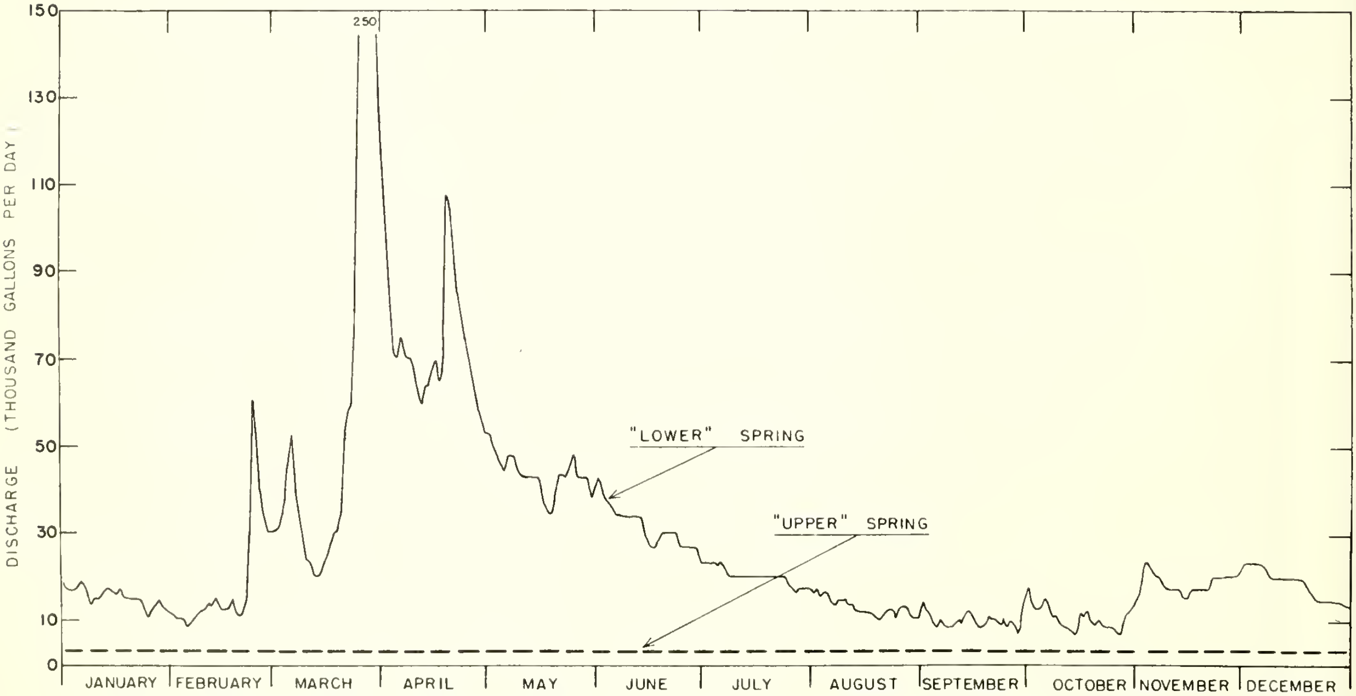

FIGURE 2. — Hydrograph of daily discharge for an upper and a lower spring on the Coulee Experimental Forest, 1961.

January 1963

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Research Forester
(Watershed Management)

U. S. FOREST SERVICE

RESEARCH NOTE LS-2

LAKE STATES FOREST EXPERIMENT STATION • U. S. DEPARTMENT OF AGRICULTURE

Visitor Reaction to Timber Harvesting in the Boundary Waters Canoe Area

Robert Marshall, for whom the Bob Marshall Wilderness Area of Montana is named, contributed much to the development of the National Forest Wilderness Areas, particularly the shift to more stringent controls on commodity uses (logging, grazing, water power). It is often forgotten that he also proposed areas where recreational trips under primitive conditions would be possible, but where some logging and other uses would be allowed.[1] In fact, he called this type "wilderness areas" and the more restricted areas "primeval areas."

The Boundary Waters Canoe Area of the Superior National Forest is the only National Forest location managed as a "wilderness area" in Marshall's terms. About two-thirds of it is available for logging under restrictions designed to maintain primitive travel conditions (fig. 1). The 1930 Shipstead-Newton-Nolan Law prohibited logging generally in a zone 400 feet back from navigable water-bodies and near portages. This restriction was extended by the Forest Service to include a no-cut zone along the Canadian border (fig. 1), and the uncut strips were extended where topography would expose logging to canoeists and boaters.[2] Under this plan of management a number of timber cutting operations are now under way in the Canoe Area. Adjoining Quetico Park in Canada has similar regulations, but lacks a no-cut zone. However, primarily because of remoteness from markets, only one small area is being cut now.

Some measure of the effectiveness of this unique policy can be obtained from sample interviews conducted with visitors in 1960 and 1961. As a part of a broad study of recreational use of the canoe country in relation to its capacity, over 200 groups visiting the study area (fig. 1) were interviewed at length.[3] One question concerned observation of logging and the reaction to it. Some of those interviewed had travelled through areas where timber was being cut or had been cut recently, but others had visited only areas of virgin timber or turn-of-the century logging. Thus, table 1 presents a cross-section of the visitors' reaction to the effects of the timber-cutting policy in the study area, rather than a direct test of the effectiveness of a screen of uncut timber. Almost all of these people had visited the Boundary Waters Canoe Area, except for the auto campers, about 40 percent of whom only used fringe areas.

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[1] *Marshall, Robert. The forest for recreation. In A National Plan For American Forestry, Senate Document No. 12, Separate, No. 6, pp. 473-476. 1933.*

[2] *Superior National Forest. Plan of management, Superior Roadless Areas, pp. 14-15. 1948. (Processed.)*

[3] *The entire Boundary Waters Canoe Area was sampled during the main summer season.*

[4] *Several Forest Service pamphlets describe the logging policy, but the recreation map-folder does not specifically mention it.*

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TABLE 1. — *Visitors' reactions to logging*

Type of recreationist	Not noticed	Noticed, not bothered	Noticed, bothered
Canoeists	71 (92%)	3 (4%)	3 (4%)
Auto campers	56 (74%)	16 (21%)	4 (5%)
Boat campers	17 (81%)	2 (10%)	2 (10%)
Resort guests	42 (86%)	5 (10%)	2 (4%)
Private-cabin users	12 (75%)	3 (19%)	1 (6%)
Day-users	4 (57%)	2 (29%)	1 (14%)
Total	202 (82%)	31 (13%)	13 (5%)

NOTE: Because of rounding, all rows do not total 100 percent.

Very few groups thought they had observed logging (28 percent thought logging in the Boundary Waters Canoe Area was prohibited, and 42 percent did not know what the policy was).[4] Canoeists, who covered more of the area, reported the fewest observations. The explanation for this probably lies in the low local relief and the almost complete concentration of travel on water routes (conditions that are absent in western mountain wilderness, wild, and primitive areas). Two canoeist groups had heard chain saws south of Lake Insula, rather than seen logging, indicating that uncut shoreline strips do not completely eliminate the awareness of active logging.

Even when groups thought they had observed logging, only about 30 percent objected to it.

It should be pointed out that these responses were tabulated at face value, and they contained considerable respondent error. Some people did not understand the terms "logging," or "timber cutting." When this was apparent to the interviewer, a definition was given, but some people probably still applied the concepts to such things as cutting wood for campfires. More important, the question related to the Boundary Waters Canoe Area and the closely related periphery. Therefore, some "observations" may have been based upon logging trucks seen on roads and so on. This seems particularly true for visitors other than canoeists, who tended to ignore the periphery in their replies (another reason for the lower observation rate for canoeists). Probably considerably less than 18 percent of those interviewed actually observed logging in the Canoe Area.

It might be argued that the observation rate is low because only a few areas are being logged now, but this will probably always be true; and areas where cutting is finished will seldom be seen or recognized as unnatural after a few years. Furthermore the heaviest recreational use is in the no-cut zone. Conflicts between different types of recreation may be a more serious problem than conflicts between recreation and other uses. That problem will be considered later in another paper.

January 1963

ROBERT C. LUCAS,
Research Social Scientist

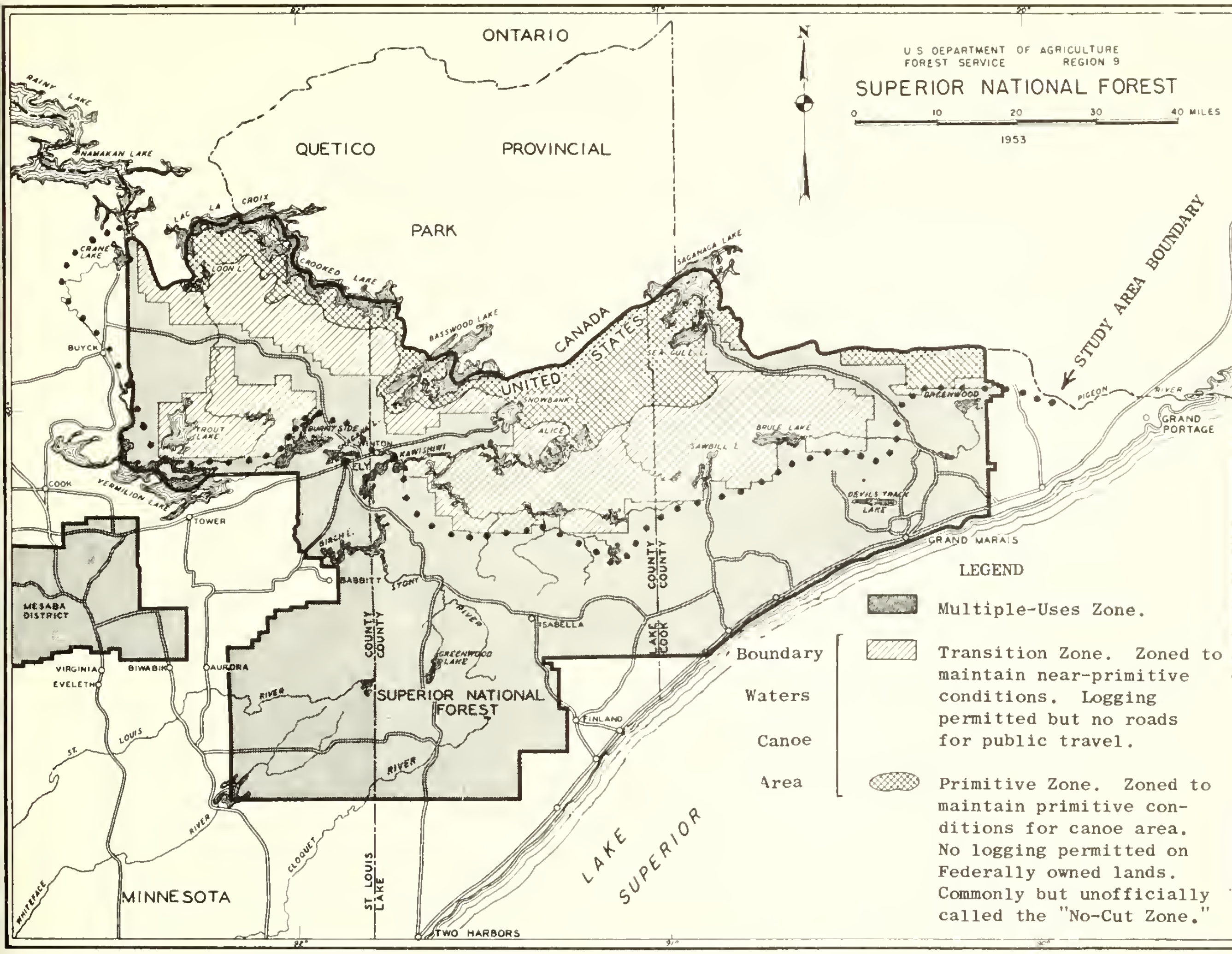

FIGURE 1. — Land use zoning on the Superior National Forest.

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U. S. FOREST SERVICE

RESEARCH NOTE LS-3

LAKE STATES FOREST EXPERIMENT STATION • U. S. DEPARTMENT OF AGRICULTURE

Device for Automatically Starting a Recording Rain Gage When Rainfall Begins[1]

Throughout the United States, many recording rain gages are used for measuring precipitation. Most of these gages are equipped with 8-day clocks which must be wound at weekly intervals, regardless of whether or not a storm has occurred. During the year there may be a number of weekly periods with no precipitation.

The device described in this paper causes a recording rain gage to operate only when precipitation begins. The clock must be rewound and the chart changed only after a period of precipitation. Thus, many routine weekly visits to the gage are eliminated.

The automatic starter holds a fully wound clock in a stopped position. It releases the pressure when triggered by precipitation. The same basic principle has proved satisfactory when employed on FW-1 water level recorders.[2] Only those time scales for use on the "daily" clock shaft can be applied. Tests have shown that back pressure on gears placed on the "weekly" shaft will not stop the clock.

Less than 0.01 inch of water is necessary to start the recording mechanism. The initial precipitation goes through the funnel opening into a small reservoir. Weight of the water in the reservoir is sufficient to close a switch. Current is supplied to a solenoid and the plunger retracts, triggering a spring-loaded clock retainer, and releasing a second switch actuator. The clock starts ticking and the power circuit is broken.

Figure 1 shows the position and mounting of the hinged-leaf actuator switch. An extension of the leaf actuator consists of a 5-inch piece of 14-gauge copper wire soldered to the switch leaf. The leaf with extension must be shaped so that a small reservoir (1-inch section from the end of a plastic toothbrush case) placed on the free end will be directly under the funnel. The actuator leaf must not touch the bucket or funnel when the gage is "set." The switch is mounted in a spring clip holder and can be removed from the holder when removing or replacing the bucket. Wires should be long enough to permit this.

The solenoid and switch arrangement can be seen in figures 2 and 3. A 6-volt D.C. continuous-duty solenoid is used. To prevent possible damage to the solenoid through overheating and to conserve battery power, a microswitch is mounted on an L-shaped bracket with the solenoid in such a way that the energized solenoid, upon retraction, will break the circuit. When "set," a small threaded pin mounted in the plunger of the solenoid holds the microswitch leaf in the depressed position to keep the circuit closed at this point (fig. 3). Upon closing of upper switch, current is supplied to the solenoid; the plunger retracts, triggers the clock retainer, and releases the switch to break the circuit (fig. 2).

The purpose of the clock retainer assembly is to apply back pressure on the clock. The retainer is spring-loaded in the "set" position and requires very little force to trigger it. Tests using the solenoid plunger as a retainer did not prove to be satisfactory; back

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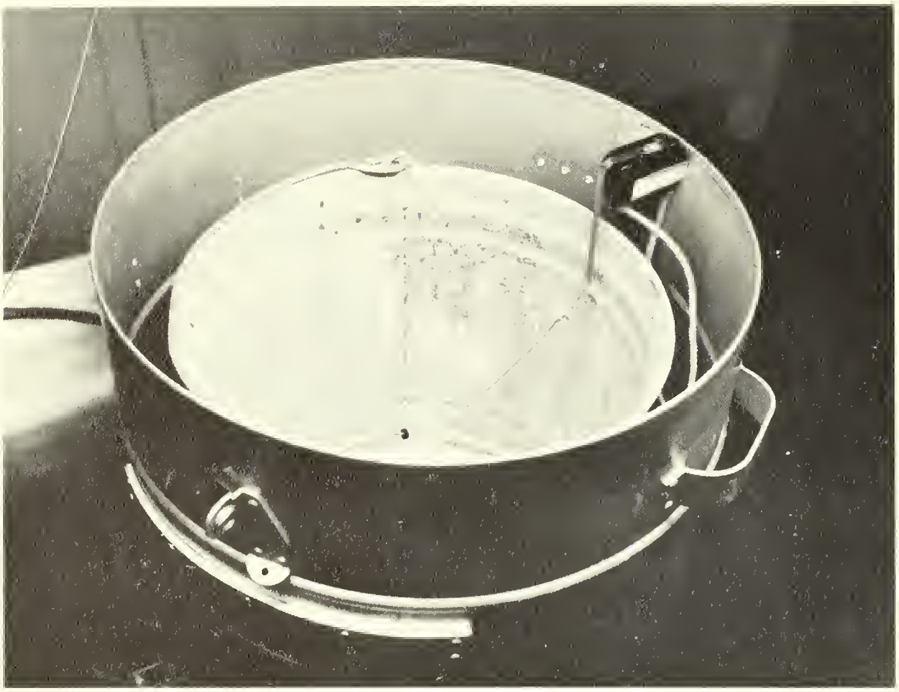
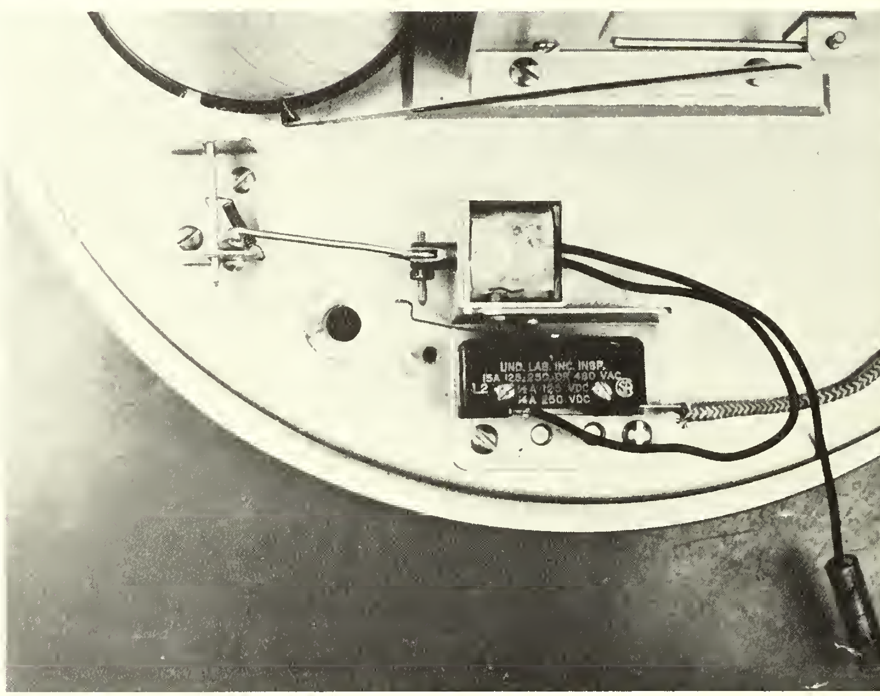
[1] *Reported by the Station's field headquarters in La Crosse, Wis., where research is conducted in cooperation with the Wisconsin Conservation Department.*

[2] *Curtis, Willie R. An automatic trigger device for use on FW-1 water level recorders. Jour. Forestry 58: 819-821, illus. 1960.*



F-501906
FIGURE 1. — Hinged-leaf actuator switch. The switch can be purchased with a 6-inch leaf actuator. A 5-inch extension is necessary. Note bends in actuator. Approximate side-to-side scale in photograph is: ½″ = 3 inches.



F-501904
FIGURE 2. — Solenoid switch assembly and the clock retainer in "triggered" position. Note notch in chart cylinder rim and threaded pin in solenoid plunger. This pin is used to activate the switch which breaks the power circuit when the device is triggered.

pressure on the clock was greater than the force exerted by the energized solenoid.

A 6-volt lantern battery is used for the power supply. There is plenty of room for the battery behind the recorder mechanism.

The switches used are so constructed that they can be wired in either normally open or normally closed circuits. It is important that both switches be wired to the normally open lugs.

The device is independent of the recording mechanism and can be "reset" without emptying the bucket. Loss of weight through evaporation from the gage does not affect the release mechanism. For recording precipitation as snowfall the bucket may be "charged" with an antifreeze solution. The reservoir on the upper switch is replaced by a piece of thin metal plate. When enough snow accumulates on the plate, the switch will be closed.

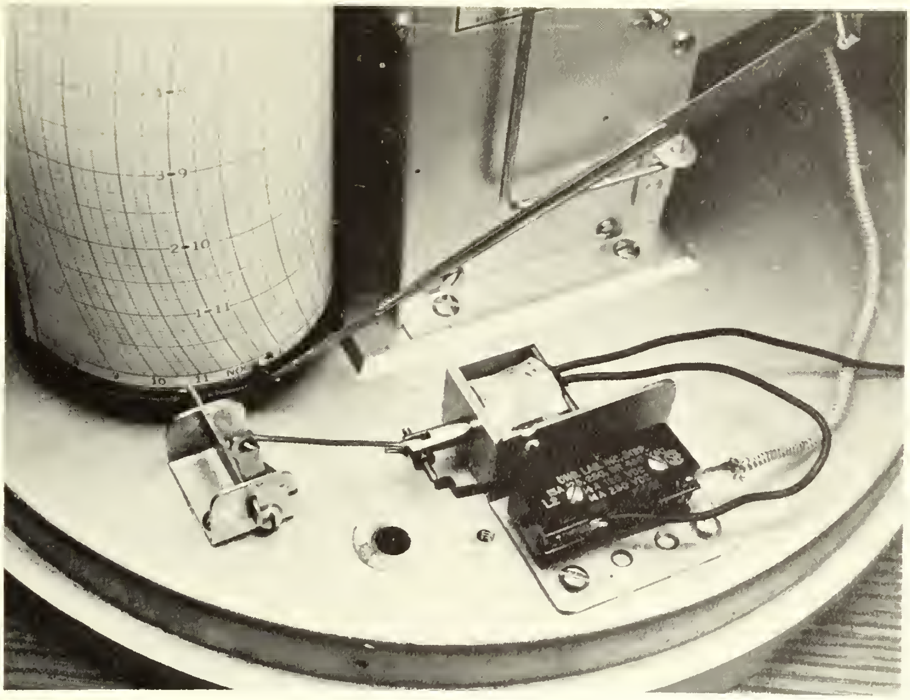


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FIGURE 3. — Device in "set" position. Spring-loaded clock retainer lever is held in notch by trigger. This trigger is attached to the solenoid plunger with 14-gauge copper wire. Pin in plunger holds switch leaf depressed, keeping the circuit closed until triggering takes place.

The device described and illustrated here was designed and constructed specifically for the model 775C gage (Belfort Instruments Corporation), but with slight modification it can be used on any float- or weighing-type of recording precipitation gage.

In computing records from the automatically started gages, it is necessary to figure time and date of storm from the end rather than from the beginning of the chart. This is only a slight inconvenience. The ink supply in the regular bucket-type pens is sufficient for periods of 2 months or longer when no precipitation occurs. Since the pen must be placed against the chart when the gage is "set," there is a continuous movement of ink from the pen to the chart. This often causes a blot on the chart, but it is not necessarily a disadvantage.

The device may be made sensitive to lesser amounts of initial rainfall by adding a few lead sinkers to the reservoir to overcome a portion of the resistance.

The mounting brackets used were fabricated from pieces of rustproof metals. The solenoid was purchased from Allied Electronics in Chicago but may also be available from other sources. Most electronics supply stores carry a full line of microswitches.[3] The parts numbers used were:

Solenoid	76PO95	6V D.C.
Top switch	BZ-2RW863	Microswitch
Bottom switch	BZ-2RL	Microswitch

However, a roller-leaf actuator on the bottom switch would eliminate the need for bending the leaf as was done here. The roller-leaf actuator switch number is BZ-2RL2.

[3] *Manufactured by Micro Switch Division of Minneapolis-Honeywell Regulator Company, Freeport, Illinois.*

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U. S. FOREST SERVICE

RESEARCH NOTE LS-4

KE STATES FOREST EXPERIMENT STATION · U. S. DEPARTMENT OF AGRICULTURE

Lake States Wood-Product Imports and Exports Via the St. Lawrence Seaway

A brief study of overseas imports and exports of wood products was made by the Station's marketing research project in Duluth to find out what influence the expanded St. Lawrence Seaway might have had for the Lake States area. Data were assembled for Minnesota, Wisconsin, and Michigan ports engaged in overseas commerce for the years 1957 to 1961. The Seaway was opened to deep-draft ocean vessels in the early spring of 1959. In that year, largely due to heavy imports of woodpulp, the total tonnage of wood and paper products that moved through the Seaway increased tremendously. This total volume has since decreased, although not to pre-1959 levels (table 1).

The significance of the large woodpulp shipments in 1959 is not clearly understood; they were, however, general throughout the area with several ports showing substantial increases. Woodpulp has for many years been an important import commodity, ranking fourth in total tonnage and dollar value for Lake States ports. However, sizable fluctuations have taken place from one year to the next and no definite trend is indicated. Because of this characteristic plus the fact that woodpulp represents such a large portion of the total overseas trade, the rather steady upward trends for relatively minor import items such as paper and paper manufactures, plywood and veneers, and wood manufactures are obscured when only total tonnage for all commodities is observed. The relationship of woodpulp imports to total import-export tonnage of the Lake States in percentage is as follows: 1957--97, 1958--85, 1959--94, 1960--63, and 1961--78. Lake States woodpulp imports have amounted to approximately 10 percent of the total U. S. woodpulp imports each year for the years studied.

Although imports have dominated the overseas wood commerce in these three States, the proportion of exports has shown a mild increase in the sixties. Imports, which accounted for more than 98 percent of the total overseas wood product traffic via the Seaway from 1957 to 1959, dropped to 73 percent in 1960, then rose to 94 percent in 1961. The big increase in exports in 1960 appears to be due primarily to one large shipment of lumber; however, in both 1960 and 1961 increases were recorded in nearly every category.

Wood and paper commodities involved in overseas commerce at Lake States ports are listed under several categories, some of which require explanation (table 1). Paper Base Stocks, N.E.C. (not elsewhere classified), includes pulp made from reclaimed papers or fibers other than wood. Paper and Manufactures, N.E.C., covers all fine and coarse papers, tissues, and boards, including hardboards, but excludes newsprint. Wood, Unmanufactured, N.E.C., includes such items as brierwood, caning, and Christmas trees. Lumber and Shingles includes flooring, furniture stock, and blanks for handles, bats, and skis. Wood Manufactures, N.E.C., takes in such things as millwork, prefabricated structural shapes, and furniture.

Ten Lake States ports have had wood-product foreign commerce traffic during these 5 years — one in Minnesota, three in Wisconsin, and six in Michigan. Those ac-

TABLE 1. — *Lake States overseas imports and exports of wood products via the Great Lakes-St. Lawrence Seaway, 1957-1961*[1]
(Thousand short tons)

Year	Minnesota		Wisconsin		Michigan		Total[2]	
	Imp.	Exp.	Imp.	Exp.	Imp.	Exp.	Imp.	Exp.
ALL WOOD AND PAPER PRODUCTS								
1957	2.7	..	8.7	0.1	16.0	*	27.3	0.2
1958	3.8	..	0.5	0.2	22.5	0.2	26.8	0.5
1959	*	..	31.4	0.6	44.2	0.3	75.6	1.0
1960	2.2	*	13.0	13.5	21.6	0.1	36.8	13.6
1961	*	*	14.5	1.2	19.4	0.8	33.9	2.0
WOODPULP								
1957	2.7	..	8.7	..	15.4	..	26.7	..
1958	3.8	..	..	..	19.4	0.2	23.2	0.2
1959	..	..	30.7	..	41.1	..	71.8	..
1960	2.2	..	12.0	*	17.7	..	31.9	*
1961	..	..	13.0	..	15.1	..	28.1	..
PAPER BASE STOCK, N.E.C.[3]								
1957	..	..	..	..	..	..	..	..
1958	..	..	..	..	..	..	..	..
1959	..	..	..	..	0.1	..	0.1	..
1960	..	..	..	..	..	..	..	..
1961	..	..	..	..	..	0.5	..	0.5
PAPER AND MANUFACTURES, N.E.C.[3]								
1957	..	..	*	0.1	0.5	*	0.6	0.1
1958	*	..	0.5	*	1.4	0.1	1.9	0.1
1959	..	..	0.3	0.3	2.4	0.2	2.7	0.5
1960	..	*	0.3	3.8	2.3	0.1	2.7	3.9
1961	*	*	0.5	0.7	2.0	0.1	2.6	0.8
TOTAL ALL PULP AND PAPER PRODUCTS								
1957	2.7	..	8.7	0.1	15.9	*	27.3	0.1
1958	3.8	..	0.5	*	20.8	0.2	25.1	0.3
1959	..	..	31.0	0.3	43.6	0.2	74.6	0.5
1960	2.2	*	12.3	3.8	20.0	0.1	34.6	3.9
1961	*	..	13.5	0.7	17.1	0.6	30.7	1.3

Year	Minnesota		Wisconsin		Michigan		Total[2]	
	Imp.	Exp.	Imp.	Exp.	Imp.	Exp.	Imp.	Exp.
LOGS								
1957	..	..	..	..	..	..	..	..
1958	..	..	..	..	..	..	..	..
1959	..	..	*	0.2	..	*	*	0.2
1960	..	..	..	0.5	*	*	*	0.5
1961	..	..	..	0.3	..	0.1	..	0.4
WOOD, UNMANUFACTURED, N.E.C.[3]								
1960	..	..	..	..	*	..	*	..
1961	..	..	..	*	*	..	*	*
LUMBER AND SHINGLES								
1957	..	..	..	*	..	..	..	..
1958	..	..	..	0.2	1.3	..	1.3	0.2
1959	..	..	..	0.1	*	*	*	0.2
1960	..	*	0.5	9.1	0.1	*	0.6	9.2
1961	..	*	0.4	0.2	0.8	*	1.2	0.2
PLYWOOD, VENEER AND COOPERAGE								
1957	..	..	..	..	..	..	..	..
1958	..	..	*	..	0.2	..	0.3	..
1959	..	..	0.2	*	0.4	..	0.6	*
1960	..	..	*	*	1.3	*	1.4	*
1961	..	..	0.5	*	1.2	*	1.7	*
WOOD MANUFACTURES, N.E.C.[3]								
1957	..	..	*	*	0.1	*	0.1	*
1958	..	..	*	*	0.1	..	0.2	*
1959	*	..	0.1	*	0.2	*	0.3	*
1960	*	..	*	*	0.2	*	0.2	0.1
1961	*	..	0.1	*	0.3	*	0.4	0.1
TOTAL ALL WOOD PRODUCTS								
1957	..	..	*	*	0.1	*	0.1	*
1958	..	..	0.1	0.2	1.7	..	1.8	0.2
1959	*	..	0.4	0.3	0.6	0.1	1.0	0.4
1960	*	*	0.6	9.7	1.6	0.1	2.2	9.7
1961	*	*	1.0	0.6	2.3	0.1	3.3	0.7

[1] *Source: Waterborne Commerce of The United States, Part III, Waterways and Harbors of the Great Lakes, U. S. Army Corps of Engineers, 1962. Data do not include trade with Canada.*

[2] *Totals may not add because of individual rounding.*

[3] *Not elsewhere classified.*

* *Less than 50 tons.*

counting for the bulk of the trade are Duluth, Minn.; Milwaukee and Green Bay, Wis.; Detroit, Port Huron, Muskegon, and South Haven, Mich. Michigan and Wisconsin share the major portion, with Minnesota playing a very minor role.

From available records, the opening of the St. Lawrence Seaway apparently produced no immediate and drastic change in overseas trade in wood products through Lake States ports. Overseas shipping is influenced by many complex factors, including trends in international distribution of production and consumption, tariff systems, and favorable conditions for world trade. However, expanded opportunities for Lake States wood products in overseas markets cannot be summarily ruled out, and the Station marketing research staff plans investigations into such possibilities.

January 1963

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Research Forester

U. S. FOREST SERVICE

RESEARCH NOTE LS-5

KE STATES FOREST EXPERIMENT STATION • U. S. DEPARTMENT OF AGRICULTURE

Frost Damage to Red Pine Conelets

During a study of seed and cone insects attacking red pine in northern Wisconsin in 1962, extensive conelet mortality was observed in an otherwise healthy, 25-year-old plantation. Careful dissections ruled out insects and diseases as possible causes. Although it is known that lack of pollination will result in similar mortality,[1] this, too, was ruled out because of the peculiar stratification of the dead conelets. Below a certain level in the crown, all the conelets were dead; above that level, all were alive.

A check of the literature revealed observations of Scotch pine conelets killed by low temperature during the pollination period.[1] Weather records in northern Wisconsin showed that freezing temperatures had occurred in the study area in early June. The stage of development of the dead conelets showed that they had died about that time. It seemed probable that these temperatures were the cause of mortality.

To test this hypothesis further, measurements of the crown level separating live and dead conelets were made on trees growing in a depression and on an adjacent slope within the plantation. To facilitate these measurements, a base point with a hypothetical elevation of 0.0 feet was established in the plantation, and base elevations of 33 sample trees in a 5-acre, rectangular area were determined by leveling. The margin of error in the tree-base elevations is approximately 1 foot. The total height and the height of dead conelets were measured for each tree and converted to elevation.

The data were plotted and regression lines fitted to show a profile of the stand and conelet mortality (fig. 1). Although tree-top and tree-base elevations are nearly parallel, the line separating live and dead conelets is roughly horizontal. Nearly all of the conelets were killed in trees located on low ground, whereas trees located on high ground suffered conelet mortality only in the lower half of the crowns. This pattern is characteristic for frost damage. The low temperature had no apparent effect on the vegetative growth of the trees.

Thus, circumstantial evidence is very strong that young trees may exhibit a significant amount of cone mortality due to late spring frosts. This may be an important consideration in the establishment of seed orchards. Specifically, trees planted in depressions may not produce seed as early as trees on higher ground.

[1] *Sarvas, Risto. Investigations on the flowering and seed crops of Pinus silvestris. Helsinki, Finland. 1962.*

January 1963

JOHN S. HARD
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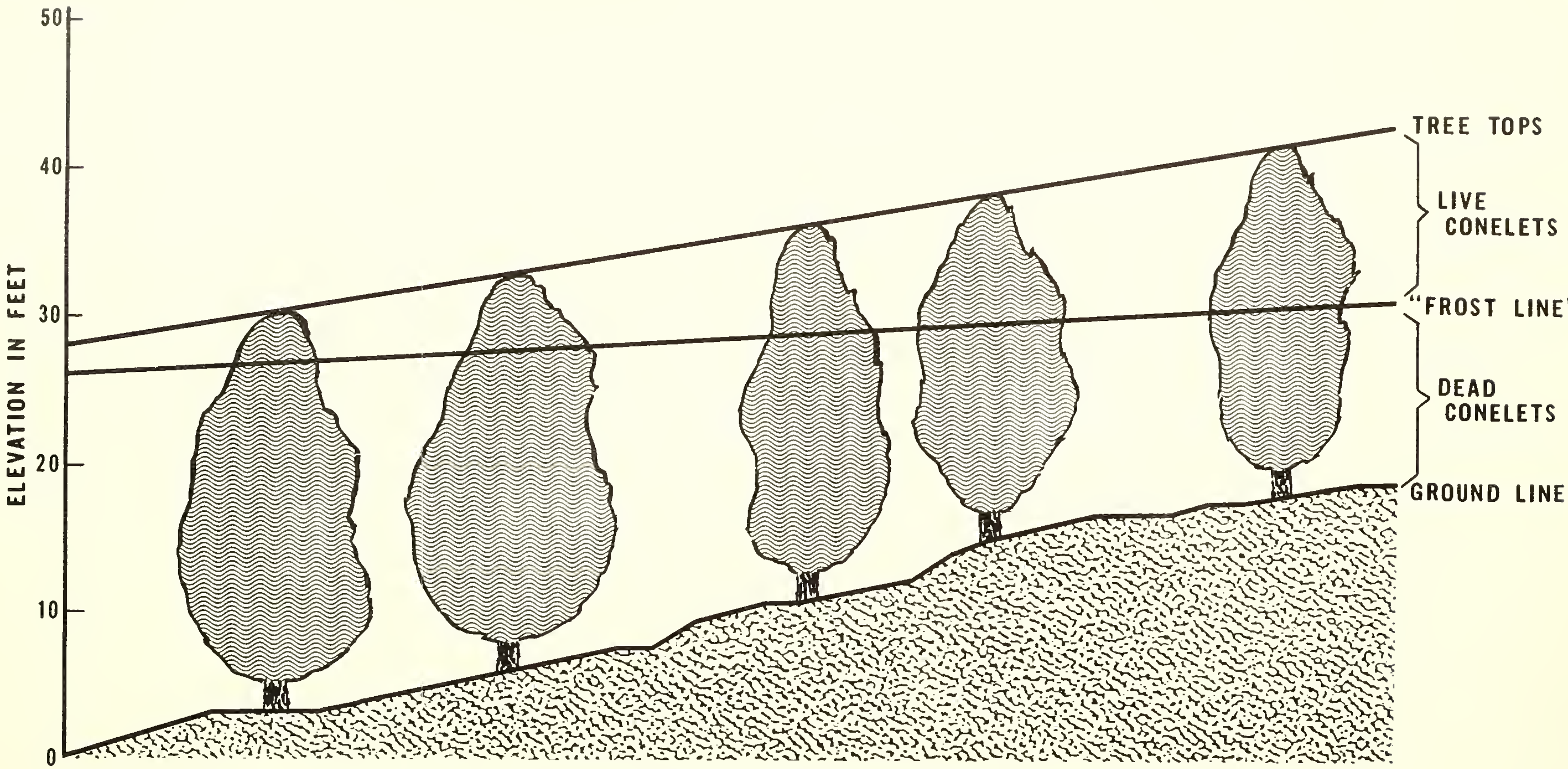

FIGURE 1. — A profile of conelet mortality caused by frost damage to 33 sample red pine trees. Conelets above the "frost line" were living; below it they were dead.

U. S. FOREST SERVICE

RESEARCH NOTE LS-6

KE STATES FOREST EXPERIMENT STATION • U. S. DEPARTMENT OF AGRICULTURE

Labor Potential for Expanding Forest Industries in Northeastern Minnesota, Oct. 1962

Expansion of forest industries has frequently been advanced as a partial remedy for chronic unemployment in northeastern Minnesota. One factor that would influence increased output of forest products is the characteristics of the potential employable labor resource. Plant expansion and location decisions require a knowledge of the qualities as well as the numbers of potential employees.

As a first step in assessing the surplus labor available, the Station's marketing research office in Duluth, in cooperation with the Minnesota Department of Employment Security, made an inventory of active job applications on file in October 1962, for five counties: Pine, Carlton, St. Louis, Lake, and Cook. Those seeking permanent employment were counted and classified by age, skills, and educational levels. A summary of the findings is shown in the accompanying table.

Of the 4,764 persons who were registered and seeking permanent employment through the Minnesota State Employment Offices, one-half resided in the Duluth area and more than 85 percent lived in St. Louis County. Those seeking temporary or part-time employment and others not registered in Minnesota State Employment Offices were not enumerated. However, it is estimated that 80 percent or more of the available unemployed labor force is included in the analysis.

More than two-fifths of the jobless are under 35 years old. Five percent fall in the professional, technical, and managerial categories; 18 percent are skilled laborers; and another 17 percent are in the clerical and sales field. The remaining 60 percent are in the service, semiskilled, and unskilled categories. More than 40 percent have high school diplomas or college training.

As indicated in the graph below, unemployment fluctuates seasonally, generally reaching a low point in September or October and a peak during the winter or early spring months. In effect, the October canvass includes in part the "hard core" unemployed who are likely the least skilled. It is possible that a study of the unemployed made later on would show an even higher proportion of skilled and educated labor. Another inventory may be taken during the winter to assess background composition during a seasonal peak of unemployment. A more complete report is planned for publication later, showing detailed skill breakdowns.

January 1963

JAMES E. BLYTH, Research Forester
Lake States Forest Experiment Station
GLENN O. GRONSETH, Research Analyst
Minnesota Department of Employment Security

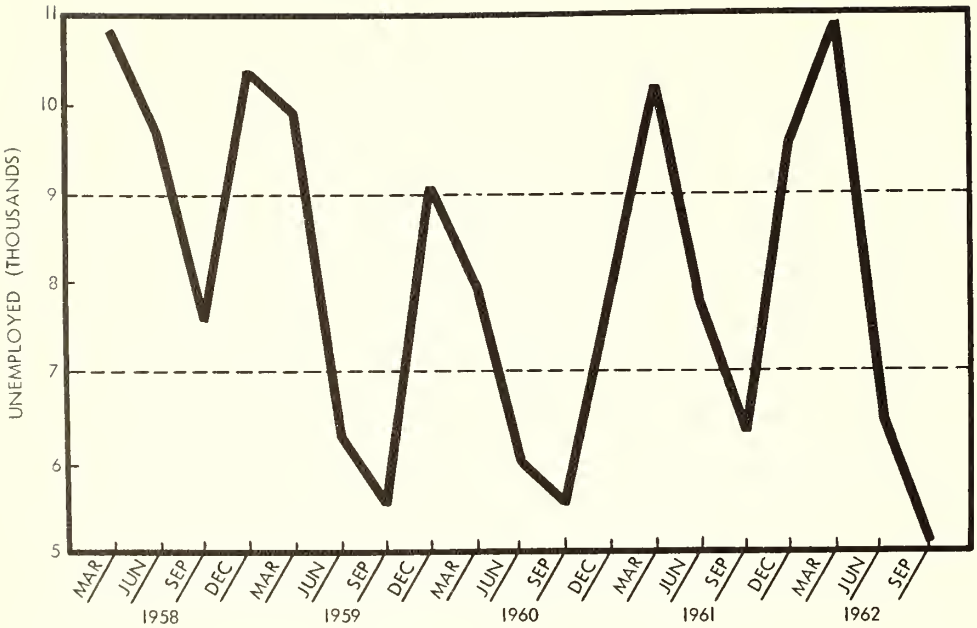

FIGURE 1. — Quarterly unemployment trends in St. Louis County including Duluth, 1958-62. St. Louis County contains 79 percent of the labor force in northeastern Minnesota (Pine, Carlton, St. Louis, Lake, and Cook Counties), 1960 Census of Agriculture.

Distribution of skills, age classes, and educational levels among the unemployed labor resource in northeast Minnesota[1], October 1962
(Percent of total)

Occupational group and educational level	Age class (years)										Total
	Under 21		21-34		35-44		45-64		65 & over		
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	
Prof., tech., & man.[2]											
Under high school	..	..	.1	..	..	*	.3	.1	.1	..	.6
High school grad.	.2	.1	.6	.1	.4	.1	.5	.2	*	..	2.2
2+ yrs. in college	..	..	.2	*	.1	..	.1	.1	..	..	.5
College grad.	..	..	.8	.1	.3	.1	.1	*	.1	..	1.5
Total	.2	.1	1.7	.2	.8	.2	1.0	.4	.2	..	4.8
Clerical & sales											
Under high school	.1	.3	.2	.5	.1	.4	.6	1.2	.1	.2	3.7
High school grad.	.4	2.4	1.5	3.3	.6	1.4	.5	1.9	*	..	12.0
2+ yrs. in college	*	*	.5	.2	.1	.1	.2	.3	..	*	1.4
College grad.	..	..	*	.1	.1	..	..	.1	..	..	.3
Total	.5	2.7	2.2	4.1	.9	1.9	1.3	3.5	.1	.2	17.4
Service											
Under high school	.2	.8	.5	.6	.3	.8	1.3	2.6	.8	.3	8.2
High school grad.	.2	.8	.2	.7	..	.6	.1	.5	*	..	3.1
2+ yrs. in college	..	..	*	*	..	..	.1	.1	..	..	.2
College grad.	..	..	..	..	..	*	..	..	..	..	*
Total	.4	1.6	.7	1.3	.3	1.4	1.5	3.2	.8	.3	11.5
Skilled labor											
Under high school	.1	..	1.5	.1	2.0	.1	6.8	.1	1.0	.1	11.8
High school grad.	.6	..	2.5	*	1.3	.1	1.4	.2	.1	..	6.2
2+ yrs. in college	*	..	.1	..	.2	*	.1	..	*	..	.4
College grad.	..	..	..	..	..	..	..	..	..	..	..
Total	.7	..	4.1	.1	3.5	.2	8.3	.3	1.1	.1	18.4
Semi-skilled labor											
Under high school	1.7	.2	3.5	.3	2.6	.5	5.4	.9	.6	*	15.7
High school grad.	1.5	.1	3.4	.3	1.1	.6	.8	.3	*	..	8.1
2+ yrs. in college	*	..	.1	..	.1	.1	*	*	..	..	.3
College grad.	..	..	.1	..	..	..	*	..	..	..	.1
Total	3.2	.3	7.1	.6	3.8	1.2	6.2	1.2	.6	*	24.2
Unskilled labor											
Under high school	.7	.1	4.4	.6	2.5	.4	7.1	1.0	.9	.1	17.8
High school grad.	.9	.1	2.4	.3	.8	.3	.4	.2	*	*	5.4
2+ yrs. in college	*	..	.2	..	.1	..	.1	..	..	..	.4
College grad.	..	..	.1	..	*	..	*	..	..	..	.1
Total	1.6	.2	7.1	.9	3.4	.7	7.6	1.2	.9	.1	23.7
All occupations											
Under high school	2.8	1.4	10.2	2.1	7.5	2.2	21.5	5.9	3.5	.7	57.8
High school grad.	3.8	3.5	10.6	4.7	4.2	3.1	3.7	3.3	.1	*	37.0
2+ yrs. in college	*	*	1.1	.2	.6	.2	.6	.5	*	*	3.2
College grad.	..	..	1.0	.2	.4	.1	.1	.1	.1	..	2.0
Total	6.6	4.9	22.9	7.2	12.7	5.6	25.9	9.8	3.7	.7	100.0

[1] *Includes all individuals seeking permanent employment through State Employment Offices in 5 counties — Pine, Carlton, St. Louis, Lake, and Cook.*
[2] *Professional, Technical, and Managerial.*
* *Less than .05 percent.*

U. S. FOREST SERVICE

RESEARCH NOTE LS-7

KE STATES FOREST EXPERIMENT STATION · U. S. DEPARTMENT OF AGRICULTURE

Natural Mortality of the Zimmerman Pine Moth in Three Michigan Plantations

The Zimmerman pine moth (*Dioryctria zimmermani* Grote) is an important pest of Scotch and red pine plantations in Michigan. Knowledge of population dynamics is essential before the most efficient control methods can be developed. In 1960 and 1961, data were collected on the degree and causes of natural mortality of larvae and pupae on one Scotch pine and two red pine plantations in Saginaw and Ottawa Counties, Mich.

In this area the insect has a 1-year life cycle, according to observations by Carlson[1] and the present author. The eggs are laid during August in bark crevices. The larvae hatch in late August and early September, then spin silken hibernacula under bark scales for overwintering. The next spring and summer, they feed in the cambium area, pupate in July and August, and transform to adults within 2 or 3 weeks after pupation. The tips and trunks of pine trees are damaged.

The plantations studied were spaced at 6x6 feet and were 8 years old with trees varying from 5 to 8 feet tall when the observations started. In the early summer of 1960 the shoots and trunks of a group of trees were carefully examined for pitch masses characteristic of Zimmerman pine moth attack.[2] One hundred pitch masses on shoots and 100 on trunks were tagged. They were examined three times during that growing season, and the insects were recorded as living, dead, or missing. At each examination, those pitch masses which did not show fresh pitch or frass were opened. All parasites were collected and reared for identification. The same procedures were followed during the 1961 observations.

Survival was low during the summers of 1960 and 1961 (fig. 1). There were about two active infestation sites per tree in June, whereas in late August there were less than 0.25 per tree — a drop of nearly 90 percent. However, these decreases appeared to have little effect on the population trend because initial 1961 infestations were hardly lower than initial 1960 infestations. Overall mortality of an insect population amounting to 90 percent is not unusual and may even permit an increasing population trend in subsequent generations because of the large reproductive potential of most insects. For the Zimmerman pine moth in the study plantations, 90 percent mortality during the segment of the life cycle studied appears to be near the point of static equilibrium — resulting in unchanged population levels in subsequent generations.

At the low-to-moderate infestation levels in these plantations, no more than one insect usually occurred per pitch mass. In heavy infestations, more than one insect per pitch mass is common.

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1 *Carlson, R. B. The life history and biology of Dioryctria zimmermani Grote (Lepidoptera, Phycitidae) in southern Michigan. M. S. Thesis, 37 pp., Mich. State Univ., East Lansing, Mich.*

2 *Three other species of pine moths in Michigan might be confused with the Zimmerman pine moth. A method of differentiating the damage of these pests is given in Lake States Technical Note 571.*

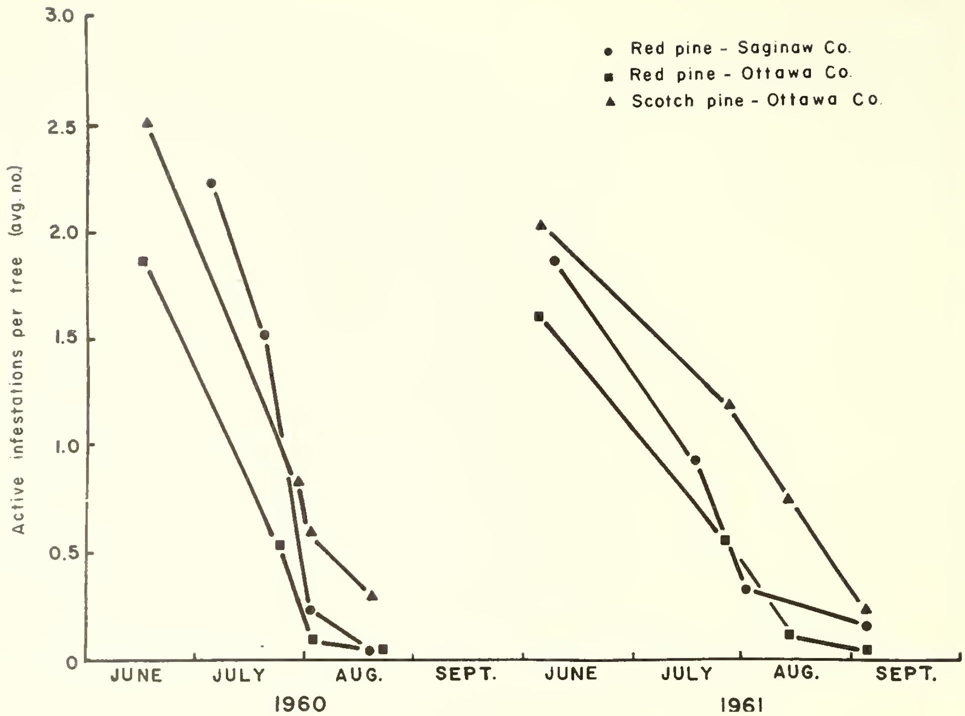

FIGURE 1. — Natural decline of the Zimmerman pine moth in three pine plantations during 1960 and 1961.

The mortality of known causes was due to parasitization. The eulophid wasp *Hyssopus rhyacioniae* (Gah.) destroyed 6 to 14 percent of the larvae in 1960 and 15 to 33 percent in 1961. A tachinid fly, tentatively identified as *Lixophaga* sp., accounted for 2 to 4 percent parasitism in 1960 and 3 to 6 percent in 1961. No diseased larvae were noted.

The large remaining proportion of the decline was due to unknown causes, the larvae and pupae simply disappearing unaccountably. In future studies on the population dynamics of the Zimmerman pine moth, the causes of this extensive presumed mortality should be investigated.

April 1963

ROBERT L. TALERICO[3]
Entomologist
(Plant Pests)

[3] *Data for this study were collected while the author was on the staff of the Lake States Forest Experiment Station. He is now a member of the Forest Pest Control Branch of the Northeastern Region, U.S. Forest Service.*

U. S. FOREST SERVICE

RESEARCH NOTE LS-8

KE STATES FOREST EXPERIMENT STATION • U. S. DEPARTMENT OF AGRICULTURE

1962 Forest Tree Seed Crop Averages Fair in the Lake States

The 1962 forest tree seed crop in general was below that of 1960 but otherwise better than for any other year since 1955, according to observations made at field centers of the Lake States Forest Experiment Station (see table on reverse side). Although one or more species had crop failures in each locality reported upon, crops for most species were fair to good. Compared to 1961, seed production was better in every locality but North Dakota. On the average, production was best in northern Minnesota and diminished steadily to the east.

In northern Minnesota quaking aspen and northern white-cedar produced bumper crops. Most other species had fair to good crops except for eastern white pine and yellow birch (poor) and red pine, bur oak, and northern pin oak (failure).

Fair to good crops prevailed for most species in northeastern Wisconsin, but that of white pine was poor and those of red pine, white ash, and black ash were failures.

In central Upper Michigan all species had fair to good crops except eastern hemlock, sugar maple, yellow birch, and black ash, which had crop failures.

The only conifers to produce fair to good crops in Lower Michigan were jack pine, eastern hemlock, and northern white-cedar. Crops of all others were poor or failures. Many deciduous species also had seed crops that failed or were poor. Exceptions were the aspens, white oak, northern red oak, black oak (in the southern half), shagbark hickory, black walnut, butternut, and black cherry (most of which had good crops) and American elm which had a bumper crop in the south half of the Peninsula (it was poor in the north half).

In north-central North Dakota all species had fair to good seed crops except Siberian elm and green ash (poor) and hackberry and bur oak (failure). This is the fifth successive year that the hackberry seed crop has failed.

Most tree seed collectors are interested chiefly in the pines and spruces. For the pines 1962 generally was poor to fair. For the spruces, it was fair to good except in Lower Michigan (poor). Mast production of value to some wildlife species was generally fair to good, except in some localities of Lower Michigan where it was poor.

PAUL O. RUDOLF
Research Forester
(Forest Management)

April 1963

TABLE 1. — *Forest tree seed crops in the Lake States, 1962*

Species	Estimated percentage of a full crop[1] in —				
	Northern Minnesota	Northeastern Wisconsin	Central Upper Michigan	Lower Peninsula Michigan	North-central North Dakota
Red pine	7	7	50	7	[2] --
Eastern white pine	25	25	50	7	--
Jack pine	50	50	--	50	--
Ponderosa pine	--	--	--	--	75
White spruce	75	50	50	25	--
Black spruce	75	50	75	25	--
Balsam fir	75	75	75	25	--
Eastern hemlock	--	75	7	50	--
Northern white-cedar	95	75	50	75	--
Tamarack	50	--	--	25	--
Sugar maple	50	50	7	7	--
Red maple	--	75	75	25	--
Boxelder	--	--	--	--	50
American beech	--	--	75	7	--
Basswood	75	75	50	25	--
Yellow birch	25	75	7	--	--
Paper birch	75	75	--	25	--
Eastern hophornbeam	--	--	--	25	--
Quaking aspen	95	75	--	75	--
Bigtooth aspen	75	50	--	75	--
Balsam poplar	75	--	--	--	--
American elm	--	75	75	[4]25--[3]95	50
Siberian elm	--	--	--	--	25
Hackberry	--	--	--	--	7
White ash	--	7	--	7	--
Green ash	--	--	--	--	25
Black ash	--	7	7	--	--
Bur oak	7	--	--	--	7
White oak	--	--	--	[3]50--[4]75	--
Black oak	--	--	--	[4]25--[3]75	--
Northern pin oak	7	--	--	25	--
Northern red oak	50	50	75	[4]50--[3]75	--
Shagbark hickory	--	--	--	75	--
Black walnut	--	--	--	75	--
Butternut	--	--	--	75	--
Black cherry	--	--	--	50	--
Chokecherry	--	--	--	--	75
American plum	--	--	--	--	50
Russian-olive	--	--	--	--	75
Caragana	--	--	--	--	50

[1] *Percentage of a full crop classified as 0-15, failure; 16-35, poor; 36-60, fair; 61-90, good; and 91-100, bumper.*

[2] *A dash (--) signifies no report on this species.*

[3] *Southern half of Lower Peninsula.*

[4] *Northern half of Lower Peninsula.*

U. S. FOREST SERVICE

RESEARCH NOTE LS-9

AKE STATES FOREST EXPERIMENT STATION • U. S. DEPARTMENT OF AGRICULTURE

Organic Matter Important in Field Analysis of Soil Texture

Practicing foresters occasionally conduct textural analysis of soils in the field by quick-test methods. While satisfactory results are obtained under many soil conditions by these methods, the forester should continually be alert to variables that influence the accuracy of the determination.

The effect of organic matter in preventing complete dispersion of the soil sample has been well documented by several investigators.[1] Tyner[2] concluded that no method of soils textural analysis is equally suited to all types of soils.

The problem is illustrated by soil samples taken from three fixed depths (0-6 inches, 6-36 inches, 36-72 inches) on 84 plots in established field shelterbelts in the eastern half of North Dakota. Textural analysis of the 252 soil samples was made by the hydrometer (Cenco-Wilde) method.[3] Subsequently textures by the pipette method of Kilmer and Alexander[4] and soil organic matter percent by the method of Walkley and Black[5] were determined on these samples in the soils laboratory at North Dakota State University.

In almost every case the hydrometer method gave lower values for silt-plus-clay content of the samples than did the laboratory analysis employing the pipette method. At the lowest level of organic matter content (0.54 percent) there is a negative difference of 1.8 percent (fig. 1). Progressively greater differences were obtained as the percentage of organic matter in the sample increased (the pipette method showing the higher silt-plus-clay percentage) until a maximum positive difference of 67.6 percent silt-plus-clay was reached where organic matter content was 7.66 percent. Differences in silt-plus-clay

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[1] *Beale, O. W. Dispersion of laterite soils and the effect of organic matter on mechanical analysis. Soil Sci. 43: 475-479. 1939.*

Robinson, G. W. Note on the mechanical analysis of humic soils Jour. Agr. Sci. 12: 287-291. 1922.

Joseph, A. F., and Snow, O. W. The dispersion and mechanical analysis of white heavy alkaline soils. Jour. Agr. Sci. 29: 106-120. 1929.

[2] *Tyner, E. H. The use of sodium metaphosphate for dispersion of soils for mechanical analysis. Soil Sci. Soc. Amer. Proc. (1939) 4: 106-113. 1940.*

[3] *Wilde, S. A., and Voigt, G. K. Analysis of soils and plants for foresters and horticulturists. Ed. 2, 117 pp., illus. 1959. Ann Arbor, Mich.*

[4] *Kilmer, V. J., and Alexander, T. T. Methods of mechanical analysis of soils. Soil Sci. 68: 15-25. 1949.*

[5] *Walkley, A., and Black, I. A. Rapid filtration method of soil organic matter determination. Soil Sci. 37: 29-38. 1934.*

MAINTAINED AT ST. PAUL 1, MINNESOTA, IN COOPERATION WITH THE UNIVERSITY OF MINNESOTA

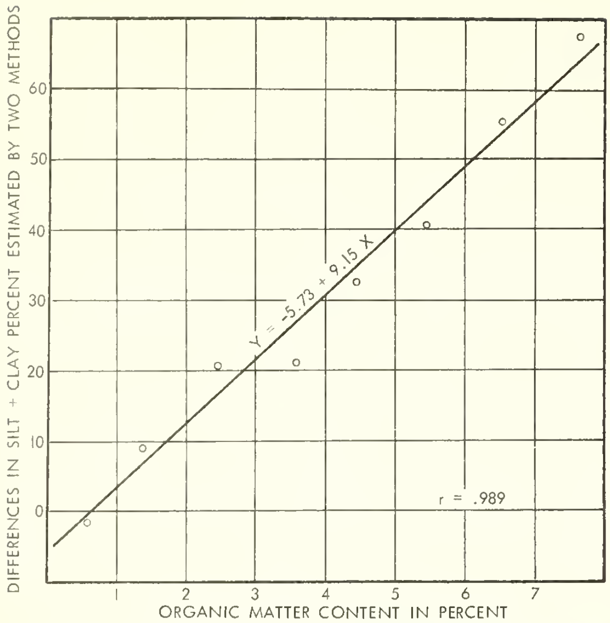


FIGURE 1. — Relationship of organic matter content to differences in silt-plus-clay determinations by two methods of analysis.

content as determined by the two methods are estimated well by a linear function of organic matter, Y = —5.73 +9.15 X.

The effect of an increase in organic matter content on the accuracy of the hydrometer method is shown in table 1 where the data for all plots were averaged for each sampling depth. In the 0-6 and 6-36 inch sampling levels, differences of 34 and 8 percent respectively were obtained in silt-plus-clay determinations by the two methods. In the 36-72 inch sampling depth the difference was less than 1 percent.

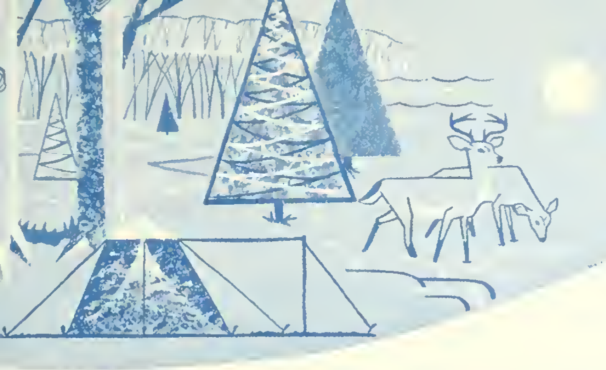
The North Dakota Chernozem soils studied illustrate the pronounced effect that the level of organic matter can have on the accuracy of field analysis. On the other hand, forest soils are generally low in organic matter. However, in some situations, the level of organic matter could contribute to erroneous conclusions.

TABLE 1. — *Mean differences in silt-plus-clay determinations by two methods of analysis as related to depth of sampling*

Sampling depth (inches)	Organic matter content	Silt-plus-clay content		
		Pipette	Hydrometer	Differences
	Percent	*Percent*	*Percent*	*Percent*
0-6	4.59	50.62	16.70	33.92
6-36	1.37	51.43	43.37	8.06
36-72	0.51	51.46	50.87	0.59

April 1963

ALBERT G. CLEGG
Research Forester



U. S. FOREST SERVICE

RESEARCH NOTE LS-10

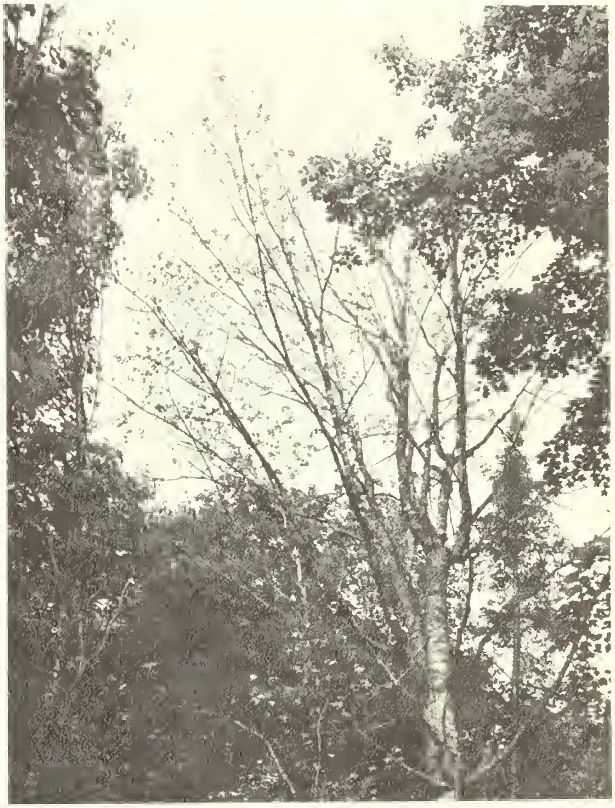
KE STATES FOREST EXPERIMENT STATION • U. S. DEPARTMENT OF AGRICULTURE

Current Status of the Sapstreak Disease of Sugar Maple in the Lake States

The first report of sapstreak in the Lake States was made by Kessler and Anderson in 1960 when they found a single sugar maple (*Acer saccharum* Marsh.) on the Upper Peninsula Experimental Forest in the later stages of the disease and isolated the causal fungus *Ceratocystis coerulescens* (Münch) Bakshi from it.[1] Hepting had described the disease and determined its cause in 1944.[2] At that time its known range was limited to a relatively small area in North Carolina. In 1959, Roth et al. found occasional yellow-poplars (*Liriodendron tulipifera* L.) infected by the same fungus and displaying similar symptoms in scattered locations in Tennessee and North Carolina.[3] They also stated that the original infection center of sugar maple in North Carolina had shown little tendency to spread beyond the relatively restricted area first reported.

After the first discovery of the disease in the Lake States, small-scale studies of incidence were made in northern Wisconsin and the Upper Peninsula of Michigan during 1961, but no additional infected trees were found.

In June and July of 1962, however, five infected trees were detected on the basis of their rather distinctive crown symptoms. Leaves were about one-half normal size and slightly chlorotic; some had far fewer leaves than normal (fig. 1). In addition, three of the trees bore a much heavier crop of seed



F-503780

FIGURE 1. — Crown symptoms of sugar maple in the later stages of the sapstreak disease. Note the abnormally small, sparse leaves.

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[1] *Kessler, K. J., Jr., and Anderson, R. L. Ceratocystis coerulescens on sugar maple in the Lake States. Plant Dis. Rptr. 44: 348-350. 1960.*

[2] *Hepting, George H. Sapstreak, a new killing disease of sugar maple. Phytopath. 34: 1069-1076. 1944.*

[3] *Roth, Elmer; Hepting, George H.; and Toole, E. Richard. Sapstreak disease of sugar maple and yellow poplar in North Carolina. Phytopath. 49: 549. Abs. 1959.*

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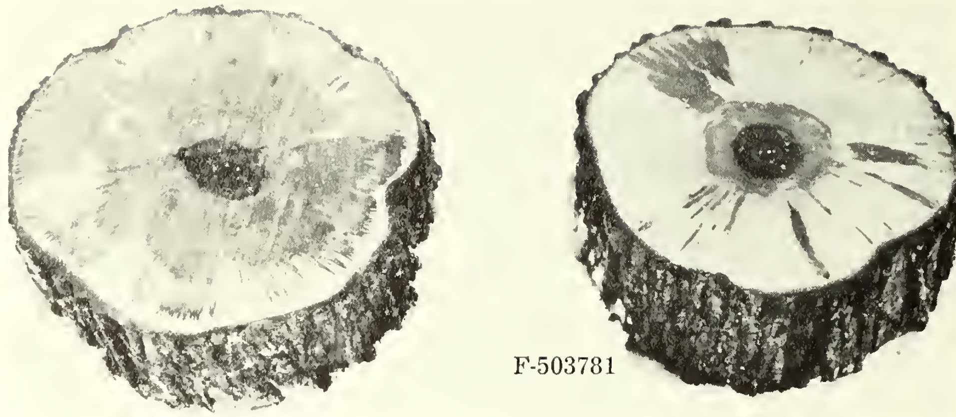
FIGURE 2. — Characteristic stain pattern in cross section. *Left*: at stump height. *Right*: at 17 feet. Note the many narrow points extending toward the cambium. On freshly cut surfaces the apices of these points are green. Reddish to grey radial streaking is present within the main body of tan to brown discoloration. The circular, darker stain in the center is dark heart.



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than nearby healthy trees. Four of the five were on the Upper Peninsula Experimental Forest located near Dukes, Mich., in the central part of the Peninsula. They were not in close proximity to the original infected tree. The fifth was approximately 20 miles west of the Experimental Forest.

These trees were cut immediately and checked for the characteristic stain pattern found within the bole of infected trees (fig. 2). All had similar patterns. Cultures of wood chips from stained areas all yielded the causal fungus. In addition, five dead but still standing sugar maples, found in the same general area, were checked for evidence of the disease. Cultures of *C. coerulescens* could not be obtained from any of these, but one faintly exhibited the stain pattern. The other four were badly decayed by saprophytic organisms. No other reason (suppression, overmaturity, etc.) could account for their death, and it seems probable that sapstreak was responsible.

As part of a long-term forest management study, the stand from which three diseased and three probably diseased sugar maples had

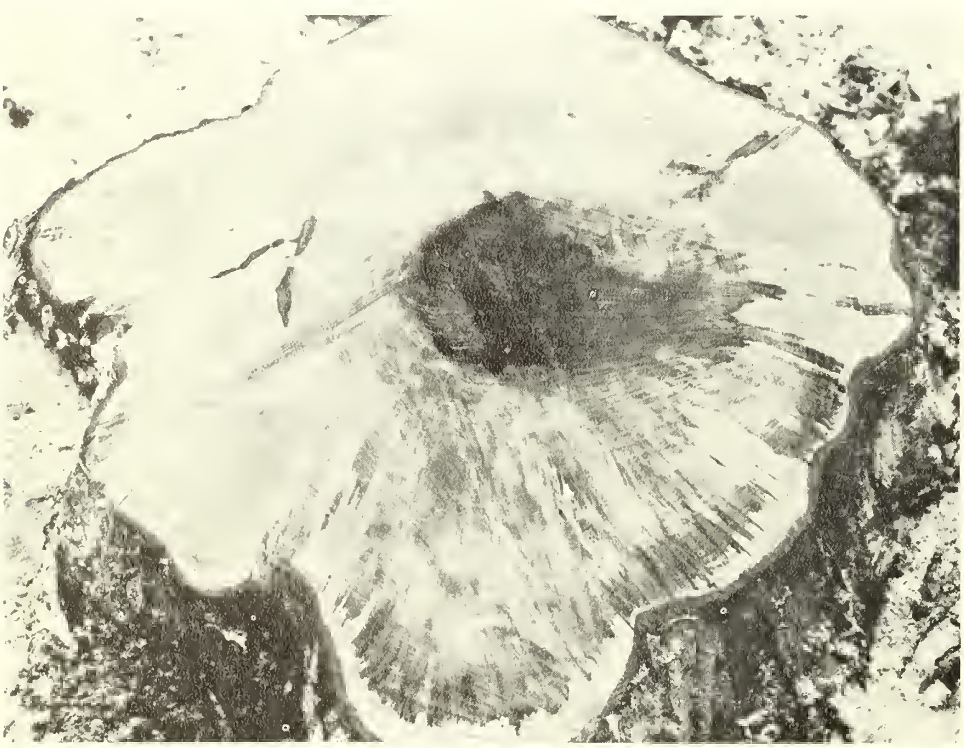

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FIGURE 3. — Stain pattern on sugar maple with incipient sapstreak infection. Five separate infections were traced from covered root wounds on this tree. The circular, darker stain in the center is dark heart.

been cut was scheduled for a selective cutting the following November. At that time, 147 felled trees were examined for sapstreak. Seven positive cases were found plus two probable cases; both of the latter were dead trees. Thus, total incidence of the disease in the trees examined in this stand was at least 6.5 percent (10 of 153) and probably 9.8 percent (15 of 153).

All of the trees examined during logging were incipient cases. The stain pattern had not progressed as far as in previous infected trees examined, and thus could be more readily traced to its likely point of entry. Figure 3 shows the pattern on a stump in which the stain appeared to have originated from at least five separate wounds on main roots. Two of these wounds and their associated stains are shown in figures 4 and 5. Six of the seven trees had wounds and associated stains of this type. That is, the wounds were old, some had considerable callus around their margins, and all were covered either by adhering dead bark or by litter and duff. The seventh infected tree differed considerably from the others examined to date: The stain was heaviest in the top, decreased toward the base, and was not visible on the stump. Its point of origin appeared to be the healed-over branch stub shown in figure 6.

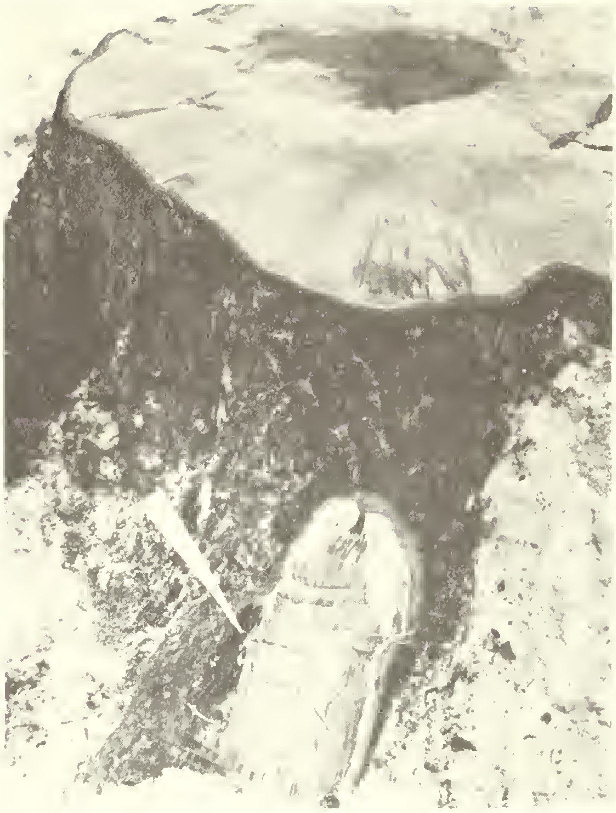

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FIGURE 4. — Stain originating from a root wound on the same stump as in figure 3. The wound is the dark area at arrow. Note the band of stain on the stump face immediately above the wound.

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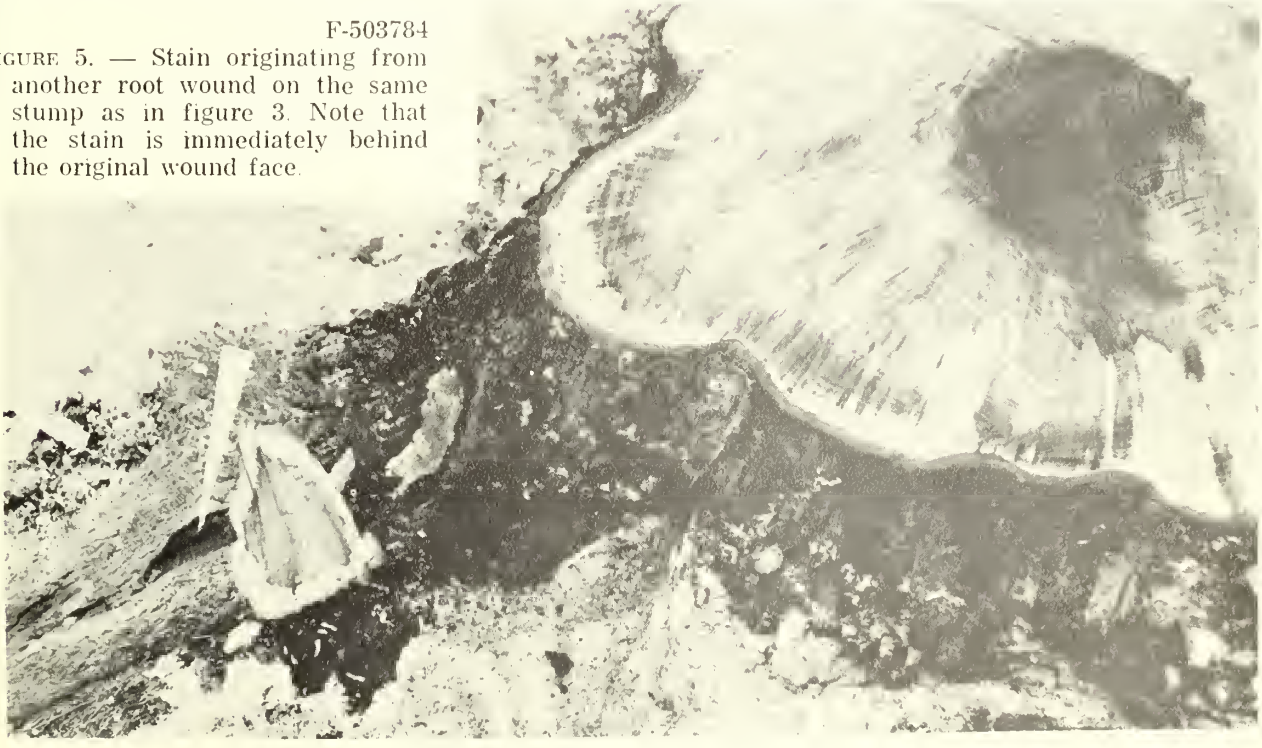
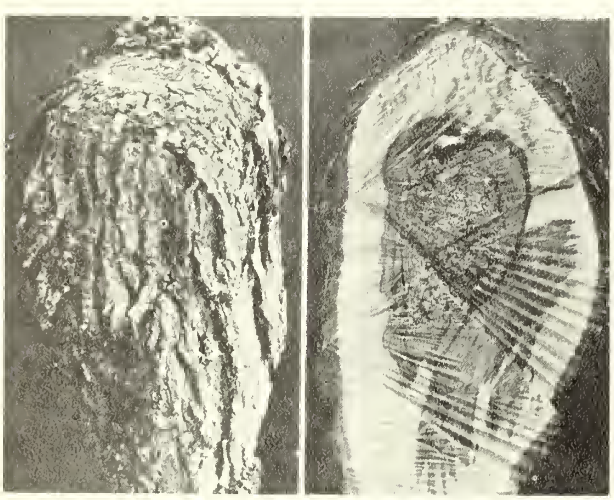
FIGURE 5. — Stain originating from another root wound on the same stump as in figure 3. Note that the stain is immediately behind the original wound face.



In October 1962 a large-scale, more intensive study of sapstreak incidence was begun. The technique being used is based primarily on the characteristic stain pattern found on the stumps of infected trees. This pattern is such that experienced personnel can rather easily distinguish it from other stains such as dark heart, mineral stain, and the stains associated with various heartrots commonly seen in sugar maple. Active or recently completed logging jobs throughout the Upper Peninsula of Michigan and northern Wisconsin are being visited, suitable stumps examined (those which have not deteriorated to the point where the stain cannot be identified with certainty), and cultures made from suspect stumps. By December 15, 1962, 23 logging operations in the Upper Peninsula had been visited and 2,193 stumps examined. Of these, only one tree located in Baraga County approximately 60 miles northwest of the Experimental Forest was infected with sapstreak. The survey is still continuing, and the results will be published when completed.

In all, 14 positive cases and 7 probable cases of sapstreak in sugar maple have been found since 1960. All infected trees were of



F-503785 — F-503786

FIGURE 6 — Surface and interior views of a swollen knot. The sapstreak discoloration is the stain extending above and below the decayed branch stub. The narrow dark stain surrounding the stub is caused by the decay.

dominant or codominant crown class and ranged in diameter from 10.6 inches to 23.0 inches d.b.h. The associated stain was present from roots to varying heights in the bole (the highest being 57 feet or well into the top branches) except in the one case already mentioned where it appeared to have entered from the top at 43 feet and extended downward to about 9 feet. In all infected trees examined, the stain was so extensive that even had they been salvaged prior to mortality much of the lumber recovered would have been of little value.

The reason for the wide discrepancy in incidence of the disease between the Upper Peninsula Experimental Forest and other areas examined to date is not known. It is fairly certain, however, that its absence in other areas is not due to the absence of the pathogen; the fungus, a common cause of sapwood stain in hardwood lumber and logs, is widely distributed throughout the Upper Peninsula. During the present survey, the authors have isolated and identified it several times in many locations where it was growing on the cut surfaces of logs and stumps, especially those cut in midsummer. Roth et al. reported that cultures obtained from sapwood stains were as pathogenic as cultures obtained from diseased trees.[4] Therefore, the high incidence on the Experimental Forest is probably related in some way to environmental conditions.

One strong possibility is that logging injuries to residual trees in stands managed under the selection system provide entry courts for the fungus. Such entry courts would not be available in undisturbed or clear-cut stands. All of the stands where sapstreak infections were found on the Experimental Forest have been partially cut at least once and some three times. Therefore, the number of wounds due to logging is probably far higher than in other areas examined.

Investigations of incidence, mode of infection, rate of spread, and methods of control of the disease are planned or in progress.

[4] *See footnote 3.*

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April 1963

U. S. FOREST SERVICE

RESEARCH NOTE LS-11

LAKE STATES FOREST EXPERIMENT STATION • U. S. DEPARTMENT OF AGRICULTURE

Changes in Northern Minnesota Timber Harvest

A survey of timber cutting made in 1961 measured the volume of the 1960 timber harvest in Minnesota.[1] This work was part of the current comprehensive Forest Survey of the State, and a full report will be made when the inventory of standing timber is complete. Because of the need for current information on the forest economy in northern Minnesota, the figures on timber cut and products output in 17 northern counties are published here ahead of schedule.

All of the area's primary wood-processing plants were canvassed in person or by mail to determine their 1960 receipts of pulpwood, logs, bolts, and other roundwood products. Measurements of felled trees on 75 widely scattered logging operations furnished factors for converting these receipts into volumes of standing timber removed in logging. Comparing results with those of a similar survey made 8 years earlier reveals changes in timber use, some of which are discussed below.

Total Cut Was Less; More Came From Larger Trees. — The total cut of growing stock in the 17-county area was 1⅓ million cords in 1960 (table 1).[2] This included 251 million board feet of logs that were of saw log size and quality plus 825,000 cords of cordwood. Most of the cordwood and nearly half of the saw log size material were used for pulpwood. Thus the 251 million board feet of saw log size material harvested should not be confused with lumber production, which was considerably less. The total cut from growing stock was about 15 percent less than in 1952 (fig. 1).

The hardwood cut (except aspen) was down 24 percent, the softwood cut was down 19 percent, and the aspen cut was about the same as 8 years ago.

The cut from sawtimber-size trees, on the other hand, was 30 percent greater than in 1952. This reflects an increase in softwood and aspen sawtimber volume available, and a shift in the intensity of cutting from some counties in the Central Pine district to counties in the northeast district where the timber generally runs heavier to sawtimber-size trees. An increasing proportion of the pulp-

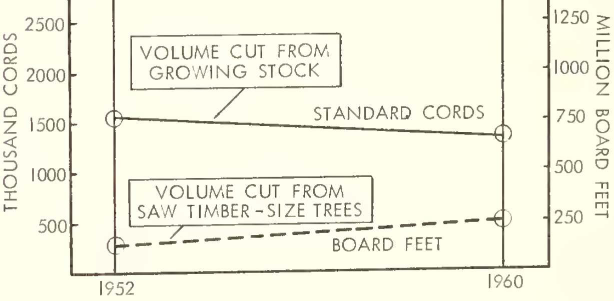

FIGURE 1. — A comparison of the 1952 and 1960 timber cut in 17 northern Minnesota counties.

[1] *The Office of Iron Range Resources and Rehabilitation, the Minnesota Division of Forestry, and the Land Commissioners of Aitkin, Becker, Beltrami, Cass, Clearwater, Crow Wing, Itasca and Koochiching Counties assisted the Station in this survey.*

[2] *The definition of growing stock is complex, but in general it includes live trees at least 5 inches in diameter at breast height that are presently or potentially merchantable.*

wood cut comes from trees of sawtimber size that are rated as sound culls for saw log uses and from upper stems beyond the 4-inch minimum in some softwood species.

Less Lumber, More Pulpwood Being Produced. — The output of some products has dropped off, while that of others has increased. In 1960 the lumber production in the 17 northern counties was 112.5 million board feet (table 2), a drop of about 25 percent from 1952. The output of fuelwood and mine timbers also declined, following the long-time trend for these products. In contrast pulpwood, veneer logs, poles and piling showed increases.

In 1960 there were 765 primary wood-processing plants operating in the 17-county area (table 3). Although small sawmills were in the majority, their number was about 10 percent fewer than in 1952. On the other hand, pulp and paper mills have expanded and modernized on a large scale, and additional small wood-using enterprises, such as charcoal plants, novelty plants, and fencing companies, have sprung up.

Value of Rough Products and Man-Days of Employment. — The value of rough forest products harvested in the northern counties is estimated at 31 million dollars in 1960 (table 4, reverse side of this page), compared to about 38 million dollars 8 years previously. Prices for most products have not varied much, but the volume of products harvested has declined.

The smaller timber harvest in 1960, together with a higher degree of mechanization, resulted in less employment for woods workers. It is estimated that about 2 million man-days of labor were required to cut and deliver (to plant or loading area) the timber products harvested in the entire State (table 4). More than three-fourths of the labor was expended in the 17-county area where most of the State's pulpwood, saw logs, mine timbers, and other products were cut.

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April 1963

TABLE 1. — *Timber cut from growing stock and sawtimber on commercial forest land in 17 northern Minnesota counties; by species group, 1960*

County	Volume cut							
	From growing stock				From sawtimber			
	Total	Hdwds[1]	Aspen	Sftwds	Total	Hdwds[1]	Aspen	Sftwds
	Thousand std. cords				*Thousand board feet*[2]			
Aitkin	59	13	34	12	12,060	4,120	5,900	2,040
Becker	21	4	8	9	5,140	710	1,310	3,120
Beltrami	110	5	44	61	21,440	1,440	7,130	12,870
Carlton	39	3	29	7	5,550	600	3,270	1,680
Cass	70	9	25	36	14,550	1,460	3,650	9,440
Clearwater	47	5	32	10	8,650	1,150	5,000	2,500
Cook	89	5	3	81	17,280	2,190	1,210	13,880
Crow Wing	29	6	8	15	6,890	960	1,990	3,940
Hubbard	44	2	21	21	7,930	340	2,520	5,070
Itasca	135	12	46	77	28,330	3,060	9,010	16,260
Koochiching	188	11	69	108	30,970	1,890	9,110	19,970
Lake	121	2	10	109	22,680	910	2,110	19,660
Lake of the Woods	36	—	13	23	5,620	—	1,460	4,160
Mahnomen	4	1	2	1	880	180	530	170
Pine	21	4	14	3	3,310	1,000	1,780	530
St. Louis	319	8	129	182	58,260	2,220	19,810	36,230
Wadena	9	—	2	7	1,880	60	190	1,630
Total	1,341	90	489	762	251,420	22,290	75,980	153,150
State total	1,590	272	527	791	320,350	78,100	82,120	160,130
17-county total as a percent of State total	84	33	93	96	78	29	93	96

1 *All commercial hardwood species except aspen.*
2 *International ¼" log rule.*

TABLE 2. — *Timber products output by products for 17 northern Minnesota counties, 1960*

County	Lumber	Veneer & cooperage logs	Pulpwood	Poles and piling	Mine timbers	Misc. industrial wood	Posts	Fuelwood
	MBM	*MBF*[1]	*M cds.*	*M pcs.*	*M cds.*	*M cds.*	*M pcs.*	*M cds.*
Aitkin	7,400	200	34	1	1	3	230	19
Becker	4,300	100	6	4	—	—	175	15
Beltrami	12,600	200	80	32	—	1	300	17
Carlton	1,900	—	29	—	—	1	30	21
Cass	9,300	100	37	13	—	1	80	38
Clearwater	5,900	—	33	1	—	1	50	14
Cook	5,400	400	83	7	—	—	5	2
Crow Wing	5,700	—	12	1	—	—	60	18
Hubbard	4,200	100	32	3	—	1	75	15
Itasca	16,300	400	89	40	1	4	185	32
Koochiching	5,800	100	169	75	—	3	415	9
Lake	5,900	500	113	18	1	1	25	3
Lake of the Woods	1,300	—	33	8	—	—	135	4
Mahnomen	600	—	1	—	—	—	5	4
Pine	1,100	100	12	—	—	1	135	18
St. Louis	23,600	700	265	25	5	10	200	37
Wadena	1,200	—	2	3	—	—	25	11
Total	112,500	2,900	1,030	231	8	27	2,130	277
State total	161,300	13,000	1,048	235	8	30	4,450	610
17-county total as a percent of State total	70	22	98	98	100	90	48	45

1 *International ¼" log rule.*

(Tables 3 and 4 on reverse side)

TABLE 3. — *Number of primary wood-using plants,[1] in 17 northern Minnesota counties, 1960*

County	All mills	Sawmills[2]				Pulp mills	Veneer mills	Misc. plants[3]
		Total	Large	Medium	Small			
Aitkin	44	42	—	—	42	—	—	2
Becker	38	36	—	—	36	—	—	2
Beltrami	51	46	1	2	43	1	—	4
Carlton	43	40	—	—	40	2	—	1
Cass	52	50	—	2	48	—	—	2
Clearwater	39	38	—	1	37	—	—	1
Cook	23	22	—	2	20	—	—	1
Crow Wing	27	26	—	2	24	—	—	1
Hubbard	27	25	—	1	24	—	—	2
Itasca	89	83	—	1	82	1	1	4
Koochiching	40	35	—	1	34	1	—	4
Lake	25	25	—	3	22	—	—	—
Lake of the Woods	15	13	—	—	13	—	—	2
Mahnomen	14	13	—	—	13	—	—	1
Pine	16	15	—	—	15	—	—	1
St. Louis	197	191	—	4	187	1	—	5
Wadena	25	23	—	—	23	—	—	2
Total	765	723	1	19	703	6	1	35
State total	1,345	1,282	1	26	1,255	9	7	47
17-county total as a percent of State total	57	56	100	73	56	67	14	74

[1] *Excludes idle mills.*

[2] *Sawmills: Large — Annual lumber output in excess of 5 million board feet.*
Medium — Annual lumber output from 1 million to 5 million board feet.
Small — Annual lumber output less than 1 million board feet.

[3] *Includes match, cooperage, charcoal, novelty, lath and shingle mills, etc.*

TABLE 4. — *Value of rough forest products and man-days of work expended to harvest these products in 17 northern Minnesota counties, 1960*

County	Value of rough forest products FOB cars[1]				Man-days of employment[2]			
	Total	Lumber	Pulpwood	Other[3]	Total	Lumber	Pulpwood	Other[3]
	Thousand dollars				*Thousand man-days*			
Aitkin	1,400	600	440	360	78	23	27	28
Becker	720	400	90	230	36	13	5	18
Beltrami	2,670	1,130	1,200	340	129	39	64	26
Carlton	780	180	350	250	52	6	23	23
Cass	1,940	880	510	550	101	29	30	42
Clearwater	1,100	560	360	180	60	18	26	16
Cook	2,160	470	1,640	50	88	17	67	4
Crow Wing	890	500	180	210	46	17	10	19
Hubbard	1,010	400	420	190	56	13	26	17
Itasca	3,410	1,430	1,410	570	165	50	71	44
Koochiching	3,540	500	2,710	330	178	18	135	25
Lake	2,620	550	1,970	100	116	18	90	8
Lake of the Woods	760	130	540	90	37	4	26	7
Mahnomen	120	50	10	60	8	2	1	5
Pine	480	90	160	230	35	4	10	21
St. Louis	6,940	2,140	4,030	770	343	72	212	59
Wadena	280	120	30	130	18	4	2	12
Total	30,820	10,130	16,050	4,640	1,546	347	825	374
State total	40,100	14,700	16,400					
17-county total as a				9,000	2,036	492	839	705
percent of State total	77	69	98	51	76	71	98	53

[1] *Unit prices by species for the important forest commodities were obtained from "Minnesota Forest Products Marketing and Pricing Review" (January-July 1961) by the Office of Iron Range Resources and Rehabilitation.*

[2] *Based on material furnished by a few producers and dealers of forest products. Labor input per unit of measure: Pulpwood, 0.8 man-day per cord; lumber (stumpage to rough lumber), 3.05 man-day per MBM; other products, 1 man-day per cord. The input figures take into account the cutting, skidding, and hauling operations, road development, and other activities. Labor input figures of individual operations are subject to wide fluctuations, depending on volume and quality of timber per acre, topography, accessibility, degree of mechanization, etc.*

[3] *Fuelwood, posts, pilings, poles, mine timbers, charcoal, etc.*

U. S. FOREST SERVICE

RESEARCH NOTE LS-12

KE STATES FOREST EXPERIMENT STATION • U. S. DEPARTMENT OF AGRICULTURE

Cordwood Heights of Mixed Oak Growing on Grayling and Rubicon Soils

Mixed stands of oak growing on glacial drift of deep coarse sand occupy about 2 million acres of former pine lands in the central portion of the Lake States. These soils, which have a low water-holding capacity, are poor for oak growth, and the principal timber products being produced are pulpwood and pallet stock material. Extensive soil series commonly associated with these poor-quality oak stands include the well-drained Podzols and Brown Podzolic sands such as Grayling,[1] Rubicon, and Graycalm sands — all of which have no texturally developed *B* horizon. This paper presents cordwood heights for oak on these soils by d.b.h. (tree diameter at breast height). These heights can be used for determining volumes from diameter tallies on timber cruises and other forest sampling work.

The cordwood height—d.b.h. data were obtained from a study underway on the growth of nine mixed oak stands growing on Grayling and Rubicon sands located in five different counties of northern Lower Michigan. The number of 8-foot bolts to a 4-inch usable top in each tree 5 inches or more in d.b.h. was obtained for a 1,000-tree sample. About two-thirds of these trees were growing on Grayling and one-third on Rubicon sand.[2]

The oak species occurring in the stands studied were white oak (*Quercus alba* L.) and oaks in the red and black oak group which are not easily identified by species in this latitude because of overlapping leaf, acorn, and other tree characteristics. They include northern pin oak (*Q. ellipsoidalis* E. J. Hill), black oak (*Q. velutina* Lam.), red oak (*Q. rubra* L.), and possibly scarlet oak (*Q. coccinea* Muenchk.). A working term name for them might be "other oak" or "ellipsoidalis complex" until more precise taxonomic investigations are made. The oak species were about equally divided between the white and other oaks. Other trees that were found in scattered numbers include aspen (*Populus tremuloides* Michx. and *P. grandidentata* Michx.), red maple (*Acer rubrum* L.), and jack pine (*Pinus banksiana* Lamb.). The stands were relatively even-aged, ranging from about 50 to 65 years. Diameters ranged from 1 to 14 inches, with an occasional oak 16 to 20 inches. Basal area densities ranged from about 50 to 80 square feet per acre.

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1 *Grayling sand is a well-drained Brown Podzolic soil developed in deep sand with a very thin grayish brown leached horizon (A_2), a yellowish brown subsoil (B_{ir}), and a pale brown sand C horizon. Rubicon sand is a well-drained Podzol with 2 to 10 inches of a light gray horizon (A_2), a dark brown subsoil horizon (B_{hir}), and pale brown sand C horizon. Graycalm is similar to Grayling except for thin ½- to 1-inch bands of loamy sand below 42 inches. The relationships of these soils to others in this region are described in "Soils of the North Central Region of the United States." No. Cent. Region. Pub. 76, and Univ. Wis. Agri. Expt. Sta. Bul. 544. 1960.*

2 *The soil under each sample stand was identified by Dr. E. P. Whiteside, Soil Science Department, Michigan State University, East Lansing, Mich.*

The number of 8-foot bolts in relation to d.b.h. was fitted best with a quadratic equation of the form Y = a+b (d.b.h) + c (d.b.h.)[2] for both oak species and soil types. Differences in the regression estimates of cordwood heights between the various oak species on both Grayling and Rubicon were generally less than 0.5 bolt with a maximum of 0.6. The maximum predicted difference in cordwood heights in terms of cordwood volume amounted to less than .01 cord per tree for oak up to 11 inches at d.b.h. and .02 cord per tree for trees 11 inches at d.b.h. and larger. This finding suggests that one combined cordwood height-d.b.h. curve has considerable practical value for determining stand volumes of mixed oak growing on the Grayling-Rubicon association as presented in table 1. Local d.b.h. volume tables may be prepared as shown for the cordwood volumes in column 3 of table 1 or cordwood volume-basal area ratios for point sampling as shown in column 4. The cordwood volume-basal area ratio averaged 0.21 for the mixed oak stands used in this study. This basal area included only trees supporting cordwood volumes.

The cordwood heights in table 1 were field checked for their accuracy in 12 additional mixed oak stands growing in northern Lower Michigan on coarse sandy soils having no textural *B* horizon. The soil type in five of these stands was later identified as Grayling sand; in the other seven it was a Graycalm sand. In each test stand cordwood height was measured for the first tree of each of the following diameters: 6.0, 8.0, 10.0, 12.0, and 14.0 inches. The average deviations of the test trees at any one d.b.h. did not exceed 0.3 bolt from the predicted heights in table 1, which was well within the desired degree of accuracy.

TABLE 1. — *Cordwood height and volume of mixed oak on Grayling and Rubicon sands, by diameter at breast height*

Diameter at breast height (inches)	No. of 8-foot bolts[1]	Cords per tree[2]	Cords per sq. ft. basal area[3]
5	1.3	0.013	0.010
6	2.0	.027	.138
7	2.6	.045	.169
8	3.2	.068	.195
9	3.8	.100	.226
10	4.2	.131	.240
11	4.6	.171	.259
12	5.0	.214	.273
13	5.2	.262	.284
14	5.4	.311	.291
15	5.6	.372	.303

[1] $Y = -3.372 + 1.090\ (d.b.h.) - .033\ (d.b.h.)^2$, $R = +.89$, $N = 1{,}057$.

[2] *Composite Volume Tables for Timber and Their Application in the Lake States, by S. R. Gevorkiantz and L. P. Olsen, U. S. Dept. Agri. Tech. Bul. 1104. 1955. Table 6 (corrected to 19 percent bark volume for oak).*

[3] *Ratio of cords per tree (from Column 3) to square feet of basal area for point sample cruising. To obtain cords for individual trees or for stand volumes multiply the square feet of basal area by the appropriate ratio computed for the various tree sizes.*

April 1963

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U. S. FOREST SERVICE

RESEARCH NOTE LS-13

LAKE STATES FOREST EXPERIMENT STATION • U. S. DEPARTMENT OF AGRICULTURE

Dieback of Sugar Maple, Upper Michigan — 1962

Beginning in 1958, observations on dieback of sugar maple (*Acer saccharum* Marsh.) and other northern hardwoods have been recorded on sample plots at the Upper Peninsula Experimental Forest at Dukes, Mich. Annually more than 2,000 trees are evaluated according to the birch dieback rating system of Hawboldt and Skolko.[1] Maple dieback is somewhat similar to the maple blight found a few years ago in northern Wisconsin except that dieback is most severe on large trees while maple blight causes severe injury to all size classes. Maple blight was caused by a complex of insect defoliation and frost damage. The cause of dieback is not known.

By the usual pattern of dieback symptom development, the crowns of affected trees appear healthy one year and then show dead twigs or branches the next growing season, indicating that the crown injury may be occurring during the dormant season. A few of the affected trees examined, however, first showed dwarfed or chlorotic foliage, followed by twig or branch mortality the next year.

Since 1958, dieback has appeared on a larger percentage of trees each year, although most of the newly attacked trees have less than 10 percent of their crowns affected. Most of the increases have been in the larger size classes (table 1). In 1958, 10.0 percent of 2,461 sugar maples inspected were injured; in 1960, 20.5 percent of 2,134 were injured; and in 1962 the proportion of injured had risen to 27.9 percent of the 2,152 trees examined. In contrast, yellow birch in the same stand in 1958 showed 47 percent of the trees injured, indicating that yellow birch was more severely affected.[2]

[1] *Hawboldt, L. S., and Skolko, A. J. Investigation of yellow birch dieback in Nova Scotia in 1947. Jour. Forestry 46: 659-671. 1948.*

[2] *For further information on yellow birch top-dying see:*

Godman, R. M. Progress of top-dying in yellow birch — Upper Michigan, 1954-1955. U. S. Forest Serv., Lake States Forest Expt. Sta. Tech. Note 444. 2 pp. 1956.

Godman, R. M. Changes in yellow birch top-dying, Upper Michigan, 1954-1957. U.S. Forest Serv., Lake States Forest Expt. Sta. Tech. Note 527. 2 pp. 1958.

Jacobs, R. D. Top-dying of yellow birch, Upper Michigan, 1955-1959. U.S. Forest Serv., Lake States Forest Expt. Sta. Tech. Note 585. 2 pp. 1960.

TABLE 1. — *Changes in dieback from 1959 to 1962*[1]
(In percent)

Crown condition	Tree diameter at breast height (inches)			
	5-9 (882 trees)	10-14 (479 trees)	15-19 (441 trees)	20 or more (214 trees)
Had dieback in 1959 and either improved or did not change	3.5	10.6	10.9	10.7
Continued deteriorating or began to deteriorate after 1959	4.3	25.7	35.6	44.9
Remained healthy	92.2	63.7	53.5	44.4

[1] *Includes only trees 5 inches or larger in 1959*

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As expected, injury was most severe in the larger size classes (table 2). Symptom progression in individual trees usually proceeds to a point where one-fourth to one-half of the crown is destroyed and then becomes stabilized. The dead branches are slow to rot and break out of the tops, so that recovery may not be apparent until several years after the dieback has stabilized. Also, in the taller trees annual terminal growth is often very small, and a considerable number of years may be required for the live terminals to grow back into the area occupied by the dead branches.

Dieback is also related to stand density (table 3). The percentage of injured trees is greatest in the heavily cut areas (30 square feet of basal area per acre in the residual stand) and considerably less in the moderately cut stands (50, 70, and 90 square feet of basal area). These differences occur primarily in the smaller size classes since the larger trees tend to have a large proportion of their numbers affected regardless of stocking level.

The cause of dieback remains unknown. No pathogenic organism has been found. Godman has speculated that top-dying in yellow birch in the Lake States may be the result of rootlet mortality caused by prolonged high water tables in the spring.[3] Drought conditions in the following years could result in extensive moisture deficiencies to the crowns because of lack of absorbing rootlets. High water tables are found in some sugar maple stands in the spring, particularly in heavily podzolized soils with hardpan layers close to the surface. The study of water table levels in relation to maple and birch dieback is being continued. Other possible causes are also being investigated.

[3] *Godman, R. M. Are water table levels an important factor in the establishment and growth of yellow birch? Mich. Acad. Sci., Arts, & Letters Papers 44: 183-190. 1959.*

TABLE 2. — *Percent of trees by injury class within four diameter classes, 1962*[1]

Dieback class	Tree diameter at breast height (inches)			
	5-9 (940 trees)	10-14 (523 trees)	15-19 (470 trees)	20 or more (219 trees)
None	91.8	65.7	51.3	45.7
Abnormal foliage[2]	.1	.8	.2	.0
Moderate[3]	7.2	31.9	47.2	53.4
Severe[4]	.7	.8	1.3	.9
Dead[5]	.2	.8	.0	.0

[1] *Numbers of trees differ from those in table 1 because of additional trees reaching 5 inches d.b.h. and changes among diameter classes in the larger trees.*

[2] *Dwarfed or chlorotic.*

[3] *Less than one-half the crown affected.*

[4] *More than one-half the crown affected.*

[5] *Died in 1962.*

TABLE 3. — *Relationship of dieback to stand density*

Basal area (sq. ft. per acre)	D.b.h. (inches)	Percent of trees		Basis: no. of trees
		Healthy	Injured	
30	5-9	84	16	176
	10-14	47	53	107
	15-19	36	64	63
	20+	40	60	5
50	5-9	93	7	315
	10-14	67	33	144
	15-19	43	57	118
	20+	51	49	39
70	5-9	93	7	259
	10-14	70	30	137
	15-19	55	45	142
	20+	41	59	81
90	5-9	95	5	190
	10-14	76	24	135
	15-19	60	40	147
	20+	48	52	94

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U. S. FOREST SERVICE

RESEARCH NOTE LS-14

LAKE STATES FOREST EXPERIMENT STATION • U. S. DEPARTMENT OF AGRICULTURE

Litter Fuels in Red Pine Plantations

The weight and composition of forest fuels in red pine plantations are being studied over a large area in central Lower Michigan. These studies are designed to produce basic information on total volume, moisture content, composition, and distribution of combustible material available in specific forested areas. To date, only red pine plantations have been studied. Fuel weight — especially available fuel weight — is an important factor in predicting fire behavior and intensity. Other factors that may be equally important are fuel moisture content, fuel size and arrangement, and chemical composition.

As a part of the Lake States Station's fuels study, some detailed measurements have been made on ground fuels under plantation stands (fig. 1). This work is a continuation and expansion of the red pine plantation fuel work done by LaMois[1] in 1958. In 1961, 16 separate stand conditions were sampled. In each of these, two 1/10-acre plots were randomly located. Age, site, and stand density were determined, and 10 subsamples of forest floor material were collected from each plot. The subsamples consisted of all dead organic material on the forest floor that could be readily separated from the mineral soil. In young red pine plantations, there appears to be a sharp line that separates combustible material from the layer that is predominantly mineral soil.

As each subsample was collected, it was divided into two parts: The *L* layer (litter) and the *F* layer (all material below the *L* layer to mineral soil). The layers were relatively easy to separate by carefully removing the surface needles down to where the darkened needles were matted and lightly bound together by fungus mycelium. These two layers of material make up that portion of the forest floor that would be consumed by fire if the fuel moisture content was sufficiently low. The *L* layer is the surface fuel component that changes rapidly in moisture content and contributes to rate of fire spread.

Individual samples were analyzed in the laboratory by determining the oven-dry weight of the needles in the *L* layer, branchwood in the *L* layer, all material in the *F* layer, and miscellaneous material such as bark and cones. From this, a total dry-weight value was determined and applied on a per-acre basis.

Depth measurements were also made of both *L* and *F* layers. Four depth measurements were averaged for each subsample. Knowing the depth of the *L* and *F* layers and the corresponding weight per acre for both layers, a total weight per acre of forest floor material was determined.

By separating the two layers and obtaining both depth and weight for each layer, density values were computed that reflect rather clearly why the less dense litter layer changes moisture content rapidly and may burn more

[1] *LaMois, Loyd. Fire fuels in red pine plantations. U.S. Forest Serv., Lake States Forest Expt. Sta., Sta. Paper 68, 19 pp., illus. 1958.*

F-500,792
FIGURE 1. — A typical plantation of good site, 33-year-old red pine showing surface fuel conditions. This stand contains approximately 150 square feet of basal area and nearly 10 tons of combustible surface fuels per acre.

readily. They also show why the *F* layer, with higher density, may retain more moisture and burn as a smoldering fire. These density values are:

L layer — 7,000 lbs. per acre-inch
F layer — 11,600 lbs. per acre-inch
Average forest floor — 9,300 lbs. per acre-inch

The *total weight* of forest floor fuels correlates well with basal area in the stands that were sampled. Figure 2 shows a weight prediction curve based on stand density or basal area per acre. Stand age may also be used to strengthen the prediction equation for determining total weight per acre, but was not included in plotting the data for figure 2.

Litter weight (*L* layer) also correlates well with stand density in stands 15 to 25 years in age (fig. 3). Not enough stands older than 25 years were available for a representative sample in that category. The stands younger than about 10 years still had a mixture of grass and weeds on the ground that precluded meaningful fuel estimates.

This study has established a procedure for systematically sampling surface fuel conditions in pure plantations of red pine. The work should now be extended to cover other conifer types and stands of mixed conifers, as well. It is generally recognized that surface fuel weights increase with both stand age and stand density. The amount of these increases has not been established for Lake States forest types. Surface materials are an important fuel component in established pine stands or plantations. Fuel volume determinations for these stands may eventually create a better understanding of fuel-fire relationships.

J. H. DIETERICH
Research Forester
(Forest Fire Research)

April 1963

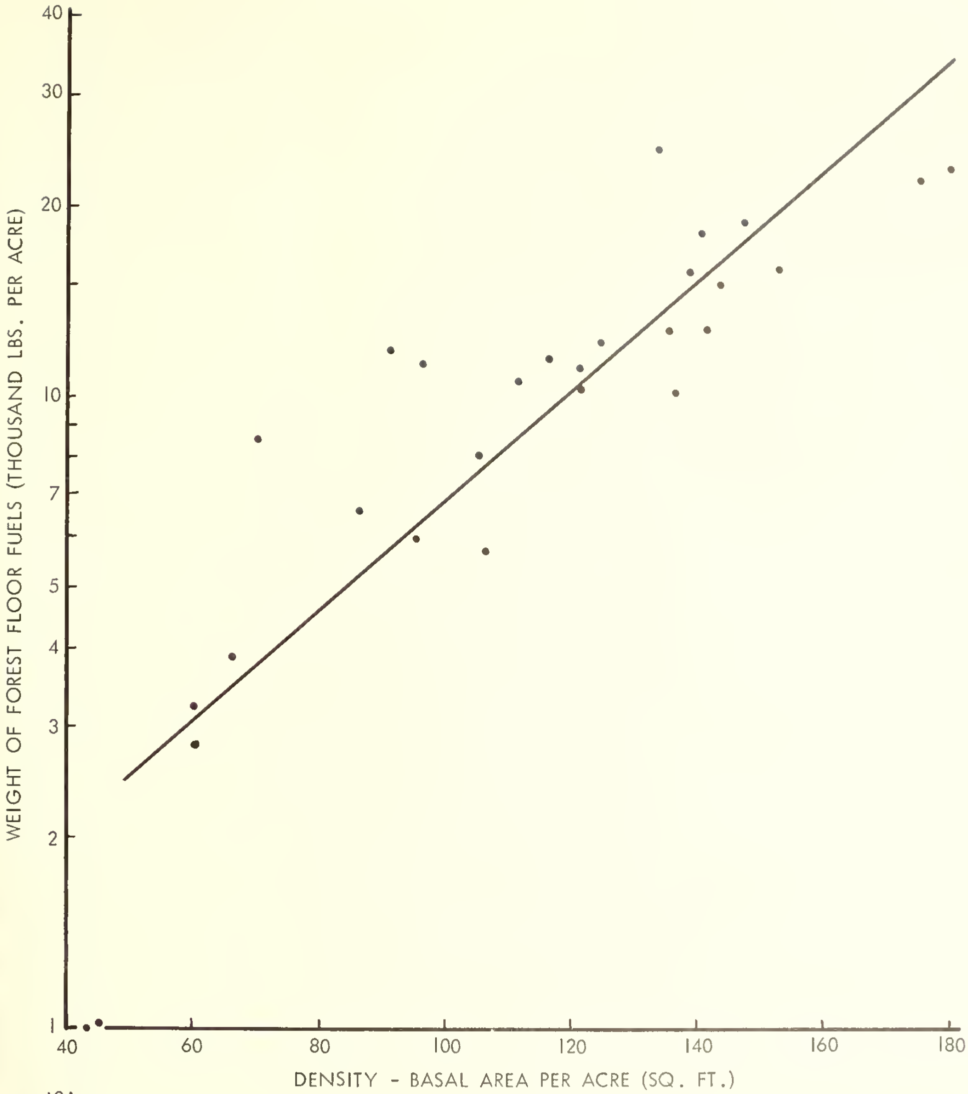


FIGURE 2. — weight of forest floor fuels, according to stand density in red pine plantations on good sites in Lower Michigan. The prediction equation is as follows:

Log (forest floor fuel weight) = 2.9640 + .00877 (basal area/acre)

r^2 = .796.

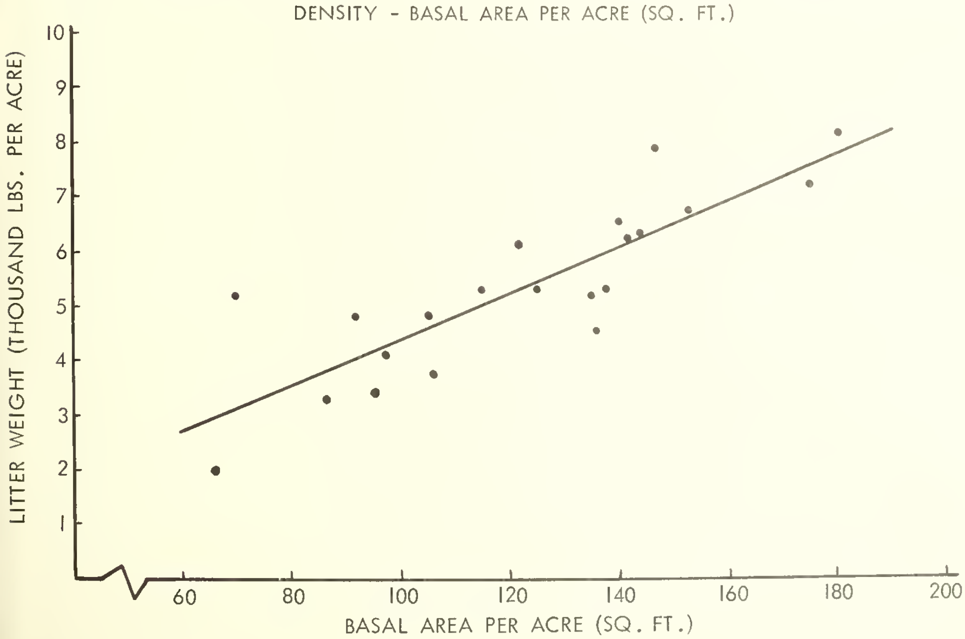


FIGURE 3. Weight of upper layer needles or litter on good site red pine plantations, 15 to 25 years old, Lower Michigan. The prediction equation is as follows:

Y = 355 + 41.18X

r^2 = .734

U. S. FOREST SERVICE

RESEARCH NOTE LS-15

LAKE STATES FOREST EXPERIMENT STATION • U. S. DEPARTMENT OF AGRICULTURE

Botanical and Commercial Range of Jack Pine in the Lake States

Accurate maps showing the distribution of important tree species are valuable to foresters, botanists, wildlife specialists, land managers, and others. Although the general botanical ranges for our principal tree species have been well known for some time, new information continues to develop. Commercial ranges, however, have not previously been mapped very precisely, and artificial extensions of ranges generally have not been mapped at all. For these reasons, range maps of the principal Lake States forest tree species have been prepared, and that for jack pine (*Pinus banksiana* Lamb.) is presented here (fig. 1).

Accuracy depends in part on the scale of the map being used. On this map, it is not practical to separate out isolated stands except when they are some distance from the main range. Accordingly, the main range boundary is so drawn as to include several outliers near the edge of the principal distribution. To complete the southern portion of the range close to the Lake States, verified distribution in Indiana and Illinois has been shown, although jack pine now appears to be extinct in Illinois.

In the silvical characteristics reports for Lake States tree species, commercial ranges were mapped, but they were based on the following broad definition: "Commercial range is defined as the distribution of the species as a major or important component in the type, now or in the past, regardless of whether it is now being utilized." In the present Note, commercial ranges are indicated for each county that presently has at least 1,000 cords or 1,000,000 board feet of jack pine.

The map of botanical range is based on the latest available published reports[1] as modified by the observations of qualified foresters and botanists[2] and on a supplemental map which shows the source location of specimens in established herbaria (fig. 2 on page 4). The map of commercial range is based primarily on published reports of the Forest Survey, supplemented for completeness by unpublished data from the same source. Commercial occurrence is indicated for each county that has at least 1,000 cords of jack pine on commercial forest land. Counties with 10,000 to 99,000 cords and those with at least 100,000 cords of jack pine are specially designated.

Within its natural range in the Lake States, jack pine grows most commonly on level to gently rolling, acid, sandy soils, although it also occurs on rocky areas and occasionally on heavy soils and peat. It grows both in extensive pure stands and in mixture with a number of tree species, the most common of which are paper birch, the aspens

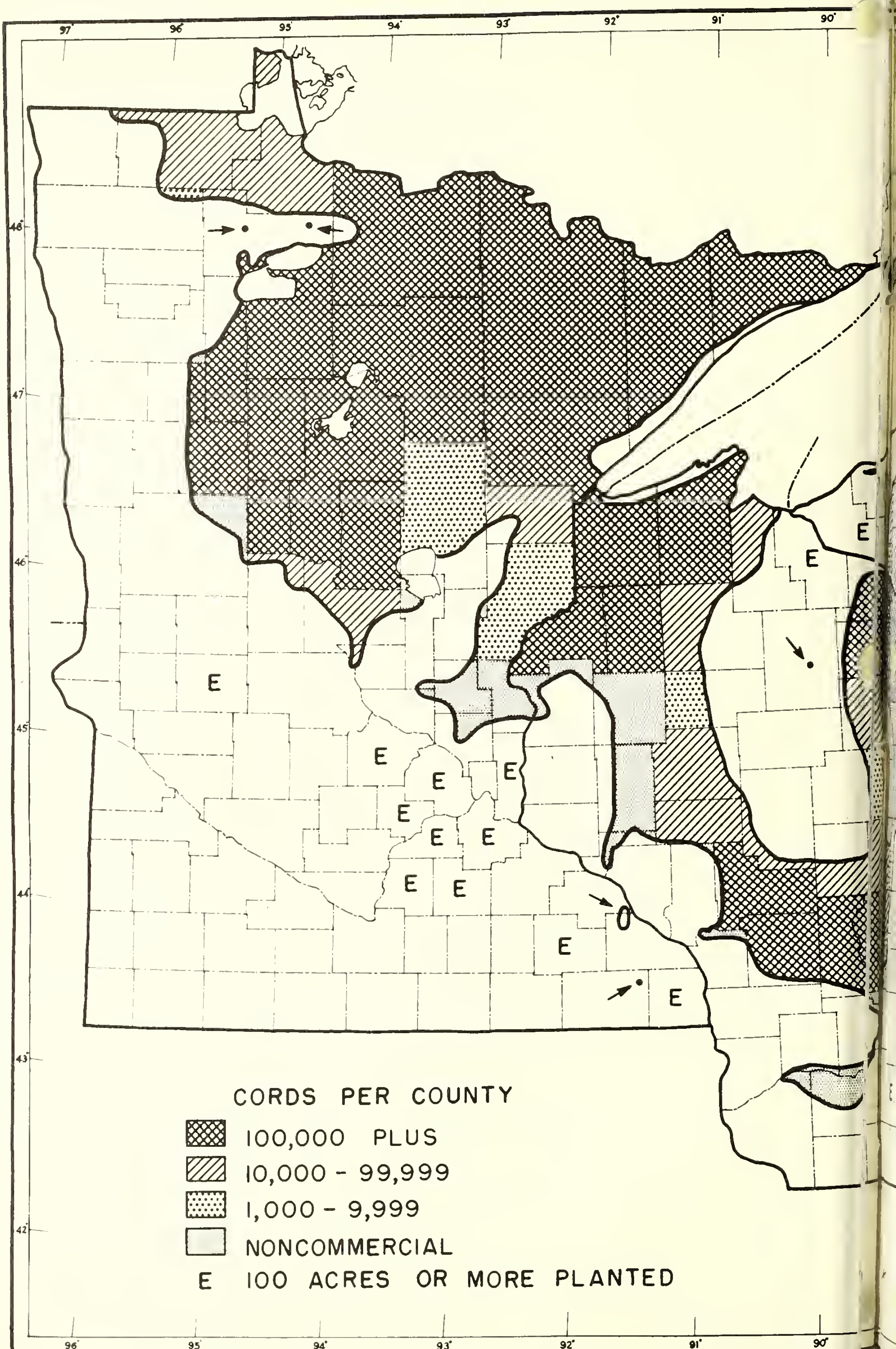
[1] *Fassett, Norman C. Preliminary reports on the flora of Wisconsin V. Coniferales. Wis. Acad. Sci., Arts and Letters Trans. 25: 177-182, illus. 1930.*

Rudolf, Paul O. Silvical characteristics of jack pine. U. S. Forest Serv., Lake States Forest Expt. Sta., Sta. Paper 61, 31 pp., illus. 1958.

Schoenike, Roland E. The distribution of jack pine in Minnesota. Univ. Minn., School of Forestry, Spec. Publ. 1, 57 pp., illus. 1962.

.... The distribution of jack pine in Wisconsin. Unpublished report on file at Univ. Minn., School of Forestry.

[2] *Information in this Note has been reviewed by Dr. John Andresen of Michigan State University, Dr. E. L. Little, Jr. of the U. S. Forest Service, Norman F. Smith of the Michigan Conservation Department, Dr. John Thomson of the University of Wisconsin, Dr. Edward Voss of the University of Michigan, S. W. Welsh of the Wisconsin Conservation Department, and staff members at all field units of the Lake States Forest Experiment Station.*



97°
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CORDS PER COUNTY
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10,000 - 99,999
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NONCOMMERCIAL
E 100 ACRES OR MORE PLANTED

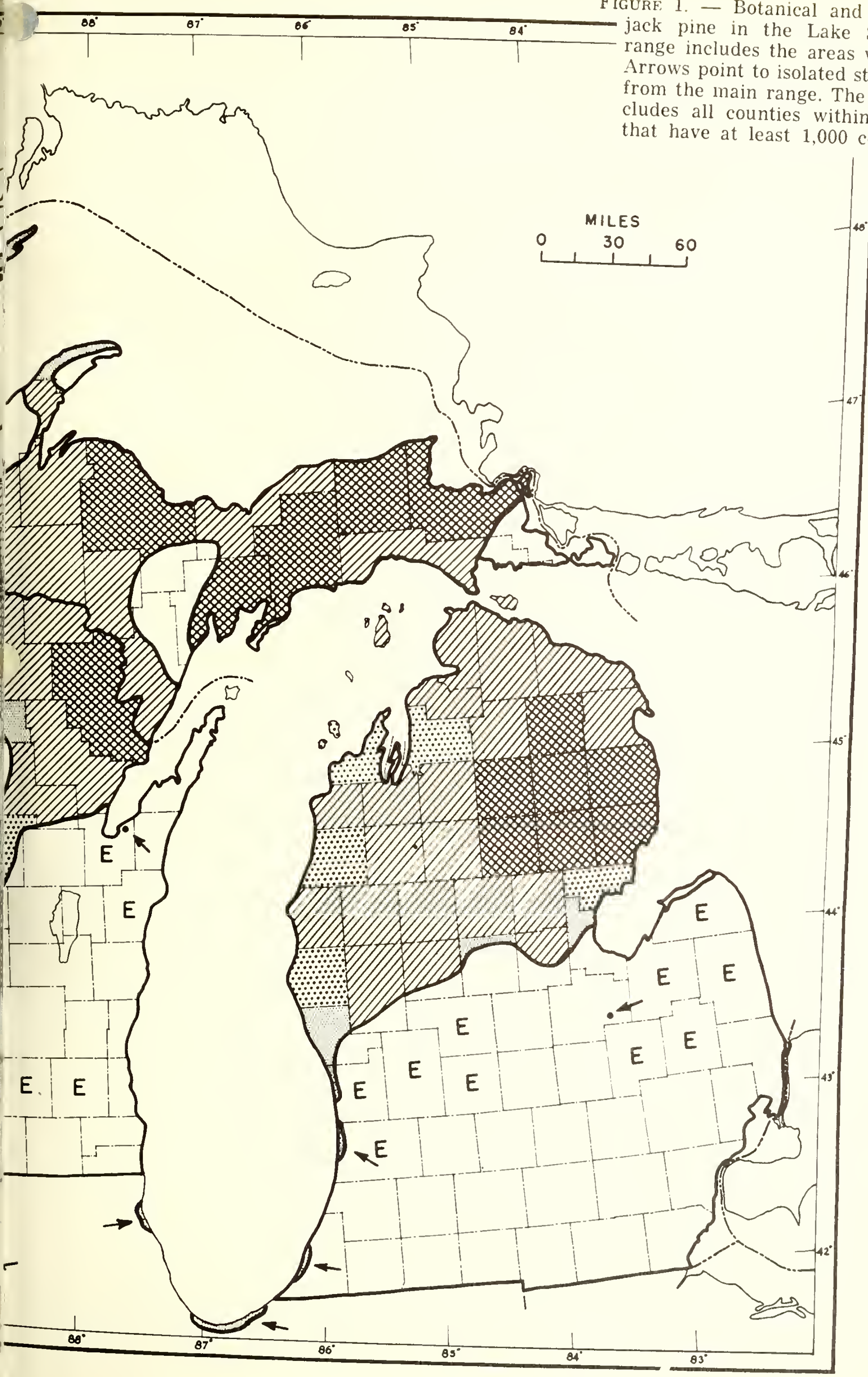

FIGURE 1. — Botanical and commercial range of jack pine in the Lake States. The botanical range includes the areas within the heavy line. Arrows point to isolated stands at some distance from the main range. The commercial range includes all counties within the botanical range that have at least 1,000 cords of jack pine.

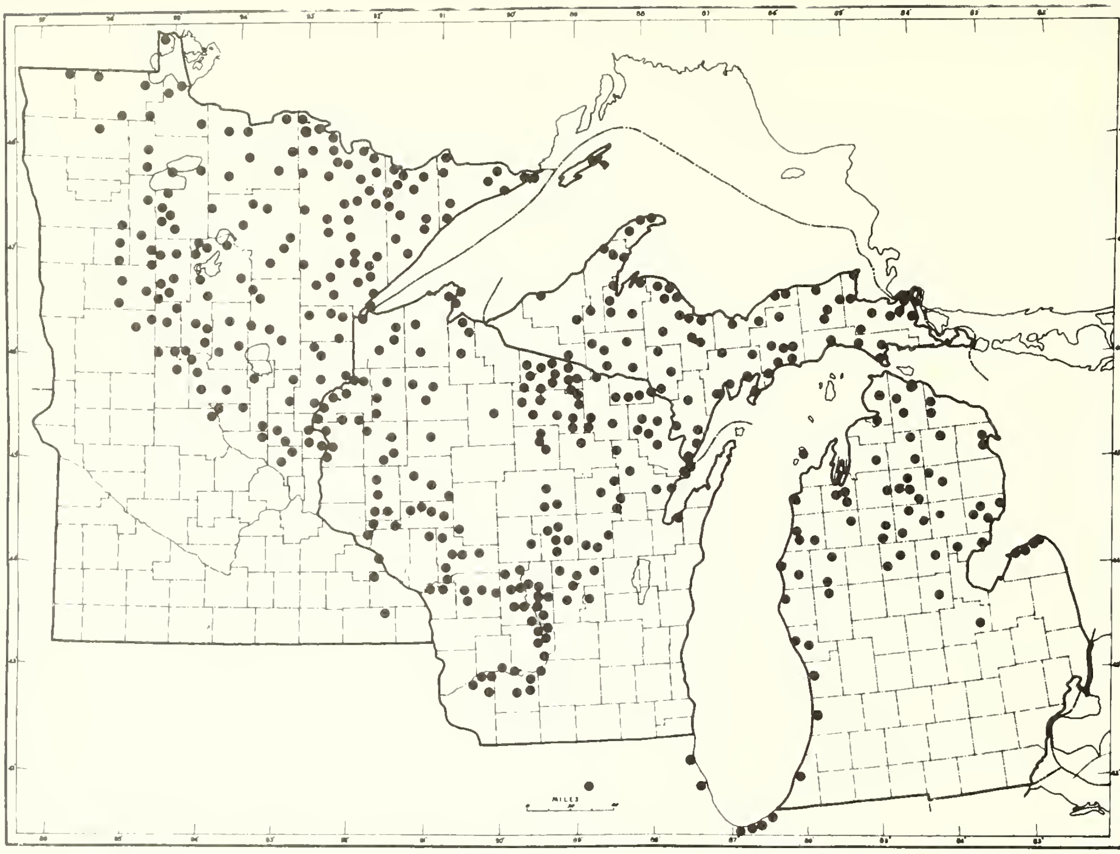

FIGURE 2. — Localities from which native *Pinus banksiana* is represented in established herbaria.

*Includes material from the following herbaria: Albion College, Brooklyn Botanic Garden, Buffalo Museum, Butler University, California Academy of Sciences, Canada Department of Agriculture (Ottawa), Carnegie Museum, Catholic University of America, Chicago Natural History Museum, Clark University, Cornell University — Bailey Hortorium and Wiegand Herbarium, Cranbrook Institute of Science, Dartmouth College, De Pauw University, Harvard University — Gray Herbarium, Illinois State Museum, Iowa State Teachers College, Iowa State University, Miami University (Ohio), Michigan Institute of Technology, Michigan State University, Milwaukee Public Museum, Missouri Botanical Gardens, Montreal Botanical Institute, Morris Arboretum, National Museum of Canada, New York Botanical Garden, New York State Museum, North Dakota State University, Northern Michigan College, Oberlin College, Ohio State University, Philadelphia Academy of Science, Queens University (Hamilton, Ontario), Quetico-Superior Wilderness Research Center, Smith College (Northhampton), Stanford University, U. S. Forest Service, U. S. National Arboretum, U. S. National Museum, University of Alberta, University of California (Berkeley), University of Illinois (Chicago), University of Illinois (Urbana), University of Indiana, University of Iowa, University of Maine, University of Massachusetts, University of Michigan, University of Minnesota (Duluth), University of Minnesota (Minneapolis), University of Missouri, University of Nebraska, University of Notre Dame, University of Pennsylvania, University of Toronto, University of Vermont, University of Western Ontario, University of West Virginia, University of Wisconsin (Madison), University of Wisconsin (Milwaukee), University of Wyoming, Wayne State University, Wellesley College, Western Michigan University, and Yale University.

(quaking and bigtooth), red oaks (northern red, black, and northern pin), red pine, white pine, and black spruce (the last primarily in northeastern Minnesota).

The natural distribution of jack pine is outlined on the map. Planting, however, is beginning to extend the range and eventually may blur the outlines of the natural range. Where planting has been extensive enough to develop at least 100 acres per county of established stand, it has appeared in Forest Survey statistics. Stands of this extent beyond the known botanical range are shown by an *E* in the counties involved. Planting within the botanical distribution is not specially designated in most instances although it may eventually increase the commercial range.

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U. S. FOREST SERVICE

RESEARCH NOTE LS-16

LAKE STATES FOREST EXPERIMENT STATION • U. S. DEPARTMENT OF AGRICULTURE

Porcupine Winter Feeding Activity in Merchantable Stands of Northern Hardwood—Hemlock

Porcupine sometimes cause considerable damage to both hardwood and conifer species in Lake States forests. But little is known of the population levels that result in appreciable damage or of the animal's behavior patterns. Although recent injury can be readily tallied from the ground, assessment of past animal activity on the standing tree is difficult. A complete picture for a period of years can be obtained only by examining the tree crowns after a cutting operation.

In the fall of 1961, a study of porcupine activity in northern hardwoods was conducted by the University of Michigan in cooperation with the Station. Tree tops from a commercial lumbering operation near Golden Lake on the Ottawa National Forest in northern Michigan were examined. A sample of 288 tops was chosen objectively, and current and past porcupine damage was recorded as to year of feeding, feeding intensity, and location on the tree. The sample was biased in that selective marking favored the removal of trees of poor form and low value. Yellow birch, basswood, and sugar maple were favored for retention, while proportionately more hemlock and elm were removed. Since hemlock is a preferred winter food and elm is also favored by the porcupine, the sample probably included more trees likely to have suffered from feeding than those uncut.

The size of the trees cut ranged from 5 to 35 inches d.b.h., although most were between 14 and 24 inches d.b.h. Within this range, neither tree height nor d.b.h. had a significant effect on porcupine activity.

Kind and location of trees used by the porcupines were also studied as related to other habitat components such as the presence of den trees and stand composition.

Fifty-eight percent of the trees examined had been gnawed on sometime during the past 20 years (table 1). Of the total sample, 30 percent (50 percent of those gnawed) showed a high degree of activity, defined as girdling or stripping of large patches of bark (fig. 1). Eleven percent of the trees had been gnawed within the previous 2 years and 5

TABLE 1. — *Porcupine activity by tree species at Golden Lake, Mich.*

Species	Number of tops in sample	Percent gnawed within each species	Species preference—expressed as a ratio[1]
Sugar maple	170	51.8	.89
Yellow birch	55	50.9	.87
Hemlock	32	90.6	1.55
Elm	17	94.1	1.61
Basswood	8	75.0	1.29
Red maple	2	50.0	.86
Ironwood	2	0	0.0
Black cherry	1	0	0.0
White spruce	1	0	0.0
Total	288	58.3	

[1] *This ratio is the percent of trees gnawed within a species divided by the percent of all trees gnawed.*

F-501816

FIGURE 1. — This 6-inch sugar maple shows partial or complete girdling by porcupines each year for 3 years.

percent within the previous year. A census of the quarter section under study showed that 9 to 12 animals were present and probably had been present during the previous winter. The data suggest that, in any given year, a population of 40 to 50 animals per square mile would affect in some way about 5 percent of the trees represented in a selectively marked commercial cutting.

Five percent is a maximum value for the entire stand, as indicated by the bias in marking toward trees previously damaged and most susceptible. Trees left standing would show a somewhat lower incidence of feeding damage.

Certain trees showed a disproportionate amount of activity. Apparently, after an animal discovers a suitable tree, he returns to it year after year and may be joined by other animals.

Activity was concentrated in relatively limited portions of the area, primarily in the vicinity of hemlock. Elm and hemlock show almost twice as much use in relation to availability of stems as do sugar maple and yellow birch; basswood is intermediate in use. Damage to elm is light since feeding is normally restricted to small twigs, while the bark is stripped on other species.

Current silvicultural practices discriminate against hemlock. This, combined with regeneration failures and deer browsing, is causing the gradual disappearance of hemlock from many stands. The change in composition may lower the carrying capacity for porcupine. Whether the final result will be a drop in the population or (more likely) less concentrated feeding activity and increased use of valuable timber species by porcupine is still in doubt. The presence of den sites is also an important factor in maintenance of porcupine populations.

Study of a hardwood logging operation near Ada Lake in Wisconsin revealed somewhat greater porcupine activity than at Golden Lake. Again, 58 percent of the total trees cut had been gnawed, but feeding activity was more intense; during the previous 2 years, it was almost four times as great (44 percent) as it had been at Golden Lake. Kills during control hunts indicated a porcupine population in the Ada Lake stand of approximately 50 to 75 animals per square mile, a considerably higher population than at Golden Lake. Thus, feeding damage appears readily related to population size.

Based on percentage of trees gnawed, degree of injury, and currentness of feeding, the activity in the Ada Lake stand was 27 percent greater than that at Golden Lake. This compares favorably with the difference (25 percent) in estimated animal populations.

Results of this study suggest that knowledge of the currentness and intensity of feeding and percentage of the trees gnawed in a stand may provide a means of estimating porcupine populations in the northern hardwood forest type. Population and behavior data will help forest managers to make intelligent decisions on the need for and the type of porcupine control measures to be exercised.

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U. S. FOREST SERVICE

RESEARCH NOTE LS-17

LAKE STATES FOREST EXPERIMENT STATION • U. S. DEPARTMENT OF AGRICULTURE

Influence of Regular Spacing on Growth of a Red Pine Plantation

The uniform spacing in plantations is known to influence their early growth and development. Only a few of the older plantations, however, have developed without hardwood overstories or have a continuity of records that show their growth characteristics and yield potentials. The record of an unmanaged 51-year-old red pine plantation in Crawford County, Mich., indicates that regular spacing results in growth characteristics markedly different from those of natural stands (fig. 1).

The study plantation was established by the Michigan Department of Conservation in the fall of 1912, using a 2-0 stock of local origin. The initial spacing, averaging 4½x5 feet, was closer to the generally dense spacing of natural stands than that of later plantings. The planting site was a level field of Grayling sand soil that had been farmed and abandoned a few years earlier. The site quality is medium for red pine, with the average dominant and codominant tree about 51 feet in height at 51 years of age. Survival, averaging 84 percent, was higher than in many of the early plantings, since there was no invasion by hardwoods.

Periodic measurements on a half-acre plot were begun in 1934 when the plantation was 24 years of age from seed. Remeasurements were made in 1939, 1949, 1956, and 1961. To illustrate the differences in growth characteristics, the plantation data at each remeasurement age are compared with those of natural stands[1] on similar sites (table 1).

[1] *Eyre, F. H., and Zehngraff, P. Red pine management in Minnesota. U. S. Dept. Agr. Cir. 778, 70 pp., illus. 1948.*

TABLE 1. — *Stand characteristics at different ages for an unmanaged red pine plantation and yield table values for natural stands, site index 50*

Total age (years)	*Trees per acre*[1]		*Basal area per acre*[1]		*Av. d.b.h.*[1]		*Cubic vol. per acre*[2]		*Cordwood vol. per acre*[2]	
	Plantation	Natural stand	Plantation	Natural stand	Plantation	Natural stand	Plantation	Natural stand	Plantation	Natural stand
	Number	*Number*	*Sq. ft.*	*Sq. ft.*	*Inches*	*Inches*	*Cu. ft.*	*Cu. ft.*	*Cords*	*Cords*
24	1,568	2,100	88	93	3.2	3.1	17	275	0.2	3.2
29	1,568	1,262	134	105	4.0	4.0	316	594	4.0	7.9
39	1,518	732	199	123	4.9	5.7	1,605	1,327	21.0	18.7
46	1,468	569	224	134	5.3	6.6	2,630	1,875	33.7	26.6
51	1,404	510	236	140	5.5	7.2	3,371	2,235	41.9	31.5

[1] *Trees 0.6 inch and larger.*
[2] *Trees 4.6 inches and larger to a 4.0-inch top diameter inside bark.*

MAINTAINED AT ST. PAUL 1, MINNESOTA, IN COOPERATION WITH THE UNIVERSITY OF MINNESOTA

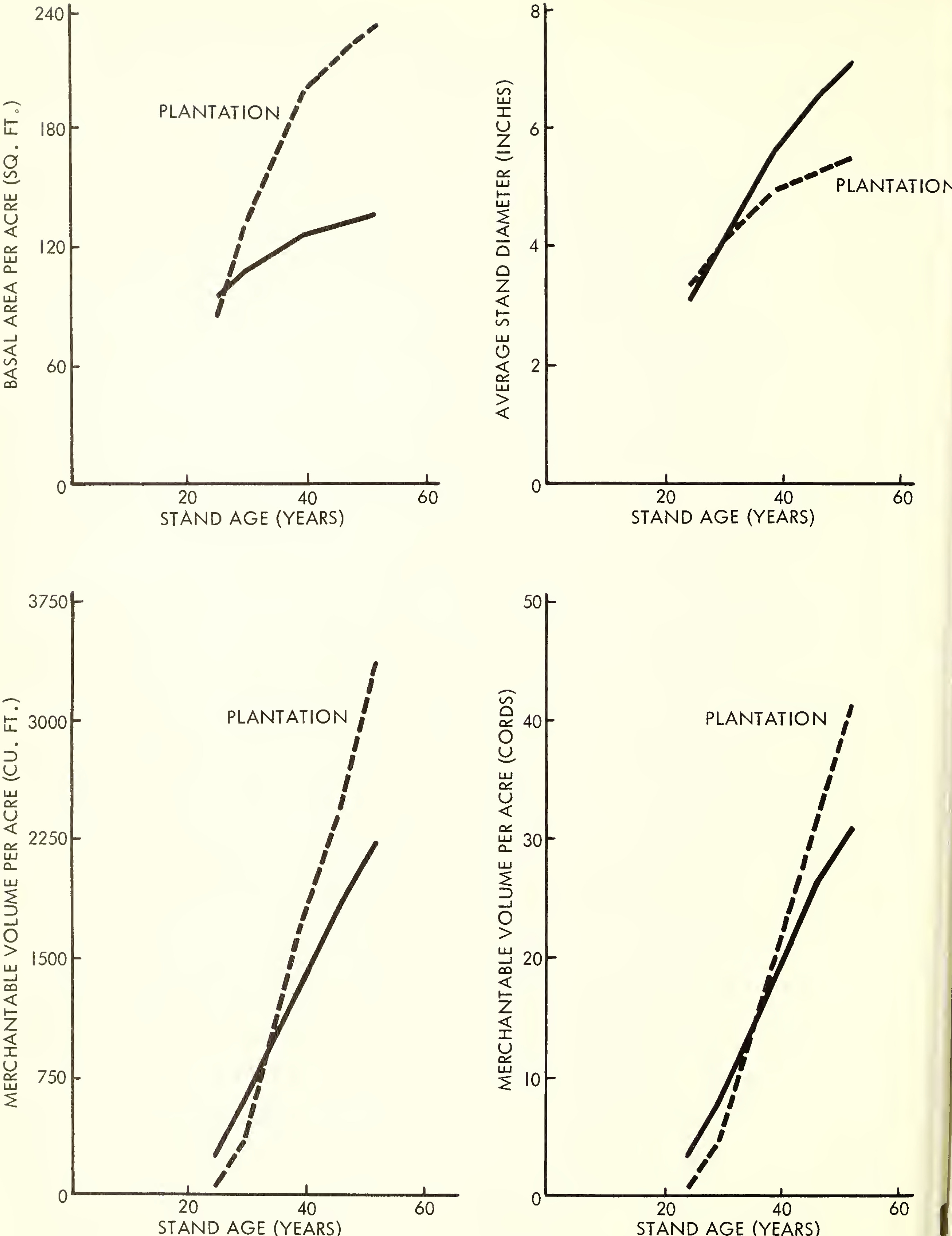

FIGURE 1. — Growth characteristics of an unmanaged red pine plantation and natural stands; site index 50.

The regular spacing in the plantation resulted in much lower mortality than occurs in most natural stands. Less than 10 percent of the planted trees died between ages 24 and 51 years, while 76 percent were lost in the natural stands. A significant differentiation of crown classes was first recorded at age 29 when the plantation had reached a density of 134 square feet per acre. At this density approximately 24 percent of the stems were in the intermediate crown class. The percentage of intermediate trees was still the same at age 51.

Basal area density of living trees in the plantation should culminate at about 250 square feet per acre. Of this stocking, however, only 215 square feet is expected to occur in trees increasing in stem diameter. The remainder is in overtopped trees that are not growing in diameter and will eventually be lost because of suppression.

Although the greater number of trees resulted in higher basal area densities in the plantation, the periodic diameter increment has progressively been reduced to only one-third that of natural stands. After age 29, when the density was 134 square feet, the rate of diameter increment rapidly dropped below that of the natural stands. Diameter growth of the 100 largest trees per acre showed a similar reduction at the same age and density, indicating that thinning should have been started.

The merchantable volume in plantations at any given age will vary because of differences in initial spacing and survival. Plantations established at wider spacings than observed here will tend to have higher volumes at earlier ages. At age 24 the volume yield in this closely spaced plantation was only 6 percent of the natural stand volume for comparable basal area density and average stand size. At 35 years of age the stand volumes were nearly equal. The merchantable cubic volume in the plantation at age 51, however, was 51 percent greater and the cordwood volume 33 percent greater than in the natural stands.

Most of the plantation volume is in small stems, with only 8 percent of the trees 8 inches or larger. Merchantable length of the stem averages only 47 percent of the total height, and the live crown length has been reduced to 39 percent. Quality of the wood is probably lower in the plantation not only because the trees are smaller but also because branch stubs are persisting. At a density of 236 square feet at 51 years of age little natural pruning has occurred.

The regular spacing in plantations is thus associated with higher survival, a rapid increase in basal area density to a maximum of about 250 square feet per acre, and a higher volume potential than normally occurs in the average natural stand. An estimated 3 million acres have been planted to trees in the Lake States. The successful plantations now comprise perhaps as much as one-fourth of the coniferous timber type, and the planted area is increasing by nearly 140,000 acres each year. With management to improve the size and quality of the final product, they should yield a large portion of the potential softwood timber requirements of the region.

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Lake States Forest Experiment Station
N. F. SMITH, Staff Officer
Michigan Department of Conservation

July 1963

U. S. FOREST SERVICE

RESEARCH NOTE LS-18

LAKE STATES FOREST EXPERIMENT STATION • U. S. DEPARTMENT OF AGRICULTURE

A Simple Weather Instrument Shelter for Plant Disease Investigations

A description of a simple, low-cost, weather instrument shelter that has been used in epidemiological studies of the University of Wisconsin, the University of Florida (Everglades Experiment Station), and the Lake States Forest Experiment Station is presented here in response to requests for the design and specifications of this shelter. Between 50 and 75 of the shelters are in use today, but no description has ever been published, although it has been mentioned in previous publications. [1 2]

The advantages of this shelter are low cost, small size, light weight, ease of transport and storage, and versatility of use. Because of the shorter distance from the floor to the top of the instrument chamber, a thinner layer of air can be measured than in shelters with taller chambers. They can be made by low-cost laborers in slack seasons rather than by cabinetmakers or carpenters. The materials listed cost about $17 for one shelter. Labor costs are variable, depending on the ability of the worker and the number of shelters made. With systematic cutting, one man can build three shelters with 2 days' labor spaced over a week to allow for paint drying. Nine shelters can be built with less than 3 man-days of labor. Seven of the shelters will fit into a sedan delivery or panel truck. With removable legs in sockets, seven will fit in the trunk and back seat of a sedan. A man can carry two shelters a half mile with ease.

The shelter shown in figure 1 is the simplest form that has been used. Several modifications not shown include: inserted, removable legs so the shelter can be stored and transported more easily; longer legs to make the height of the shelter conform to that of a standard U.S. Weather Bureau shelter; and a hinged front, opening forward, so

[1] *Van Arsdel, Eugene Parr. Climatic factors affecting the distribution of white pine blister rust in Wisconsin. Ph. D. thesis, Univ. Wis., Madison. 1954.*

[2] *Van Arsdel, E. P., A. J. Riker, T. F. Kouba, V. E. Suomi, and R. A. Bryson. The climatic distribution of blister rust on white pine in Wisconsin. U.S. Forest Serv., Lake States Forest Expt. Sta., Sta. Paper 87, 34 pp. 1961.*

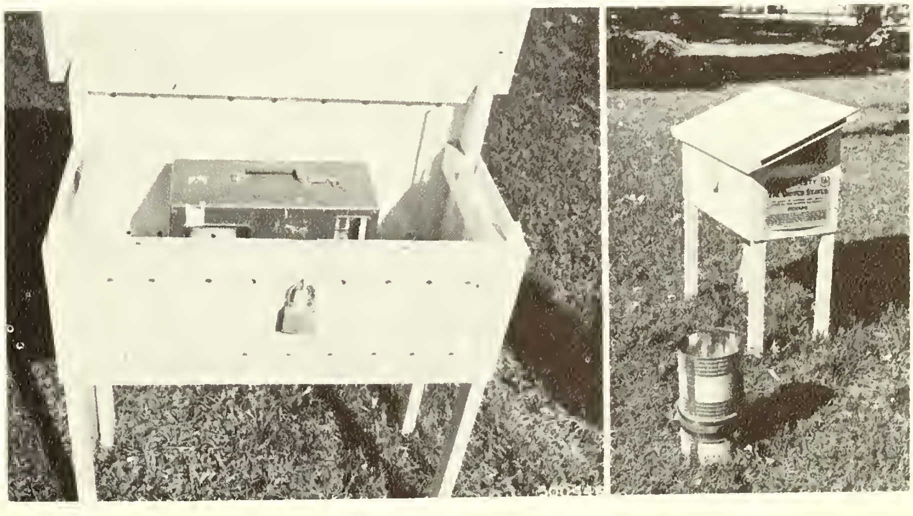

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FIGURE 1. — The instrument shelter in use.

that instruments located at or above eye level can be read more easily. In the last form, the legs were widespread to increase stability. In another model the height of the sides, front, and back was increased to allow for the use of higher instruments; the back was 15 inches high and the front 11 inches high.

General Description

The shelter is constructed of ⅛-inch Tempered Masonite Presswood nailed to pine, cedar, or cypress 1x2-inch lumber. It has a double roof, ventilated at the ends to prevent warming in sunlight. The frame is left open at the ends, and the sides of the shelter are perforated with drilled ½-inch-diameter holes to allow free circulation of air around the instruments in the shelter.

Dimensions of the shelter are shown in figure 2. The floor stands 18 inches above the ground. Outside dimensions are 2 feet long and 1 foot wide; the back side is 13 inches high, and the front 9 inches high. The

(Continued on page 4)

List of Materials for One Shelter

Tops and sides of the shelter are made of Tempered Masonite Presswood, smooth two faces. The difference in cost between the smooth one surface and the smooth two surfaces is less than the cost of the extra paint used on the rough surface.

Masonite parts (all pieces to be drawn on the Presswood prior to sawing to prevent waste):

Top	16″ x 27″	2 pieces
Ends	12″ x 9″	2 pieces
Front	24″ x 9″	1 piece
Back	13″ x 24″	1 piece
Bottom	12″ x 22½″	1 piece

Parts made from 1x2-inch planed lumber:

Front legs	28″ x 1″ x 2″	2 pieces
Back legs	31″ x 1″ x 2″	2 pieces
Longitudinal braces	22½″ x 1″ x 2″	4 pieces
Bottom end braces	10½″ x 1″ x 2″	2 pieces
Top end braces	11¼″ x 1″ x 2″	2 pieces
Roof spacers	27″ x 1″ x 2″	2 pieces
Blocks	6″ x 1″ x 2″	4 pieces

Hardware:

Hinges (brass butts)	¾″ x 2″	2 pieces
Hasp	1″ x 3″	1 piece
Hasp loop	1″ x 1½″	1 piece

½ pound sixpenny, galvanized, adhesive-coated nails (enough for 3)

1 pound ¾-inch, flathead galvanized roofing nails (enough for 3)

Screws for hinges, hasps, and hasp loop (usually provided)

For one shelter, 30 linear feet, allowing 5 feet for trimming loss (blocks are made from trim), of 1x2-inch lumber is needed. Six shelters require 180 linear feet of 1x2-inch lumber and 3 sheets of 4x8 Tempered Masonite Presswood. Five Sheets of Presswood will make 12 shelters, with 360 linear feet of 1 by 2.

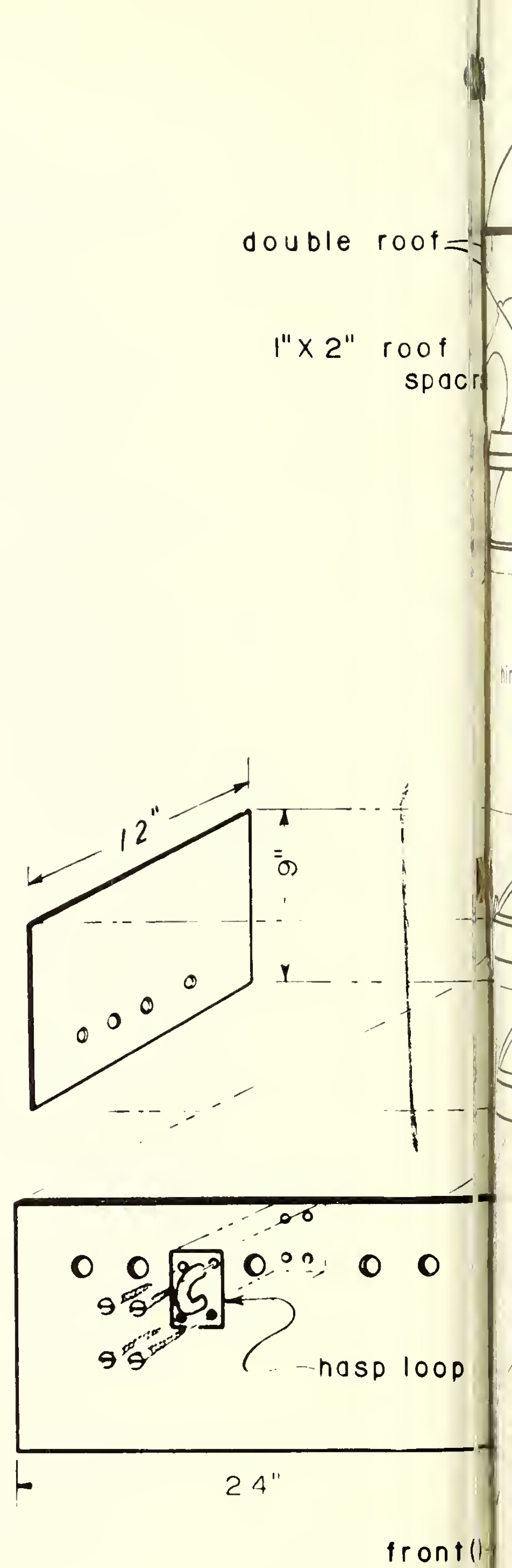
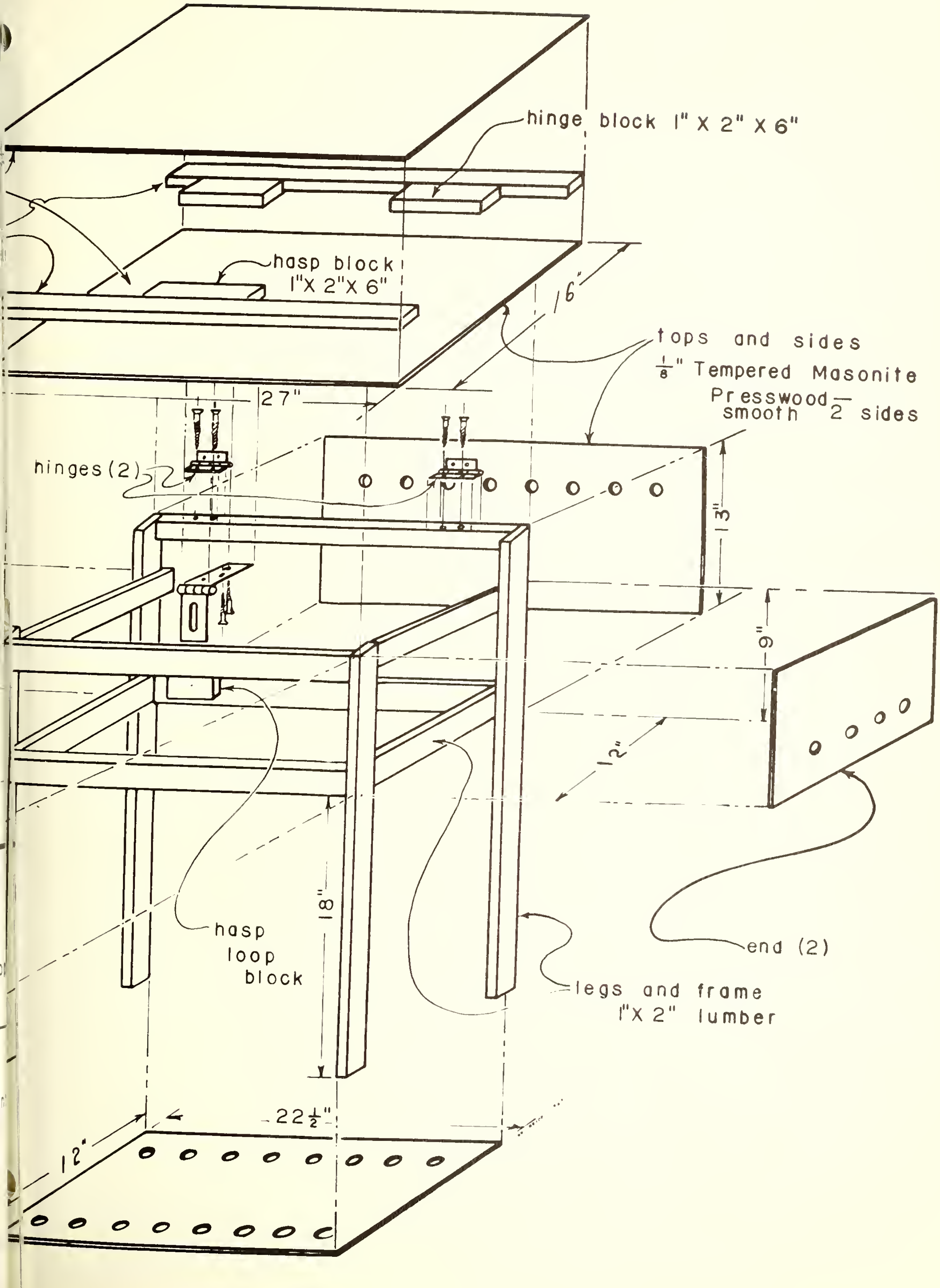


FIGURE 2. — Diagram of instrument shelter showing construction details.


hinge block 1" X 2" X 6"
hasp block 1"X 2"X 6"
16"
tops and sides
1/8" Tempered Masonite
Presswood— smooth 2 sides
27"
hinges (2)
13"
9"
12"
18"
hasp loop block
end (2)
legs and frame
1"X 2" lumber
22 1/2"
12"

roof is 16 by 27 inches. All parts are cut and painted with outside white house paint prior to nailing together.

Hinges, hasp, and hasp loop are of brass. The frame is nailed together with galvanized, adhesive-coated sixpenny box nails, and the smooth, two-surface, masonite sheeting is nailed on with ¾-inch galvanized, flathead roofing nails.

The shelter is again painted after assembling. Shelters are painted annually to keep a bright, reflective, white surface.

Construction Procedure

The most economical method of construction is to make the shelters in groups of three or multiples thereof. The pieces for the frame of the shelter are precut and painted before nailing together.

Sawing is best done on a circular table saw. The Presswood pieces should be drawn on the large boards in such a way that the first cut is a straight line across the middle of the 4x8-foot sheet so that two pieces close to the 4x4-foot size are produced. This aids handling. Brace and leg pieces of one length should all be cut at one time. For example, for six shelters twelve 31-inch legs should be cut at the same setting.

The end frames are nailed together first and then the longitudinal crosspieces. The frame pieces are precut from 1 by 2's. Legs should be knotfree; but other pieces, such as hasp blocks and hinge blocks, can have knots in them since these are not strength pieces.

The Use of the Instrument Shelter

To prevent the shelter from being blown over in high winds, four stakes are driven into the ground next to the legs, the shelter is leveled with a spirit level, and the legs are nailed to the stakes.

The location in which the shelter is placed greatly influences the results obtained. For comparing the effects of topography on local climate, the vegetative site must be standardized. A flat place with mowed grass away from any trees or buildings is a good site. If the effects of local vegetation on climate are to be studied, the same topographic site should be used, with shelters placed in the various vegetations desired. As an example, the instruments in a flat plane could compare the weather under tree crowns in a forest opening and an open meadow away from trees. To determine the range of climate of a slope, nine instruments would be used: three along the top in various or replicated vegetative covers, three similarly placed in the middle of the slope, and three along the bottom of the slope. The minimum period needed to make reasonable climatic comparisons between weather stations is 30 days. Measurements should be repeated during the same periods for at least 3 years, because wind and weather patterns vary greatly from year to year.

Accuracy of Weather Measurements

Measurements with an especially accurate platinum resistance thermometer showed that the temperature inside the boxes varied only about 0.2° C. from the temperature outside during the times of most rapid diurnal temperature change.

The standardized height of 18 inches above the ground was selected in 1951 because this was found to be a common height of blister rust cankers on white pine and of blister rust infection on ribes. Conditions favoring blister rust infections are extremely rare at the height of a standard U.S. Weather Bureau shelter. In rice disease studies, shelter floors were set 3 inches above the water surface because that was more nearly the level of the disease infections on the plants.

At 18 inches above the ground diurnal variations in temperature were greater in clear weather than for the standard U.S. Weather Bureau shelter. Nightly minimum temperatures were lower, and daytime maximum temperatures were higher. Humidities were generally higher at the 18-inch level. When placed at the height of a U.S. Weather Bureau shelter with the bottom about 4½ feet from the ground, the temperature and relative humidity results were the same on the same site. In cloudy weather, there were almost no variations as a result of differences in the height above the ground.

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July 1963

U. S. FOREST SERVICE

RESEARCH NOTE LS-19

KE STATES FOREST EXPERIMENT STATION • U. S. DEPARTMENT OF AGRICULTURE

Crown Weights in Red Pine Plantations

Red pine plantations represent a large concentration of fuels associated with relatively high forest investments. These fuels are present from the ground to the treetops. They consist mainly of dead needles, woody and herbaceous vegetation, dead branches, and green crowns (fig. 1).

Fuel weight is an important basic fire behavior consideration. Determining fuel weight on specific areas will provide for more adequate hazard reduction measures, indicate potential energy release on fires, and help predict possible blowup fire conditions. A previous Station Paper has described weights of dead branches and surface fuels in red pine plantations.[1]

The study discussed in this paper was undertaken to determine the crown weights of red pine at different tree diameters, and the influence of different conditions of site and density on the weight of individual crowns.

In plantations on the Lower Michigan National Forest, trees ranging from 2 to 9 inches d.b.h. were selected for crown weight measurements. Weight of the overstory for this range of diameters was studied on good and poor sites in high- and low-density stands.

All live branches on each sample tree were cut and weighed. On representative trees in each diameter class, needles were stripped from one branch per whorl and weighed to provide an estimate of needle weight per tree. Green weights were reduced to dry weights, using a moisture content of 110 percent — an average based on moisture content of needles and branchwood from the sample trees.

For purposes of this study, a site index of 68 or greater was considered good, and one of 52 or less was considered poor. The diameter distributions for stand densities

FIGURE 1. — This high-density red pine plantation is growing on a good site. Needles on the ground, dead branches, and green crowns make up the major fuel components. One acre contains approximately 29,100 pounds (dry weight) of live pine crowns.

[1] *LaMois, Loyd. Fire fuels in red pine plantations. U.S. Forest Service, Lake States Forest Expt. Sta., Sta. Paper 68, 19 pp., illus. 1958.*

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sampled in this experiment on both good and poor sites are tabulated below:

Diameter distribution (d.b.h.)	*High-density stands (No. trees/acre)*	*Low-density stands (No. trees/acre)*
2 to 4	1190	550
5 and 6	980	400
7 to 9	690	440

The highly significant regression of crown weight on d.b.h. shows that there are differences in crown weight per tree at different sites and levels of density (fig. 2). For trees of the same d.b.h., individual crowns on good sites weigh more than crowns on poor sites, and crowns from low-density stands weigh more than crowns from high-density stands. A summary of crown weight per tree is shown in table 1.

The quantity of slash resulting from a cutting operation can be determined by first obtaining a good estimate of site and density from which crown weight per tree is calculated, using figure 2. Next, the number of trees harvested in each diameter class is multiplied by the appropriate crown weight per tree. This result is summed through diameter classes to obtain total crown weight for the operation. Whenever a stand falls in the middle of either the site or stand density ranges, crown weight per tree may be interpolated from figure 2.

A more convenient, though somewhat less accurate, method of estimating fuel weight in tree crowns is to use cordwood volume as a predictor of crown weight. Using figure 3,

TABLE 1. — *Crown weight per tree by d.b.h. and stand condition (in pounds, dry weight)*

Site and density	DBH (inches)		
	4	6	8
Good site, high density	22	36	60
Good site, low density	36	54	82
Poor site, high density	13	28	59
Poor site, low density	23	42	75

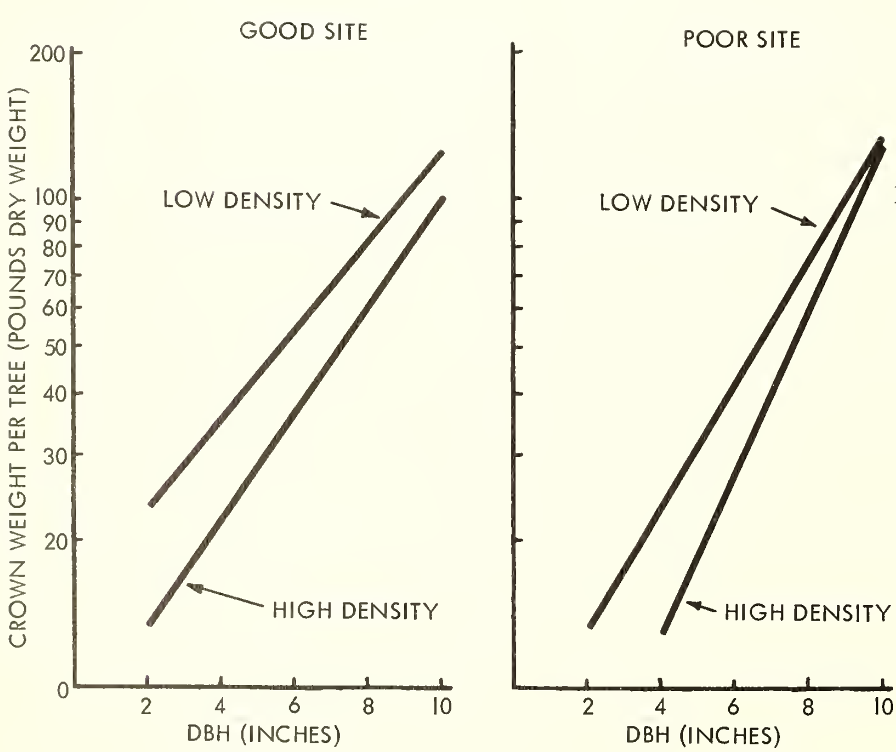

FIGURE 2. — Crown weight per tree for different site and density conditions. Equations for each site according to density conditions are as follows (Lc = log of crown weight per tree; D = d.b.h.; ** = highly significant regression):

A. Good site, low density: Lc. = 1.1967 + .0893D**, r^2 = .77
B. Good site, high density: Lc. = .9072 + .1087D**, r^2 = .91
C. Poor site, low density: Lc. = .8590 + .1269D**, r^2 = .92
D. Poor site, high density: Lc. = .4394 + .1666D**, r^2 = .93

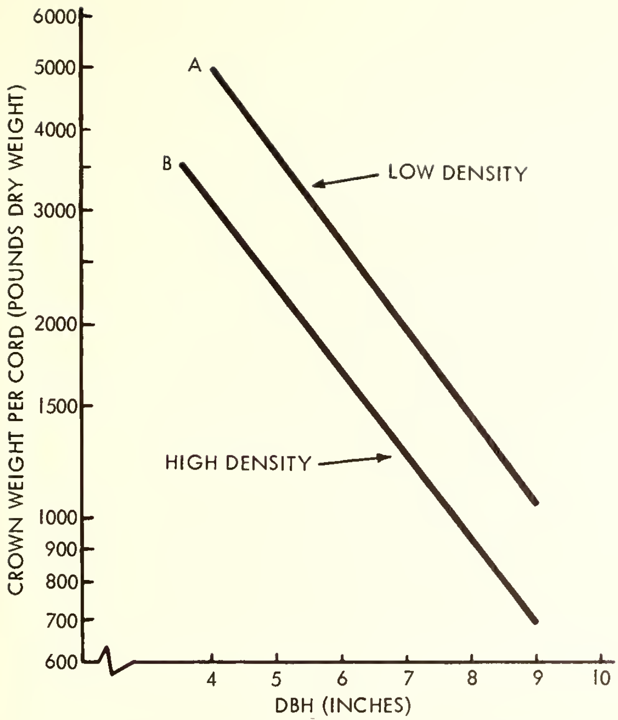

FIGURE 3. — Crown weight per cord on good sites at different densities. Equations for each density condition are as follows (Lc.cd. = log of crown weight per cord; D = d.b.h. ** = highly significant regression):

A. Low-density condition:
Lc.cd. = 4.2436 -- .1358D**, r^2 = .57

B. High-density condition:
Lc.cd. = 4.0013 -- .1293D**, r^2 = .78

the quantity of crown weight produced per cord can be estimated, knowing the average d.b.h. of harvested trees and the relative stand density. If stand density falls between the high and low standards, interpolation of crown weight will improve the results. This method is more accurate if the harvested trees are of a uniform diameter.

Crown weight per cord varies considerably with different stand densities and average diameters. The following tabulation shows the weight (in pounds) of tree crowns to be expected from cutting one cord of wood on a good site under different density conditions:

	DBH Class (inches)		
Density	4	6	8
Low	5,012	2,684	1,436
High	3,049	1,681	927

Weight of the overstory for larger cordwood volumes may be obtained by multiplying number of cords times crown weight in proper diameter and density classes in the tabulation above.

An explanation of the variables used for regression analysis in figure 3 may be of interest. Diameter (d.b.h.) was measured on each sample tree. Crown weight per cord was obtained by first determining the cordwood volume in each sample tree, next calculating the number of trees per cord (1.0 divided by cordwood volume per sample tree), then multiplying this value times the crown weight per tree. Volume for each sample tree was determined from a cordwood volume table based on a 3-inch merchantable top.[2]

The weight of needles per crown expressed as a percent of total crown weight with 95-percent confidence intervals is shown below for each of four stand conditions:

Stand condition		*Percent of crown weight in needles*	
Site	*Density*	*Mean*	*Confidence level*
Good	High	51	47-55
	Low	42	34-50
	High and low	46	39-53
Poor	High	43	38-48
	Low	38	33-43
	High and low	41	36-46
Good and poor	High and low	43	40-46

In good-site, high-density stands, approximately 50 percent of the crown weight is in needles. Poor-site, low-density stands may have only 38 percent of their crown weight in needles. A representative estimate for all sites and densities would be approximately 43 percent of crown weight in needles, the remaining 57 percent being in branchwood and top, excluding the stem of the tree.

Fire behavior is dependent upon the interaction of many factors. The primary in-

[2] *Gevorkiantz, S. R., and Olsen, L. P. Composite volume tables for timber and their application in the Lake States. U.S. Dept. Agr. Tech. Bul. 1104, 51 pp., illus. 1955.*

fluence comes from weather conditions associated with the quantity, composition, and continuity of fuels. Knowledge of crown weights furnishes a way of estimating the amount of overstory fuel in uncut stands as well as the amount of slash created by thinning or harvest cuttings. These estimates of weight, together with knowledge of other fire influences, will provide for more accurate prediction of fire behavior.

July 1963

JAMES K. BROWN, Research Forester

U. S. FOREST SERVICE

RESEARCH NOTE LS-20

LAKE STATES FOREST EXPERIMENT STATION · U. S. DEPARTMENT OF AGRICULTURE

Diameters and Numbers of Trees in Red Pine Stands Are Greatly Affected by Density, Age, and Site

Tree diameter and number of trees per acre greatly influence the value and kind of products produced from red pine stands. Until recently, predictions of diameters and numbers of trees per acre have not been available for intensively managed red pine stands. They have now been computed for a range of management alternatives. These computations show that diameters and numbers of trees produced are affected by site, and can be controlled through the choice of initial spacing in new plantations and thinning intensity in existing stands.

In this Research Note, the diameter of the tree of average basal area is used as the average stand diameter. This can be computed from the following formula if the basal area and number of trees per acre are known:

$$D^2 = (BA/N)(4/\pi)(144)$$

where D = average stand diameter
BA = basal area in sq. ft. per acre
N = number of trees per acre

A current study by the junior author has estimated basal areas for red pine plantations with given numbers of trees per acre at age 35 over a range of sites. A recent study has provided basal area growth and yield estimates by basal area density, age, and site for stands over 35 years of age.[1] These basal area estimates were used in a method developed by the senior author to predict the number of trees per acre left after thinning to an assigned basal area at age 35 and every 10 years thereafter. It was assumed that the stand is cut from above and below so that the proportion of trees cut per acre at each thinning is the same as the proportion of basal area cut. This assures that the diameter of the tree of average basal area is not changed by the thinning. It was further assumed that no trees die between thinnings.

From these estimated number of trees and known basal areas after thinning every 10 years, the diameter of the tree of average basal area was computed. For want of better information, the growth and yield data from regularly thinned stands of a natural origin are assumed to apply to regularly thinned plantations as well.

To illustrate how much diameters and numbers of trees per acre can vary in periodically thinned red pine stands, three stand densities and two sites have been selected as examples (table 1).

Many other combinations of initial stocking (the number of trees per acre before thinning at age 35) and basal area density after thinning could be used. However, it was not possible to consider separately the effect of initial stocking and basal area density in this Note. Instead, the two measures of stand density are presented jointly. The examples were deliberately chosen to show how density extremes can affect future diameters and numbers of trees: low initial stocking thinned to a low basal area density; medium initial stocking thinned to a medium basal area

[1] *Buckman, Robert E. Growth and yield of red pine in Minnesota. U. S. Dept. Agr. Bul. 1272, 50 pp., illus. 1962.*

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TABLE 1. — *Number of trees and basal area per acre for three stand densities, before and after thinning*

Stand density	Basal area left after each thinning	Before thinning at age 35		
		Trees	Basal area at site index	
			50	60
	Square feet	*Number*	*Square feet*	
Low	90	800	165	180
Medium	120	1,200	180	195
High	150	1,600	195	210

density; and high initial stocking thinned to a high basal area density. These approximate the range of current stand density management practices in the Lake States.

As figure 1 shows, by keeping a stand at a low rather than a high density, the forest manager can produce trees of a given diameter at an earlier age, or he can produce larger diameter trees at any given age. For example, if he wishes to grow 15-inch trees on site-index-60 land, he will get them at age 75 with low-density management, at age 105 with medium-density management, and at age 165 with high-density management. Or, at age 95 he will have 20-inch, 13-inch, or 10-inch trees depending upon whether he chooses to manage his stands at a low, medium, or high density. It also follows that at a given age the trees removed in thinning will be larger in low-density stands than in high.

Larger diameter trees can be grown at earlier ages on better sites. For example, by age 95 with low-density management, site-index-60 land will produce trees averaging 3½ inches larger than those on site-index-50 land. This difference in diameters is especially large at older ages and low densities. Of course the trees will also be taller on the better sites, thus increasing the difference in individual tree volume.

The combined influence of stand density and site on diameter growth rates is large (table 2). In low-density stands on site-index-60 land, diameter growth is rapid, with never more than 10 annual rings per inch after age 45. At the other extreme, in high-density

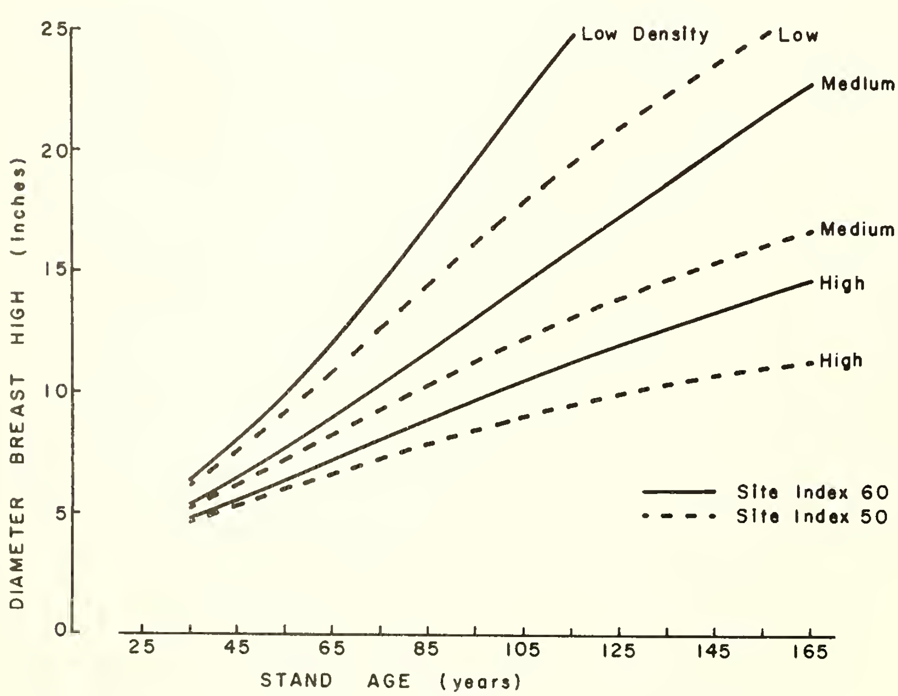

FIGURE 1. — Expected diameter of the tree of average basal area in red pine stands managed at low, medium, and high densities.

TABLE 2. — *Average number of rings per inch at d.b.h. for red pine thinned to the indicated basal area every 10 years*

Stand age (years)	Site index 50			Site index 60		
	Square feet of basal area per acre			Square feet of basal area per acre		
	90	120	150	90	120	150
35 - 45	14	22	29	12	18	29
45 - 55	12	20	29	10	17	25
55 - 65	12	18	33	10	15	25
65 - 75	11	20	33	8	15	25
75 - 85	11	20	33	8	14	22
85 - 95	12	20	33	8	14	25
95 - 105	12	22	40	7	14	25
105 - 115	12	22	40	8	14	29
115 - 125	14	25	50	([1])	14	29
125 - 135	14	25	50	—	14	29
135 - 145	17	29	50	—	15	29
145 - 155	17	33	67	—	14	33
155 - 165	([1])	33	67	—	14	29

[1] *Stand clearcut at beginning of period because of low number of trees per acre.*

TABLE 3. — *Number of red pine trees per acre after thinning to the indicated basal area every 10 years*

Stand age (years)	Site index 50			Site index 60		
	Square feet of basal area per acre			Square feet of basal area per acre		
	90	120	150	90	120	150
35 (before thinning)	800	1,200	1,600	800	1,200	1,600
35	434	794	1,226	405	744	1,156
45	284	570	946	253	515	865
55	194	422	749	165	368	665
65	138	323	610	112	271	525
75	102	255	508	78	205	424
85	79	207	433	57	160	350
95	63	173	378	43	128	294
105	51	147	335	33	104	252
115	43	128	303	([1])	87	220
125	38	114	277	—	74	194
135	33	102	257	—	63	174
145	30	93	241	—	55	156
155	([1])	86	227	—	48	142

[1] *Stand clearcut at this age because of low number of trees per acre.*

stands on site-index-50 land, growth rates are very low at older ages, with never fewer than 40 annual rings per inch after age 95.

The advantages of getting larger diameters at earlier ages from low-density management must be weighed against the smaller number of trees available for harvest (table 3). At any age there are fewer trees in low-density stands than in high. It is also true that in low-density stands fewer trees per acre are available for harvest when they reach a given size (compare table 3 and figure 1).

To illustrate this last point, the forester growing 15-inch red pine on site index 60 will have available for final harvest either 112 trees at age 75, 128 at age 105, or 142 at age 165, depending upon whether he carries his stand at a low, medium, or high density.

The number of trees per acre is also affected by site. On better sites there will be fewer trees at any given age and density level than on poorer sites. Basal area growth rates are higher on better sites, so a larger proportion of the trees must be cut each time the stand is thinned to the assigned basal area level.

The examples given indicate that foresters can control the diameters and numbers of trees produced at a given age by varying the initial stocking and thinning intensity in red pine stands on different sites. A more detailed analysis now being completed will predict diameters and numbers of trees for any combination of initial stocking, stand basal area density, age, and site index over a wide range. With this information the forest manager will be in a better position to grow the number and kinds of red pine trees that will best satisfy his objectives.

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July 1963

U. S. FOREST SERVICE

RESEARCH NOTE LS-21

KE STATES FOREST EXPERIMENT STATION • U. S. DEPARTMENT OF AGRICULTURE

Growth Response of Some Shelterbelt Species Following Sod Removal — Preliminary Results

The establishment and growth of shelterbelt trees are seriously hindered by the competitive growth of grasses and other weeds throughout much of the Northern Great Plains. In the semi-arid parts of the region where droughts are frequent, trees often cannot compete successfully against the better adapted grasses for sparse soil moisture. The results are poor survival and stunted growth. For the best survival and growth, authorities recommend cultivation of shelterbelts, if possible, until tree crown closure shades out the undergrowth.[1] Unfortunately, this practice has not been followed in many tree plantings. A 1954 survey showed a large percentage of windbreaks, especially in the Dakotas, were sod- and weedbound. Less than 1 percent of all sample windbreaks were still being cultivated.[2]

[1] *George, E. J. Cultural practices for growing shelterbelt trees on the Northern Great Plains, U. S. Dept. Agr. Tech. Bul. 1138, 33 pp. 1956.*

[2] *Read, Ralph A. The Great Plains shelterbelt in 1954. Great Plains Agr. Council Pub. 16, Bul. 411, 125 pp. 1958.*

The question arises: Can the various species of a sod-bound planting be stimulated to increased growth by renewed cultivation, and if so, what degree of sod removal is actually necessary to obtain a satisfactory response?

In an attempt to answer this question, two shelterbelts were selected in 1960 for renewed cultivation in north central North Dakota, one near the town of Souris and the other near Westhope. The one near Souris is a 1949 farmstead planting of two rows of caragana, one of boxelder, and one of green ash. It had been cultivated for about the first 5 years, after which brome grass and other weeds invaded the site and created a dense ground cover (fig. 1). The one near Westhope is a field shelterbelt that was planted in 1946. It consists of one row each of caragana, Rocky Mountain juniper, American elm, boxelder, and a mixed row of caragana and chokecherry. It had reportedly been cultivated no more than 2 or 3 years after planting and was densely sod-bound, primarily with brome grass. Both sites have a medium to heavy-

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FIGURE 1. — Sod-bound shelterbelt partially renovated by sod removal (moderate treatment) using a 4-foot-wide rototiller. Grass is *Bromus inermis*, height 3 to 4 feet. Souris, No. Dak.

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textured Barnes loam soil, level topography, and water tables well below 10 feet.

Cultivation treatments were designed as follows: complete — sod removal between tree rows and between the trees in the row; moderate — sod removal between tree rows only; light — sod removal between tree rows but about half the width of the moderate treatment; check — no sod removal. About 20 trees of each species were included in each treatment. Treatments were arranged in a randomized block design with two replications in each belt.

Cultivation was initiated in July 1960. Complete, moderate, and light treatments were mowed, cultivated with a rototiller, and then disked. Mowing was necessary to prevent clogging of the tiller blades. All implements were tractor-drawn, except a small gasoline-powered roto-tiller used for cultivation around trees in the complete treatment. The check was left undisturbed.

During subsequent cultivations in 1961 and 1962 the work was accomplished with a tractor-drawn field cultivator and tandem disk. The distance between rows in both belts was approximately 10 feet, which was sufficient to allow passage of tractor and implements. The number of cultivation operations necessary during a season varied, of course, with weather conditions. During dry years such as 1960 and 1961, with precipitation totals of 11.74 and 8.24 inches respectively, two or three operations were sufficient. With more favorable temperatures and precipitation, additional cultivations might be necessary.

Height, diameter, and crown spread were the three measurements of treatment effects. Height and crown spread were measured to

TABLE 1. — *Two-year growth averages after cultivation — Westhope area planting*

Species	Height	Diameter	Crown spread
(Row)	*(Feet)*	*(Inches)*	*(Feet)*
Complete Cultivation			
Caragana	1.15	[1]—	—
Rocky Mtn. juniper	1.53	0.44	1.15
American elm*	1.89	0.44	0.70
Boxelder	1.44	0.26	0.56
Caragana[2]	0.88	—	—
Moderate Cultivation			
Caragana	0.50	—	—
Rocky Mtn. juniper	1.56	0.44	1.16
American elm*	1.86	0.49	1.03
Boxelder	1.36	0.29	0.66
Caragana[2]	0.74	—	—
Light Cultivation			
Caragana	0.89	—	—
Rocky Mtn. juniper	1.37	0.41	1.09
American elm*	1.47	0.37	0.02
Boxelder	0.85	0.29	--0.07
Caragana[2]	0.86	—	—
Check			
Caragana	0.51	—	—
Rocky Mtn. juniper	1.34	0.33	0.99
American elm	0.60	0.22	--0.52
Boxelder	0.68	0.22	--0.06
Caragana[2]	0.57	—	—

* *Cultivation treatments significantly different (5-percent level) from check.*

[1] *A dash (—) means no measurements taken.*

[2] *This row was a mixture of caragana and chokecherry; only the caragana was measured.*

TABLE 2. — *Two-year growth averages after cultivation — Souris area planting*[1]

Species	Height	Diameter	Crown spread
(Row)	*(Feet)*	*(Inches)*	*(Feet)*
Complete Cultivation			
Caragana	.73	[2]—	—
Boxelder	1.64	0.35	1.34
Green ash	2.02	0.56	1.74
Caragana	1.53	—	—
Moderate Cultivation			
Caragana	0.63	—	—
Boxelder	1.97	0.44	1.68
Green ash	2.11	0.59	2.09
Caragana	1.76	—	—
Light Cultivation			
Caragana	0.59	—	—
Boxelder	1.74	0.36	1.06
Green ash	1.70	0.54	0.93
Caragana	1.37	—	—
Check			
Caragana	0.25	—	—
Boxelder	0.03	0.15	--0.38
Green ash	0.13	0.16	0.05
Caragana	0.54	—	—

[1] *All cultivation treatments significantly different (5-percent level) from check.*

[2] *A dash (—) means no measurements taken.*

the nearest one-tenth of a foot and diameters were measured to the nearest one-tenth of an inch at a height of 3 feet (to include as many of the small trees as possible). Average height, diameter, and crown spread increments were calculated for each year after the start of cultivation.

After one year's cultivation, growth increments of some of the species showed slight gains for the cultivation treatments over the control. After 2 years the beneficial effects of the cultivation were much more pronounced (tables 1 and 2).

All species have benefited in height growth from all degrees of cultivation. This is particularly true of the faster growing American elm, boxelder, and green ash. Comparative gains between the complete and moderate cultivations are not as clearly defined, however, and further trial and study will be necessary to determine whether complete sod removal is necessary or even advisable. Growth, measured in terms of diameter and crown spread, is also generally better in the cultivations than in the check. Growth losses in the check are the result of widespread dieback, resulting probably from drought conditions of the 2 previous years coupled with the effects of the competing grasses.

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July 1963

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RESEARCH NOTE LS-22

E STATES FOREST EXPERIMENT STATION • U. S. DEPARTMENT OF AGRICULTURE

Survival and Growth of 12-Year Hybrid Aspen Compared to Native Wisconsin Stock

In 1951, a small-scale test planting of several aspen hybrids and native aspen was established on the Argonne Experimental Forest in northern Wisconsin. The hybrids tested were: *Populus tremuloides* Michx. of Massachusetts origin x *Populus tremula* L. from Munich, Germany, and *Populus tremuloides* from Massachusetts x *Populus tremuloides* from Colorado. Native quaking aspen wildlings, *Populus tremuloides,* were used for a comparison. All stock was 1 year old at the time of planting.

Twelve years after planting, the hybrid of European aspen x Massachusetts quaking aspen was superior to native Wisconsin aspen in height, diameter, and percentage of survival; the native quaking aspen, however, had better stem form and considerably less canker. The Massachusetts x Colorado quaking aspen hybrid was a complete failure.

Statistics for the surviving hybrid and native aspens are as follows:

Species	*Average height (Feet)*	*Average d.b.h. (Inches)*	*Survival (Percent)*
Populus tremuloides, Mass. x *P. tremula,* Munich	24.4	2.9	59
P. tremuloides Forest County, Wis.	21.1	2.5	54

The two groups of hybrids and one group of native wildlings had been planted in 50-tree lots within a small deer- and rabbit-proof exclosure. The planting site was a sod-bound clearing formerly occupied by northern hardwoods. The soil is a loam of good fertility, but quite stony.

About 6 months prior to planting, the area had been disked, but exposure of mineral soil was estimated at only 50 percent. Trees were planted in deep holes and received no subsequent cultivation. All hybrids were cut back to the ground line 1 year after planting. This treatment was supposed to improve stem form, but it was ineffective.

Fourth-year survival and growth of this plantation was reported by Stoeckeler and Strothmann.[1] The three tree groups have continued to exhibit the same relative growth characteristics during the subsequent 8 years. The Massachusetts x Colorado hybrid was already decadent at 4 years. Mice and frost were the chief causes of early mortality among all three groups.

Although the survival of the hybrid of German x Massachusetts aspen has been better than that of native aspen, it may not maintain this favorable position much longer. This can be shown by plotting survival over time since planting (fig. 1). Mortality among the native aspen has nearly ceased, but mortality among the hybrids has continued at a nearly uniform rate.

This prediction is substantiated by a close examination of each surviving tree. One-third of the hybrids have hypoxylon cankers, whereas only one-ninth of the residual native aspen have cankers. Furthermore, some of the cankers on the hybrids are quite large, having maximum dimensions

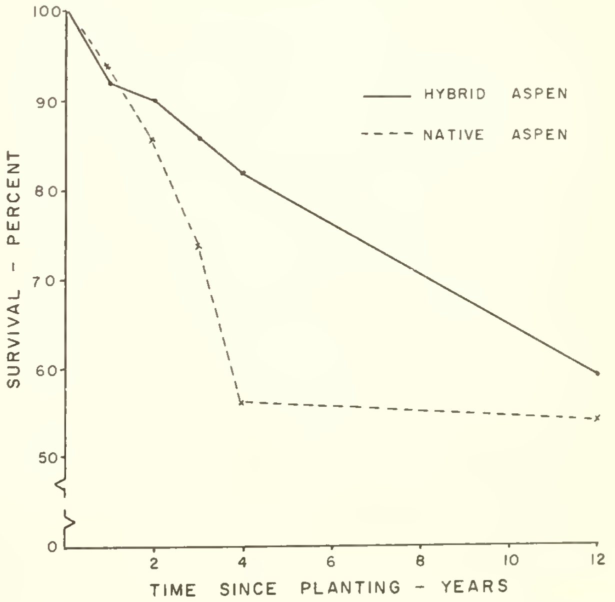

FIGURE 1. — Survival of hybrid and native aspens, by years, since planting.

[1] *Stoeckeler, J. H., and Strothmann, R. O. Early development of native and hybrid aspens. U. S. Forest Serv., Lake States Forest Expt. Sta. Tech. Note 427, 1 p. 1954.*

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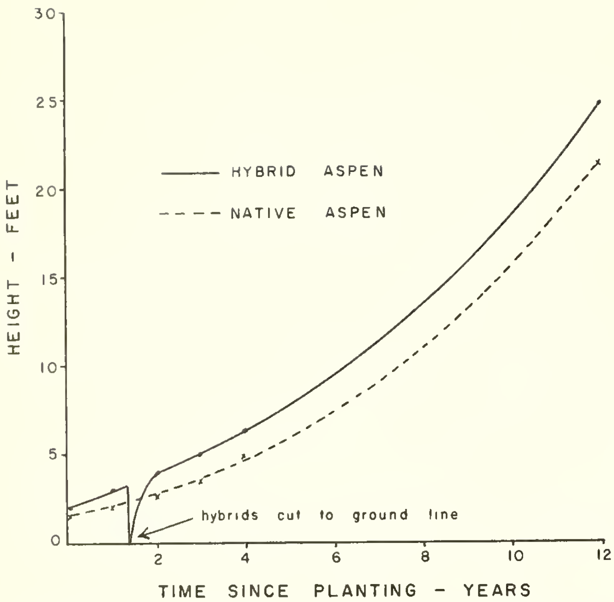

FIGURE 2. — Average total height of hybrid and native aspens by years since planting.

of 6x36 inches. The few cankers on the native aspens are all less than 2x4 inches. The incidence of *Hypoxylon pruinatum* on *Populus tremula* in Wisconsin has been reported by Anderson, Joranson, and Einspahr.[2] These authors indicated that the prevalence of infection on European aspen was comparable to that on trembling aspen of the same age. Therefore, *Populus tremula* cannot be considered as a source of hypoxylon canker resistance when used in crosses with native aspens.

The average total height of the hybrid has always been greater than that of the native aspen. In fact, the difference in height between these two surviving tree groups is becoming greater each year (fig. 2), despite the fact that the hybrids were cut back to the ground line 1 year after planting. Also, some of the surviving hybrids were top-killed by mice for the next three growing seasons. Thus, there is a difference in age of 4 years between the stems of certain hybrids and the stems of the native aspens. Yet the average height of the surviving hybrids has been consistently greater.

Stem taper of the hybrids is slightly less than that of the native aspens. This is shown by an illustration of height over d.b.h. (fig. 3). The curves showing these height-diameter relationships were developed from the following regression equations, in which Y equals height in feet and X equals d.b.h. in inches:

Hybrids $Y = 5.00 + 9.9145X - 0.9267X^2$
Native aspens $Y = 4.035 + 9.1755X - 0.647X^2$

Although the hybrids have made better growth and have less taper, the native aspens have better stem form. Many of the hybrids have substantial crook and sweep and lean away from the prevailing wind. Some trees are forked. The native aspens, however, are generally straight and perpendicular. Also, all native aspens are single stemmed, whereas 13 percent of the surviving hybrids are multistemmed clumps. It is not known whether the basal sprouting is due to the practice of cutting back the stems, the subsequent rodent damage, or an inherent characteristic of this hybrid.

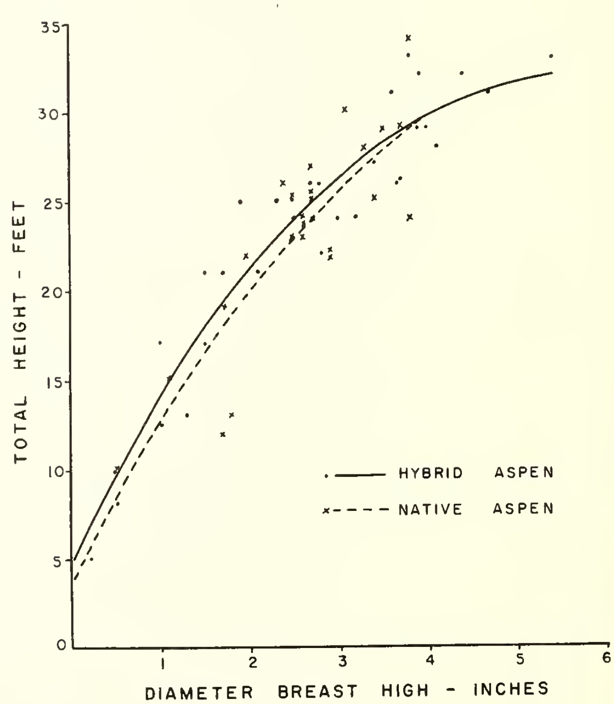

FIGURE 3. — Twelve-year height-diameter relationships for native and hybrid aspens.

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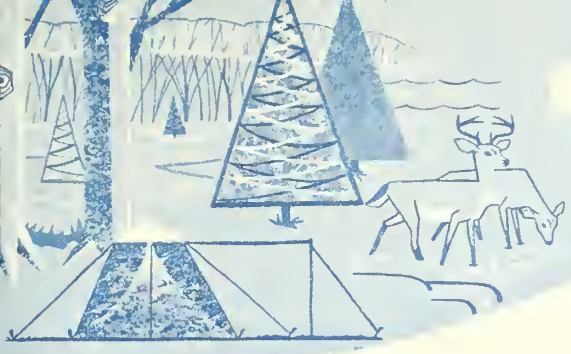
July 1963

[2] *Anderson, Ralph L., Joranson, Philip N., and Einspahr, Dean W. Hypoxylon canker on European aspen. Abstract. Plant Dis. Rptr. 44:132. 1960*



U. S. FOREST SERVICE

RESEARCH NOTE LS-23

KE STATES FOREST EXPERIMENT STATION • U. S. DEPARTMENT OF AGRICULTURE

Lake States Pulpwood Production Up While Canadian Imports Drop to All-Time Low, 1962

After a mild setback in 1961, Lake States pulpwood production bounced back with a record cut of approximately 3,342 thousand cords in 1962. This was an increase of 6 percent over 1961 and a shade more than the all-time high recorded in 1960. The increase in cut was regionwide, as each of the Lake States produced more pulpwood than the year before. Michigan continued to be the leading pulpwood producing State with 1,223 thousand cords, Wisconsin was second with 1,140 thousand cords (a record amount for this State), and Minnesota was third with a cut of 979 thousand cords.

Of the total regional production, about 98 percent was roundwood — the remaining 2 percent was wood chips, slabs, and veneer cores. Chipped and unchipped mill residues shipped to pulpmills amounted to approximately 65 thousand cords in 1962, an increase of more than 50 percent over the previous year.

A heavier cut of hardwood species contributed to the overall increase in 1962. White birch, with a 25-percent increase, posted the largest gain of all hardwood species; miscellaneous dense hardwoods and aspen increased 11 percent and 8 percent respectively. The cut of softwoods, as a group, was about 1 percent less than that of the previous year.

Total 1962 pulpwood receipts at Lake States mills were approximately 3,630 thousand cords, an increase of 5 percent from the previous year. Wisconsin and Minnesota receipts were up 8 percent and 6 percent respectively, while those of Michigan were down 3 percent. Lake States forests supplied 91 percent of the pulpwood received, Canada 6 percent, and Western States 3 percent (see table below). The proportion of wood received from Canada each year has been progressively smaller. Station records show that less than 10 years ago Canadian producers furnished more than 20 percent of the pulpwood consumed by Lake States mills. As a result of this change in source of wood, the proportion of spruce pulpwood supplied by Minnesota forests has generally been increasing. In 1962, Minnesota supplied almost one-half of the spruce needs of the Lake States pulpwood industry.

The table on the reverse side shows pulpwood production, imports, and exports for the Lake States by species, for 1962.

Geographic origin and destination of pulpwood received by Lake States mills, 1962

Species	Percent of pulpwood originating from:					Percent of pulpwood received by mills in:		
	Minn.	Wis.	Mich.	Canada	Other U.S.	Minn.	Wis.	Mich.
Aspen	25	36	38	1	—	26	50	24
Balsam fir	41	18	39	2	—	28	59	13
Birch	3	64	33	—	—	2	77	21
Hemlock	—	43	57	—	—	—	100	—
Pine	30	27	27	6	10	28	58	14
Spruce	47	3	18	32	—	24	70	6
Tamarack	48	29	23	—	—	—	100	—
Misc. hardwoods[1]	9	51	40	—	—	10	57	33
Slabs, etc.	—	54	46	—	—	—	100	—
Wood chips	*	37	17	—	46	*	100	—
All wood material	27	31	33	6	3	23	58	19
Previous year (1961)	28	31	31	9	1	23	57	20

[1] *Mostly dense hardwoods.* * *Less than ½ of 1 percent.*

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July 1963

Production and imports of pulpwood, Lake States, 1962
(in standard cords, unpeeled)

Species and destination	Production by states[1]				Imports			Total Receipts
	Minnesota	Wisconsin	Michigan	Region	Other U.S.[2]	Canada	Total imports	
Aspen								
Minn	392,922	15,080	—	408,002	—	9,825	9,825	417,827
Wis.	13,119	555,672	214,818	783,609	—	—	—	783,609
Mich.	—	1,103	386,027	387,130	—	—	—	387,130
Total	406,041	571,855	600,845	1,578,741	—	9,825	9,825	1,588,566
Balsam fir								
Minn.	68,563	—	—	68,563	—	5,832	5,832	74,395
Wis.	39,662	46,224	69,322	155,208	—	31	31	155,239
Mich.	—	250	34,698	34,948	—	—	—	34,948
Exported[3]	1,474	—	—	1,474	—	—	—	—
Total	109,699	46,474	104,020	260,193	—	5,863	5,863	264,582
Birch, white								
Minn.	1,290	—	—	1,290	—	—	—	1,290
Wis.	426	41,457	7,368	49,251	—	—	—	49,251
Mich.	—	—	13,657	13,657	—	—	—	13,657
Total	1,716	41,457	21,025	64,198	—	—	—	64,198
Hemlock								
Minn.	—	—	—	—	—	—	—	—
Wis.	—	42,230	57,004	99,234	—	—	—	99,234
Mich.	—	—	—	—	—	—	—	—
Total	—	42,230	57,004	99,234	—	—	—	99,234
Pine								
Minn.	145,484	208	—	145,692	—	43,073	43,073	188,765
Wis.	55,534	187,493	86,477	329,504	65,464	—	65,464	394,968
Mich.	—	—	97,316	97,316	—	—	—	97,316
Total	201,018	187,701	183,793	572,512	65,464	43,073	108,537	681,049
Spruce								
Minn.	110,021	—	—	110,021	—	1,117	1,117	111,138
Wis.	98,259	15,266	57,918	171,443	—	145,524	145,524	316,967
Mich.	548	26	28,123	28,697	—	—	—	28,697
Exported[3]	7,673	—	—	7,673	—	—	—	—
Total	216,501	15,292	86,041	317,834	—	146,641	146,641	456,802
Tamarack								
Minn.	—	—	—	—	—	—	—	—
Wis.	9,273	5,634	4,372	19,279	—	—	—	19,279
Mich.	—	—	—	—	—	—	—	—
Total	9,273	5,634	4,372	19,279	—	—	—	19,279
Misc. dense hdwds.								
Minn.[4]	34,254	—	—	34,254	—	—	—	34,254
Wis.[4]	—	178,549	27,133	205,682	—	—	—	205,682
Mich.[4]	—	—	116,980	116,980	—	—	—	116,980
Exported[3]	231	9,358	—	9,589	—	—	—	—
Total	34,485	187,907	144,113	366,505	—	—	—	356,916
Total roundwood								
Minn.	752,534	15,288	—	767,822	—	59,847	59,847	827,669
Wis.	216,273	1,072,525	524,412	1,813,210	65,464	145,555	211,019	2,024,229
Mich.	548	1,379	676,801	678,728	—	—	—	678,728
Exported[3]	9,378	9,358	—	18,736	—	—	—	—
Total	978,733	1,098,550	1,201,213	3,278,496	65,464	205,402	270,866	3,530,626
Slabs, etc.								
Minn.	—	—	—	—	—	—	—	—
Wis.	—	7,257	6,082	13,339	—	—	—	13,339
Mich.	—	—	—	—	—	—	—	—
Exported[3]	—	—	—	—	—	—	—	—
Total	—	7,257	6,082	13,339	—	—	—	13,339
Wood chips								
Minn.	*	—	—	*	—	—	—	*
Wis.	—	33,870	9,486	43,356	43,015	—	43,015	86,371
Mich.	—	—	—	—	—	—	—	—
Exported[3]	—	670	6,512	7,182	—	—	—	—
Total	*	34,540	15,998	50,538	43,015	—	43,015	86,371
All wood material								
Minn.	752,534	15,288	—	767,822	—	59,847	59,847	827,669
Wis.	216,273	1,113,652	539,980	1,869,905	108,479	145,555	254,034	2,123,939
Mich.	548	1,379	676,801	678,728	—	—	—	678,728
Exported[3]	9,378	10,028	6,512	25,918	—	—	—	—
Total	978,733	1,140,347	1,223,293	3,342,373	108,479	205,402	313,881	3,630,336

[1] *Vertical columns of figures under box heading "Production by States" presents the amount of pulpwood cut in each state.*
[2] *Mostly Western States.*
[3] *Pulpwood shipped to mills outside of Region.*
[4] *Some balsam poplar in Minnesota, mostly dense hardwoods in other States.*
* *Negligible.*

U. S. FOREST SERVICE

RESEARCH NOTE LS-24

LAKE STATES FOREST EXPERIMENT STATION • U. S. DEPARTMENT OF AGRICULTURE

Healing Time for Pruning Wounds in a Red Pine Plantation

In red pine plantations the branches are persistent, and little knot-free lumber will be produced in less than 80 years without artificial pruning. When applied judiciously in managed stands, pruning should be a profitable investment.

A pruning study on red pine was established in Lower Michigan in 1950, and the effect of pruning on height and diameter growth was reported by Slabaugh.[1] This Note describes the effect of pruning date and other characteristics on the healing time of pruning wounds from that same study.

The test was established in a 14-year-old red pine plantation on a good site in Lower Michigan. Trees were pruned on July 27, September 25, and November 13 of 1950; and on April 5, May 4, May 21, and July 31 of 1951. The trees, which averaged 3.4 inches d.b.h. and 16 feet tall, were pruned to a height of 6 to 8 feet, using a hand saw. All the branches were alive when pruned.

On trees pruned on the first six dates, pruning wounds from whorls at heights of 3.0 and 4.5 feet averaged 0.84 inch in diameter in July 1951. Most wounds were covered with pitch, but only those pruned on April 5 or before showed much evidence of healing at this time. In October 1953, two growing seasons after pruning, the wounds had begun to heal and averaged only 0.5 inch in diameter.

In April 1961, ten growing seasons after pruning, three sample trees pruned on each of the seven pruning dates were felled, and all the knots in the two sample whorls were cut open in transverse sections to determine the manner in which the annual rings grew over the wounds. Wound width just after pruning, branch stub length, and radial growth of the bole during the 10 years after pruning were measured to the nearest 0.05 inch on 183 sections and averaged 0.80, 0.28, and 1.06 inches respectively. About one-third of the wounds had not yet completely healed; their healing times, on the basis of present unhealed width and growth rate, were estimated and averaged 13 years. For all wounds the average number of years before clear wood was produced, as determined by a ring count, was 9.7 years. These data were used to compute an equation for predicting wound healing time. The equation is:

$$Y = 11.115 + 4.380X_1 + 14.279X_2 - 8.382X_3$$

where Y = years before clear wood is produced

X_1 = wound width (inches)

X_2 = stub length (inches)

X_3 = radial growth during the 10-year period after pruning (inches)

Each of the independent variables was highly significant (.01 level). Radial growth accounted for a third of the variation in healing time while the three factors combined accounted for half the variation. Predicted healing times, based on the measured values of the three independent variables, were determined for all the wounds. The difference in healing times between pruning dates was not

[1] *Slabaugh, Paul E. Effects of live crown removal on the growth of red pine. Jour. Forestry 55: 904-906, illus. 1957.*

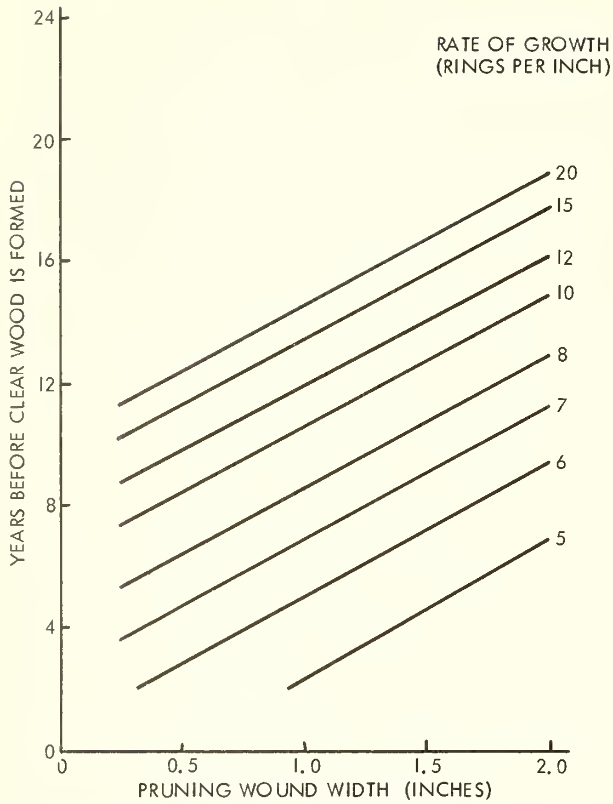

FIGURE 1. — Relationship between pruning wound width, bole radial growth, and time until clear wood is formed in a red pine plantation (branch stub length constant at 0.25 inch).

significant when the residuals were tested by analysis of variance.

In this study the branch stub length was measured from the cambium. Branches cut flush with the bark had a stub length equal to the bark thickness or about 0.25 inch. Increasing the average stub length another 0.25 inch would have increased the healing time 3.6 years, but increasing the wound width 0.25 inch would have increased the healing time only 1.1 years. For rapid wound healing, therefore, the branch stubs should be short, even though the wound width is increased slightly.

A series of regressions to show the relationship of wound width and growth rate to healing time was computed from the equation above. These regressions (fig. 1) show the importance of growth rate on healing time. A 1-inch-wide pruning wound, for example, was healed in 7 years where the growth after pruning was 7 rings per inch, but 12 years were required where the growth was 12 rings per inch. Thus, for the early formation of clear wood over pruning wounds the trees had to grow fast.

As a rule of thumb, the wounds of average width were usually healed when a layer of wood about as thick as the width of the wound had been formed. The thickness of the layer required was slightly less than the wound width for the larger wounds and more than the wound width for the smaller wounds. Thinning pruned plantations will stimulate diameter growth on the remaining trees, thereby reducing the time required to heal the pruning wounds and increasing the return on the investment in pruning costs.

July 1963

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U. S. FOREST SERVICE

RESEARCH NOTE LS-25

LAKE STATES FOREST EXPERIMENT STATION • U. S. DEPARTMENT OF AGRICULTURE

Forest Area Trends in Minnesota Counties

The total area of forest land in Minnesota, now 19 million acres, has decreased less than 3 percent in the last 30 years. This relatively small loss is due primarily to increased urbanization and new rights-of-way that have been cleared for highways and utility lines. Land-clearing activities have more than offset any additions to forest land from natural restocking and tree planting. Most tree planting is done on land already classified as forest — this does not change the total forest area.

Although the patterns are indistinct, significant changes in forest area have occurred in several counties and certain sections of the State. Counties with the greatest reductions in forest area are Beltrami, Pine, Aitkin, and Roseau. Those with the largest increases include Becker, Otter Tail, and Anoka. Forest area increased in 40 counties between 1953 and 1962, but decreased in another 47 (table 1). Only 7 of the counties in the northern half of the State had increases, and all of the counties in the Red River Valley have less forest area now than a decade ago.

Commercial forest land, at first glance, shows a decrease in area of about 6 percent in the last 10 years. However, this decrease very probably reflects improved survey procedures rather than an actual change in commercial forest acreage. When forest area distributions by ownerships and forest types are available a more accurate analysis of the change can be made. The commercial forest area is now estimated as 17.1 million acres, compared with 18.1 million recorded in the last survey. Newer aerial photos, more widely dispersed sampling, and more objective methods of site determination account for a part of this decrease, particularly in Beltrami County. A small part of this change resulted from expansion of parks and other reserved recreational areas. The reported decrease in commercial forest land should not result in decreased timber volume because most of the excluded area is marginal for growing tree crops.

Commercial forest land, as a percent of all land, declines across Minnesota from northeast (about 80 percent) to southwest (less than 1 percent). Minnesota's Arrowhead country is in large measure her woodshed, containing all of the most heavily forested counties (fig. 1 on last page).

The sampling error for forest areas from this survey is less than 1.5 percent (at one standard deviation) per million acres, and is somewhat smaller in the northern counties which were sampled more intensively.

The forest area information reported in this Note is part of the results of the Third Minnesota Forest Survey made during 1960-63 by the Office of Iron Range Resources and Rehabilitation and the Lake States Forest Experiment Station in cooperation with other public and private agencies. Other publications giving details of Minnesota forest areas, timber volumes, growth, and cut are being prepared and will be published during the next 12 months.

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July 1963

TABLE 1. — *Minnesota forest areas by county in 1962, and changes since 1953*

County	Land area 1/	Forest land 2/		Noncommercial 4/		Commercial forest as a percent of area	Change in forest land since 1953	Change in commercial forest land since 1953
		Total	Commercial 3/	Productive reserve 5/	Unproductive 6/			
	Thousand acres	Thousand acres	Thousand acres	Thousand acres	Thousand acres	Percent	Thousand acres	Thousand acres
Aitkin	1,167.4	900.4	850.6	-	49.8	72.9	-41.7	-43.3
Anoka	272.0	74.4	62.1	-	12.3	22.8	+28.2	+15.9
Becker	841.6	390.1	385.9	3.5	.7	45.8	+42.1	+38.2
Beltrami	1,610.9	1,178.2	993.0	.3	184.9	61.6	-80.3	-227.2
Benton	258.6	35.0	27.3	-	7.7	10.6	-14.9	-21.7
Big Stone	326.4	4.0	3.8	-	.2	1.2	+.7	+.7
Blue Earth	473.6	33.3	31.4	.1	1.8	6.6	-4.4	-6.3
Brown	392.3	15.8	14.7	.2	.9	3.7	-5.2	-6.1
Carlton	550.4	383.4	367.0	8.4	8.0	66.7	-7.1	-2.4
Carver	229.1	28.4	23.9	-	4.5	10.4	+1.9	-2.6
Cass	1,313.9	1,023.8	1,006.4	-	17.4	76.6	+2.8	-11.5
Chippewa	372.5	8.5	7.8	.3	.4	2.1	+2.4	+1.7
Chisago	268.2	66.1	52.9	.1	13.1	19.7	-2.0	-15.0
Clay	672.0	24.9	20.0	.1	4.8	3.0	+5.6	+.7
Clearwater	643.2	394.5	367.7	19.4	7.4	57.2	-4.6	-11.9
Cook	897.9	868.9	710.0	157.0	1.9	79.1	+1.6	-12.8
Cottonwood	409.6	7.1	6.7	-	.4	1.6	+2.7	+2.3
Crow Wing	639.4	449.5	447.5	-	2.0	70.0	-15.5	-11.9
Dakota	365.4	42.1	33.6	-	8.5	9.2	+5.5	-3.0
Dodge	278.4	9.0	8.5	-	.5	3.0	-5.1	-5.6
Douglas	407.7	48.2	42.3	.3	5.6	10.3	+6.3	+.6
Faribault	456.3	13.6	12.8	-	.8	2.8	-.1	-.9
Fillmore	549.8	90.1	83.7	-	6.4	15.2	-5.1	-8.9
Freeborn	449.3	16.4	15.4	.1	.9	3.4	+2.3	+1.4
Goodhue	485.1	71.1	63.0	.6	7.5	13.0	+4.6	-1.6
Grant	356.5	5.4	5.1	-	.3	1.4	+.6	+.4
Hennepin	361.6	36.8	30.6	.2	6.0	8.5	+5.4	-.8
Houston	361.6	127.8	114.8	.4	12.6	31.7	+1.9	-7.5
Hubbard	596.5	445.8	440.1	3.8	1.9	73.8	+.5	-.5
Isanti	282.9	60.9	51.2	-	9.7	18.1	-4.1	-13.8
Itasca	1,704.3	1,480.9	1,411.9	1.4	67.6	82.8	-16.1	-45.8
Jackson	446.7	6.8	6.2	.2	.4	1.4	-1.3	-1.7
Kanabec	336.0	177.4	154.6	-	22.8	46.0	+9.1	-11.5
Kandiyohi	527.4	23.2	21.2	.7	1.3	4.0	-11.6	-13.2
Kittson	719.4	119.7	94.2	.5	25.0	13.1	-1.7	-10.1
Koochiching	2,002.6	1,868.7	7/1,574.7	-	7/294.0	78.6	+7.5	+52.8
Lac qui Parle	494.7	8.6	8.1	-	.5	1.6	-.7	-1.0
Lake	1,364.5	1,306.8	1,104.0	173.3	29.5	80.9	-8.6	-34.6
Lake of the Woods	837.1	623.4	528.5	-	94.9	63.1	-26.0	-26.4
Le Sueur	282.2	31.2	29.5	-	1.7	10.5	+6.1	+4.4
Lincoln	345.6	5.4	5.1	-	.3	1.5	+2.6	+2.3
Lyon	456.3	6.7	5.9	.4	.4	1.3	+1.0	+.6
Mahnomen	367.4	128.8	126.6	-	2.2	34.5	-16.1	-18.3
Marshall	1,152.0	203.2	151.6	.2	51.4	13.2	-24.1	-74.5
Martin	452.5	7.2	6.8	-	.4	1.5	+3.0	+2.6
McLeod	318.7	11.0	10.4	-	.6	3.3	-1.1	-1.7
Meeker	396.8	16.6	15.7	-	.9	4.0	-.5	-1.3
Mille Lacs	363.5	157.5	131.3	6.1	20.1	36.1	-14.1	-40.0
Morrison	727.0	230.3	200.3	.3	29.7	27.6	-15.0	-42.7
Mower	449.9	9.9	9.4	-	.5	2.1	-3.5	-4.0
Murray	453.1	5.1	4.6	.2	.3	1.0	+1.2	+.9
Nicollet	293.8	18.2	17.1	.1	1.0	5.8	-1.5	-2.4
Nobles	455.7	3.3	3.1	-	.2	.7	+.8	+.6
Norman	566.4	33.3	30.0	-	3.3	5.3	-7.6	-10.9
Olmsted	419.2	52.9	47.9	-	5.0	11.4	+4.9	+.9
Otter Tail	1,280.0	268.2	232.3	.1	35.8	18.1	+23.7	-11.7
Pennington	398.1	44.0	35.6	-	8.4	8.9	-18.8	-27.2
Pine	903.7	515.9	459.4	26.6	29.9	50.8	-42.6	-67.1
Pipestone	297.0	1.9	1.8	-	.1	.6	+.7	+.6
Polk	1,287.7	91.8	74.5	-	17.3	11.8	-18.6	-33.2

Table 1 (cont'd)

County	Land area 1/	Forest land 2/ Total	Commercial 3/	Noncommercial 4/ Productive reserve 5/	Noncommercial 4/ Unproductive 6/	Commercial forest as a percent of area	Change in forest land since 1953	Change in commercial forest land since 1953
	Thousand acres	Thousand acres	Thousand acres	Thousand acres	Thousand acres	Percent	Thousand acres	Thousand acres
Pope	435.8	18.2	17.2	-	1.0	3.9	+3.3	+2.4
Ramsey	102.4	8.7	6.6	-	2.1	6.4	+1.9	- .2
Red Lake	276.5	43.1	36.9	.1	6.1	13.3	-9.8	-15.8
Redwood	559.3	10.9	10.3	-	.6	1.8	-4.3	-4.7
Renville	627.2	15.0	14.2	-	.8	2.3	-1.5	-2.3
Rice	316.8	25.7	23.0	.5	2.2	7.3	+4.8	+2.1
Rock	310.4	2.0	1.9	-	.1	.6	+.2	+.1
Roseau	1,072.6	336.6	271.0	-	65.6	25.3	-37.0	-99.3
St. Louis	4,019.8	3,464.6	3,204.3	95.2	165.1	79.7	+4.9	-29.6
Scott	225.3	27.0	23.6	-	3.4	10.5	-1.0	-2.4
Sherburne	280.3	59.1	42.3	-	16.8	15.1	+.6	-16.2
Sibley	371.8	24.9	23.5	-	1.4	6.3	+5.0	+3.7
Stearns	867.8	103.1	78.2	-	24.9	9.0	+8.6	-15.8
Steele	272.0	10.5	9.7	.2	.6	3.6	+2.4	+1.7
Stevens	364.8	2.5	2.4	-	.1	.7	-.8	-.9
Swift	478.1	8.4	7.8	.1	.5	1.6	-2.9	-3.3
Todd	606.1	147.6	128.3	-	19.3	21.2	-17.1	-36.4
Traverse	366.1	2.6	2.5	-	.1	.7	-.3	-.4
Wabasha	333.4	65.3	51.6	.1	13.6	15.5	+.4	-10.0
Wadena	343.0	132.5	130.0	.7	1.8	37.9	-8.1	-10.6
Waseca	265.6	12.3	11.6	-	.7	4.4	-2.3	-2.9
Washington	249.6	33.3	26.9	.4	6.0	10.8	+2.5	-3.8
Watonwan	277.1	5.4	5.1	-	.3	1.8	+1.1	+.8
Wilkin	481.3	2.1	2.0	-	.1	.4	-.4	-.5
Winona	398.7	114.7	96.5	.9	17.3	24.2	-1.3	-13.6
Wright	429.5	49.4	42.6	-	6.8	9.9	-3.1	-9.9
Yellow Medicine	485.1	10.5	9.9	-	.6	2.0	-.2	-.8
State total	51,205.8	19,047.4	17,062.0	503.1	1,482.3	33.3	-296.3	-1,035.6

1 *1960 Bureau of Census.*

2 *Land at least 10 percent stocked by forest trees of any size, or formerly having such tree cover, and not currently developed for nonforest use. Does not include lands currently developed for nonforest use such as urban or thickly settled residential or resort areas, city parks, orchards, improved roads, or improved pasturelands. The minimum area classified as forest land was 1 acre. Roadside, streamside, and shelterbelt strips of timber with crown width of 120 feet wide qualified as forest land. Unimproved roads and trails, streams, and clearings in forest areas were classified as forest if less than 120 feet in width.*

3 *Forest land which is producing or capable of producing crops of industrial wood and not withdrawn from timber utilization.*

4 *Unproductive forest land incapable of yielding crops of industrial wood because of adverse site conditions and productive public forest land withdrawn from commercial timber use through statute or administrative regulation.*

5 *Productive public forest land withdrawn from timber utilization through statute or administrative regulation.*

6 *Forest land incapable of yielding crops of industrial wood because of adverse site conditions.*

7 *Differs slightly from published Koochiching County Report due to computer rounding.*

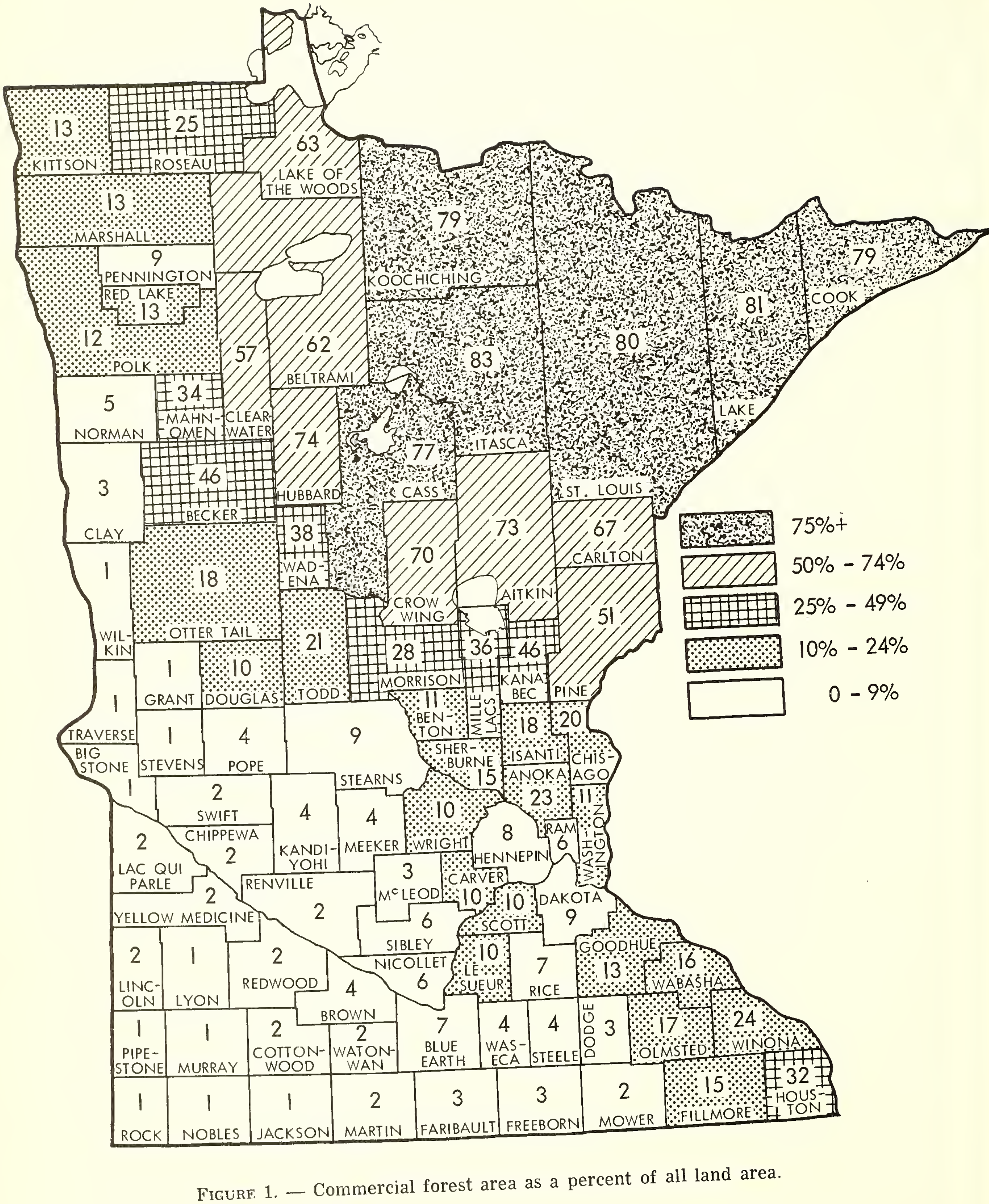

FIGURE 1. — Commercial forest area as a percent of all land area.

U. S. FOREST SERVICE

RESEARCH NOTE LS-26

LAKE STATES FOREST EXPERIMENT STATION · U. S. DEPARTMENT OF AGRICULTURE

White Pine Root Rot at the Chittenden Nursery

The Chittenden Nursery was established by the U.S. Forest Service at Wellston, Mich., in 1934. During the 3 years following establishment, seedling production was good, but in 1937 and 1938 mortality began occurring in white pine (*Pinus strobus* L.) seedling and transplant beds. Seedbed losses reached 59 percent in 1939. These losss were at first attributed to white grubs (*Phyllophaga* sp.), but as losses continued, drought and acid injury were suspected. By 1944, however, it was decided that the white pine were being killed by root rot organisms.

Beginning in 1945, various attempts were made to determine the cause of this root rot. Fungus isolations from soil and from infected seedlings were inconclusive. Eleven species of nematodes were isolated but, although five were plant parasites, they were not considered abundant enough to have caused the damage. Tests in which nine different minor soil elements were applied to the beds showed no reduction of losses. Addition of organic matter was likewise ineffective.

A method of controlling the root rot was found as a result of a series of tests with various chemicals. The soil sterilant, methyl bromide, gave the best control (Anderson et al. 1956).[1] It also reduced weeding costs and stimulated seedling vigor. For these reasons, treatment with methyl bromide has been adopted as a standard nursery practice at the Chittenden Nursery.

Investigations have been continued to learn the exact cause of the root rot. Riffle and Strong (1960) conducted experiments with fungi isolated from the nursery. They reported that various species of *Fusarium* were re-isolated from 50 to 60 percent of their diseased experimental seedlings.

This paper reports the finding of *Cylindrocladium scoparium* Morg. in the Chittenden Nursery and the results of some inoculation experiments with isolates of this fungus. Two isolates of *Rhizoctonia* sp. obtained from this nursery were also used in the experiments.

During the summer of 1962, isolations were made from some of the few diseased white pine seedlings that can still be found in the nursery. Approximately 1,200 root pieces, ½ to 1 cm. in length, were plated on 2-percent malt agar containing 200 p.p.m. streptomycin sulfate. The root pieces were washed in running water for 1 hour, placed in a 1-percent solution of sodium hypochlorite for 1 minute, washed twice in sterile distilled water, and then plated on the malt agar medium. *Rhizoctonia* was isolated from several of these root sections, but *Cylindrocladium* was not recovered.

Cylindrocladium was recovered from Vernal alfalfa, *Medicago sativa* L., grown in soil taken from 2-1 and 2-2 white pine transplant beds

[1] *Names and dates in parentheses refer to literature cited at end of Note.*

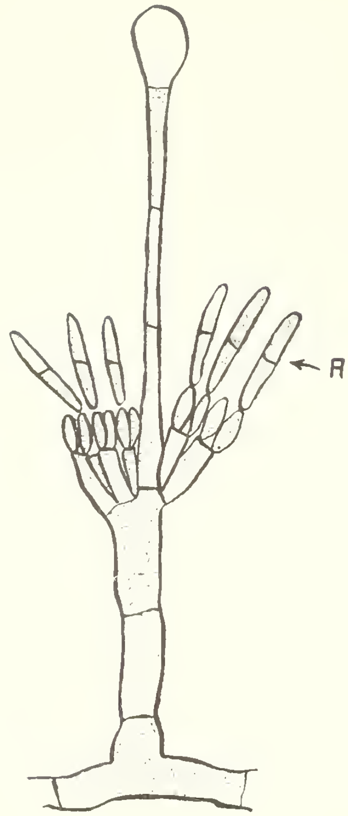

FIGURE 1 — Diagramatic sketch of *C. scoparium* conidial apparatus. Drawn approximately to scale. Conidia (A) are approximately 50 microns long.

(Bugbee 1962). Seedlings grown in this soil damped off soon after emergence. Under moist conditions the fungus sporulated on the dead tissue and the characteristic conidial apparatus of this fungus could be recognized, using a 10x hand lens (fig. 1). When sections of these diseased seedlings were placed on malt agar, *Cylindrocladium* grew out onto the medium. It produced characteristic reddish-brown microsclerotia and a mycelium having concentric zones and radial striations.

Inoculation tests were conducted with inoculum prepared by growing isolates of *Rhizoctonia* and *Cylindrocladium* on sterile mixtures of 10-percent cornmeal and soil for 3 weeks. This inoculum was mixed 1:25 with steamed soil. Dormant 2-0 seedlings of black spruce (*Picea mariana* (Mill.) B.S.P.), red pine (*Pinus resinosa* (Ait.)), and white pine were then potted in this inoculated soil. Thirty-six trees of each species were used.

After 8 weeks all of the trees planted in soil that had been inoculated with *Cylindrocladium* were dead. Most of those growing in soil that had been inoculated with *Rhizoctonia* and those growing in uninoculated soil were still healthy after 90 days. The one check seedling and the three seedlings growing in soil inoculated with *Rhizoctonia* that did die may have been damaged in transplanting.

Re-isolation tests were made from roots of the seedlings that died after being transplanted in soil inoculated with *Cylindrocladium* and from apparently healthy roots of seedlings transplanted in soil inoculated with *Rhizoctonia.* For the *Cylindrocladium* test, 100 root pieces from each tree species were placed in petri plates containing 2-percent malt agar. For the *Rhizoctonia* test, 76 root pieces were similarly treated. Three weeks later the percent of recovery of the two species of fungus was as follows:

	Cylindrocladium	*Rhizoctonia*
Black spruce	65	1.0
Red pine	41	4.0
White pine	13	2.5

Discussion

A serious root rot of pine and spruce in Lake States nurseries is caused by *Cylindrocladium scoparium.* Losses range from 10 to 20 percent to more than 90 percent. The fungus has been isolated from various conifer species at six nurseries in Minnesota, six in Wisconsin, and two in Michigan. However, attempts to isolate the fungus directly from diseased seedlings grown at the Chittenden Nursery over a 3-year period have been unsuccessful.

In the experiments reported in this paper, *Cylindrocladium scoparium* was isolated from Chittenden Nursery soil using the alfalfa technique. Three species of seedlings planted in soil inoculated with pure cultures of the fungus were killed within 8 weeks. Re-isolation from these dead seedlings yielded *Cylindrocladium* from 65 percent of the black spruce, 41 percent of the red pine, but only 13 percent of the white pine. The low recovery of *Cylindrocladium* from white pine may explain why previous workers have not isolated the fungus at the Chittenden Nursery.

Riffle and Strong (1960) did not indieate that *Cylindrocladium* was reeovered in their study but did report that 36 pereent of the fungi they isolated from the Chittenden Nursery failed to sporulate on acidified potato dextrose agar. It is possible that some of these fungi were *Cylindrocladium scoparium* beeause none of the isolates from 15 conifer nurseries the authors have worked with has sporulated on acidified potato dextrose or malt agar. They all sporulated, however, when grown on Czapeks medium (Anderson et al. 1962).

The root rot situation at the Chittenden Nursery is apparently unique among Lake States nurseries. At this Nursery only white pine were infected. In other nurseries where *Cylindrocladium* has been isolated, several eonifer species have suffered root rot damage. In recent greenhouse experiments, the *Cylindrocladium* fungus was found to be parasitie on 12 of 13 conifer species. Northern white-cedar, *Thuja occidentalis* L., was the only resistant speeies (Anderson et al. 1962). More research is needed to determine the eeologieal conditions which apparently limit *Cylindrocladium* root rot to white pine at the Chittenden Nursery.

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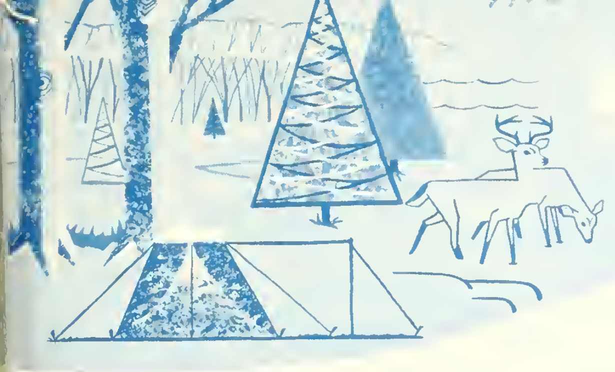


U. S. FOREST SERVICE

RESEARCH NOTE LS-27

LAKE STATES FOREST EXPERIMENT STATION • U. S. DEPARTMENT OF AGRICULTURE

Early Survival of Planted Trees in Southwestern Wisconsin by Species, Age Classes, and Site Factors[1]

One of the pressing forestry needs in the Driftless Area of southwestern Wisconsin, southeastern Minnesota, and adjoining counties of northeastern Iowa and northwestern Illinois is for more information on reforestation to make the currently intensified program of tree planting more effective. This area is characterized by steep topography and rich loessal soils with local intrusion of alkaline prairie soils and sometimes areas of shallow soil over bedrock.

Most of the potential planting sites are on 20- to 60-percent slopes lying between farmed land in the valleys and on the broader ridgetops. The 13-county Driftless Area in Wisconsin alone has about 303,000 acres of open but potential forest land that needs to be reforested.[2] In addition, it is estimated that some of the areas now in poorly stocked or low-value hardwood forest (approximately 1.5 million acres) require conversion to conifers or reinforcement planting to achieve better stocking. So the planting job is sizable.

With an approximate cash outlay of $50 per acre for the planting, the investment in the landowner's time and money will be quite large. The current program is still largely on land of moderate slope where mechanical tree planters accomplish about 80 percent of the total job. On the steeper, rockier lands where hand methods are necessary, costs will tend to increase. Every effort, therefore, is necessary to obtain satisfactory survival and growth once the trees are planted.

[1] *The research reported here was conducted in cooperation with the Wisconsin Conservation Department.*

[2] *Thorne, Harry W., and Stone, Robert N. Commercial forest land by forest type. U.S. Forest Serv., Lake States Forest Expt. Sta. Tech. Note 562, 2 pp, 1959.*

Studies and Treatments

To help guide forestation efforts in the Driftless Area, some experimental plantings were installed over a 2-year period (1961-1962) on the Coulee Experimental Forest near La Crosse, Wis. They involve approximately 40,000 trees. These were planted on 10 major plots with 433 subplots of 50 or 100 trees each and on 29 half-acre plots of 500 trees each. Topographic variables are north slopes, south slopes, ridgetops, and coves. The tests included five age classes; three species of broadleaf trees (white ash, red oak, and walnut), six species of pine, two of spruce, one of juniper, and one of larch; two chemical transpiration retardants; and two mechanical means of mulching and shading the soil near trees (twigs and rocks).

The standard experimental design in most of the trials involved five replications of each treatment, with treatments randomized within blocks laid out on the contour.

Ground Preparation, Planting, and Aftercare

Ground preparation for all plots planted in 1961 (Nos. 1 to 6 inclusive) was by light angle dozer with a 6-foot-wide adjustable blade which made contour terraces 12 to 16 inches wide. In 1962 ground preparation and planting was done in scalps about 1 foot square in three plots and five different methods of ground preparation on another plot.

The 1961 angle dozing did a very satisfactory job of reducing subsequent first-year weed competition on two plots. The other four plots (3, 4, 5, and 6) had hayfields with a high proportion of alfalfa or red clover or rank growth of timothy at the time of ground preparation; these had to be hoed (table 1). Alfalfa 2 to 3 feet high was the worst problem, especially on plot 5 which had to be hoed several times for 2 years to keep it from smothering out the trees. No aftercare was given on plots 1, 2, 8, or 9.

Description of the Experimental Plots

The 10 experimental plots involved in the study include 7 plots on sidehills which were previously either in hayland or pasture, 2 ridgetop plots (formerly hayland), and 1 plot in a cove.

A general description of the 10 plots is given in table 1, along with first- and second-year field survival. The plots cover a range of topography, aspect, soil, and vegetation.

Nine of the ten plots are considered as having adequate moisture relations in all except extreme drought conditions. One plot is considered a droughty site of deficient soil moisture (plot 8). It is a steep, windswept, alkaline, bluestem prairie site with a pH of 7.7 in the surface foot of soil. In contrast, all the remaining sites were formerly forest land on sites less likely to induce heavy evapotranspiration, and all had a pH in the range of 5.2 to 5.7.

TABLE 1. — *Brief description of the 10 planting plots and field survival*

Plot number[1]	Year planted	Aspect	Percent of slope	Elevation in feet	Soil based on map type[2]	Relative ground competition	Compare with plot	Former land use	Percent of field survival: All trees 1st yr.	All trees 2d yr.	Red pine 1st yr. 2-0	Red pine 1st yr. 3-0	Red pine 1st yr. 2-1
SIDEHILL PLOTS													
2	1961	North	24	940	Gale-Hixton sa.l.	Moderate	1	Pasture	90	86	94	83	96
1	1961	South	32	940	Gale-Hixton sa.l.	do.	2	do.	86	85	96	75	90
4	1961	North	20-30	820	Fayette si.l.	do.	3	N. half hay; S. half pasture	92	90	--	--	96
3	1961	South	20-26	870	Fayette si.l. and Gale-Hixton sa.l.	do.	4	Hay	95	92	--	--	96
9	1962	North	20-32	940	Gale-Hixton l. to si.l.	do.	8	Pasture	96	--	95	96	98
8	1962	South-east	53-55	1,100	An alkaline, stony, prairie soil	Light	9	Occasional pasture	76	--	81	55	91
7	1962	South	26-28	940	Hixton sa.l.	Moderate	9	Pasture	92	--	--	90	95
RIDGETOP PLOTS													
5	1961	Mostly west	10-16	1,270	Dubuque si.l.	Very severe	3, 4, 10	Hay	85	81	--	--	82
6	1961	North	10-16	1,270	Dubuque si.l. and Fayette si.l.	Severe	3, 4, 10	do.	90	89	--	--	81
COVE PLOT													
10	1962	North	8-26	890	Colluvial l. to si.l. and some Gale-Hixton sa.l.	Severe	3, 4, 5, 6	Partly crop; partly pasture	[3]96	--	--	--	95

[1] *The convenience of the reader in comparing data determined the order in which plots are listed.*

[2] *From La Crosse County Soil Survey of 1960 by Wisconsin College of Agriculture and U.S.D.A. Sa.l. = sandy loam; l. = loam; si.l. = silt loam.*

[3] *Excludes direct seedings of walnut.*

Field Survivals and Causes of Loss or Damage

The survivals for all species and age classes combined are all quite satisfactory, ranging from 85 to 96 percent, except for the droughty plot where survival was 76 percent (table 1). The drop in survival from the first to second year on six plots ranged from 1 to 4 percent and averaged 2.5 percent. A comparison in a key species (red pine) showed that transplants usually had better survival than seedlings, and 2-0 was statistically superior to 3-0 in three of four trials.

The chief causes of mortality were drought (19.6 percent of all the trees planted on plot 8), small or spindly stock (range 0.1 to 3.0 percent), trees weakened by partial drying in transit by rail (2.6 to 5.4 percent), white grub damage (0.1 to 0.5 percent), and smothering by weeds (0.1 to 0.3 percent).

Injury to trees by animals such as deer, cottontail rabbits, and mice was negligible — usually less than 0.1 percent for any one plot. Systematic use of rodenticides and use of prescribed burns on sites with long bluegrass cover have been effective in keeping mouse populations at a low level. The most important disease was cedar-apple rust on eastern redcedar where 70.6 percent of all trees planted were infected 2 seasons after planting.

Conclusions to Date on Preferred Species and Age Classes

A marked contrast was observed in survival of various species and age classes in the wide spectrum of sites planted. Based on these early results and supplemented by observations by the Wisconsin Conservation Department[3] regarding site adaptability of various species, a table has been compiled (table 2 on next page) showing species and age classes which have prospects of giving excellent to good initial survival on the soils and the six categories of site explored to date on the Coulee Experimental Forest.

Preferred age classes are listed first within each category. These may be expected to give 90 percent or better survival in years of approximately normal rainfall in May to August inclusive. The second choice may give about 10 percent less survival if it is seedling stock. Black walnut seeding, on the other hand, has not been very successful; to date only about 50 percent of the spots seeded have been occupied by seedlings. White pine can be planted fairly safely, providing a few precautions are observed to minimize white pine blister rust.[4]

Three of the pine species listed (Austrian, ponderosa, and Scotch) are not now distributed by Wisconsin Conservation Department nurseries. They are included in the table because they show promise of adaptability to dry, exposed, south-facing slopes with alkaline soils (known locally as "goat pastures"). The primary purpose of planting these species on such sites may be for game cover, Christmas trees, or ornamental or aesthetic values.

In summation, the table emphasizes a preference for transplants over seedlings on some sites, the possible use of seedlings on others, the exclusive need of transplants in certain species, and drought-resistant, hard pines or eastern redcedar on windswept, dry alkaline slopes.

[3] *Wisconsin Conservation Department. Tree planting in Wisconsin. Wis. Conserv. Dept. Pub. 527-59. 20 pp. 1959.*

[4] *Van Arsdel, E. P., Parmeter, J. R., and Riker, A. J. Elevation effects on temperature and rainfall correlated with blister rust distribution in southwestern Wisconsin. Phytopath. 47: 536. 1957.*

October 1963

JOSEPH H. STOECKELER
Soil Scientist

TABLE 2. — *Age classes of trees that show early promise for success on six categories of planting sites*[1]

Tree species	Hillsides			Ridgetop		Coves
	North and east slopes	South and west slopes		With dense alfalfa	With red clover or timothy	
		Former forest land	Alkaline prairie soil			
Conifer						
Larch						
European	2-1, 2-0	--	--	2-1, 1-2	2-1, 2-0	2-1, 2-0
Pine						
Austrian 2/	--	--	1-1, 2-1, 2-0 3/	--	--	--
Jack	--	--	1-1, 2-0	--	--	--
Ponderosa 2/	--	--	1-1	--	--	--
Red	2-2, 2-1, 2-0, 3-0	2-1, 2-0, 3-0	2-1 2/	2-2	2-2, 2-1	--
Scotch 2/	--	--	1-1, 2-0	--	--	--
White	2-2, 2-1, 3-0	2-1, 2-2	--	2-2	2-2, 2-1	2-2, 2-1
Redcedar						
Eastern	--	2-1, 1-1, 2-0	2-1, 1-1, 2-0	--	--	--
Spruce						
Norway	2-2	--	--	2-2	2-2	2-2
White	2-2	--	--	2-2	2-2	2-2
Broadleaf						
Ash						
White 2/	2-0	--	--	--	--	2-0
Walnut						
Black 2/	Seed	--	--	--	--	Seed
Oak						
Red 2/	1-0	1-0	--	--	--	--

[1] *Underlined age classes are suggested age classes observed elsewhere to give good survival but not actually used in the trials discussed here. If two or more age classes are given for a site condition, they are listed in order of preference.*

[2] *Still in an experimental stage, and, for conifers, only from viewpoint of Christmas trees or game cover.*

[3] *If 2-0 Austrian pine is used at all, it must be substantially better in top-root ratio and in root development than the trees used in these experiments.*

U. S. FOREST SERVICE

RESEARCH NOTE LS-28

LAKE STATES FOREST EXPERIMENT STATION • U. S. DEPARTMENT OF AGRICULTURE

Ground Preparation Costs and First-year Survival of Planted Red Pine in Southwestern Wisconsin[1]

Low cost and relative ease of preparing the ground and planting the trees are primary considerations for farmers and other owners of open land with a potential for reforestation. Therefore, many prefer mechanized methods, providing costs are reasonable.

In 1962 a study involving 40 rows of 100 trees each was initiated on the Coulee Experimental Forest near La Crosse, Wis., to compare two age classes and five methods of ground preparation and planting. There were eight rows of each method. The site was on the lower third of a 26- to 28-percent slope on an abandoned pasture. The soil is mapped as Hixton sandy loam; and the site, formerly forested, is 940 feet above sea level. Prior to planting, it had a medium-density stand of young, 1- to 3-foot-high sumac sprouts. The main ground cover was bluegrass, which offered only moderate competition to planted trees.

Treatments Used in Study

Treatment 1.—Contour bench terraces, 12 to 16 inches wide, were made with a light John Deere crawler tractor equipped with a 6-foot-wide adjustable angle-dozer blade. The ground preparation went exceptionally well in spite of having to "deadhead" the full length of the plot to start each new row. It was deemed cheaper to do this than to change the angle of the blade manually for each return trip. Prior removal of the long, dry bluegrass by prescribed burn (summer 1961) and of the large stems of sumac by cutting, piling, and burning, plus ideal soil-moisture content, facilitated ground preparation.

Treatments 2 and 3.—Single and double furrows were made by an Allis Chalmers D-17 – a heavy, rubber-tired tractor – pulling a reversible, two-way plow with four plowshares on it. For single furrowing (treatment 2) the outer plows were removed. To avoid damaging the plows, they were raised whenever stumps 2 inches in diameter or larger were encountered. The reversible plow had the advantage of throwing all furrow slices downhill without a deadheading operation and produced clean, open furrows. (When the furrow slice is thrown uphill on such sloping land, it often flops back into the furrow and closes it; later it has to be chopped out before planting a tree.)

Treatment 4. – The Lowther planting machine was also tested. This 1,600-pound, heavy-duty, crank-axle machine was pulled by a light crawler tractor (a Case 310) with dozer blade. With this equipment, plowing and planting are done in one operation. The work went reasonably well, considering the steep slope and short rows (400 feet long) which slowed up the operation because of time lost in turning. Furthermore, the planter had to be raised to clear scattered apple and thornapple stumps and prevent damage to equipment. Since all rows were made on the contour, they had gentle curves toward the end. On these curves, the wheel packer failed to firm about 15 to 20 percent of the 800 trees satisfactorily. In a separate operation, it required an hour and 10 minutes for one man to straighten and firm or repack the loose or fallen trees.

Treatment 5. – Scalps about 10 inches square were prepared by hand with a narrow-bladed planting mattock.

Cost of Ground Preparation and Planting

The lowest cost per 1,000 trees planted was achieved by the Lowther machine ($13.38 per 1,000 trees) (table 1). It was followed closely by single furrows made with a two-way plow and hand planted ($14.01 per 1,000 trees). The hand-scalping operation was surprisingly cheap, $15.53 per 1,000 trees. The crew was well trained and efficient, and all had previous planting experience.

[1] *The research reported here was conducted in cooperation with the Wisconsin Conservation Department.*

TABLE 1. — *Time and cost for ground preparation and planting on a 26- to 28-percent slope Coulee Experimental Forest, Wis.*

Ground preparation and planting methods[1]	Ground preparation time per mile of row[2]	Planting time per mile of row[2]	Average cost of operation per mile of furrow for both age classes used[3]: Ground preparation	Planting	Total	Total per 1,000 trees
	Hours	Hours	Dollars	Dollars	Dollars	Dollars
Bench terrace with angle dozer (H)	0.85	11.22	5.95	14.69	20.64	15.64
Single furrow with two-way plow (H)	.88	11.77	3.08	15.41	18.49	14.01
Double furrow with two-way plow (H)	1.79	12.21	6.26	16.00	22.26	16.86
Lowther[4]	--	1.48	[5] 1.53	16.13	17.66	13.38
Scalps (H)	3.66	11.99	4.79	15.71	20.50	15.53

[1] *(H) refers to hand planting with mattocks by center-hole method.*

[2] *Time is expressed in man- or machine-hours and includes turning time at end of rows. Values do not include transport time to and from the job; time studies began when the equipment or men were on the planting site ready to go. Nursery stock costs are excluded in the table. Spacing of plants within rows was 4 feet, or at the rate of 1,320 trees per mile of row.*

[3] *Basic costs were as follows:*
a. Angle dozer $7 per hour including driver.
b. Single and double furrows by wheel tractor at $3.50 per hour including driver.
c. Labor for scalping and hand planting at $1.31 per hour.
d. Total costs for the Lowther planting machine operation were $10.90 per hour. Items were: crawler tractor to pull Lowther planter at $7 per hour including driver; man on Lowther planting machine doing planting at $1.50 per hour; rental charge on the Lowther machine at $3.00 per 1,000 trees or $2.40 per hour.

[4] *Ground preparation and planting were accomplished in the same operation by the Lowther tree planting machine.*

[5] *This item is for firming the loose trees by heel after the planting machine had passed.*

The double furrow proved to be the most expensive of any of the ground preparation methods ($16.86 per 1,000 trees). The chief reason was the time lost in pulling out sumac roots and chunks of sod wedged between the closely spaced plows. Single furrowing had no such problem. The angle dozer moved at a good pace, and, although a more expensive piece of equipment, it was cheaper per 1,000 trees than the double furrows made by wheel tractor.

Hand planting time and costs in the four methods of ground preparation (excluding the mechanical planter) were:

Ground preparation method	Man-hours per 1,000 red pine: 3-0 stock	2-1 stock	Average	Ratio to scalping
Bench terrace with angle dozer	8.33	8.67	8.50	0.94
Single furrow with two-way plow	9.00	8.83	8.91	.98
Double furrow with two-way plow	8.17	10.33	9.25	1.02
Scalps	9.33	8.83	9.08	1.00

Planting time was lowest (8.50 hours per 1,000 trees) in the bench terraces made by the angle dozer; these were about 12 to 16 inches wide and easiest to walk on and to plant. The other methods ranged from 8.91 to 9.25 hours per 1,000 trees. Differences in rate of planting between 3-0 and 2-1 were minor. (For this reason the cost data in table 1 were pooled for both age classes.) The planting time per tree for 1,600 trees for each age class was 0.523 man-minute for 3-0 versus 0.550 man-minute for 2-1, or a mere 5-percent difference. All hand planting was done with mattocks by the center-hole method. Stock costs were $15 and $27 per 1,000 trees for the 3-0 and 2-1 age classes respectively.

Cost of Preliminary Brush Cutting and Aftercare

A prescribed burn was run over the area in 1961 in the year before planting, and all sumac brush (5 to 8 feet high) and scattered brush were cut, piled, and burned at a cost of $23.58 per 1,000 trees planted. Of this cost, about half can be considered as applicable to a larger scale operation and half as an additional research cost due to experimental requirements.

TABLE 2. — *First-year survival and percent of planted red pine growing vigorously*
(In percent)

Ground preparation method	First-year survival		High-vigor trees		
	3-0	2-1	3-0	2-1	Difference in favor of 2-1
Bench terrace with angle dozer	90.0	95.2	72.0	89.2	17.2
Single furrow with two-way plow	94.0	96.0	76.2	86.7	10.5
Double furrow with two-way plow	89.5	91.7	63.5	82.5	19.0
Lowther	93.0	95.5	72.2	85.7	13.5
Scalps	84.7	94.5	61.5	84.2	22.7
Average	90.2	94.6	69.1	85.7	16.6

Some resprouting of sumac occurred, and such sprouts as actually interfered with the individual trees were cut the following year. The labor and costs of release cutting in summer 1962 were:

Ground preparation treatment	*Man-hours per 1,000 trees*	*Cost per 1,000 trees*
Bench terrace with angle dozer	4.47	$5.86
Single furrow with two-way plow	5.31	6.96
Double furrow with two-way plow	4.71	6.28
Lowther	5.73	7.51
Scalps	5.41	7.09

Brush cutting was cheapest on the land prepared by angle dozer. On this land, much of the resprout growth of summer 1961 had been smashed down and broken the next spring during ground preparation; furthermore, the ground preparation job itself was somewhat better. Thus, the angle dozer has an advantage of $1.23 over scalps and $1.65 over the Lowther in terms of first-year aftercare in brush cutting.

Survival and Vigor

The only significant differences in survival between ground preparation methods were in 3-0 red pine where both the Lowther method and single furrow were better than scalps at the .10 level of significance (table 2). Between age classes within the same ground preparation method, only in scalps were transplants statistically superior to seedlings — in this case at the .05 level.

When trees were classified by vigor, there was an overall advantage in favor of transplants over seedlings. The average is 16.6 percent (table 2). The maximum was 22.7 percent in ground prepared by scalping. The advantage of 2-1 over 3-0 is significant at, or better than, the .05 level in all five ground preparation methods.

Some contrast also appears in terms of percent of vigorous trees between ground preparation methods — all comparisons favoring furrowing of some type over scalps. Specifically for 3-0 stock, the single furrow was better than scalps at the .05 level and angle dozing over scalps at .10 level. For 2-1 stock, differences between ground preparation methods were minor, and only angle dozing showed any superiority; it was better than double furrows at the .10 level of significance.

Evaluation of the Ground Preparation and Planting Methods

Considering costs and survival and the general ease of accomplishing the job, the Lowther mechanical tree planter was the most efficient on this site (slope of 26 to 28 percent). It is followed closely by single furrow with hand planting. The results are in general agreement with those of Merz and

Funk.[2] The steepness of the slope and the number of stumps encountered were about a maximum for use of this type of mechanical tree planter. However, many planting sites in the Driftless Area are of this degree of slope or less and many have no stumps whatever, so it would appear as the preferred method of the five used.

On the other hand, farmers having their own furrowing or terracing equipment may well choose to use their own equipment and do their own ground preparation and planting to reduce their actual cash outlay for the reforestation job. Plowing of single furrows with a reversible plow seems feasible on any slopes that the Lowther can operate on — i.e., up to about 30 percent. The angle dozer can be safely used at a satisfactory production rate on slopes up to around 40 percent, providing the land has few, if any, outcrops of sandstone or limestone and comparatively little loose rock on the surface. On very steep, rocky land (over 40-percent slope) both ground preparation and planting will probably have to be done by hand.

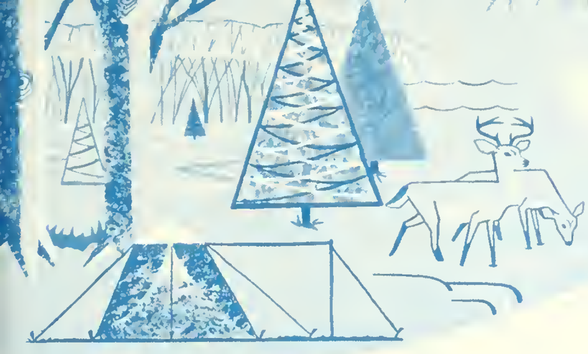
[2] *Merz, Robert W., and Funk, David J. Preplanting ground preparation tests for white pine in southeastern Ohio. U.S. Forest Serv., Central States Forest Expt. Sta. Tech. Paper 167, 8 pp. 1959.*

All costs for the type of site involved in the study are in the range of 5.2 to 6.8 cents per surviving tree for 3-0 stock; the average is 5.5. The lowest costs are 5.2 cents in single furrows and 5.3 cents by Lowther machine. For 2-1 stock the range is 6.4 to 6.9 cents per tree and the average 6.6 cents for the five planting and ground preparation methods. The average cost per tree for single furrows and the Lowther machine is 6.4 cents. These figures per surviving tree include all costs of ground preparation, planting, stock, and aftercare, plus a preliminary clearing cost of 1.4 cents per tree.

The range of costs and first-year results are fairly narrow in this particular trial, and the method of ground preparation or age class chosen could be heavily influenced by the type of equipment available on the farm or for rent nearby, the amount of money the landowner was inclined to spend for nursery stock, and his choice on expending his own labor on hand planting versus hiring a planting machine.

JOSEPH H. STOECKELER
Soil Scientist

October 1963



U. S. FOREST SERVICE

RESEARCH NOTE LS-29

LAKE STATES FOREST EXPERIMENT STATION • U. S. DEPARTMENT OF AGRICULTURE

Soil Moisture Trends in Thinned Red Pine Stands in Northern Minnesota

The forest manager or silviculturist generally manages a forest stand for timber production. At the same time, knowingly or unknowingly, he is also managing the soil moisture supply under the forest; management practices that affect the composition and density levels of forest stands can also affect the depletion and recharge of soil moisture. In turn, this soil moisture supply can affect the growth of a forest stand and the recharge of ground water tables, lakes, and streams.

Although soil moisture conditions under forest stands have received considerable attention in other regions, little information is available to forest land managers about northern Minnesota conditions. This paper reports on one phase of an overall study of soil moisture under forest stands in north-central Minnesota.[1] Another aspect of the study is reported in Research Note LS-30.

Soil moisture plots were established on the Cutfoot Experimental Forest, 35 miles northwest of Grand Rapids, Minn., in three density levels of red pine — 140, 100, and 60 square feet of basal area per acre. Established previously to determine growth response to various thinning treatments, these 5-acre compartments provided an opportunity to determine the interrelations between density level and soil water.

The soils are loamy outwash sands. They consist primarily of medium to coarse sand throughout the profile, with discontinuous 2- to 6-inch clay lenses at depths of 6 to 10 feet.

Samples were obtained on eight dates throughout the 1957 growing season, and on three dates in 1958 — spring, midsummer, and at the end of the summer growing season. Gravimetric soil samples were taken at depths of 0-1, 1-2, 2-3, 3-5, and 5-7 feet at five randomly selected points in each plot on each sampling date.

Soil moisture content was determined on an oven-dry weight basis, then corrected for the average weight of stones 2 mm. and greater in diameter. Bulk density for each sampling horizon on each plot was determined from undisturbed soil cores and used to convert soil moisture to a volume basis. Field moisture content in early spring, shortly after snowmelt, was used as an estimate of field capacity. This corresponded very closely to the moisture content at .05-atmosphere tension. The amount of water in the soil at any time in excess of the estimated wilting point (15-atmosphere tension) was expressed as available water.

Soil moisture content in all density levels was high in early May 1957, the beginning of the growing season (fig. 1). Early depletion was rapid during May when rainfall was only 60 percent of normal. However, excessive rains in June (nearly 2½ times the long-term average) recharged the entire profile. Then, despite midsummer rains, a general depletion took place until late August, the end of the growing

[1] *Acknowledgment is due Dr. J. H. Stoeckeler, Soil Scientist at the Lake States Station, who planned the initial study and selected sampling sites.*

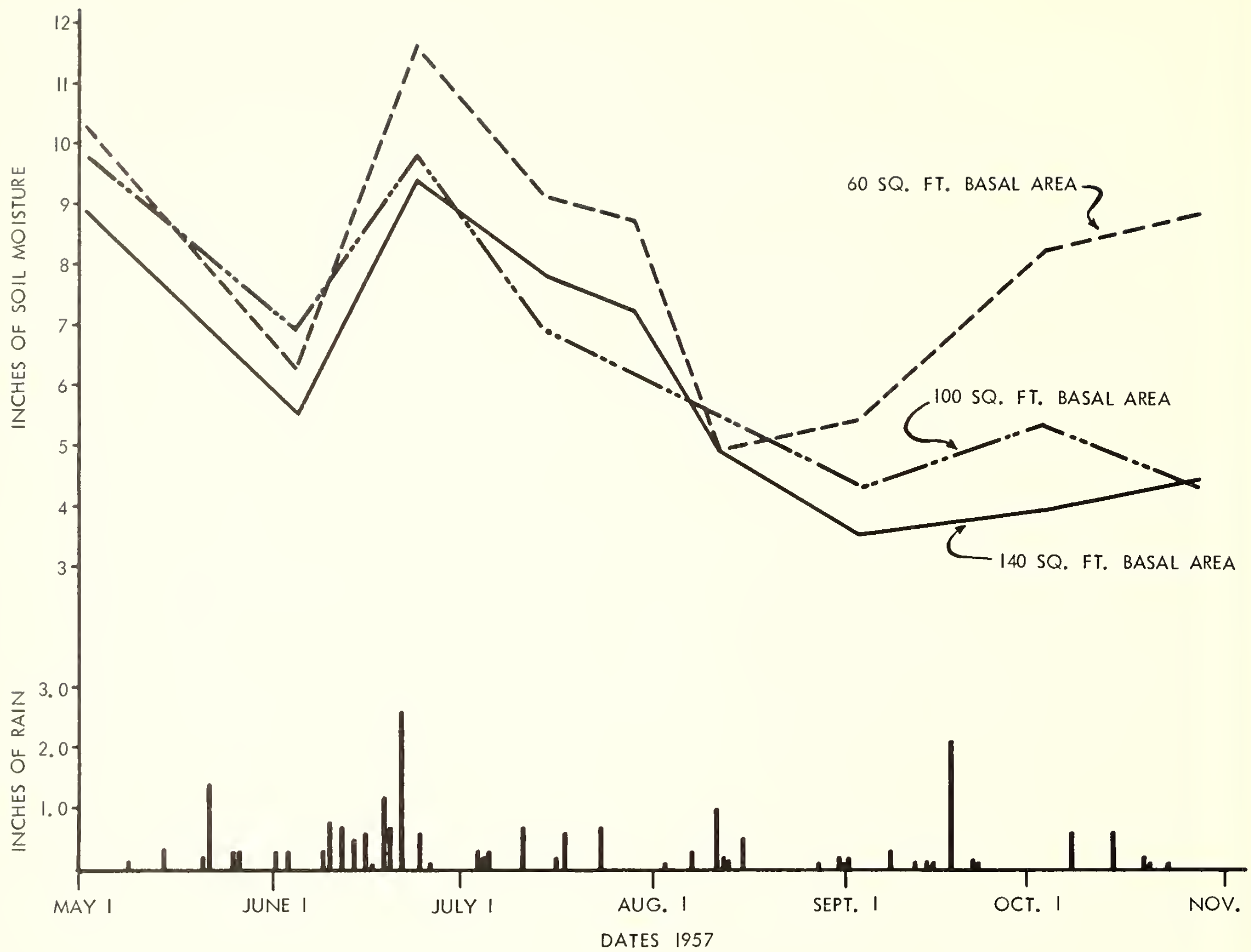


FIGURE 1. — Available soil moisture under three density levels of red pine, 1957.

season. During these latter 2 months, precipitation was 83 and 69 percent of the long-term average.

A comparison of the two extreme density levels indicates a trend of slightly less available moisture under the higher density stand. The difference was probably due in part to greater interception of precipitation as well as increased moisture use by the more densely stocked stand. This agrees with other findings in the Lake States.[2, 3]

[2] *Della-Bianca, Lino, and Dils, Robert E. Some effects of stand density in a red pine plantation on soil moisture, soil temperature, and radial growth. Jour. Forestry 58: 373-377. 1960.*

[3] *Haberland, F. P., and Wilde, S. A. Influence of thinning of red pine plantation on soil. Ecology 42: 584-586. 1961.*

Soil moisture loss, or use, followed the same depletion trends in all density levels. Within the soil profile, withdrawals took place throughout each horizon down to 7 feet. Examination of several soil pits revealed that some red pine roots do extend that deep, although most roots are concentrated in the upper 0- to 3-foot horizon. Of the total water lost in the 7-foot profile of each density level, approximately 60 percent occurred from the upper 3 feet (fig. 2). However, depletion between density levels was similar.

The soils dried gradually at all depths during the 1957 growing season, but moisture contents were not depleted to the theoretical wilt-

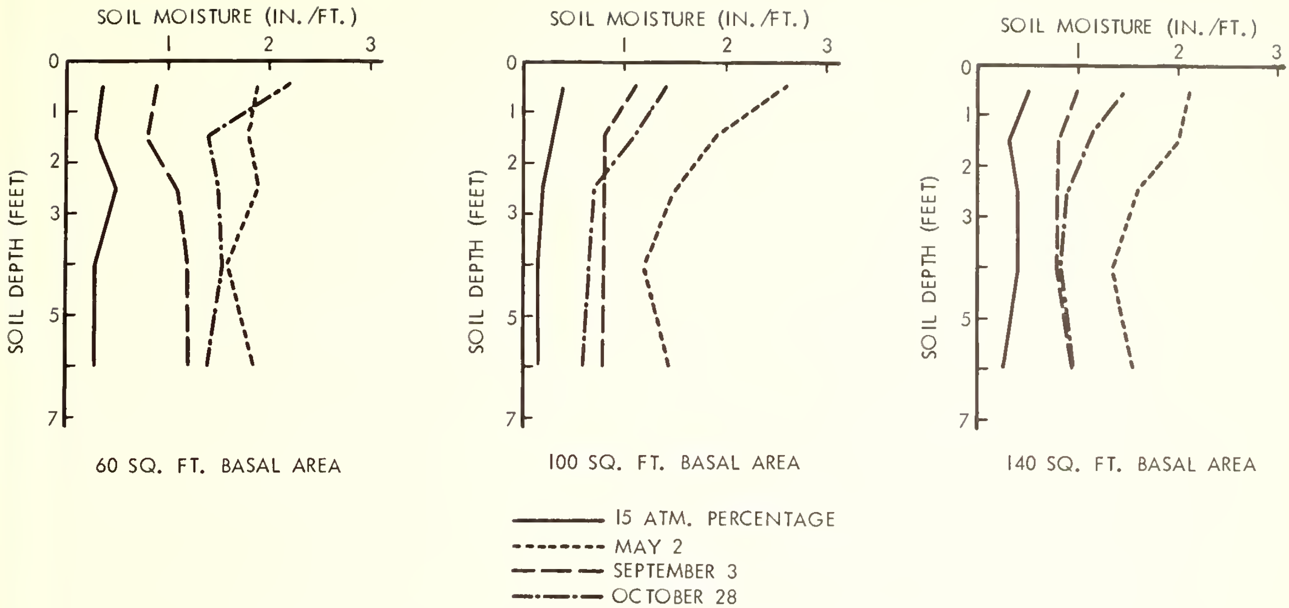


FIGURE 2. — Soil moisture depletion curves for three red pine density levels, 1957.

ing point (15-atmosphere moisture percentage) on any of the dates sampled. Moisture recharge started from the surface of the profile in early September (fig. 2). The lower density levels were recharged first. By late October, soil moisture recharge had reached the 7-foot level in the lowest density level of red pine and the 4-foot level in the densest stand.

When soil moisture values in the autumn were subtracted from the early spring moisture content on May 2, 1957 (approximate field capacity), fall moisture deficits were consistently less under the lowest density level:

Square feet of basal area	*Deficit (inches of water) on:* Nov. 1, 1956	Sept. 3, 1957	Sept. 10, 1958
140	6.6	5.4	5.8
100	5.2	5.5	4.8
60	4.8	4.9	2.6

Thus, less winter snowmelt water would be required to recharge the soil mantle under the plot with 60 square feet of basal area. Excess water would be available for ground water recharge and streamflow. Late fall and overwinter precipitation was required to fully recharge soil moisture in all density levels. The value of snow to annual recharge of soil moisture and ground water is evident.

October 1963

ROGER R. BAY, Research Forester
DON H. BOELTER, Soil Scientist

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RESEARCH NOTE LS-30

LAKE STATES FOREST EXPERIMENT STATION • U. S. DEPARTMENT OF AGRICULTURE

Soil Moisture and Radial Increment in Two Density Levels of Red Pine

As part of an overall study of soil moisture and thinning relationships, individual tree radial increment and soil moisture content were measured in two density levels of red pine at the Cutfoot Experimental Forest near Grand Rapids, Minn. This paper reports on the growth-soil moisture aspects of the study.

Gravimetric soil samples were collected periodically during the 1957 and 1958 growing seasons within 60 and 140 square feet of basal area density levels of 90-year-old red pine. Sampling methods and the soil moisture-thinning relationships are reported in Research Note LS-29.

In general, available soil moisture levels fell during both years throughout the growing season and then rose again during the fall recharge period (fig. 1 shows the soil moisture data for 1957). Slightly more soil water was available under the lower density stand on nearly all sampling dates. However, because of adequate summer precipitation, soil moisture was always plentiful in the 7-foot sampling horizon. This was also true in 1958, a summer when precipitation before and during the growing season was below normal.

A dial gage dendrometer was used to measure the radial increment in 1957 and 1958 on 10 dominant and codominant trees in each of the two density levels (table 1).

After a short period of varying expansion and contraction, continued radial expansion began about May 10 each year in both stands (fig. 2). Monthly growth tended to be slightly better distributed in the 60-square-foot basal

TABLE 1. — *Annual and total radial increment values in two density levels of red pine, 1957 and 1958.*

Tree number	D.b.h.[1]	Radial increment 1957	Radial increment 1958
	Inches	Inches	Inches
DENSITY LEVEL: 140 SQ. FT. BASAL AREA			
1	11.08	0.077	0.045
2	9.98	.050	.045
3	10.21	.072	.038
4	13.33	.065	.046
5	13.60	.076	.071
6	13.15	.082	.072
7	12.10	.072	.099
8	13.00	.096	.080
9	13.38	.065	.086
10	12.24	.086	.082
Average		.074	.066
DENSITY LEVEL: 60 SQ. FT. BASAL AREA			
11	14.25	.133	.130
12	13.50	.089	.135
13	13.00	.161	.144
14	14.10	.112	.162
15	12.80	.107	.147
16	13.62	.092	.099
17	13.96	.092	.115
18	12.86	.073	.078
19	13.75	.166	.189
20	14.29	.125	.119
Average		.115	.132

[1] *D.b.h. at time dendrometer station was established.*

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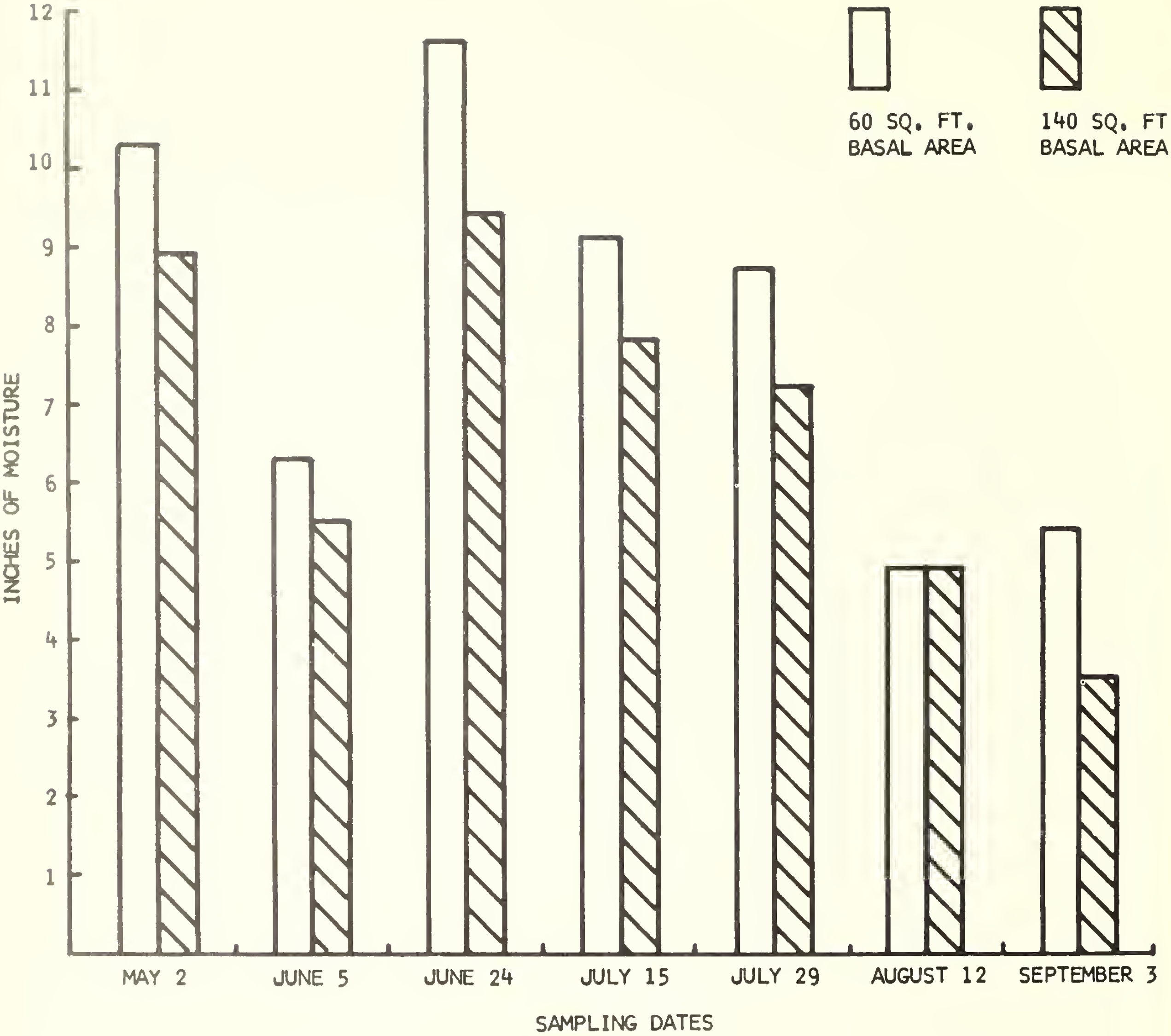

FIGURE 1. — Available soil moisture in the 0-7 foot profile under two density levels of red pine, 1957.

area block (table 2). However, in each stand during both years the greatest monthly radial growth occurred during June.

Growth ceased in both stands during early September each year even though the low-density level contained about 2 inches more soil moisture than the high-density level. Thus, the end of radial growth was not dependent upon soil moisture in the years of this study. This has been noted by others.[1]

In addition, midsummer soil moisture levels did not drop low enough to influence growth seriously in either stand because of frequent rains during the study period. Other studies in areas where summer droughts are common have shown close relationships between soil moisture depletion and growth patterns.[2] However, other factors, such as light, temperature, genetic qualities, and the previous season's growth also contribute to each year's growth behavior.

[1] *Dils, Robert E., and Day, Maurice W. The effect of precipitation and temperature upon radial growth of red pine. The Amer. Midland Naturalist 48: 730-734, 1954.*

[2] *Boggess, W. R. Weekly diameter growth of short-leaf pine and white oak as related to soil moisture. Soc. Amer. Foresters Proc. 1956: 83-89. 1956.*

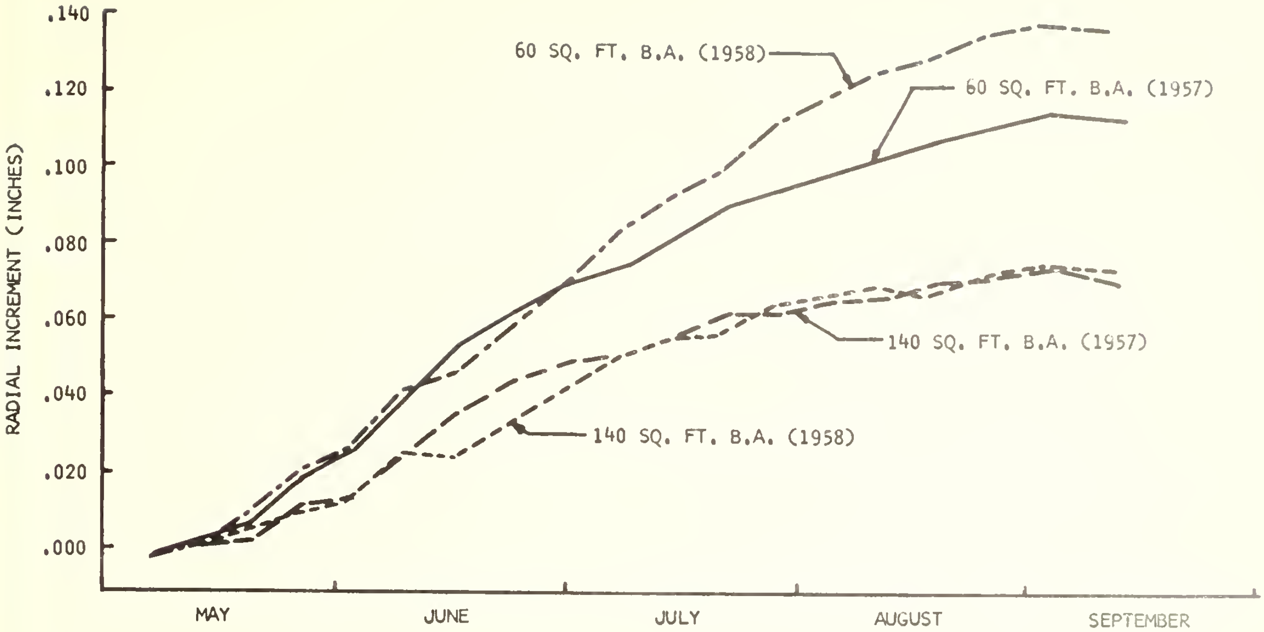

FIGURE 2. — Radial increment patterns in two density levels of red pine, 1957 and 1958.

TABLE 2. — *Monthly radial increment as a percent of total growth in red pine between May 1 and September 1*

Month	60 sq. ft. basal area		140 sq. ft. basal area	
	1957	1958	1957	1958
May	21.1	18.7	17.8	16.2
June	33.3	33.1	42.5	40.5
July	29.8	31.7	26.0	31.1
August	15.8	16.5	13.7	12.2

An interesting sidelight of this study dealt with overwinter shrinkage of the tree bole and daily fluctuation in dendrometer measurements. Overwinter radial measurements reached a minimum in late March or early April. The greatest radial shrinkage was 0.022 inch and the average was approximately 0.015 inch, or about 20 percent of the previous year's growth, in the 140-square-foot level. Early spring bole swelling recaptured most of this shrinkage before sustained radial growth began. Dendrometer measurements were also taken three times a day for a short time to obtain an idea of tree-size fluctuations in a day. The measurements indicated that shrinkage of the bole took place during some days, but the trees regained or exceeded their former size overnight. These data point out the need for standardizing the time of measurement in this type of study.

The most important relationship indicated is the large increase in diameter growth in the thinned stand, compared to the much smaller diameter growth in the denser stand. Average basal area growth on the individual trees in the lighter stocking level was 1¾ times the growth in the denser stand in 1957 and over twice as much in 1958. There was little difference in per-acre basal area growth for these stands during a 10-year period that included the years of this study.[3] Thus, nearly the same amount of per-acre basal area growth was added to each stand, but this growth was put on fewer trees in the thinned stand, resulting in more growth per tree.

[3] *Buckman, Robert E. Three growing stock density experiments in Minnesota red pine. U.S. Forest Serv., Lake States Forest Expt. Sta., Sta. Paper 99, 10 pp., illus. 1962.*

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October 1963

U. S. FOREST SERVICE

RESEARCH NOTE LS-31

LAKE STATES FOREST EXPERIMENT STATION, U. S. DEPARTMENT OF AGRICULTURE

Nursery Selection Affects Survival and Growth of Birch

Numerous studies have shown that size of the planting stock affects survival and growth of many conifers. Much less is known about deciduous species, but Engstrom and Stoeckeler[1] reported better survival of 12 different species with increasing size of the seedlings. The only study of birch showed that first-year survival and height growth of paper birch and yellow birch were directly related to the initial size of the nursery stock.[2] However, the effect is not restricted to the first year after planting. Recent observations of two other birch species demonstrated that trees grown from the largest nursery stock had better survival than those originating from smaller stock after 9 years in the field. Furthermore, the plants originally classified as large, medium, and small still maintained their relative positions with respect to both height and diameter of the trees.

The birches studied, *Betula pubescens* Ehrh. and *B. pendula* Roth,[3] are European white birches; both lots were of Finnish origin. These trees are growing in a small arboretum on the Argonne Experimental Forest in northern Wisconsin. The seedlings were raised in the Hugo Sauer Nursery and planted in the arboretum as 3-0 stock in the spring of 1954 at a 6.6 by 6.6-foot spacing. At the time of lifting, the seedlings were sorted into lots of large, medium, and small plants. Fifty seedlings of each grade of *B. pubescens* and 100 large, 50 medium, and 50 small seedlings of *B. pendula* were planted.[4]

When the plots were checked for survival during the summer of 1962, a pronounced gradient in the size of the trees was observed within each plot. To check whether this gradient coincided with the original size of the plants, the height and diameter of each of the surviving trees were measured in September 1962. The data were kept separate for the original subplots of large, medium, and small plants of each species.

The survival for both species was highest for the large grade, less for the medium, and poorest for the small grade as shown below.

Species and grade	*Survival (percent)*	*Mean height (feet)*	*Mean d.b.h. (inches)*
Betula pubescens			
Large	98.0	12.9	2.14
Medium	90.0	8.7	1.05
Small	68.0	6.5	.55
Average	85.3	9.7	1.33
Betula pendula			
Large	83.0	12.5	1.74
Medium	42.0	9.4	1.15
Small	38.0	7.5	.59
Average	61.5	11.2	1.46

[1] *Engstrom, H. E., and Stoeckeler, J. H. Nursery practice for trees and shrubs suitable for planting on the prairie-plains. U.S. Dept. Agr., Misc. Pub. 434, 159 pp., illus. 1941.*

[2] *Stoeckeler, J. H., and Jones, G. W. Forest nursery practice in the Lake States, U.S. Dept. Agr., Agr. Handb. 110, 123 pp., illus. 1957.*

[3] *This species is also known as B. verrucosa Ehrh. in Europe.*

[4] *The nursery work as well as the outplanting in the arboretum was supervised by J. H. Stoeckeler of the Station staff.*

The large-grade and medium-grade trees of *B. pubescens* survived considerably better than those of the small grade. On the average, the large-grade trees were 4.2 feet taller than the medium-grade trees, which again were 2.2 feet taller than the small-grade trees. A similar pattern is apparent in the diameter of the trees. The mean d.b.h. of the large grade was 1.09 inches greater than that of the medium grade, which exceeded the small grade by 0.50 inch. All differences are statistically significant.

The large-grade *B. pendula* had about twice as high survival percentage as the medium and small grade. The medium-grade trees survived only slightly better than the small-grade trees. The large-grade trees averaged 3.1 feet taller than those of the medium-grade, which in turn were 1.9 feet taller than the small-grade trees. The pattern is repeated in the diameter measurements: The difference between trees of the large and medium grades was 0.59 inch and between the medium and small grade was 0.56 inch. All differences in tree height and d.b.h. between the three grades are statistically significant.

When the species are compared, it is clear that *B. pubescens* survived better than *B. pendula.* It also had the tallest and thickest trees in the large grade; but in the other two grades, it was exceeded by the *B. pendula.* The latter species had the greatest mean height and diameter when all three grades are considered together as one plot. This is due partly to the comparatively larger trees in the medium and small grades but also to a greater number of trees of the large grade. Although this subplot had poorer survival than the corresponding subplot in *B. pubescens,* it originally contained twice as many plants, thus raising the mean values for the *B. pendula.*

In birches the use of small nursery stock should therefore be discouraged since it not only may lead to a poor stocking level but in addition has an adverse effect on the growth rate of the stand. These results further suggest that it may be feasible to identify potential superior birch trees at an early age by selecting the most vigorous seedlings in the nursery beds.

October 1963

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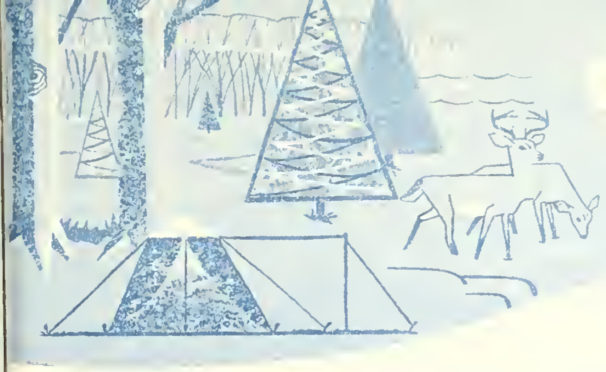
Plant Geneticist



U. S. FOREST SERVICE

RESEARCH NOTE LS-32

LAKE STATES FOREST EXPERIMENT STATION, U. S. DEPARTMENT OF AGRICULTURE

Artificially Constructed Mounds Show Promise in Yellow Birch Regeneration

Previous attempts to increase the proportion of yellow birch in hardwood stands at the Upper Peninsula Experimental Forest in Michigan by exposing mineral soil have shown that while birch established itself well on scarified areas, growth was poor.[1] Subsequent observations of birch seedling growth indicated that growth was better on naturally occurring mounds than on adjacent hollows and flats.

Mounds (or hummocks) are apparently formed by the action of windthrown trees. Soil of mounds is usually deep, friable, and better drained than that of the surrounding area. McLintock,[2] studying soil moisture patterns in a coniferous forest, speculated that hummocks might prove to be more productive since they dropped below saturation more rapidly in spring and were only a little drier during dry periods.

Accordingly, a test was made of birch seedling growth on artificial mounds in a hardwood-hemlock stand cut to an average of 70 square feet of basal area per acre.[3]

Three sites were tested — mounds, the exposed mineral soil between mounds, and adjacent undisturbed humus.

Twelve mounds were constructed by a small bulldozer. The top 3 to 6 inches of soil was scraped up and pushed into a mound which averaged 2 to 3 feet high and 5 feet long, and was roughly triangular in shape. The resulting mounds were a mixture of leaves, humus, mineral soil, and other forest debris (fig. 1,A).

Soil exposed between mounds was generally the grey, leached A_2 which is usually deficient in nutrients and is compacted. Trials with a penetrometer indicated that these intervening spaces averaged about five times as compact as the mounds (fig. 1, B).

In adjacent unscarified areas, advance reproduction and the litter were removed from quarter milacre spots (fig. 1, C).

Quarter milacre plots were established on each site and seeded heavily with yellow birch and sugar maple. After 1 year's growth, the tallest trees were tagged and measured on each plot. Twenty-five birch were tagged for each condition. Because of the unequal distribution of maple, 19 were chosen on mounds, 11 between mounds, and 26 on humus plots.

First-year measurements did not reveal any great differences in the growth of the selected trees. During the second year, yellow birch growth was greatest on mounds, least on humus, and intermediate on the mineral soil between mounds (differences are significant at the 1-percent level). Sugar maple appeared to be unaffected by differences in site. Yellow birch growth was superior to that of sugar maple on all sites. The total height at the end of the second year was about equal on humus plots for both species, but birch exceeded maple on the other sites as shown below.

	Total height (feet)		*Second-year growth (feet)*
	1961	*1962*	
On mounds			
Yellow birch	0.20	0.78	0.58
Sugar maple	.18	.33	.15
Between mounds			
Yellow birch	.12	.48	.36
Sugar maple	.16	.32	.16
Humus			
Yellow birch	.11	.39	.28
Sugar maple	.20	.31	.11

The better growth of seedlings on mounds may be due to less compaction, better drainage, and increases in fertility. (Tests of available nutrients with an agricultural kit indicate that some elements

[1] *Godman, Richard M., and Laurits W. Krefting. Factors important to yellow birch establishment in Upper Michigan. Ecology 41: 18-28, illus. 1960.*

[2] *McLintock, T. Soil moisture patterns in a northern coniferous forest. U.S. Forest Serv., Northeast. Forest Expt. Sta., Sta. Paper 128, 5 pp., illus. 1959.*

[3] *Residual stand 10 inches d.b.h. and up.*

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FIGURE 1.—(A) Mounds constructed by a small bulldozer; (B) exposed mineral soil on area scraped up to collect material for mounds; (C) humus plots in adjacent unscarified areas.

may be in better supply on the mounds, a reasonable assumption since the more fertile humus is mixed in with the mineral soil.) Also, Jarvis[4] has reported that yellow birch grew better on mixed humus and mineral soil than on compacted mineral soil in Quebec.

Equally important is the ability of yellow birch to outgrow sugar maple of the same age on this shaded site. Probably height growth could be speeded up by opening the stand more since other studies show that birch seedling height growth increases as shade decreases from a closed canopy to clear cut.[4 5]

[4] *Jarvis, J. Cutting and seedbed preparation to regenerate yellow birch, Haliburton County, Ontario. Canad. Dept. of Northern Affairs and Nat. Resources, Forest Res. Div. Tech. Note 53, 17 pp., illus. 1957.*

[5] *Linteau, A. Factors affecting germination and early survival of yellow birch in Quebec. Forestry Chron. 24: 27-86, illus. 1948.*

The effect of artificial mounds on birch germination and establishment should be similar to that of some other scarification methods, and in addition may result in better height growth than has previously been reported for this area.[6]

In conclusion, artificial mounding may have merit for reproducing birch in selectively cut stands. Construction of mounds is simple, quick, and could be accomplished a little at a time at each harvest cut. However, variations will doubtless occur in different environments. Tests will be devised to find the management situations where artificial mounding could be recommended.

[6] *See footnote 1.*

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U. S. FOREST SERVICE

RESEARCH NOTE LS-33

LAKE STATES FOREST EXPERIMENT STATION, U. S. DEPARTMENT OF AGRICULTURE

Root Development of Yellow Birch in Humus and a Sandy Loam

During a study of the effects of various environments on yellow birch behavior, it was observed that the birch often established itself on the border of the plots between the humus and surrounding mineral soil. A few plants were excavated and the rooting habit examined. Most of them showed the greatest development of rootlets in the humus.

Redmond, seeking soil for optimum root development, found that the roots of young yellow birch seedlings developed in loam but remained undeveloped in sand.[1] He attributed this to the greater nutrient content of the loam. Redmond also found that a high portion of yellow birch rootlets was in the humus layer in various forest environments.[2]

To determine whether root production is better in humus than in sandy loam, a test was established in the greenhouse.

Twenty 4-inch plastic pots were filled so that half of each pot contained mineral soil, and half humus (fig. 1). The mineral soil was a sandy loam[3] from the B horizon under a hemlock-hardwood stand. The humus, taken from a mixed hardwood stand, was crumbled up before using.

Two-year-old yellow birch wildlings, growing in mineral soil of a hemlock-hardwood stand, were lifted and their roots spread evenly over both media. Perlite was spread over the top of the roots and kept moist. Pots were kept on a greenhouse bench with a 10-hour-day fluorescent light source. Lights were cool white type (40 watts) and were 2½ feet above the table level.

Half the pots were fertilized with a commercial fertilizer solution containing 7 percent N, 6 percent P, and 19 percent K. Pots were watered from above for 3 weeks and thereafter from below.

After 45 days the roots in 10 pots were washed from the soil. Tops showed a definite response to

F-504579

FIGURE 1. — Four-inch plastic pots were filled, half with a sandy loam and half with humus (white line marks division between media), and roots were spread over both sides.

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[1] *Redmond, D. R. Variations in development of yellow birch roots in two soil types. Forestry Chron. 30: 401-406, illus. 1954.*

[2] *Redmond, D. R. Observations on rootlet development in yellow birch. Forestry Chron. 33: 208-212. 1957.*

[3] *Texture breakdown in percent was as follows:*

Larger than 1 mm — fine gravel	*3*
1-.5 mm — coarse sand	*23*
.5-.25 mm — medium sand	*19*
.25-.05 mm — fine and very fine sand	*33*
Smaller than .05 mm	*22*

F-504577, 504578
FIGURE 2. — Two typical examples of root development. The rootlets at the left side of each of these plants were in humus; those on the right side of each plant were in mineral soil.

the fertilizer (fertilized trees grew an average of 257 mm in 45 days while unfertilized trees grew only 141 mm); but the greatest development of roots was in the humus section (fig. 2) in 9 of the 10 pots regardless of fertilization. Results were so obvious that weights were not recorded.

Thereafter, the previously unfertilized pots were fertilized with the same solution on the mineral soil side only in an attempt to induce the development of roots on the mineral side. After 3 months the remaining plants were removed from the pots and washed. Again root production was best in the humus section in 9 of the 10 pots. Roots did not develop on the mineral side except for those moving down the pot wall. Even these had a propensity to move to the humus side. Roots in the two pots that had equally good development in both mineral and humus appeared to have originated primarily in the humus.

To summarize: Yellow birch seedlings with roots placed in a sandy loam and in humus developed best in the humus in 18 of 20 pots. Pots were fertilized in various ways in an attempt to stimulate development in the mineral soil without success.

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October 1963

U. S. FOREST SERVICE

RESEARCH NOTE LS-34

AKE STATES FOREST EXPERIMENT STATION • U. S. DEPARTMENT OF AGRICULTURE

Germination of Yellow Birch Seed Following Natural Stratification in Upper Michigan

Yellow birch *(Betula alleghaniensis)* seed ripens in the fall and is deposited over the fall and winter months.[1] Germination has been observed throughout the summer months. Dormancy of the seed can be broken by exposure to a cool-moist environment. As Joseph[2] showed in laboratory studies, the temperature of this environment and the length of exposure to it affect germination.

Since yellow birch seed is released over a considerable period of time, it is exposed to a variety of environments and is subject to dormancy-breaking conditions for different lengths of time.

A study was conducted during the winter of 1961-62 and the following growing season to determine what effect natural stratification had on germination.

METHODS

Seed used for the study was collected from a 120-year-old, upland-site yellow birch tree of good vigor and kept in cold storage for a year. A test indicated 50-percent germination.[3]

[1] *Benzie, John W. Sugar maple and yellow birch seed dispersal from a fully stocked stand of mature northern hardwoods in the Upper Peninsula of Michigan. U.S. Forest Serv., Lake States Forest Expt. Sta. Tech. Note 561, 1 p., 1959.*

[2] *Joseph, Hilda C. Germination and vitality of birch seeds. Bot. Gaz. 87: 127-151. 1929.*

[3] *The proportion of seed germinating in 30 days on moist sand under laboratory conditions. Seed was stratified for 30 days at 41° F.*

Seeds were placed three or four layers deep in small nylon mesh bags and set out in a hardwood stand at the Upper Peninsula Experimental Forest at Marquette, Mich. during November, December, January, and February. Those placed in November were on the ground, while in later months the bags were placed on the snow. Snow depth increased to 2 feet in February. Bags were picked up after snowmelt just prior to testing.

Six hundred seed from each stratification period were counted and placed on moistened perlite in three covered petri dishes, 200 to a dish. On May 10, the dishes were placed outside in a closed hardwood stand. A duplicate set of 600 seed was tested in the laboratory. Water was added to all dishes periodically to prevent drying out.

Temperatures were recorded outside with maximum and minimum thermometers. Between May 10 and July 2 the average maximum temperature was 81° F., while the average minimum was 44°. The range of minimum temperatures was 30° to 62° F. Freezing temperatures were recorded as late as the end of June. Temperatures in the laboratory were a constant 75°.

RESULTS

Natural stratifications produced no statistical differences in *total* germination percent when tested under room temperatures but did result in different rates during the first few days (table 1).

TABLE 1. — *Cumulative percent germination in the room temperature test*

Month of stratification	First day	Fourth day	Tenth day	Total
November	20	35	45	49
December	24	42	51	52
January	5	33	49	53
February	4	32	49	53

Although some seed from each month of stratification germinated the 1st day, numbers germinating on that day were higher for the November and December lots. After 4 days, the number germinated was about the same for all stratification times. For those tested in an outdoor environment, however, the differences between months of stratification were marked (table 2).

Germination began in the November and December lots after 19 days; the January and February lots started germinating at 21 and 23 days respectively. The November lot reached its peak rate 3 days after germination started. December reached its peak rate 21 days after germination started, and the others may not have reached a peak by the time observations ended (July 2).

DISCUSSION

Joseph (see footnote 2) speculated that natural stratification of birch seeds would allow easy spring germination. The results of this test indicate that only part of the yellow birch seed germinate in the spring in cool, moist environments, while part will not germinate until later in the summer or fall. In the latter case, germination would depend on favorable moistures, which are often uncertain and of short duration in the summer months. Summer germination may result in greater mortality during hot, dry periods. Also, those seedlings produced by such germination may be less sturdy and less able to withstand the leaf fall which is often cited as an important cause of yellow birch mortality.

TABLE 2. — *Cumulative percent germination in an outdoor environment*[1]

Month of stratification	0 - 18 days (May 10-May 28)	21 days (May 31)	31 days (June 10)	39 days (June 18)	53 days (July 2)
November	0	7	12	21	28
December	0	3	13	35	44
January	0	*	1	6	12
February	0	0	0	2	2

1/ Curved values

* Less than 1 percent

January 1964

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U. S. FOREST SERVICE

RESEARCH NOTE LS-35

LAKE STATES FOREST EXPERIMENT STATION · U. S. DEPARTMENT OF AGRICULTURE

Variable Stocking Is a Problem in Experiments Involving Direct Seedings of Northern Red Oak

That direct seeding may create problems in experiments where uniform stocking and precise accountability of each tree are requisites was indicated in a recent study involving northern red oak.

In 1952, direct seedings of northern red oak acorns (*Quercus rubra L.)* were used to establish several small experimental plots[1] near Galesville, Wis. The purpose was to study the effect of competing vegetation and damage by wild animals upon the survival and growth of the small trees during the ensuing 10-year period. Problems of suppression by the forest overstory were eliminated by utilizing a 1-acre clearing from which all timber had been removed several years earlier. However, this previously forested site never had been cultivated, and in 1952 it was covered with herbaceous plants and woody shrubs common to the locality.

In planning the study, it was assumed that a fairly uniform stocking of about two northern red oak seedlings per "hill" would be obtained by planting three acorns in each 18 x 18-inch scalped (de-sodded) spot. For a number of reasons, this objective was not attained. First, the acorns either failed to germinate or were pilfered by rodents in more than one-sixth (18.3 percent) of the 1,250 seed spots (Table 1). These 229 voids affected the adequacy of the initial stocking, but wild oak seedlings "restocked" 22 of these blank spots 2 to 10 years after the direct seedings were made.

The lack of uniformity in stocking of occupied spots at the end of the first growing season (mid-September) is shown below:

Number of oak seedlings per spot	*Percentage of spots in each numerical category*
1	31.8
2	37.1
3	27.8
4	3.1
5	0.2
Total	100.0

Why more than three oak seedlings occur in 3.3 percent of the occupied spots is a matter for conjecture. Some possible explanations are: (1) more than three acorns were accidentally planted in these few seed spots, (2) an occasional acorn sent up multiple shoots, or (3) the extra trees were "wildlings" planted by squirrels.

This initial variability in stocking was augmented during the 10-year period of the regeneration study by a permanent increase in the number of oak seedlings on 1.3 percent of the seed spots and by interim fluctuations on 8.6 percent of them; the latter started and ended with the same number of trees (Table 1). The permanent increase in stocking probably was the result of single-stem trees forming new shoots from their root collars or the introduction of "wildlings," whereas the interim fluctuations could be due to the loss of tops by shading or animal damage and the subsequent resprouting of these missing or "dead" seedlings.

Although a perfectly uniform stocking of seedlings over the entire area of the site would have been advantageous, there was good accountability for the trees on 71.8 percent (897) of the 1,250 seed spots involved in the experiment. During the 10-year study, eighteen 100-percent tallies were made for the northern red oak seedlings occupying these 897 spots. An analysis of these data shows no change in stocking on 307 spots

[1] *These plots are located on the Hardies Creek Timber Harvest Forest, a state-owned, 53-acre mixed-oak tract. This area is used for research and demonstration on a cooperative basis by the Wisconsin Conservation Department, the U.S. Forest Service, and the Extension Service of the University of Wisconsin.*

Table 1. — *Condition of stocking in direct seeding of northern red oak at the end of the tenth year*

What happened	Total seed spots in each category[1/]	
	Number	Percent
1. No trees came up in the spots during the 10-year period	207	16.6
2. Spots were blank for 2 years or longer but eventually were occupied by wild seedlings	22	1.7
3. The stocking of seedlings in individual spots was unchanged for 10 years	307	24.6
4. Same number of seedlings at beginning and end of 10-year period, but with interim variability	107	8.6
5. Stocking of spots decreased and--		
a. Spots were still occupied at the end of the 10-year period	288	23.0
b. No trees were left in spots	302	24.2
6. Permanent increase in stocking	17	1.3
TOTAL	1,250	100.0

1/ All comparisons are based upon the counts at the end (September) of the first growing season.

and a permanent decrease in the number of trees on 590 of them (Table 1).

The obvious alternative to direct seedings of northern red oak acorns is the planting of nursery-grown trees. This was done in 1953 and 1954 on 1,174 18 x 18-inch scalped spots. Both 1-0 and 2-0 seedlings proved satisfactory. By their use, it was possible to obtain a 100-percent initial stocking uniformly dispersed over the entire area of the site.

Because of the success obtained with nursery stock, its use in preference to direct seedings is recommended in all future studies where *precise* accountability of individual trees is a requisite. Subsequent mortality, damage to tops and lateral branches, formation of new sprouts, etc., thus can be equated with a known single-tree stocking for each spot. Another advantage of nursery stock is the speed and low cost of subsequent examinations of planted plots compared to seeded areas. It is much easier to find or account for one tree per spot than for several. This is true particularly during the growing season when the small oaks are overtopped or surrounded by lush vegetation.

In some cases the additional cost of growing and transporting nursery stock and hand-planting the trees might have to be justified in terms of greater research accomplishments.

A final consideration in favor of using trees rather than acorns is that the weaker, poorly formed seedlings can be eliminated *before* they are planted. The practical result of this roguing process in the tests discussed here was that both the 10-year survival (71 as compared to 64 percent) and the average 10-year height (79 versus 62 inches) were better for 1-0 nursery stock than for seedlings of the same age grown directly from acorns.

January 1964

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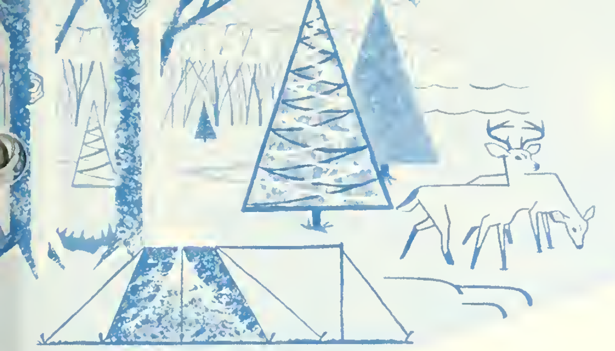

U. S. FOREST SERVICE

RESEARCH NOTE LS-36

LAKE STATES FOREST EXPERIMENT STATION • U. S. DEPARTMENT OF AGRICULTURE

Heavy Crop of Red Pine Cones Yields Many Thousands of Good Seeds

Red pine *(Pinus resinosa)* usually produces good crops of cones at intervals of 3 to 7 years, with light crops occurring in most intervening years.[1] But, as in most tree species, little information is available as to what such crops mean in terms of actual seed production. In northern Minnesota medium-stocked stands of mature red pine were found to disperse from 75,000 to 110,000 seeds per acre in a moderately heavy year,[2] and a poorly stocked 40- to 50-year-old stand in Lower Michigan had an annual production (10-year period) ranging from 8,000 to 12,000 good seeds per acre.[3]

Little has also been recorded as to the time, rate, and quality of the seedfall. The Lower Michigan data indicate that, while dispersal began about mid-September and was 70-percent complete by mid-December, it continued at a low rate until the following August. Soundness during the period studied varied from 14 to 63-percent.[3]

To add to the knowledge of seed production, the Lake States Forest Experiment Station is conducting a comprehensive study in managed and natural stands and in two age classes, 50 and 90 years; a third age class, 120 to 140 years, has recently been added. Since the study has so far sampled only one good cone crop, no final conclusions can be made as to the seed production of these kinds and age classes of stands. However, because of the interest in the seeding and planting of this species, it would seem helpful to present the results obtained thus far.

METHODS

The data sampled the entire seed yield of the heavy 1957 cone crop on the Cutfoot Experimental Forest. It was collected from October 1, 1957, to October 1, 1958, in three stand conditions in pure red pine: (1) 90-year managed, (2) 90-year natural or unmanaged, and (3) 50-year managed.

For the managed stands, seed production was sampled on the cutting units of two growing stock level studies, both of which had been cut to five different levels of basal area — 60, 80, 100, 120, and 140 square feet. In the 90-year timber, two blocks were involved — one of 5-acre compartments, the other of 2½-acre units. The 50-year stand had its compartments located in one block. Both age classes had been cut from above and below in 1949-50 and again 5 years later.

In the 90-year natural stand, a few jack pines had been salvaged during the thirties, but for all practical purposes it had never been cut. Basal area here averaged about 140 square feet of which 123 square feet were red pine and the balance mostly jack pine.

On each of these three stand conditions seed production was sampled by means of 1/4000-acre seed traps, which were emptied at 2- to 3-week intervals (sometimes 5 to 6 weeks) throughout the year. After counting, the seeds were pooled by growing stock levels within each stand class. The seed size and germination of the seed lots were then determined either for the whole lot or for a representative sample of it.

MANAGED STANDS PRODUCE MANY THOUSAND GOOD SEEDS

The yield of seed, both total and viable, for the year, October 1, 1957, to September 30, 1958, is given in table 1. Of the three stands, the 90-year managed timber was by far the best producer of seed, averaging over a million seeds per acre of which 916,000 were viable. On the other hand, production by the 90-year natural stand was less than half of that of the managed timber and that of the 50-year stand less than one-tenth as much.

Germination, considering that no attempt was made to eliminate the empty seeds, was quite high.

[1] *U.S. Forest Service. 1948. Woody-plant seed manual. U.S. Dept. Agr. Misc. Publ. 654, 416 pp., illus.*

[2] *Shirley, Hardy L. 1933. Improving seedbed conditions in a Norway pine forest. Jour. Forestry 31: 322-328, illus.*

[3] *Rudolf, Paul O. 1957. Silvical characteristics of red pine (Pinus resinosa Ait.). U.S. Forest Serv., Lake States Forest Expt. Sta., Sta. Paper 44, 32 pp., illus.*

TABLE 1 — *Total and viable seed production of managed and unmanaged red pine stands,*[1] *Cutfoot Experimental Forest, October 1, 1957, to September 30, 1958*

Basal area level (sq. ft.)	Seed production per acre		Average germination	Average cleaned seeds per pound	Basis, seed traps
	Total seeds	Viable seeds			
	Number	Number	Percent	Number	Number
			90-YEAR MANAGED STAND		
60	919,400	794,400	83.9	66,800	6
80	981,300	817,200	81.3	67,600	6
100	1,004,000	867,400	84.3	65,000	6
120	1,300,300	1,120,600	85.4	67,300	6
140	1,148,000	980,300	83.4	66,200	6
All levels	1,070,600	916,000	83.7	66,600	30
			90-YEAR NATURAL STAND		
140 2/	453,500	369,800	81.6	63,800	6
			50-YEAR MANAGED STAND 3/		
80	142,000	127,700	89.6	58,400	2
100	100,000	84,000	84.0	60,300	2
120	76,000	66,000	86.8	63,200	2
140	82,000	77,500	95.0	65,900	2
All levels	100,000	88,800	88.7	61,200	8

1/ Trapped seeds only; does not include losses from rodents and possible collection by cone pickers.
2/ Includes about 17 square feet of jack pine.
3/ No samples taken of the 60-square-foot level in 1957-58.

It varied from 82 percent for the natural stand to 89 percent for the 50-year managed stand; most of the seeds failing to germinate were empty. Good-quality commercially cleaned seed runs only a little higher, 95 percent or more. Because of its higher soundness, such seed is, of course, somewhat heavier (averaging 52,000 clean seeds per pound)[4] than the seed in this study (58,400 to 67,600 per pound).

YIELD NOT RELATABLE TO STAND DENSITY

The data from the 90-year managed stand was subjected to an analysis which assumed seed production to be a linear function of density. However, the linear model did not adequately explain the seed yields at different densities; individual plot yields were widely dispersed about the regression line. Two items worth noting may have weakened this test: the small numbers of seed traps (2 to 4 in each of 5 compartments), and the erratic yield pattern in the block having the poorer yields.

Some of the difference may have been due to the location of the compartments in the poorer-yielding block. These were either in small isolated stands of red pine (3 to 4 acres in size) surrounded by much younger stands or were on one edge of the main body of 90-year timber, within which, at some distance from its margins, the compartments of the better-yielding block were located. It may, therefore, be that some factors related to the location and size of these particular compartments had a negative effect on yield. If this is the explanation, the reduced yield in this block should also be evident in future seed crops. In general, seed production of this sample increased with density up to 120 square feet and then dropped off slightly (table 1).

Seed production by the 50-year managed stand tended to decrease as density increased, but the sample

[4] *See footnote 1, p. 1.*

was hardly large enough to provide a reliable basis for judgment. This trend, however, unlike that shown by the treatments in the 90-year-old managed stand, agrees with recent findings in Lower Michigan. In a twice-thinned stand in that area, the number of cones produced in 1961, and presumably the amount of seed, decreased sharply as the residual basal area increased, the lightest thinning (174 square feet) bearing practically no cones. However, 1961 was a poor seed year for red pine.[5]

DISPERSAL OCCURS THROUGHOUT YEAR

Seedfall occurred throughout the year. It began in early October, continued at a high level during that month and November (54 percent of the total fall), gradually dropped to a low point in February, and reached a second peak in June. This is shown best by the 90-year managed stand (fig. 1).

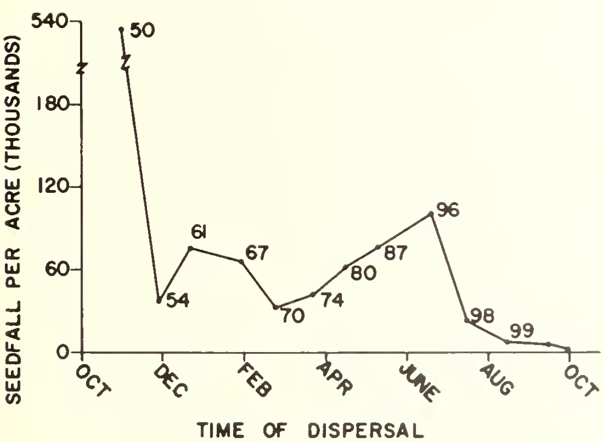

Figure 1. — Amount of seedfall as affected by time of year; 90-year managed red pine, all density levels. Values along trend line represent the proportion of the total seedfall collected up to the date shown.

Here, the daily fall averaged 16,200 seeds per acre during October, 1,300 in February, and 2,600 to 3,200 from April to mid-June. This pattern, in general, agrees with that found by Rudolf in Lower Michigan except that dispersal there began about 2 weeks earlier and was somewhat more rapid.[6]

An appreciable amount of seed was still being shed at Cutfoot at the end of the first year; in fact, 30 to 90 seeds per acre per day were trapped during the second season (1958-59) even though no new cones were observed to have been produced in the fall of 1958.

QUALITY DECREASES WITH TIME OF DISPERSAL

Germination of the seed produced by the 90-year managed stand showed a general decline from the first collection to that of late February. It then increased with the rising seedfall, reaching a second peak in June and declining rapidly thereafter (fig. 2). Some of the seed trapped the second season was still good, however.

Figure 2. — Relation of germination to time of seedfall; 90-year managed red pine, all density levels.

Part of the reduction in germination was due to the greater proportion of empty seed and part to an increase in the number of filled seeds which apparently were dead at the beginning of the tests and did not germinate. Such dead seeds formed a significant portion of the yield only in the January 30 collection in the 90-year stands (7 percent of the yield)[7] and in the July-September collections there (7 to 16 percent). At all other times dead seed did not comprise more than 2 percent of the yield; it usually was less than one percent.

HEAVIEST SEED FALLS FIRST

The number of clean seeds per pound increased markedly during the dispersal period. For the 90-

[5] *Godman, R. M. 1962. Red pine cone production stimulated by heavy thinning. U.S. Forest Serv., Lake States Forest Expt. Sta. Tech. Note 628, 2 pp., illus.*

[6] *See footnote 3, p. 1.*

[7] *This seed was embedded in snow and could be retrieved only by collecting and melting the latter. Some may, therefore, have been injured during collection and subsequent treatment.*

year managed stand, this value ranged from an average of 63,200 seeds per pound in October 1957 to 85,000 in mid-August 1958. Statistical analysis (regression method) showed that the relationship of number per pound to time was highly significant.

Some of the increase was due to the increasing proportion of empty seeds falling as dispersal ran its course (these were found to have a decided influence on the number per pound), and some may also have been the result of a decrease in the size and weight of the filled seeds.

The largest seed appeared to be borne by the 50-year managed stand, and the smallest by the 90-year managed stand. However, these differences could not be tested for significance.

CONCLUSION

On the basis of one heavy seed crop, it can be concluded that:

1. The amount of seed produced by red pine in a good crop year is much larger than previous reports indicate. In this study it varied from about 16.1 pounds per acre for a 90-year managed stand to 7.1 pounds per acre for a 90-year natural stand. That from a 50-year managed stand, on the other hand, was only 1.6 pounds. Although total seed production appeared to be affected by stocking, this proved to be not significant.

2. The seed produced was of good quality in all stands, germination of the unfanned collections ranging from 82 to 89 percent. As a consequence, the 90-year managed stand bore 916,000 viable seeds per acre, the 90-year natural stand 370,000 seeds, and the 50-year managed timber 89,000 seeds.

3. Although half of the total amount of seed fell during the first month (October), some fell during the winter, and a significant amount also was shed during the spring and early summer months.

4. Seed soundness also decreased as time elapsed, indicating that seed of the best quality falls first. However, enough viable seed fell during the spring and early summer months to be of considerable significance from the standpoint of regeneration cuttings.

January 1964

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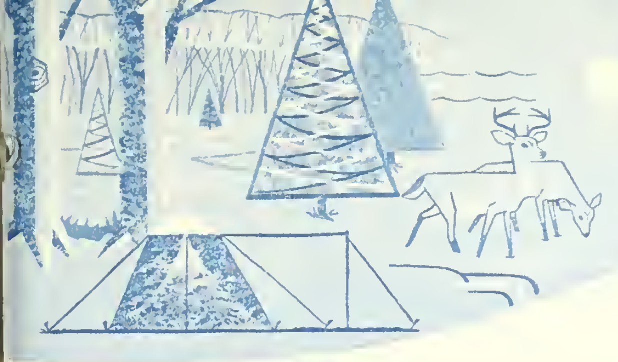

U. S. FOREST SERVICE

RESEARCH NOTE LS-37

AKE STATES FOREST EXPERIMENT STATION • U. S. DEPARTMENT OF AGRICULTURE

A Test of Concentrated Silvicides on Sugar Maple

In a recent test of silvicides by the Lake States Forest Experiment Station in cooperation with the Diamond-National Corporation, 2,4-D amine salts applied in frill girdles produced greater mortality of cull sugar maple trees than did any of the other treatments tested.

A series of unpublished earlier trials, using both esters and amines of 2,4,5-T and 2,4-D, indicated more rapid killing could be obtained with amine salts than with esters. Consequently it was decided to test concentrated amines of these two chemicals applied at full strength (4 pounds acid equivalent per gallon) and diluted 50 percent with water.[1] Two methods of application were employed: (1) sprayed into freshly cut frills made by axe girdling and (2) injected with a tree injector at 1-inch spacings around the root collar. Thus, eight treatments — two chemicals, two concentrations, and two methods of application — were tested. Each treatment was randomly assigned to a group of 10 trees ranging from 7 to 14 inches in diameter at breast height. These treatments were repeated in three separate blocks, making a total of 240 trees in the study.

The study was installed in northern Minnesota on July 24, 1961. The treatments were appraised on June 13, 1962, and a final examination was made on June 21, 1963.

[1] *The two chemicals used in this test, triethylamine salts of 2,4,5-T and alkanolamine (ethanol and isoproponol series) salts of 2,4-D, were supplied through the courtesy of the Dow Chemical Company.*

The results in 1962 showed that 2,4-D had killed a greater proportion of the trees than had 2,4,5-T. A greater proportion of the trees were also three-fourths or more defoliated with 2,4-D than with 2,4,5-T (table 1). An analysis of variance showed both these differences significant at the 5-percent confidence level. These same differences were still significant in 1963, and in addition the application of the chemicals in frills proved more effective than with the tree injector. There was no significant difference between the two concentrations of chemicals used.

Application of the concentrated silvicides into freshly cut frills was facilitated by a pressure oil can. It is possible that the frill girdling itself contributed some to the success of this method. The effects of girdling alone, however, were not tested in this study because of extremely slow results obtained in the past.

The chemicals had the least effect on dominant trees, which averaged only 30 percent dead compared to 49 percent of the codominant, 68 percent of the intermediate, and 75 percent of the suppressed.

During the field examination it was noted that many of the trees classified as living had no live tissue around their stem below where the silvicide was applied. Two possible explanations are: (1) Some trees are able to keep their crowns alive for a considerable length of time with food reserves stored in the root system. (2) The sample trees are scattered throughout a stand of

Table 1 — *Success of concentrated silvicides in defoliating and killing sugar maple*

Chemical	Application	Concentration	Average volume per tree	Condition of tree: 3/4 defoliated, June 1962	Condition of tree: 3/4 defoliated, June 1963	Condition of tree: Dead, June 1962	Condition of tree: Dead, June 1963
		Percent	C.c.	Percent	Percent	Percent	Percent
2,4-D	Frills	100	28	93	87	30	80
		50	28	73	70	3	57
	Injector	100	28	91	62	25	39
		50	42	92	61	22	54
2,4,5-T	Frills	100	28	76	66	7	49
		50	30	67	68	0	52
	Injector	100	40	68	53	7	37
		50	43	80	47	10	43

untreated trees; if any root grafts should exist between treated and untreated trees the untreated tree might supply the crown of the treated tree, at least while its xylem cells are still functioning. This might prolong the life of the treated tree even though the chemical was successful. In areas where all trees are treated this condition would not exist.

January 1964

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U. S. FOREST SERVICE

RESEARCH NOTE LS-38

LAKE STATES FOREST EXPERIMENT STATION • U. S. DEPARTMENT OF AGRICULTURE

Early Pruning Reduces Blister Rust Mortality In White Pine Plantations

Early pruning of lower branches in a young white pine plantation in north-central Wisconsin has reduced fatal blister rust infection from 59 to 19 percent. This Wisconsin location is in Zone 4 (Van Arsdel, 1961b) which is favorable to blister rust spread.

White pine has been extensively planted in the southern two-thirds of Wisconsin during the past 30 years, and there are many additional sites where it would be the best species to use. Most of it is planted in small blocks on private land where intensive management can be very profitable.

White pine should be grown in the shade of other species, except in the extreme southern part of the region. Unfortunately, however, most of it has been planted on open land where blister rust, tip weevil damage, and abnormal growth are often serious problems. Blister rust control by ribes eradication is often too costly or impractical on such small areas, and chemical control of the tip weevil has not been fully worked out.

In the Lake States, a high percentage of lethal blister rust infections enters the stems of young white pines through needles on the lower branches where the microclimate is most favorable (Van Arsdel, 1961a). As these lower branches gradually die from natural shading, particularly in a well-stocked stand, many branch cankers also die before the fungus can reach the stem. The reduced needle surface low in the crown also lessens the potential for new infection. In many instances, however, lethal infections reach the stems of small trees before the lower branches die. Therefore, early removal of live branches (fig. 1) is a recommended blister rust control practice (King, 1958).[1] Research results have also indicated that some form of annual or biennial pruning, started when the trees are young, can be more profitable than conventional pruning methods (Ralston and Lemmien, 1956).

In 1957 a long-range study was initiated to see if pruning could be used both to reduce the number of fatal blister rust cankers in the stand and to provide additional well-formed crop trees with surface-clear butt logs. The earliest pruning test is located in a Lincoln County forest plantation established in 1954 in SESW Sec. 26, T. 33 N., R. 7 E. The plot consists

FIGURE 1.—The first pruning was performed 3 years after planting.

[1] *The practice would not be of much value, however, in most of the northern part of Zone 4 (Lake Superior coastal region) where numerous infections often occur high in the crowns.*

of six rows of trees, with pruned and unpruned rows alternating. Pruning was done and blister rust infection data were recorded in the spring of 1957 and in the falls of 1958, 1960, and 1962. Hand clippers were used to remove one or two whorls at each pruning. At least one-half the live crown was left in each tree. Blister rust infection data as of 1962 are as follows:

	Pruned	*Unpruned*
Healthy trees	178	105
Fatally infected[1]	43	152
Total trees	221	257
Percent fatally infected	19	59

[1] *With a fatal stem canker or a branch canker that would probably be lethal if not pruned.*

Tree height averaged 1 foot in 1957 and 9 feet by 1962. No appreciable loss of height growth has been noted in pruned trees as compared to the unpruned checks. Thus far, a total of 5 man-hours has been spent on the four biennial prunings — less than 2 minutes per tree.

Now that the lower half of the crown has been removed to an average height of 4 feet (fig. 2), it is unlikely that any appreciable amount of fatal infection will occur. Therefore, additional pruning at 2- or 3-year intervals may actually be of more value to correct growth malformation and to hold the core of knotty wood in the stem to a minimum size.

Research results show that early and frequent pruning of young white pines greatly reduces the amount of fatal blister rust infection. It is a practical disease control measure that owners of small plantations and ornamental trees can use to advantage. Further pruning at 2- or 3-year intervals will evaluate the additional reduction of fatal blister rust infection and the cost of early pruning compared to conventional methods.

FIGURE 2. — The fourth pruning took place 8 years after planting.

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January 1964

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RESEARCH NOTE LS-39

LAKE STATES FOREST EXPERIMENT STATION · U. S. DEPARTMENT OF AGRICULTURE

Spruce Budworm Defoliation in Northeastern Minnesota Decreases in 1963

The 1963 aerial survey[1] for damage by the spruce budworm (*Choristoneura fumiferana* (Clem.)) in northeastern Minnesota showed a considerable decrease of noticeable current defoliation as compared to that recorded for 1961 (table 1, fig. 1)[2]. This has been brought about partly by the reduction, through mortality, of susceptible spruce-fir type. Also, large areas showed no appreciable defoliation for 1963 even where heavy defoliation had been recorded in previous years. Compared with 1961, the infestation in 1963 has retreated mostly along the eastern edge, with some retraction being noted along the southern edge. The western expansion of the infestation has also diminished.

An egg-mass survey indicated that generally light defoliation will occur in 1964, although continued heavy defoliation by the budworm can be expected on certain areas.

In addition to defoliation information, spruce-fir mortality resulting from past years of heavy budworm feeding was also mapped for the first time in 1963. Mortality classed as 10 to 50 percent of balsam fir trees was found on 112,200 acres of spruce-fir type and that classed as 51 to 100 percent on 130,700 acres (fig. 2).

[1] *The survey, conducted during July, was a cooperative effort by the Beltsville Forest Insect Laboratory, Superior National Forest, and Lake States Forest Experiment Station, all of the U.S. Forest Service, and by the Minnesota Department of Agriculture, Division of Plant Industry.*

[2] *Batzer, H. O., and Bean, J. L. Spruce budworm defoliation causes continued top killing and tree mortality in northeastern Minnesota. U.S. Forest Serv., Lake States Forest Expt. Sta. Tech. Note 621, 2 pp. 1962.*

TABLE 1. — *Defoliation of spruce-fir type by the spruce budworm in northeastern Minnesota*

Current defoliation	1961		1963	
	Acres	Percent of total	Acres	Percent of total
None-to-light	428,600	42	611,000	71
Moderate-to-heavy	366,300	35	130,600	15
Severe	240,800	23	116,200	14

April 1964

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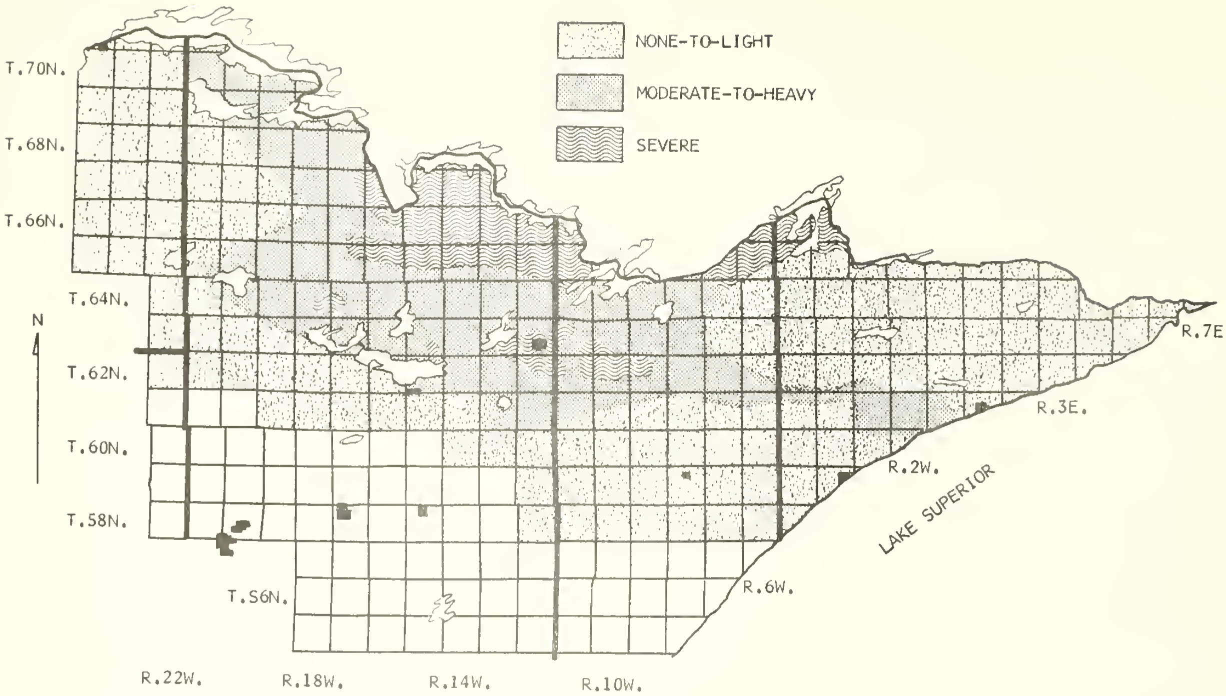

FIGURE 1. — Spruce budworm defoliation in northeastern Minnesota based on the 1963 aerial survey. Zones show degree of current defoliation of spruce-fir.

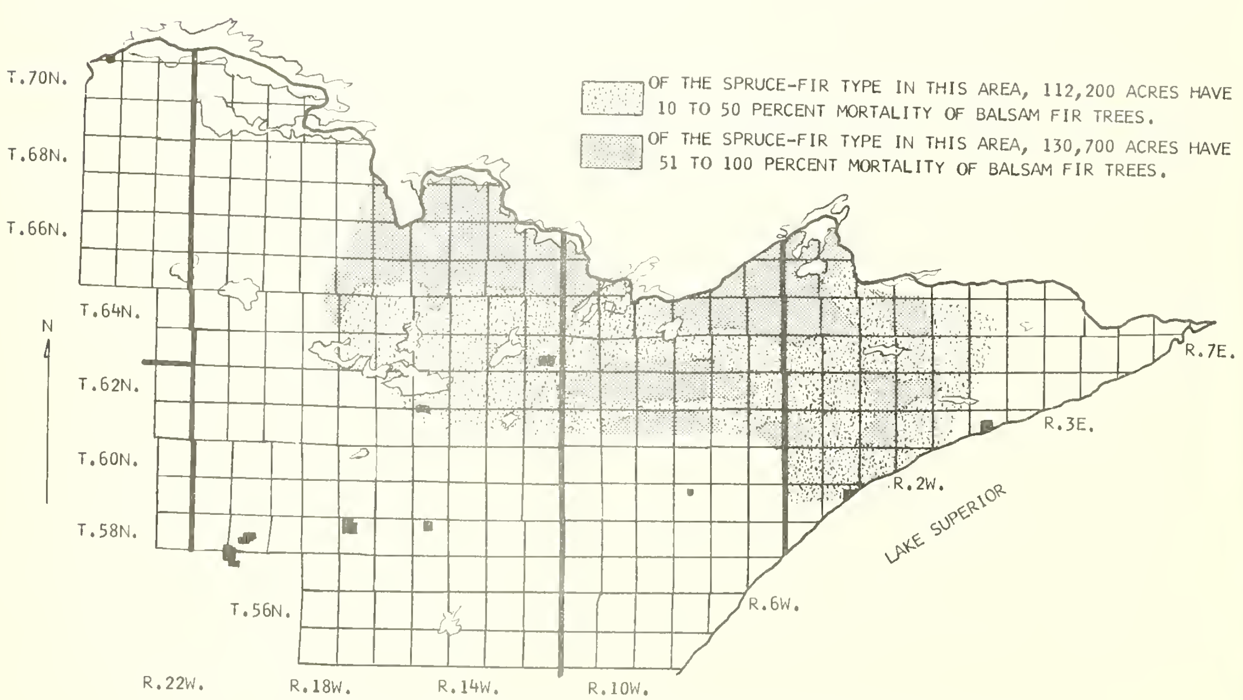

FIGURE 2. — Mortality of spruce-fir in northeastern Minnesota based on the 1963 aerial survey. Zones show degree of mortality.

U. S. FOREST SERVICE

RESEARCH NOTE LS-40

LAKE STATES FOREST EXPERIMENT STATION · U. S. DEPARTMENT OF AGRICULTURE

Duration of Percolation From a Loess Soil[1]

Until fairly recently it was generally believed that gravitational water drained from a soil profile quite rapidly — in a few hours', or at most, a few days' time. It was further believed that at the end of this period of rapid drainage the soil was at field capacity, and that percolation then ceased abruptly.

That water is discharged from loess soils over extended periods of time is shown by the record from a series of lysimeters that were operated near La Crosse, Wis., in the 1930's. The data, not analyzed until recently, confirm the observations of Nixon and Lawless[2] in California for soils *in situ* and those of Hewlett[3] in North Carolina for soils in a model. This phenomenon helps explain why streams continue to supply a base flow during long periods without rainfall.

The lysimeters were 20 feet long, 10 feet wide, and 4 feet deep. They were filled with undisturbed subsoil blocks plus a layer of topsoil, both of Fayette silt loam. This is a well-drained, loessel soil that is commonly found on the ridges and upper slopes of Wisconsin's "Driftless Area."

Percolate normally flowed from the lysimeters only during the spring thaw period, when soil moisture was at a high level and melting snow provided a continuing supply of water. Percolate flowed in the summer and fall seasons but rarely. This was because rain that infiltrated the soil during summer and fall months normally was held in the soil, replenishing moisture losses from evapotranspiration.

Since rains fell at frequent intervals during the spring season, there was only limited opportunity during the years of the experiment to study soil drainage during long rainless periods. Percolation did occur a few times, however, during extended periods without soil moisture recharge. During these periods percolate flowed continuously for as long as 20 days without additional rainfall (fig. 1). Vegetation on the lysimeter was a seedling stand of red and white oak and black walnut, and the soil was covered with a layer of hardwood leaf litter. Thus losses from evapotranspiration were minimal during the periods shown. If percolation can flow for 20 days from the 4-foot soil mass of a lysimeter without recharge, it is conceivable indeed that drainage from the much greater soil mass of natural watersheds could supply the flow of streams for much longer periods.

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1 *Reported by the Station's field headquarters in LaCrosse, Wis., where research is conducted in cooperation with the Wisconsin Conservation Department.*

2 *Nixon, Paul R., and Lawless, G. P. Translocation of moisture with time in unsaturated soil profiles. Jour. Geophys. Res. 65: 655-661, illus. 1960.*

3 *Hewlett, John D. Soil moisture as a source of base flow from steep mountain watersheds. U.S. Forest Serv., Southeast. Forest Expt. Sta., Sta. Paper 132, 11 pp., illus. 1961.*

April 1964

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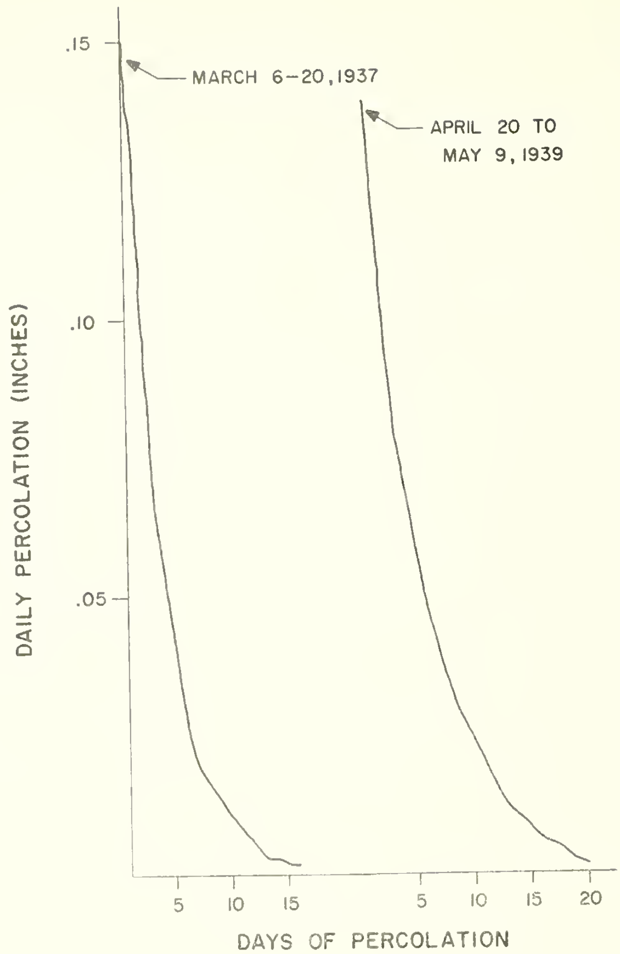

FIGURE 1. — Duration of soil moisture drainage during periods without recharge.

U. S. FOREST SERVICE

RESEARCH NOTE LS-41

LAKE STATES FOREST EXPERIMENT STATION · U. S. DEPARTMENT OF AGRICULTURE

Sugar Maple Veneer Logs Should be Graded for Pith Flecks[1]

Pith flecks are abnormal wood features caused by the feeding of Agromyzid (Diptera) fly larvae on the cambial tissues of growing trees. In the northern Lake States forests pith flecks are most frequently found in certain diffuse porous tree species such as maple, birch, aspen, willow, cherry, and basswood. All larvae found mining the living cambium of these trees appear to belong to the genus *Phytobia*, but the individual species have not been identified.

Pith flecks on face veneers of sugar maple, *Acer saccharum* Marsh., are often considered a defect (worm crawl) and substantially reduce veneer value, but the present veneer log grading rules do not recognize pith flecks as defects. The purpose of this paper is to show the degrading effect of pith flecks on veneer values in order to illustrate the need for recognizing pith flecks in sugar maple veneer log grading.

On sugar maple log ends, pith flecks are normally light-colored (fig. 1, *A*), but on the tangential (fig. 1, *B*) and radial (fig. 1, *C*) surfaces the same pith flecks show as brown streaks. When the brown streaks are numerous or cross the grain, matched and uniform grade face veneers are degraded.

It seemed likely that the greater the number of pith flecks on log ends, the greater the losses in veneer values. To test this, seven 8½-foot sugar maple butt logs with varying intensities of pith fleck were selected for a mill study.

All seven logs were graded as No. 1 (Veneer Grade),[2] and were from second-growth trees ranging between 13.5 and 14.1 inches in diameter at breast height. Minimum small-end diameter was 12 inches inside bark with less than a 6-inch central core in heart or mineral stain. The central non-usable core, 6½ inches in diameter, was determined by the size of the lathe chuck, and any pith flecks in this core did not appear in the veneer yields. No log-end defects other than pith fleck and the heart center were allowed. All logs were straight and contained no defect indicators on the bark surface.

Pith-fleck intensity for each log was determined by counting flecks on the usable perimeter of both log ends and calculating the number of pith flecks per square foot of end area (fig. 2).

The logs were cut into 4-foot bolts for turning, debarked, and cut into 1/16-inch-thick veneer on a rotary lathe. The green veneer was clipped to uniform sizes, dried, and clipped again. Veneer yields were determined according to the grades currently being used by the study mill during commercial production (fig. 3):

Grade	*Specification*
White	Clear, except admits traces of light pith fleck
Unselect white	Clear, except admits maximum of two 3-inch pith flecks along grain in 6-inch square
Unselect	Admits all pith fleck, spots, and streaks and mineral spots and streaks
Center	Admits small, sound knots, pinholes, checks, rough grain, mineral, and heartwood
Random widths	Sound cuttings of three top grades in sizes not fitting current cutting orders
Golf	Sound cuttings in three sizes: 9 by 11 inches, 9 by 16 inches, 9 by 21 inches. These pieces are used in the manufacture of laminated golf club heads

For comparative purposes, veneer values were calculated in two ways. First the actual value with pith flecks present was computed. Second, the value that could have been obtained if cambium miners had not invaded the tree was computed. This second calculation meant that all pieces of unselect white veneer and certain pieces of unselect veneer were upgraded to the white grade and were re-evaluated according to the current

[1] *The cooperation of Mr. Henry Bannack, Frost Veneer Company, Antigo, Wis., is gratefully acknowledged.*

[2] *Northern Hemlock and Hardwood Manufacturers Association. Official grading rules for northern hardwood and softwood logs and tie cuts. 12 pp. 1959.*

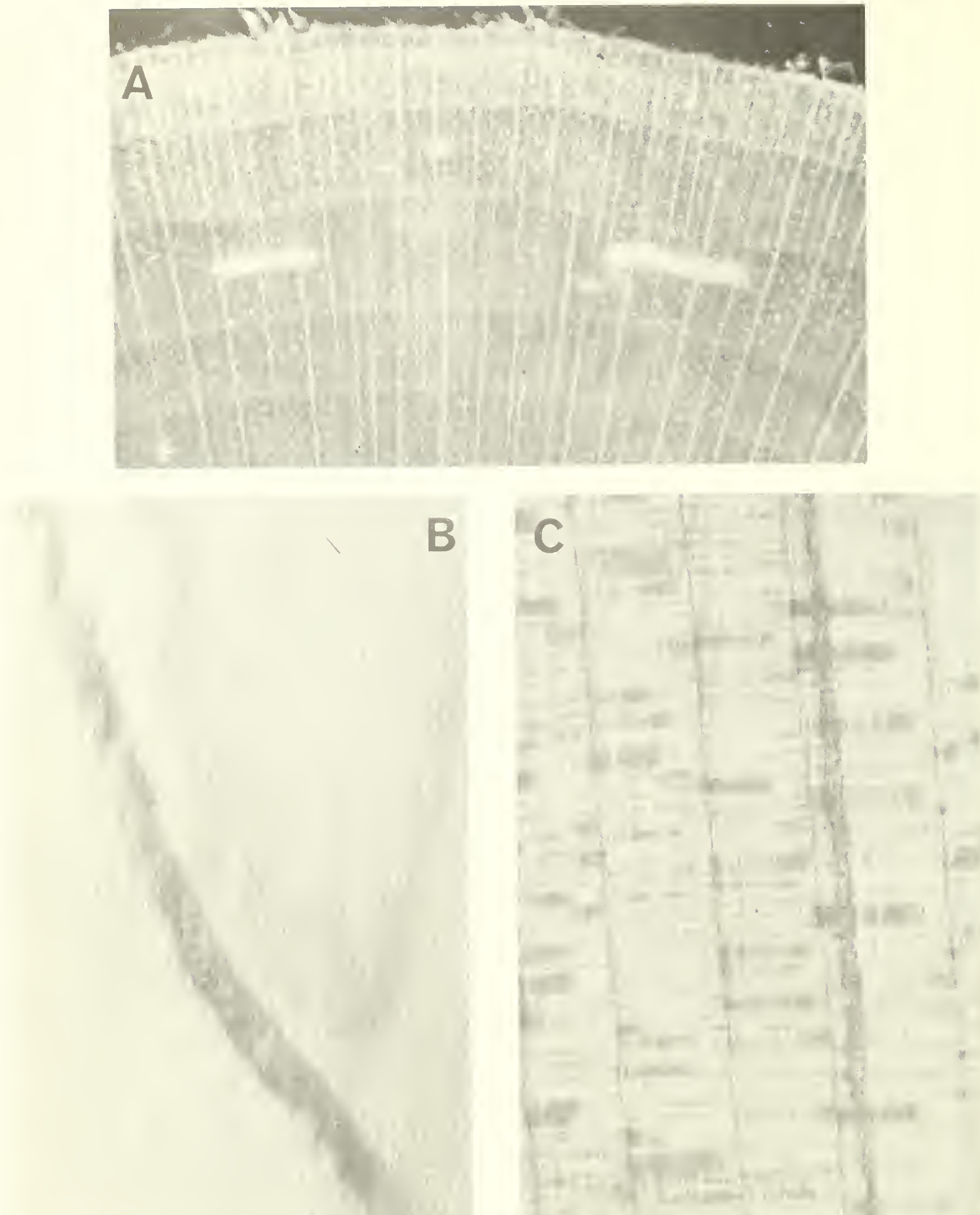

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FIGURE 1. — Example of *Phytobia*-caused pith fleck in sugar maple from northern Wisconsin. (*A*) Cross-section view, enlargement 10X; (*B*) tangential view (rotary cut veneer), enlargement 6X; (*C*) radial view, enlargement 10X.

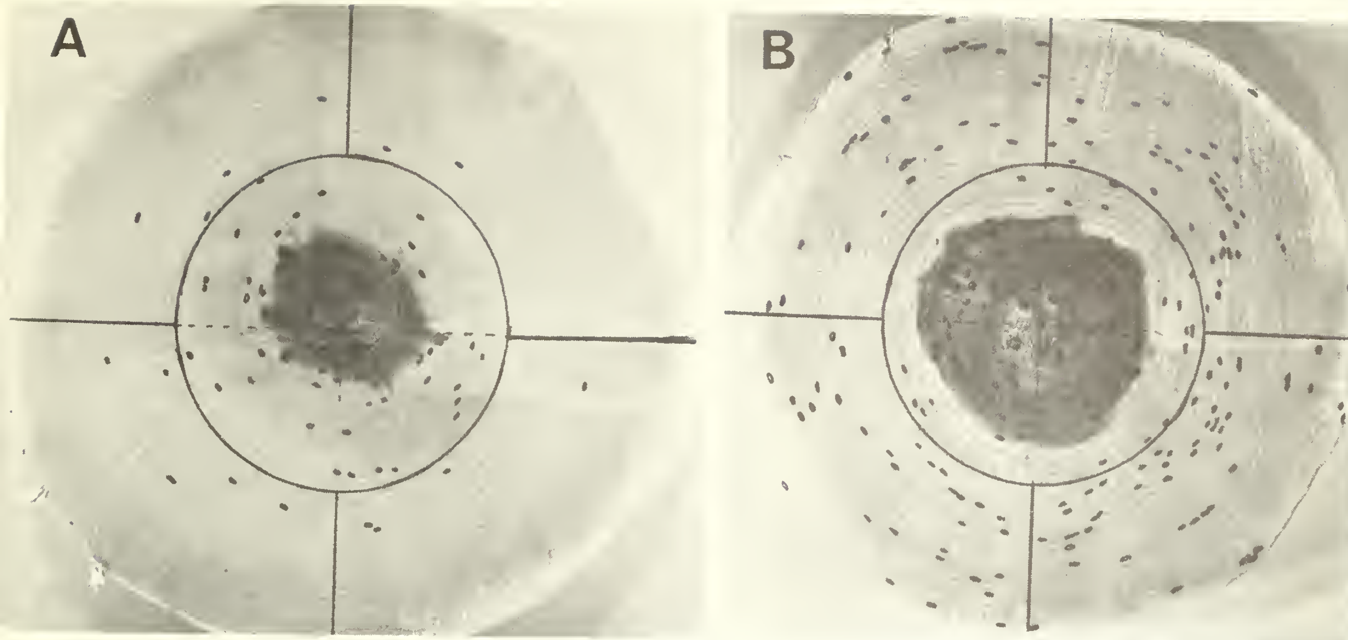

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FIGURE 2. — Sugar maple log ends with pith flecks outlined for illustrative purposes. (*A*) Light pith fleck infestation, 21 per square foot; (*B*) heavy pith fleck infestation, 221 per square foot.

TABLE 1. — *Dollar loss in 1/16-inch veneer cut from pith-fleck-infested No. 1 grade sugar maple logs.*

Log number	Pith flecks per sq. ft.[1/]	Actual value of study yield	Estimated value if no pith flecks present	Monetary loss due to pith flecks	
	Number	Dollars	Dollars	Dollars	Percent
		LIGHT INFESTATION			
1	18	20.88	21.70	0.82	3.8
2	20	25.16	25.40	.24	.9
		MEDIUM INFESTATION			
3	41	22.43	24.48	2.05	8.4
4	68	15.03	15.14	.11	.7
5	84	15.20	16.47	1.27	7.7
		HEAVY INFESTATION			
6	164	19.70	21.77	2.07	9.5
7	190	21.63	25.04	3.41	13.6

[1/] Number of pith flecks per square foot of usable perimeter (outside of a 6½-inch diameter center core) on both end surfaces of the log.

average market price for the top grade. The monetary loss due to pith flecks is the difference between the actual veneer value and estimated values of pith fleck-free veneer (table 1).

Results show that an increasing number of pith flecks on log ends generally indicate an increasing loss in the value of the veneer produced. Exceptions occur (log 4) when pith flecks are restricted to one quarter of the log or clustered around the inner diameter of the usable log perimeter. This suggests that some qualification for area distribution must be employed when grading logs for pith fleck.

The high dollar losses from pith flecks are consistent enough during actual veneer production to warrant special log-grading considerations. A preliminary study of the influence of cambium-mining *Phytobia* larvae on the general quality of sugar maple timber has been concluded. Investigations of insect behavior currently underway may help explain the distribution of pith flecks. Further investigation is needed to develop specifications for grading veneer logs.

April 1964

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(See reverse for Fig. 3)

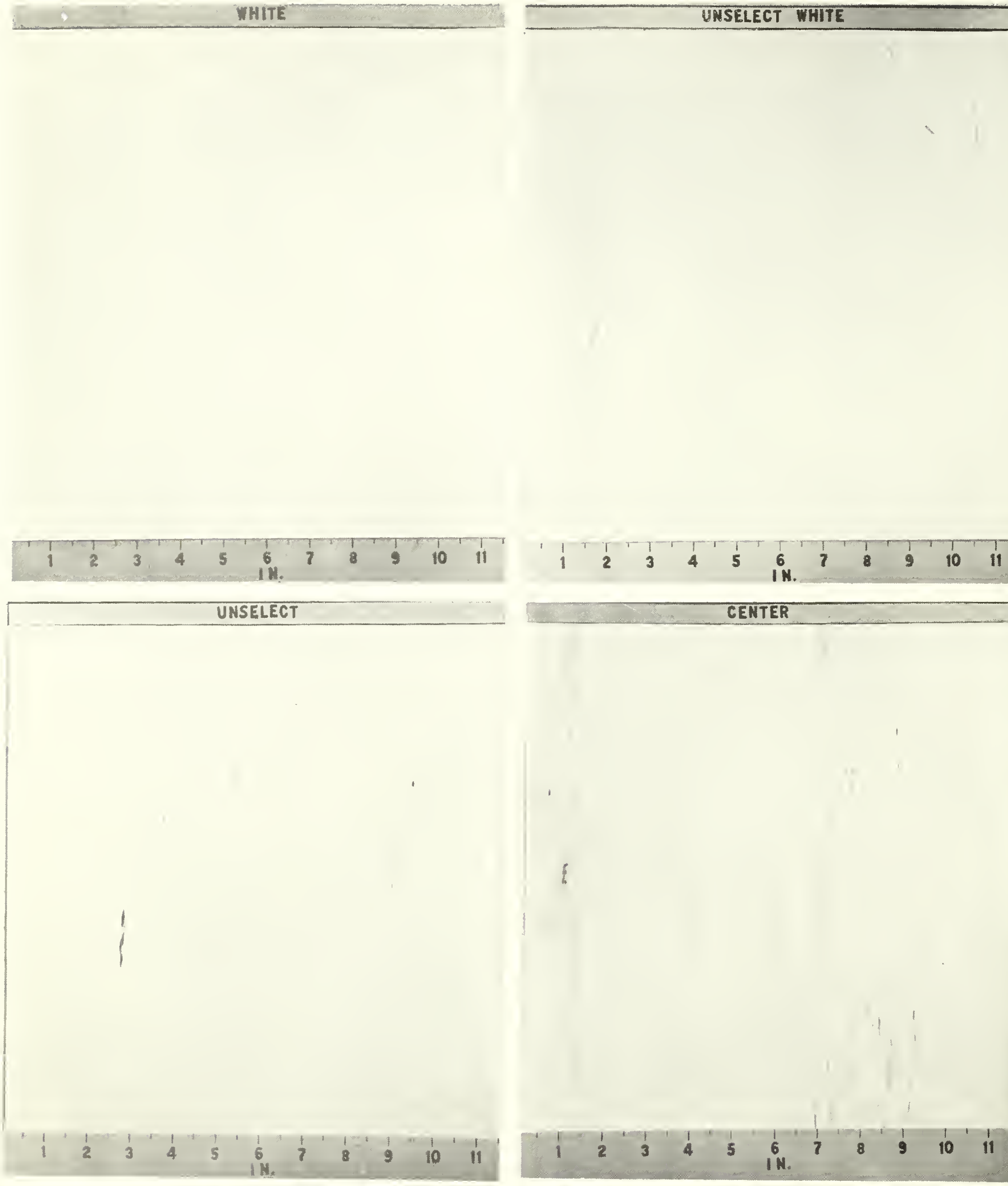

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FIGURE 3. — Examples of the four best veneer grades used in this study.

U. S. FOREST SERVICE

RESEARCH NOTE LS-42

LAKE STATES FOREST EXPERIMENT STATION · U. S. DEPARTMENT OF AGRICULTURE

Growing White Pines to Avoid Blister Rust — New Information for 1964

This Note updates control information in Station Paper No. 92[1] by providing improved pictures for canker identification (figs. 1, 2), a revised map for determining the intensity of control required in various parts of the Lake States (fig. 3), and some guides for identifying ribes bushes (fig. 4).

Literature on blister rust control in the past has stressed the great loss of unprotected white pine to the blister rust disease. Increased knowledge of the disease has permitted a shift in emphasis, stressing that many trees can survive blister rust attack and grow to saw-log size. In Zones 1 and 2 (fig. 3) enough pines will usually survive in an acre of plantation to give a commercial stand of pine even without control. In Zone 3 surviving pines would provide an important part of the mature crop mixture. Even in parts of Zone 4, some pine will survive without control.

Zone 3 is the area where ribes eradication is most important. In much of Zone 4, long-distance spread reduces the effectiveness of control by ribes eradication. Perhaps eradicant fungicides, now being tested, can kill established cankers. But for the difficult areas of Zone 4, I feel the most effective blister rust control is the use of the trees resistant to blister rust infection that are being developed at the University of Wisconsin. They are not yet ready for release.

Reducing Rust Damage by Silviculture

Four general principles of white pine culture will help hold rust damage to a minimum:

1. *Maintain a closed canopy.* Grow pines close together so branches soon touch and maintain a uniform closed canopy. This keeps the air dry below the canopy.

2. *Prune off lower branches.* Start pruning 2 years after planting. Cut out cankered leaders so that a side branch can take leadership. Keep the lower third of the crop trees free of branches by pruning. Branches near the ground are more likely to become infected because it is wetter there.[2]

3. *Avoid small openings.* Openings in the crown canopy with a diameter less than the height of surrounding trees are cold and wet. This favors blister rust infection. Do not plant pines there.

4. *Maintain an overstory cover* of thin-crowned species in Zones 3 and 4. White pine usually grows well if brush is kept down; lack of moisture reduces rust.

April 1964

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F-506316

FIGURE 1. — First visible symptoms of a blister rust canker (in circle). Needles persist where fungus threads from the entrance point in the needle hold them to the twig. Canker color is light yellow-orange.

[1] *Van Arsdel, Eugene P. Growing white pine in the Lake States to avoid blister rust. U.S. Forest Serv., Lake States Forest Expt. Sta., Sta. Paper 92, 11 pp., illus. 1961.*

[2] *Weber, Ray. Early pruning reduces blister rust mortality in white pine plantations. U.S. Forest Serv. Res. Note LS-38, 2 pp., illus. Lake States Forest Expt. Sta., St. Paul, Minn. 1964.*

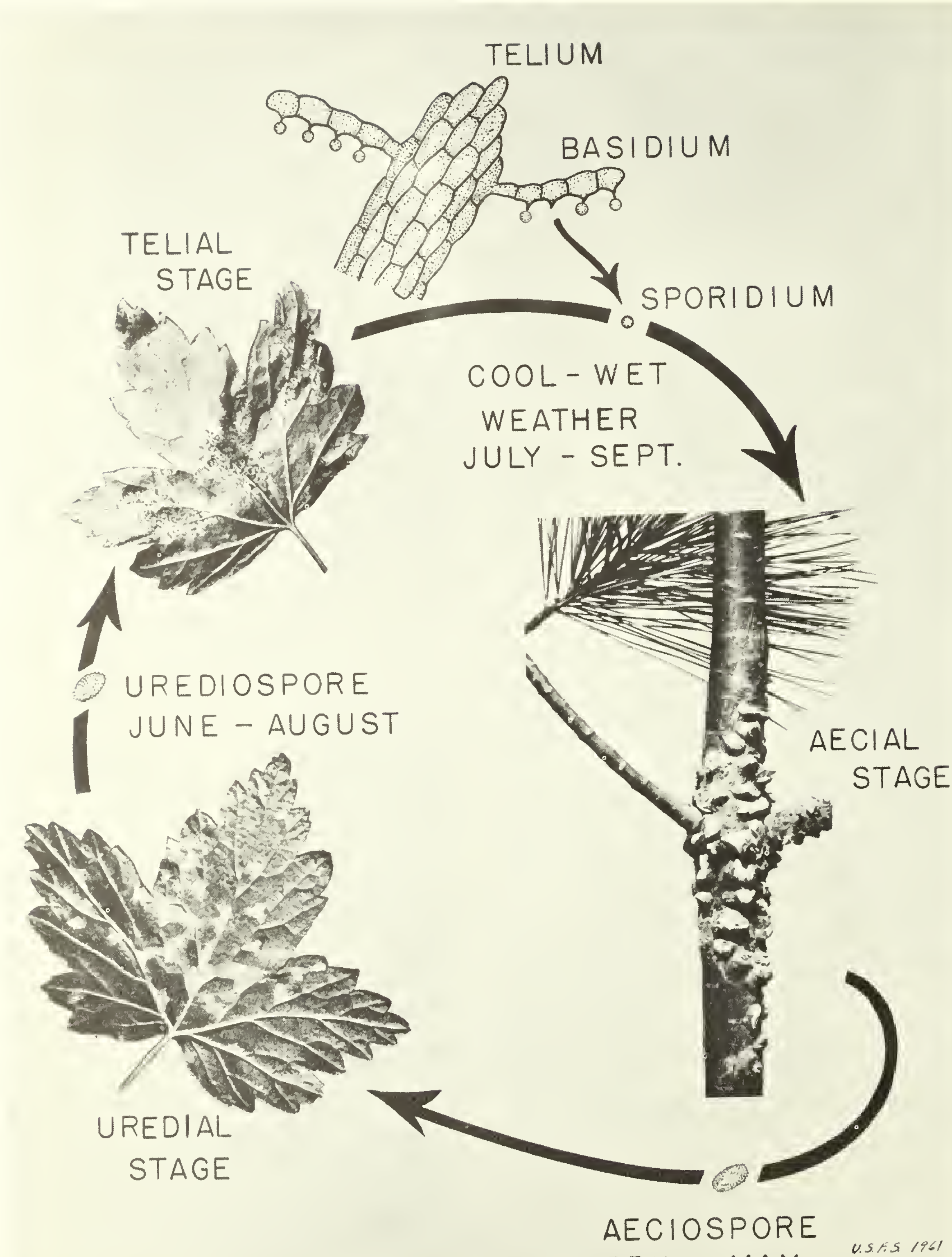


FIGURE 2. — Life cycle of the rust fungus showing typical signs on white pine and *Ribes nigrum*.

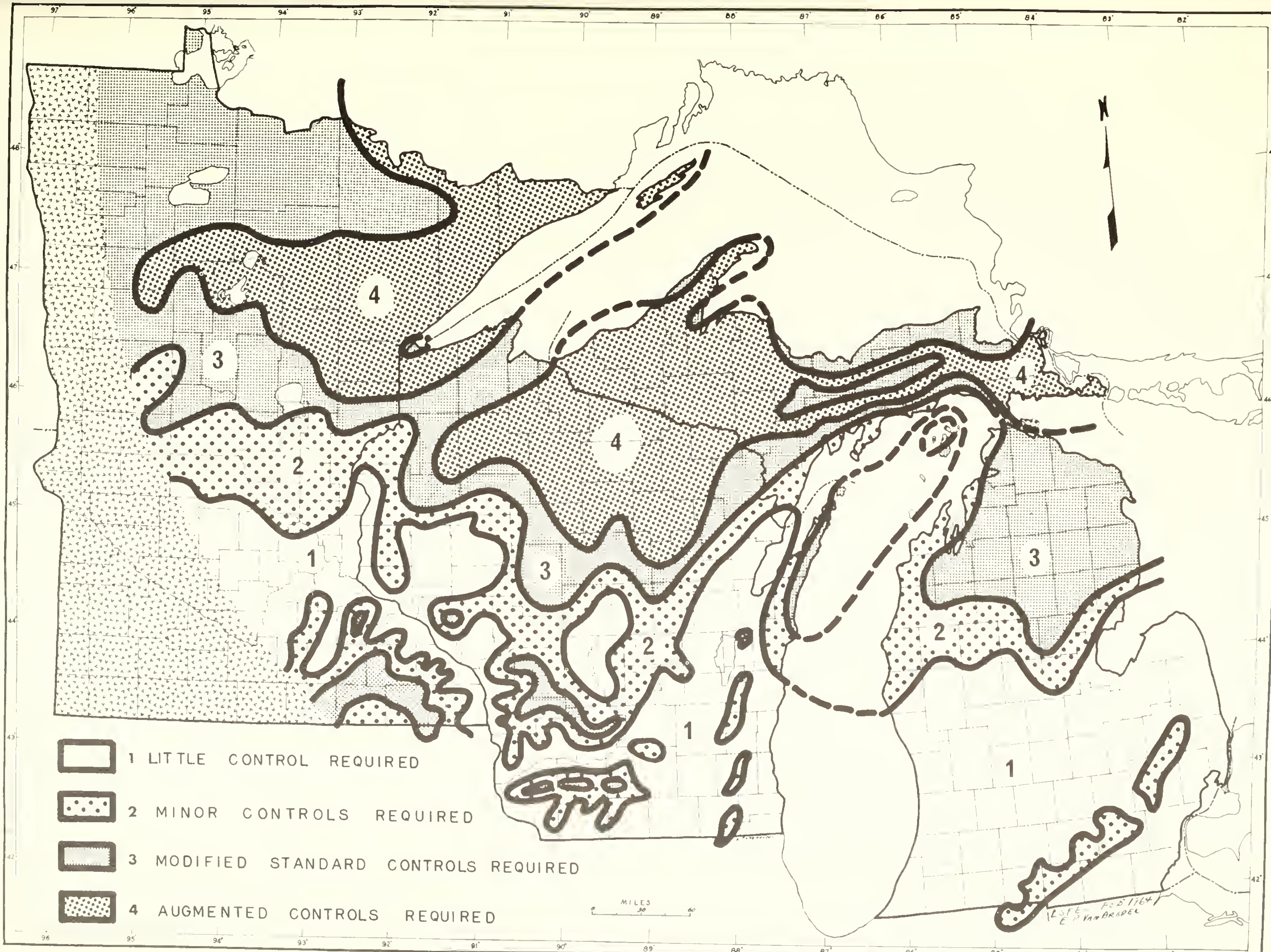
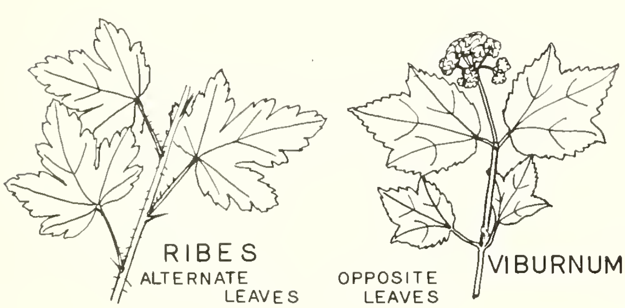


FIGURE 3. — Revised map showing climatic zones of rust infection potential.

What Ribes Look Like

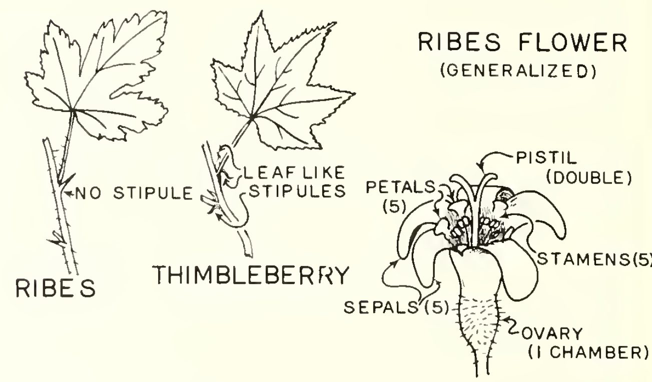
Some characteristics that separate ribes from other plants are presented below because this information is not readily available elsewhere.

Ribes (gooseberries and currants) are shrubs up to 10 feet tall. Many kinds are thorny or prickly. Ribes leaves are always alternate on the stem; some look-alikes, such as maple, have opposite leaves.

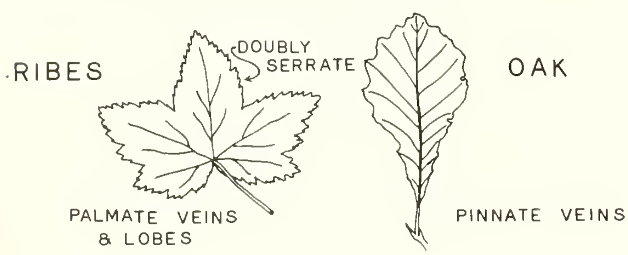


Ribes never have little leaf-like growths (stipules) at the base of the leaf stem as do the thimbleberry and ninebark which look much like ribes.

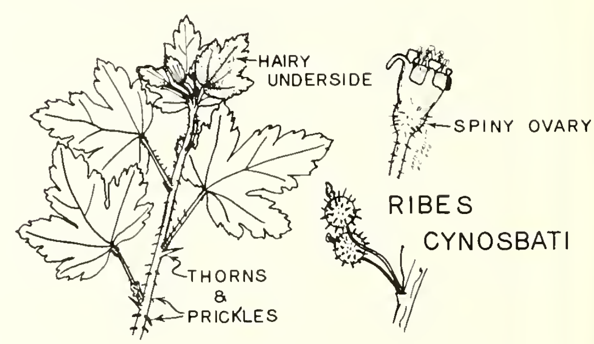
Ribes flowers have five petals, five sepals, five stamens, and a one-chambered ovary with a double style. The withered flowers remain attached to the berry as it ripens.



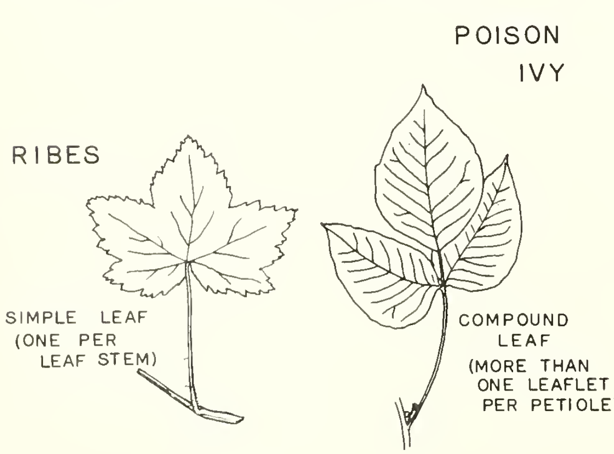
Ribes leaves are palmately veined, palmately lobed, and have saw-toothed edges.



A typical gooseberry is *Ribes cynosbati.*



Ribes leaves always have one leaf on a leaf stem, unlike roses or raspberries which have many.



A typical currant is *Ribes americanum.*

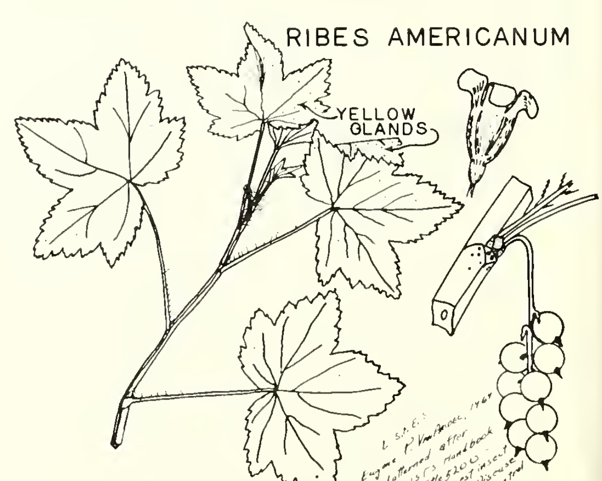
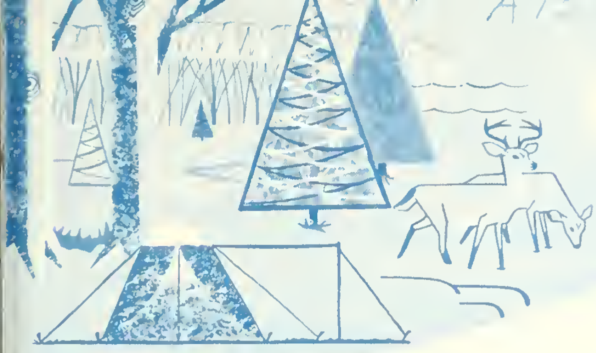


FIGURE 4. — Guide for identifying ribes bushes.



U. S. FOREST SERVICE

RESEARCH NOTE LS-43

LAKE STATES FOREST EXPERIMENT STATION • U. S. DEPARTMENT OF AGRICULTURE

Minnesota's Timber Volume

Minnesota's timber volume increased nearly 34 million cords between 1953 and 1962 to over 124 million cords (table 1). A wave of young trees in northern Minnesota reaching merchantable size in stands previously classed as "restocking" accounts for much of the 37-percent increase in timber volume. Included in the growing stock are 15.5 billion board feet of sawtimber (table 2). This volume, expanded from 12.5 billion board feet in 1953, reflects both an improved growing stock and a maturing of Minnesota's second-growth forests. Average growing stock volume per acre increased from 5.0 to 7.3 cords; average sawtimber volume per acre changed from 693 to 910 board feet.

The three northeastern survey units contain almost 90 percent of the State's growing stock and nearly 80 percent of its sawtimber volume. In 1953 these figures were 78 percent and 67 percent, respectively. Southern Minnesota has had a decrease in volume. Part of the loss is due to timber harvest and land clearing, although differences in definitions between surveys account for some of the loss. Definition differences had little effect in the north.

Conifers comprised 37 percent of the growing stock volume and 42 percent of the sawtimber volume in 1962. Over nine-tenths of the conifer volume is in northeastern Minnesota.

Aspen, jack pine, and paper birch, in that order, are the most prominent species; they include 47 percent of Minnesota's growing stock volume. Since all three are short-lived, greater harvests seem warranted. Paper birch has moved from the sixth most plentiful species in 1953 to the third in 1962, just ahead of black spruce and balsam fir. Paper birch growing stock volume has almost tripled in St. Louis County and has nearly doubled in Lake and Itasca Counties.

Aspen maintains its lead in sawtimber volume. Red pine, almost doubling in volume, has moved ahead of jack pine as the second-ranked sawtimber species. About 45 percent of the increase in red pine sawtimber volume is in Itasca County.

Both growing stock and sawtimber volumes have accumulated rapidly since 1953 (table 3), especially in the Central Pine Unit where the increase exceeds 60 percent in most counties. The increase was large but less uniform in other northern units. Volumes were reduced as much as 20 to 40 percent in most of the southern and western counties except along the forested edge of the Red River Valley. Much of this apparent reduction is attributed to more rigid specifications for sawtimber trees. Some poor-quality large trees classed as growing stock in 1953 are now classed as culls.

These statistics are based on results from the cooperative Forest Survey conducted during 1960-63 by the Lake States Forest Experiment Station, the Iron Range Resources and Rehabilitation Commission, and several other cooperators. This is the second of a number of reports being prepared to make forest resource statistics available to the public. The first was Research Note LS-25, "Forest Area Trends in Minnesota Counties," July 1963.

Sampling error (at one standard deviation) is estimated to be ±0.6 percent for the growing stock volume in the State. This approximates ±7 percent error per million cords or ±22 percent error per 100,000 cords. The percent error figure doubles as the volume is divided by 4. Sampling error is somewhat lower than this in the north, where sampling was more intensive than in the south.

APRIL 1964

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Research Forester
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Table 1.--Growing stock volumes in Minnesota counties, 1962 1/

(Thousands of cords) 2/

County	All species	All conifers	All hardwoods	White & red pine	Jack pine	Spruce	Balsam fir	Tamarack & cedar	Elm, ash, & basswood	Oaks	Aspen	Paper birch	Other hardwoods
LAKE SUPERIOR UNIT													
Carlton	1,420.3	364.1	1,056.2	51.7	60.4	60.3	126.7	65.0	277.4	60.3	397.1	205.6	115.8
Cook	7,132.3	3,865.3	3,267.0	344.7	694.0	1,565.1	861.2	400.3	97.2	2.1	2,056.6	906.0	205.1
Lake	9,596.7	4,813.2	4,783.5	445.4	1,049.2	1,443.8	1,144.9	729.9	250.1	5.5	2,489.8	1,438.0	600.1
Pine	1,481.2	144.9	1,336.3	7.1	77.0	37.7	4.6	18.5	420.6	107.8	601.6	124.2	82.1
St. Louis	25,163.7	11,625.7	13,538.0	1,966.7	3,988.3	2,359.5	2,387.5	923.7	1,161.2	23.2	8,702.3	2,370.1	1,281.2
Total	44,794.2	20,813.2	23,981.0	2,815.6	5,868.9	5,466.4	4,524.9	2,137.4	2,206.5	198.9	14,247.4	5,043.9	2,284.3
RAINY RIVER UNIT													
Koochiching	14,271.0	7,924.0	6,347.0	406.1	270.6	3,858.0	1,478.2	1,911.1	981.2	13.4	3,745.1	620.9	986.4
Lake of the Woods	2,773.2	1,704.5	1,068.7	103.6	177.3	643.6	394.4	385.6	271.2	38.6	499.9	39.6	219.4
Total	17,044.2	9,628.5	7,415.7	509.7	447.9	4,501.6	1,872.6	2,296.7	1,252.4	52.0	4,245.0	660.5	1,205.8
CENTRAL PINE UNIT													
Aitkin	5,541.8	1,202.2	4,339.6	184.9	55.5	218.1	228.6	515.1	1,085.8	538.7	1,432.3	469.2	813.6
Becker	3,136.8	632.0	2,504.8	205.9	218.1	51.5	112.8	43.7	556.5	434.1	1,136.6	188.7	188.9
Beltrami	6,066.4	2,089.1	3,977.3	296.8	380.8	350.8	317.6	743.1	860.0	128.5	1,966.9	405.3	616.6
Cass	7,444.7	2,436.5	5,008.2	898.2	821.8	100.8	348.8	266.9	566.1	603.6	2,793.0	652.5	393.0
Clearwater	2,760.5	418.2	2,342.3	145.4	98.7	59.3	43.7	71.1	509.2	198.7	1,254.8	216.7	162.9
Crow Wing	4,101.0	926.5	3,174.5	346.7	436.7	16.9	54.3	71.9	567.2	784.1	1,468.1	271.3	83.8
Hubbard	3,040.4	1,047.0	1,993.4	217.8	645.8	103.0	31.2	49.2	76.9	220.8	1,418.1	205.4	72.2
Itasca	13,752.1	5,018.8	8,733.3	1,115.0	852.1	944.5	1,378.0	729.2	1,406.0	284.5	5,138.7	1,120.3	783.8
Wadena	512.2	316.1	196.1	52.6	227.4	17.3	4.5	14.3	37.2	45.9	80.0	16.8	16.2
Total	46,355.9	14,086.4	32,269.5	3,463.2	3,736.9	1,862.2	2,519.5	2,504.5	5,664.9	3,238.9	16,688.5	3,546.2	3,131.0
SOUTHEAST UNIT													
Anoka	289.3	49.8	239.5	1.5	-	-	-	48.3	82.0	82.6	34.5	14.9	25.5
Benton	127.1	2.6	124.5	1.1	-	-	-	1.5	44.2	44.6	11.4	7.7	16.6
Carver	138.1	1.1	137.0	.6	-	-	-	.5	60.5	37.8	8.0	2.8	27.9
Chisago	245.9	18.3	227.6	.6	-	-	-	17.7	92.2	65.5	16.6	9.8	43.5
Dakota	151.0	2.1	148.9	.6	-	-	-	1.5	46.6	60.1	12.7	6.7	22.8
Douglas	212.1	2.7	209.4	-	-	-	-	2.7	89.5	46.4	24.3	7.5	41.7
Fillmore	559.4	3.8	555.6	2.1	-	-	-	1.7	174.6	248.5	34.6	12.2	85.7
Goodhue	421.3	2.6	418.7	-	1.0	-	-	1.6	133.6	180.2	26.7	10.6	67.6
Hennepin	159.1	1.3	157.8	.7	-	-	-	.6	65.5	47.8	7.1	4.0	33.4
Houston	756.7	4.5	752.2	2.7	-	-	-	1.8	186.5	395.3	49.8	17.3	103.3
Isanti	230.0	16.3	213.7	.8	-	-	-	15.5	75.5	78.2	20.9	10.7	28.4
Kanabec	619.0	11.6	607.4	2.7	-	.5	-	8.4	139.2	147.3	258.7	35.8	26.4
Le Sueur	193.3	.5	192.8	-	-	-	-	.5	96.5	44.2	5.9	3.6	42.6
Mille Lacs	551.2	34.1	517.1	5.4	-	3.9	-	24.8	192.1	115.1	156.5	27.4	26.0
Morrison	746.2	90.9	655.3	4.8	63.9	3.9	-	18.3	245.8	164.1	178.3	36.2	30.9
Olmsted	317.2	1.3	315.9	.6	-	-	-	.7	72.6	167.9	26.6	8.9	39.9
Otter Tail	1,029.1	97.5	931.6	10.5	17.1	4.0	-	65.9	370.3	211.6	260.0	50.3	39.4
Ramsey	19.0	-	19.0	-	-	-	-	-	7.0	6.2	1.1	.5	4.2
Rice	123.3	-	123.3	-	-	-	-	-	52.4	35.6	6.8	2.2	26.3
Scott	128.5	.5	128.0	-	-	-	-	.5	54.3	36.2	7.9	2.6	27.0
Sherburne	162.6	9.9	152.7	1.8	-	-	-	8.1	36.5	75.4	14.8	7.3	18.7
Stearns	383.4	5.0	378.4	1.6	-	-	-	3.4	126.3	145.0	34.1	15.6	57.4
Todd	606.5	54.5	552.0	6.3	27.9	2.6	-	17.7	202.9	146.5	148.9	31.9	21.8
Wabasha	310.2	2.7	307.5	.7	-	-	-	2.0	90.5	137.8	20.1	9.0	50.1
Washington	152.5	1.8	150.7	.7	-	-	-	1.1	65.0	41.9	9.6	4.4	29.8
Winona	600.8	7.8	593.0	5.6	-	-	-	2.2	150.6	302.7	41.1	16.7	81.9
Wright	258.0	1.5	256.5	-	-	-	-	1.5	108.4	70.9	14.4	4.8	58.0
Total	9,490.8	424.7	9,066.1	51.4	109.9	14.9	-	248.5	3,061.1	3,135.4	1,431.4	361.4	1,076.8
WESTERN UNIT													
Clay	60.0	-	60.0	-	-	-	-	-	25.5	14.9	13.9	.2	5.5
Kittson	237.8	-	237.8	-	-	-	-	-	22.1	19.5	154.3	1.7	40.2
Mahnomen	1,184.3	89.6	1,094.7	26.3	26.5	5.1	25.5	6.2	240.6	128.3	582.4	70.2	73.2
Marshall	363.5	29.5	334.0	-	-	-	-	29.5	34.6	31.7	209.0	2.3	56.4
Norman	106.5	-	106.5	-	-	-	-	-	48.2	21.1	29.6	.3	7.3
Pennington	93.2	-	93.2	-	-	-	-	-	17.2	12.9	46.3	.6	16.2
Polk	216.2	7.7	208.5	-	-	-	-	7.7	40.3	24.7	108.4	1.2	33.9
Red Lake	132.9	-	132.9	-	-	-	-	-	29.0	15.5	70.6	.7	17.1
Roseau	1,448.2	560.2	888.0	86.7	134.5	110.3	117.9	110.8	157.3	41.7	371.3	38.6	279.1
Southwest 3/ counties	2,545.8	21.8	2,524.0	-	-	-	-	21.8	1,750.3	386.7	6.5	-	380.5
Total	6,388.4	708.8	5,679.6	113.0	161.0	115.4	143.4	176.0	2,365.1	697.0	1,592.3	115.8	909.4
State total	124,073.5	45,661.6	78,411.9	6,953.0	10,324.6	11,960.5	9,060.4	7,363.1	14,550.0	7,322.2	38,204.6	9,727.8	8,607.3

1/ Net volume of live merchantable sawtimber and poletimber trees from the stump to a variable 4-inch top diameter outside bark of the central stem. Does not include limbs or cull tree volume.

2/ Standard cord equals 79 cubic feet of solid wood.

3/ Includes: Big Stone, Blue Earth, Brown, Chippewa, Cottonwood, Dodge, Faribault, Freeborn, Grant, Jackson, Kandiyohi, Lac Qui Parle, Lincoln, Lyon, McLeod, Martin, Meeker, Mower, Murray, Nicollet, Nobles, Pipestone, Pope, Redwood, Renville, Rock, Sibley, Steele, Stevens, Swift, Traverse, Waseca, Wantonwan, Wilkin, and Yellow Medicine Counties.

Table 2.--Sawtimber volumes 1/ in Minnesota counties, 1962

(Million board feet) 2/

County	All species	All conifers	All hardwoods	White and red pine	Jack pine	Other conifers	Sug.maple and yel.birch	Basswood	Ash and elm	Red oaks	White oaks	Aspen and paper bir.	Other hardwoods
						LAKE SUPERIOR UNIT							
Carlton	118.8	40.1	78.7	19.2	12.0	8.9	15.1	7.9	31.8	8.2	1.7	11.1	2.9
Cook	839.7	511.1	328.6	100.6	108.9	301.6	27.1	4.6	10.5	-	0.2	281.6	4.6
Lake	899.5	476.3	423.2	115.7	146.3	214.3	22.5	25.4	26.6	2.6	0.2	308.8	37.1
Pine	174.5	25.5	149.0	1.9	19.5	4.1	13.8	18.5	88.7	8.1	2.2	17.7	-
St. Louis	2,385.6	1,534.5	851.1	597.2	500.7	436.6	33.4	35.7	185.0	1.4	0.9	454.1	140.6
Total	4,418.1	2,587.5	1,830.6	834.6	787.4	965.5	111.9	92.1	342.6	20.3	6.2	1,073.3	185.2
						RAINY RIVER UNIT							
Koochiching	1,307.0	729.7	577.3	144.5	25.0	560.2	1.0	54.9	118.9	-	4.1	306.7	91.7
Lake of tbe Woods	239.4	151.1	88.3	34.6	14.3	102.2	0.1	10.0	17.0	-	1.3	44.6	15.3
Total	1,546.4	880.8	665.6	179.1	39.3	662.4	1.1	64.9	135.9	-	5.4	351.3	107.0
						CENTRAL PINE UNIT							
Aitkin	828.0	176.2	651.8	57.8	12.3	106.1	143.5	59.2	131.0	64.6	53.1	107.4	93.0
Becker	395.9	155.2	240.7	89.4	49.4	16.4	5.4	45.7	66.5	34.4	23.7	58.0	7.0
Beltrami	685.1	254.9	430.2	112.2	35.1	107.6	21.4	57.5	115.5	12.2	8.7	163.8	51.1
Cass	772.3	466.2	306.1	309.8	117.6	38.8	40.7	37.3	24.0	49.8	10.6	137.8	5.9
Clearwater	332.4	106.3	226.1	57.3	36.2	12.8	3.6	29.5	72.6	4.8	10.1	78.3	27.2
Crow Wing	438.4	187.3	251.1	101.9	65.6	19.8	6.0	33.3	40.9	55.6	25.5	76.3	13.5
Hubbard	275.1	182.1	93.0	83.5	87.2	11.4	1.6	1.1	8.0	15.7	5.8	60.1	0.7
Itasca	2,252.7	1,313.8	938.9	664.4	230.8	418.6	76.3	100.7	116.0	10.6	62.2	511.8	61.3
Wadena	55.8	36.4	19.4	12.2	21.6	2.6	0.1	1.0	6.7	6.7	1.2	3.1	0.6
Total	6,035.7	2,878.4	3,157.3	1,488.5	655.8	734.1	298.6	365.3	581.2	254.4	200.9	1,196.6	260.3
						SOUTHEAST UNIT							
Anoka	48.2	3.5	44.7	-	-	3.5	2.8	8.0	8.7	13.2	4.7	3.3	4.0
Benton	30.5	-	30.5	-	-	-	1.4	5.4	6.7	8.1	3.5	2.1	3.3
Carver	45.2	-	45.2	-	-	-	4.1	9.7	12.5	8.9	4.0	1.6	4.4
Chisago	67.8	1.4	66.4	-	-	1.4	5.4	12.7	19.7	12.8	5.8	2.1	7.9
Dakota	44.7	-	44.7	-	-	-	1.6	6.0	10.3	12.8	5.9	3.0	5.1
Douglas	58.1	-	58.1	-	-	-	4.7	11.5	18.6	8.8	4.4	2.2	7.9
Fillmore	173.8	-	173.8	-	-	-	8.5	26.3	35.6	52.4	24.5	9.4	17.1
Goodhue	134.0	-	134.0	-	-	-	7.1	20.3	27.9	40.2	18.4	7.1	13.0
Hennepin	56.7	-	56.7	-	-	-	3.8	9.7	16.3	12.1	6.0	1.8	7.0
Houston	241.0	-	241.0	-	-	-	8.7	29.1	39.5	87.9	41.9	12.6	21.3
Isanti	54.2	1.1	53.1	-	-	1.1	3.6	10.5	11.4	13.9	6.5	2.5	4.7
Kanebec	38.0	1.7	36.3	1.7	-	-	0.6	1.3	12.6	7.3	4.0	8.6	1.9
Le Sueur	70.5	-	70.5	-	-	-	6.6	15.9	21.4	11.7	5.3	1.8	7.8
Mille Lacs	61.4	5.4	56.0	2.4	-	3.0	0.1	6.6	27.0	9.6	5.1	4.4	3.2
Morrison	102.0	27.5	74.5	2.0	22.7	2.8	0.3	10.3	33.9	13.6	7.3	5.8	3.3
Olmsted	96.4	-	96.4	-	-	-	3.0	10.3	15.8	34.9	16.3	7.5	8.6
Otter Tail	125.2	16.2	109.0	5.9	6.1	4.2	0.3	17.0	47.8	22.2	9.3	7.2	5.2
Ramsey	11.6	-	11.6	-	-	-	0.5	1.4	2.5	3.5	1.6	0.8	1.3
Rice	44.3	-	44.3	-	-	-	3.6	8.9	12.7	8.6	4.2	1.4	4.9
Scott	43.4	-	43.4	-	-	-	3.9	8.6	12.0	8.4	4.0	2.0	4.5
Sherburne	40.9	0.6	40.3	-	-	0.6	1.4	5.0	7.0	14.3	6.6	2.2	3.8
Stearns	105.1	0.3	104.8	-	-	0.3	5.8	17.4	23.7	28.5	13.5	5.3	10.6
Todd	81.7	16.0	65.7	3.6	9.9	2.5	-	8.6	28.7	15.5	5.7	4.2	3.0
Wabasha	95.2	-	95.2	-	-	-	4.1	12.3	20.2	29.1	14.0	5.0	10.5
Washington	47.8	-	47.8	-	-	-	4.6	9.6	13.0	9.6	4.4	1.8	4.8
Winona	181.7	-	181.7	-	-	-	6.7	21.3	29.7	66.5	31.2	10.1	16.2
Wright	91.5	-	91.5	-	-	-	7.3	15.8	25.9	18.4	8.8	4.5	10.8
Total	2,190.9	73.7	2,117.2	15.6	38.7	19.4	100.5	319.5	541.1	572.8	266.9	120.3	196.1
						WESTERN UNIT							
Clay	14.3	-	14.3	-	-	-	-	2.8	2.6	-	6.9	1.5	0.5
Kittson	14.0	-	14.0	-	-	-	-	2.6	2.6	-	2.4	5.6	0.8
Mahnomen	106.9	26.7	80.2	12.3	8.0	6.4	0.6	12.8	16.2	3.3	8.4	27.8	11.1
Marshall	26.7	5.7	21.0	-	-	5.7	-	3.8	2.9	-	4.7	8.1	1.5
Norman	23.7	-	23.7	-	-	-	-	5.4	6.0	-	9.0	2.7	0.6
Pennington	10.0	-	10.0	-	-	-	-	1.9	1.2	-	3.8	2.2	0.9
Polk	23.4	1.5	21.9	-	-	1.5	-	4.2	4.4	-	6.6	5.0	1.7
Red Lake	14.4	-	14.4	-	-	-	-	2.9	3.5	-	4.0	3.4	0.6
Roseau	180.8	105.2	75.6	51.8	31.0	22.4	-	-	16.2	-	2.7	38.3	18.4
Southwest 3/ counties	913.6	-	913.6	-	-	-	32.5	162.3	501.4	36.9	71.9	-	108.6
Total	1,327.8	139.1	1,188.7	64.1	39.0	36.0	33.1	198.7	557.0	40.2	120.4	94.6	144.7
State total	15,518.9	6,559.5	8,959.4	2,581.9	1,560.2	2,417.4	545.2	1,040.5	2,157.8	887.7	598.8	2,836.1	893.3

1/ Net volume of live merchantable sawtimber trees (conifers 9.0 inches d.b.h. or larger and hardwoods 11.0 inches d.b.h. and larger) from the stump to a point in the central stem at which utilization for sawn products is limited by large branches, forks, or other defects, or by a diameter outside bark of 8.0 inches.

2/ International log rule, 1/4-inch kerf.

3/ See footnote 3/for table 1.

Table 3.--Changes in volumes in Minnesota counties by percent classes,[1] 1953-1962

Counties	Percent change in growing stock volume	Percent change in sawtimber volume
LAKE SUPERIOR UNIT		
Carlton	+40 to 60	+40 to 60
Cook	+20 to 40	- 1 to 20
Lake	+40 to 60	- 1 to 20
Pine	+ 1 to 20	+ 1 to 20
St. Louis	60+	+40 to 60
Total	+40 to 60	+ 1 to 20
RAINY RIVER UNIT		
Koochiching	60+	60+
Lake of the Woods	+ 1 to 20	+ 1 to 20
Total	60+	+40 to 60
CENTRAL PINE UNIT		
Aitkin	60+	60+
Becker	60+	60+
Beltrami	+40 to 60	+40 to 60
Cass	+40 to 60	- 1 to 20
Clearwater	+20 to 40	60+
Crow Wing	60+	60+
Hubbard	60+	60+
Itasca	60+	60+
Wadena	+20 to 40	+40 to 60
Total	60+	60+
SOUTHEASTERN UNIT[2]		
Total	-20 to 40	-20 to 40
WESTERN UNIT[2]		
Total	+ 1 to 20	+ 1 to 20
State total	+20 to 40	+20 to 40

1/ Twenty-percent classes are used to indicate relative changes, since sampling errors preclude the use of direct comparisons for county volumes.

2/ Because of sampling errors, small volumes, and definition differences, comparisons in volume for individual counties in the Southeastern Unit and the Western Unit (which includes the Red River Valley and the southwestern counties) are not statistically meaningful.

U. S. FOREST SERVICE

RESEARCH NOTE LS-44

LAKE STATES FOREST EXPERIMENT STATION · U. S. DEPARTMENT OF AGRICULTURE

Ownership of Commercial Forest Land in Minnesota, 1962

The relative amounts of Minnesota's commercial forest land held by public and private owners has remained stable during the last 10 years (table 1). In both 1953 and 1962 public agencies controlled 56 percent of the commercial forest acreage and private owners 44 percent. Within this generalization are many undercurrents of change — mostly of a minor nature. Exchanges between Federal and State, and between counties and the forest industry have tended to consolidate holdings somewhat. Land purchases have resulted in a few of the larger ownerships increasing in size. Fragmentation of parcels has been minor in Minnesota despite the development of recreational use.

These are some of the conclusions drawn from the Third Forest Survey of Minnesota which was made from 1960 to 1963 by the Office of Iron Range Resources and Rehabilitation and this station in cooperation with other public and private agencies. In 18 northern counties, a 100-percent tally of ownership was made, and county owner-

Table 1.--Area of commercial forest lands 1/ by survey units and ownership, Minnesota, 1962

(In thousand acres)

Survey unit	All ownership	National Forest 2/	Other public 3/	Forest industry 4/	Farmer and miscellaneous private 5/
Lake Superior	5,844.7	1,570.9	2,298.0	345.9	1,629.9
Rainy River	2,103.2	.8	1,572.4	207.8	322.2
Central Pine	6,033.1	569.7	3,049.2	157.8	2,256.4
Southeastern	1,900.9	-	179.8	2.5	1,718.6
Western	1,180.1	-	298.4	.8	880.9
Total in 1962	17,062.0	2,141.4	7,397.8	714.8	6,808.0
Total in 1953	18,098.0	2,195.0	7,963.0	7,940.0	
Percent in 1962	100	12.5	43.4	4.2	39.9
Percent in 1953	100	12.1	44.0	43.9	

1/ Forest land which is producing or capable of producing crops of industrial wood and not withdrawn from timber utilization.
2/ Federal commercial forest land which has been designated by Executive Order or statute as National Forests or purchase units, and other lands under the administration of the Forest Service.
3/ Public lands other than National Forest lands, including lands administered by Federal, State, or local public agencies.
4/ Lands owned by companies or individuals operating wood-using plants.
5/ Land privately owned by other than forest industry.
6/ Privately owned lands other than forest industry or farmer-owned lands.

Table 2.--Area of commercial forest land[1/] and of total land[2/] by counties and ownership classes, 18 northern counties, Minnesota, 1962

(In thousand acres)

County	All ownerships	Nat'l Forest[3/]	Indian[4/]	Other Federal[5/]	State[6/]	County and munic[7/]	Forest industry[8/]	Farmer owned[9/]	Misc. private[10/]
			COMMERCIAL FOREST LANDS						
Aitkin	850.6	-	.8	7.7	295.5	272.5	3.0	65.5	205.6
Becker	385.9	-	5.5	26.2	26.2	98.7	9.8	145.3	74.2
Beltrami	993.0	54.4	196.2	4.2	310.1	165.7	6.4	75.4	180.6
Carlton	367.0	-	8.5	-	51.6	103.5	10.9	106.0	86.5
Cass	1,006.4	249.6	11.4	*	113.0	290.5	24.5	157.7	159.7
Clearwater	367.7	-	74.7	.2	23.4	93.6	5.6	101.4	68.8
Cook	710.0	449.3	41.1	-	123.5	14.0	48.5	-	33.6
Crow Wing	447.5	-	*	.1	17.2	106.4	17.9	51.9	254.0
Hubbard	440.1	-	-	.1	75.1	141.2	22.0	112.2	89.5
Itasca	1,411.9	265.7	7.4	.6	260.1	403.5	55.3	96.8	322.5
Koochiching[11/]	1,574.7	.8	42.9	48.4	792.5	291.8	203.1	34.7	160.5
Lake	1,104.0	513.6	-	-	157.0	154.0	126.0	.5	152.9
Lake of the Woods	528.5	-	78.3	6.6	311.7	.2	4.7	52.1	74.9
Mahnomen	126.6	-	33.1	-	9.5	19.5	.4	29.2	34.9
Pine	459.4	-	1.2	*	86.1	153.8	.4	119.9	98.0
Roseau	271.0	-	1.5	3.3	129.1	16.8	.4	88.0	31.9
St. Louis	3,204.3	608.0	19.2	.4	430.8	953.3	160.1	283.6	748.9
Wadena	130.0	-	-	-	5.0	16.4	13.3	63.2	32.1
Total	14,378.6	2,141.4	521.8	97.8	3,217.4	3,295.4	712.3	1,583.4	2,809.1
Percent	100.0	14.9	3.6	.7	22.4	22.9	5.0	11.0	19.5
			TOTAL LAND						
Aitkin	1,167.4	-	.8	12.9	388.8	320.8	4.4	124.4	315.3
Becker	841.6	-	6.9	31.0	35.3	106.8	10.2	511.4	140.0
Beltrami	1,610.9	59.7	303.9	6.4	577.4	178.0	7.5	186.1	291.9
Carlton	550.4	-	10.0	-	76.2	115.3	12.0	225.7	111.2
Cass	1,313.9	281.7	15.6	*	151.5	325.0	28.7	297.9	213.5
Clearwater	643.2	-	129.5	.2	46.4	115.1	7.4	233.6	111.0
Cook	897.9	630.0	41.9	-	127.3	14.5	48.6	-	35.6
Crow Wing	639.4	-	.1	.1	22.0	120.0	20.2	113.3	363.7
Hubbard	596.5	-	-	.1	83.5	150.0	24.8	203.8	134.3
Itasca	1,704.3	298.1	8.1	.6	325.4	431.1	58.8	157.9	424.3
Koochiching	2,002.6	1.6	52.7	53.3	1,085.0	305.9	212.7	65.2	226.2
Lake	1,364.5	725.4	-	-	177.5	157.9	129.7	1.4	172.6
Lake of the Woods	837.1	-	106.3	8.9	470.6	.3	4.8	130.6	115.6
Mahnomen	367.4	-	40.0	-	23.7	23.4	.7	206.0	73.6
Pine	903.7	-	1.3	.2	144.0	194.9	.9	417.8	144.6
Roseau	1,072.6	-	5.8	7.9	306.7	40.7	.9	534.4	176.2
St. Louis	4,019.8	767.8	21.7	.6	566.7	1,044.3	172.4	479.2	967.1
Wadena	343.0	-	-	-	7.0	27.9	17.9	212.3	77.9
Total	20,876.2	2,764.3	744.6	122.2	4,615.0	3,672.9	762.6	4,101.0	4,093.6
Percent	100.0	13.2	3.6	.6	22.1	17.6	3.7	19.6	19.6

1/ Forest land which produces or is capable of producing crops of industrial wood and not withdrawn from timber utilization.

2/ The area of dry land and land temporarily or partially covered by water such as marshes, swamps, and river flood plains; streams, sloughs, estuaries, and canals less than one-eighth of a statute mile in width; and lakes, reservoirs, and ponds less than 40 acres in area. Total land in all ownership by counties is based on U.S. Bureau of the Census Land and Water Area of the United States, 1960.

3/ Federal lands which have been designated by Executive Order or statute as National Forests or purchase units, and other lands under the administration of the Forest Service, including experimental areas and Bankhead-Jones Title III lands.

4/ Federal lands administered by the Bureau of Indian Affairs (that is Indian tribal lands held in fee by the Federal government but administered for Indian tribal groups and Indian trust allotments).

5/ Federal lands other than National Forests and Indian lands administered by the Bureau of Land Management, and miscellaneous Federal agencies.

6/ Lands owned or administered by the State.

7/ Lands owned by counties and local public agencies.

8/ Lands owned by companies or individuals operating wood-using plants.

9/ Land owned by operators of farms.

10/ Privately owned lands other than forest-industry and farmer-owned lands.

11/ These figures differ slightly from those in the Koochiching report due to machine rounding.

* Less than 50 acres.

ship maps were prepared.[1] A sample survey was made of ownership in the remainder of the State.

Eighty-two percent of the commercial forest land and 95 percent of that owned by the public and forest industries is in the three northeastern survey units. Farmer and miscellaneous private ownership varies from 15 percent in the Rainy River Unit to 90 percent in the Southeastern Unit. Public ownership in the Western Unit is largely confined to Mahnomen and Roseau Counties.

In the 18 northern counties about 45 percent of the commercial forest land is divided nearly equally between county ownership and state ownership (table 2). Both hold substantial acreages in each of these counties. Miscellaneous private ownership is the third largest class with 19.5 percent of commercial forest land. These holdings are widely scattered. National Forests are next with 14.9 percent, concentrated in six counties — St. Louis, Lake, Cook, Itasca, Cass, and Beltrami. Two-thirds of the forest industry land occurs in just three counties — Koochiching, St. Louis, and Lake.

Distribution of total land in the northern counties by ownership classes is similar to that for commercial forest land. Ninety percent or more of the lands held by forest industries and counties are commercial forest. Only 39 percent of farmer-owned lands in the 18 northern counties is commercial forest, while about three-fourths of the total holdings of other owners is so classified.

[1] *Ownership maps of Itasca, St. Louis, Beltrami, Crow Wing, Aitkin, Koochiching, Lake, Cook, and Cass Counties have been published. They are available from the Office of Iron Range Resources and Rehabilitation, 60 State Office Building, St. Paul, Minnesota, 55101.*

April 1964

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RESEARCH NOTE LS-45

LAKE STATES FOREST EXPERIMENT STATION • U. S. DEPARTMENT OF AGRICULTURE

Hourly Variation in Fire Danger in the Lake States

Rating forest fire danger by combining basic weather and fuel moisture measurements has been a standard operating procedure in all forest fire control agencies for nearly 30 years. Fire danger is rated by determining a numerical index that represents the burning conditions for a particular unit of land; the index is then used to assist in fire preparedness planning for more efficient expenditure of funds for fire control.

Recent fire research has been directed toward developing a Unified National System of Fire Danger Rating — that is, a uniform procedure on a nationwide basis for measuring and interpreting forest fire danger. Already completed is a Fire Spread Index designed to indicate the *relative* rate of fire spread in light and intermediate forest fuels. Yet to be developed are reliable indicators of risk, ignition probability, and fire intensity. When all these indexes are completed and combined, they will give a more complete picture of fire job load requirements.

To obtain adequate weather measurements for fire weather forecasting, the Unified National System requires that the official danger rating measurement should be taken near the time of average maximum Spread Index for the day. Fire weather observations should be made during the afternoon period of highest fire danger so that the most meaningful fire weather is recorded and made available to the fire weather forecaster for use in his forecast for the following day. Fire weather forecasts made by the Weather Bureau utilize temperature, relative humidity, and wind observations as well as other weather factors taken during the time of day when fires are most likely to start and spread.

The study reported here was undertaken to provide answers to two questions for the Lake States region: (1) On the average, what time of day does the highest fire danger occur, and (2) is it possible to use 1:00 p.m. (a convenient observation time) as the official time for the daily fire danger measurement?

To determine when the most severe fire weather conditions may be expected, hourly Spread Index values and wind velocity readings were summarized for the months of April, July, and October at four First Order Weather Bureau Climatological Stations. A 3-year period, 1961-1963, was used for April and July, and 2 years for October except at Grand Rapids, Mich., where 3 years was used. The four weather stations (International Falls and Minneapolis-St. Paul, Minn., LaCrosse, Wis., and Grand Rapids, Mich.) are representative of the daily trend in fire weather for the Lake States area. However, local fluctuations in wind, temperature, and relative humidity may produce a pattern of weather somewhat different than for any of the selected stations or for the region as a whole.

Fire spread index. — Spread Index for brush or timber fuel types is adjusted for cumulative drying conditions by means of the Buildup Index. However, for this study no adjustment for the buildup factor was made, so the Spread Index is related only to light surface fuels where fires may start easily and spread rapidly. Calculation of Spread Index was based on a fixed condition of vegetation (herbaceous stage) for each month and location. April and July were considered "cured" and "green" respectively. October was based on 20 days in "transition" and 11 days in the "cured" stage. Past records indicate that these are reasonable assumptions concerning the herbaceous stage of the vegetation.

Results show that average differences in Spread Index between the afternoon hours are small (table 1). Hence, fire danger conditions between 1 and 4 p.m. are, on the average, similar and represent the period of most severe fire weather for the day. Individual days may diverge considerably from this average daily pattern of fire weather.

Wind velocity. — Average hourly wind velocities for each of the four stations indicated only a 1 to 3 m.p.h. variation between the hours of 10 a.m. and 4 p.m., and average velocity remained nearly constant from 1 p.m. to 4 p.m. (table 2). The fact that Spread Index increased from morning to early afternoon while the average wind velocity showed little change demonstrates the importance of relative humidity on fine fuel moisture during

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TABLE 1. — *Average Spread Index from 10 a.m. to 4 p.m. standard time during April, July, and October at four locations in the Lakes States*[1]

Location	Month	Time of day							Standard error of mean
		10	11	12	1	2	3	4	
LaCrosse, Wis.	April	34	38	40	43	44	45	44	2.2
	July	12	15	18	19	18	19	19	.9
	October	19	23	28	30	31	32	30	2.1
Grand Rapids, Mich.	April	32	37	39	41	42	44	44	1.9
	July	14	16	17	19	19	20	20	.7
	October	18	22	27	30	30	30	29	1.4
Minneapolis, Minn.	April	30	32	36	39	40	39	38	2.1
	July	11	13	16	17	17	17	16	.8
	October	18	22	26	28	30	29	28	1.8
International Falls, Minn.	April	23	26	29	31	32	33	33	1.3
	July	11	12	14	15	16	15	14	.8
	October	13	18	22	24	25	24	24	1.6

1 *Average Spread Index values are rounded off to the nearest whole number.*

TABLE 2. — *Average wind velocity from 10 a.m. to 4 p.m. standard time during April, July, and October at four locations in the Lake States*[1]

Location	Month	Time of day							Standard error of mean
		10	11	12	1	2	3	4	
LaCrosse, Wis.	April	13	14	15	15	15	16	15	.7
	July	9	10	11	11	11	11	12	.5
	October	12	12	13	13	13	13	12	.8
Grand Rapids, Mich.	April	13	14	14	14	14	14	14	.5
	July	9	10	10	11	11	12	12	.4
	October	10	11	11	12	12	12	11	.4
Minneapolis, Minn.	April	13	14	14	15	15	14	14	.6
	July	10	10	11	11	11	11	11	.5
	October	11	11	12	12	12	11	11	.6
International Falls, Minn.	April	10	11	11	12	12	12	12	.6
	July	8	9	9	10	9	9	8	.4
	October	9	9	10	10	11	10	10	.7

1 *Average wind velocity values are rounded off to the nearest whole number.*

the same period. Thus, the average daily increase in fire danger was due primarily to a general lowering of relative humidity from morning to mid-afternoon.

Conclusion. — The hourly trend in *average* Spread Index for the four locations studied showed that fire danger conditions between 1 p.m. and 4 p.m. did not vary appreciably. To fire control agencies, this indicates that weather observations used for computing maximum daily Spread Index will be satisfactory when taken at 1 p.m. or near the end of the normal noon lunch hour when personnel at ranger district headquarters or other field stations are available.

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U. S. FOREST SERVICE

RESEARCH NOTE LS-46

LAKE STATES FOREST EXPERIMENT STATION • U. S. DEPARTMENT OF AGRICULTURE

Twenty-Two-Year Results of a Precommercial Thinning Experiment in Jack Pine

In August 1936 a forest fire burned 30,000 acres in northeastern Minnesota. Half of the burn was on the Aurora District of the Superior National Forest. A 150-acre tract was seeded to jack pine in April 1937 with unexpected success.[1] By 1941 portions of the stand contained more than 10,000 stems per acre.

An experiment in precommercial thinning was installed in the stand in the fall of 1941. The spacing treatments are 4x4, 6x6, and 8x8 feet plus unthinned controls. The individual treatments are replicated three times in ½-acre plots in a randomized block design. Except for a slight fertility gradient the stand is uniform; the growth responses among the three replications are more consistent than is commonly found in experiments of this kind. The experiment was measured at ages 10, 16, 22, and 27 years. Site index is 70 feet at 50 years, which is excellent for jack pine.

In November 1947 a heavy wet snow flattened patches and strips in the control plots, in the adjacent unthinned stand, and in plots thinned the previous year at age 10. This damage resulted in openings or partially occupied growing space approximately 10 to 20 feet across in portions of the unthinned plots. The thinning treatments at age 5 suffered little damage from the 1947 storm; the plots thinned at age 10 were severely damaged and are not included in this analysis. Additional background and early results for the experiment were previously reported by Roe and Stoeckeler.[2]

Stand Growth

Stand characteristics at age 27 (22 years after thinning) are given in table 1 and described below:

1. Average height of dominants and codominants, including the unthinned plots, has not been significantly affected by spacing.

2. Basal area and total cubic-foot volume are greatest in the 4x4-foot spacing, next on the 6x6, and least in the 8x8. The unthinned plots are presently intermediate between the 6x6 and the 8x8-foot spacings in both basal area and volume. Had the patchwork storm damage at age 11 not occurred, the unthinned plots would now have the greatest basal area and volume per acre. Subplots in the portions of the unthinned stand not damaged by the 1947 storm currently have 150-165 square feet of basal area and 2,500-2,800 cubic feet per acre.

3. The live crown has receded most on the close spacings. Height to the first live branch and height to full crown (defined as the minimum height at which each one-third sector of the crown, divided vertically, contains live branches) are greater with close spacings.

4. Average branch diameters (measured 0.25 foot from the bole in a section from 6 to 12 feet above the ground) increase with wider spacings. All branches in this bole section are dead. There is no statistical difference between spacings in the number persisting to this date. (The average is 41 branches per tree in the 6-foot bole section.)

5. Average tree diameter (the tree of average basal area) for the 8x8-foot, 6x6-foot, 4x4-foot, and unthinned stands is 5.8, 5.1, 4.1, and 3.5 inches, respectively. Probably all trees on the 8x8-foot spacing will reach merchantable size (presently about 6 inches d.b.h.), as will most on the 6x6-foot spacing; but there will be additional mortality from suppression on the 4x4-foot and unthinned plots. Control of tree size is the chief silvicultural advantage of precommercial thinning.

Stand Taper

Trees were measured to determine the effect of spacing on average taper in the first 20 feet of stand height. Diameters to the nearest 0.10 inch were measured at 0.5, 4.5, 8.0, 12.0, 16.0, and 20.0 feet above ground on 14 trees mechanically chosen on each of the thinned plots. Average diameters, and the ratio of diameter at various heights to the diameter at breast height were computed (table 2). Cubic-foot volumes for each bole section were also calculated.

[1] *Roe, Eugene I. Seeding jack pine after fire in Minnesota. Forest and Outdoors 47(10): 20-22, illus. 1951.*

[2] *Roe, Eugene I., and Stoeckeler, Joseph H. Thinning over-dense jack pine seedling stands in the Lake States. Jour. Forestry 48: 861-865. 1950.*

Table 1. — *Stand and tree characteristics at age 27 of jack pine precommercially thinned at age 5*

Characteristics of stand and trees	Spacing			
	4x4 feet	6x6 feet	8x8 feet	Control (unthinned)
Number of trees per acre	1,632	950	615	1,809
Basal area per acre (square feet)	147	136	113	123
Cubic-foot volume per acre (inside bark)	2,480	2,290	1,900	2,070
Average height of dominants and codominants (feet)	42	42	41	40
Height to first live limb (feet)	25	23	19	([1])
Height to total crown (feet)	27	25	23	([1])
Average limb diameter (inches)	0.36	0.46	0.54	([1])
Diameter of tree of average basal area (inches)	4.1	5.1	5.8	3.5

[1] *Not measured.*

Table 2. — *Diameters at various heights, ratios to diameter at breast height, and cubic feet of volume per square foot of basal area*

Height (feet)	Spacing, in feet					
	4x4		6x6		8x8	
	Diameter	Ratio to d.b.h.	Diameter	Ratio to d.b.h.	Diameter	Ratio to d.b.h.
0.5	5.2	1.24	6.9	1.28	7.6	1.29
[1]4.5	4.2	1.00	5.4	1.00	5.9	1.00
8.0	4.0	0.95	5.1	0.94	5.7	0.97
12.0	3.8	0.90	4.8	0.89	5.3	0.90
16.0	3.5	0.83	4.4	0.81	4.9	0.83
20.0	3.2	0.76	4.1	0.76	4.2	0.71
Cubic feet[2]	17.27		17.33		17.33	

[1] *Average d.b.h. departs slightly from these shown in table 1 because of sampling error.*

[2] *Total cubic feet outside bark per square foot of basal area in first 20 feet of stand height.*

There is a slight tendency for tree taper at 20 feet and butt flare at 0.5 foot to be greater on the wide spacings than on the close spacings. None of these differences is statistically significant, however.

For each square foot of basal area at breast height there were on the 4x4-, 6x6-, and 8x8-foot spacings 17.27, 17.33 and 17.33 cubic feet of volume, respectively, in the first 20 feet of stand height. These differences are again not significant. Apparently, the spacings used in this study make no practical difference in taper in the first 20 feet of stand height. On the more open spacings the slight loss of volume in the upper stems is offset by the volume contributed by greater butt flare.

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U. S. FOREST SERVICE

RESEARCH NOTE LS-47

AKE STATES FOREST EXPERIMENT STATION • U. S. DEPARTMENT OF AGRICULTURE

Comparing Severity of Fire Seasons

An unusually bad or exceptionally easy fire season always stimulates interest in just *how* bad or easy the season was. For instance, how much do we remember about previous bad fire years? Frequently one large fire may create a false and lasting impression of an exceptionally bad fire season, or a small number of fires may be falsely interpreted as an easy fire season. Do we recall only the years when rainfall was below normal and the temperature was above average, or are our most vivid memories of the years with a high fire incidence and large area burned?

In comparing fire seasons, the number of fires and area burned, when considered alone, do not always indicate the severity of burning conditions. The best means of accurately comparing the burning conditions for 2 or more years is to use an accumulative daily fire weather index computed from basic weather data collected at representative weather stations. This index, described below, can then be used to compare individual years.

Rating Fire Danger

Rating forest fire danger involves more than just recording daily weather data. Figures pertaining to both cumulative and current weather variables are needed to permit a better understanding of fire potential.

There has been a need for an index that could be computed from daily weather records and that could indicate a buildup or decrease in fire weather severity. Such an index has been provided through the recent development of the first phase of a Unified National System of Fire Danger Rating. This first phase has been tested at selected weather stations and is now ready for operational use. Included in the first phase is a Buildup Index, which is an indicator of progressive drying conditions in intermediate-size forest fuels (2- to 3-inch litter layer or 3-inch-diameter dead branchwood), and a Fire Spread Index, in which the Buildup Index, wind, and relative humidity are used to rate current fire weather in much the same way as the Lake States Burning Index meter has been used at Lake States fire-weather stations. Research is underway on the associated factors of risk, ignition, and fire intensity; these variables may eventually be integrated to provide the total fire danger rating picture. The Lake States Burning Index, based on a 100-point scale, rates day-to-day burning conditions and is influenced by current wind, humidity, and precipitation. The Buildup Index is mainly concerned with moisture content of forest fuels as influenced by air temperature, air moisture, and precipitation; wind is not considered.

The Buildup Index has an "open-end" numerical scale which increases as fuel moisture decreases and drying conditions become more critical. With an increasing Buildup Index, an increasing amount of fuel becomes dry enough to burn and fires are more difficult to control. Buildup Index values in excess of 150 will probably rarely occur in the Lake States. However, in the more arid sections of the West, values of 200 to 300 would not be uncommon.

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Using the Buildup Index

The Buildup Index is essentially a "fire warning system." It is used for alerting fire control agencies of changes in fuel moisture and burning conditions. When plotted daily, it gives a realistic picture of the *potential* for large, damaging fires. A high Buildup Index does not mean that all fires that occur during these periods will become large — it does indicate that fires that do occur are likely to be more difficult to control than those occurring in the lower *range* of Buildup Index.

Comparison of 1936 and 1961 Fire Seasons in Northern Minnesota

The following example illustrates how the Buildup Index can be used, together with other weather variables, as a basis for comparing two fire seasons. Fire control agencies are encouraged to utilize this simple method of fire weather analysis to help them better understand, from a weather standpoint, some of the differences between fire seasons.

We know that the 1961 spring and early summer fire season in northern Minnesota was unusually severe; but to determine just *how* severe, we needed data on at least one more bad fire year. The 1936 fire season, remembered by many as one of the most severe in history, was chosen. In 1936 high temperatures and subnormal rainfall created a moisture deficit in the forest fuels that lasted into late summer and early fall. Altogether, 302,580 acres of State and National Forest timberland burned.

Six northern Minnesota weather stations were chosen as being representative of the area. These were Cass Lake, Littlefork, Waskish, Ely, Baudette, and Cut-Foot Sioux Ranger Station. The 1961 weather records for these stations were available locally, and the 1936 weather records were obtained from the U.S. Weather Bureau's National Weather Records Center in Asheville, N.C. Annual State weather summaries, published by the U.S. Weather Bureau, were also used in the analysis.

The maximum Buildup Index for the six stations during May, June, July, and August 1936 and 1961 is summarized in table 1. In general, June and July 1961 were more critical from a fire-weather standpoint than the same months in 1936, but in August the 1936 weather was generally more severe. The following quotes, taken from the U.S. Weather Bureau's Climatological Data for August 1936, reflect the seriousness of the situation: "Unusually dry weather prevailed during the first two weeks . . . record-breaking high temperatures occurred on August 15 . . . high temperatures during the first half of the month caused considerable deterioration to growing crops. Meadows and pastures dried up . . . reports of trees and game and fish dying because of the drought . . . forest fire situation was acute."

TABLE 1. — *Maximum Buildup Index for May, June, July, and August, 1936 and 1961*

Station	May		June		July		August	
	1936	1961	1936	1961	1936	1961	1936	1961
Baudette	61	72	75	84	70	93	67	70
Ely	26	45	54	102	61	142	86	50
Littlefork	51	62	64	112	56	150	61	67
Waskish	39	55	51	87	75	117	83	39
Cut-Foot Sioux—Cass Lake[1]	44	47	37	96	83	96	127	74
Five-station avg.	44	55	52	96	69	120	85	60

[1] *These two stations represent similar conditions of fuels and weather and are combined here for analysis purposes.*

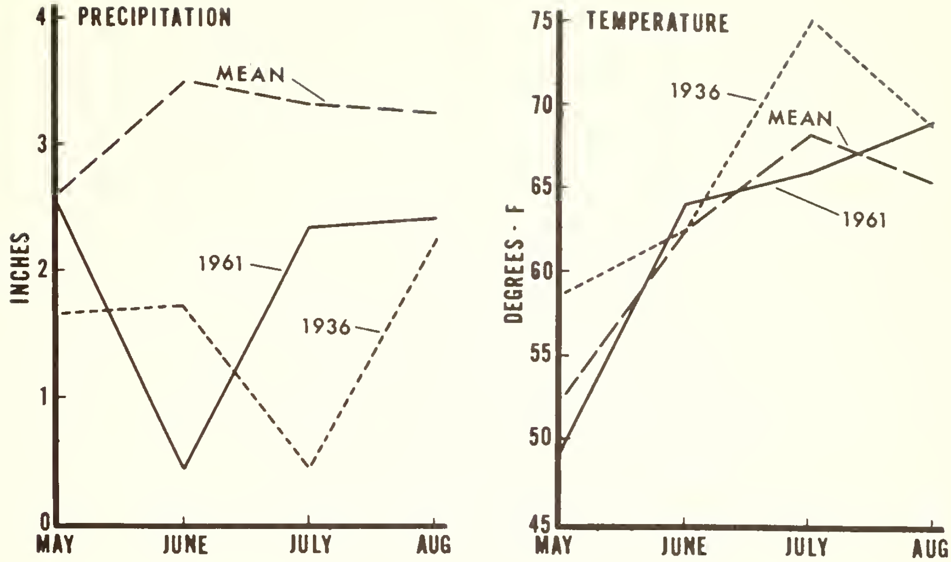

FIGURE 1. —Comparison of precipitation and temperature for 1936 and 1961 with the 29-year means (1921-1950), Bemidji, Minn.

Looking at the individual stations, we find that for June and July 1961 the burning conditions at Ely and Littlefork were much more critical than they were for the same period in 1936. Burning conditions at Baudette in May, June, July, and August were nearly the same for 1936 and 1961.

Figure 1 shows precipitation and temperature in relation to a 29-year mean recorded at Bemidji, Minn. Except for May 1961, precipitation for the spring and summer months was well below the mean for both 1936 and 1961. Extreme precipitation deficiencies were recorded in June 1961 and July 1936. The May and June mean temperatures in 1936 were both well above the established 29-year means. However, the temperatures during the period of high fire danger in June and July 1961 deviated only slightly from the established mean, indicating that severe fire weather can occur without abnormally warm daytime temperatures.

In Figure 2 an average daily Buildup Index for May through August is shown for four primary weather stations: Baudette, Ely, Littlefork, and Waskish. This graph indicates that the 1961 burning conditions in northern Minnesota during May, June, and early July were more severe than for the same period in 1936. However, the 1936 weather for late July and August was more severe than for the same period in 1961.

In general, the 1961 fire season was more severe. Several moderately high peaks of Buildup Index for 1936 indicate the frequent occurrence of rather severe burning conditions. However, the potential for large fires was greater in 1961, at least during late June and early July, when the average Buildup Index for the four stations reached a peak of 122 on July 9.

July 1964

J. H. DIETERICH and JAMES K. BROWN
Research Foresters

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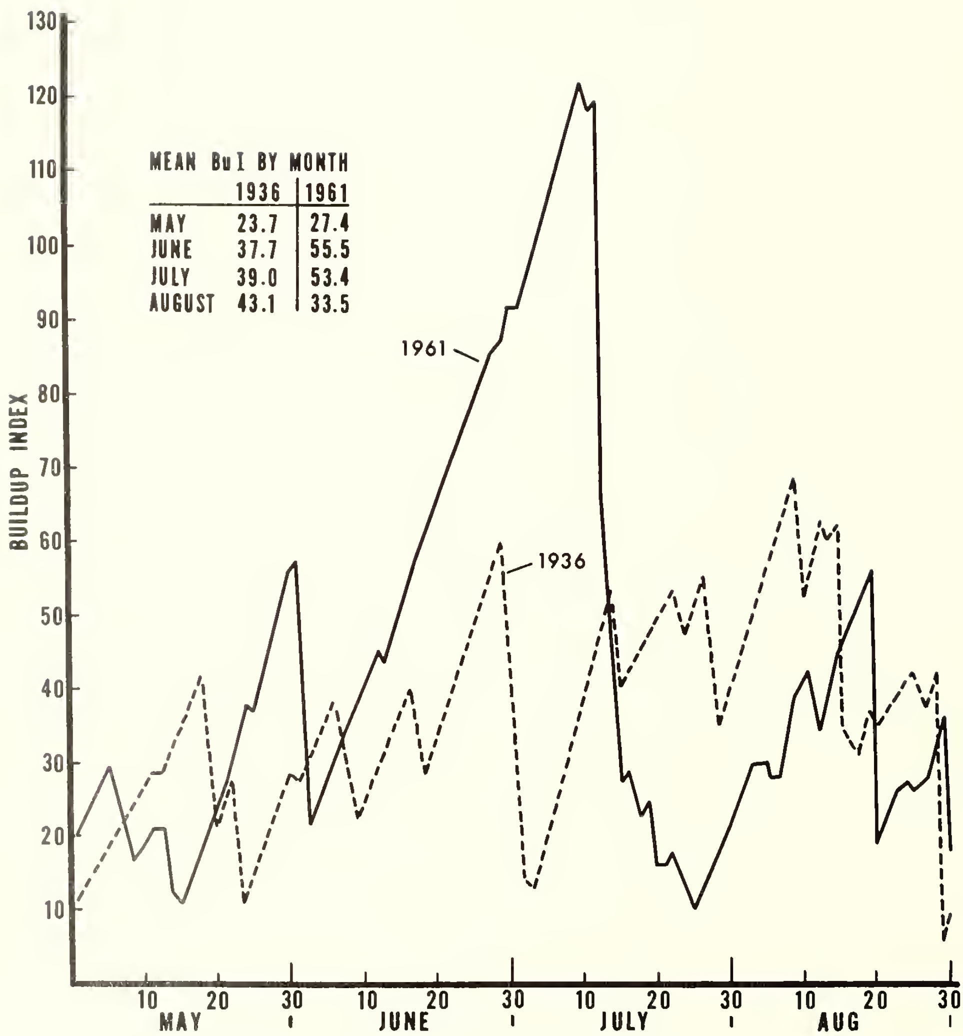

FIGURE 2. — Average Buildup Index for 1936 and 1961; data from four weather stations — Ely, Littlefork, Waskish, and Baudette, Minn.

U. S. FOREST SERVICE

RESEARCH NOTE LS-48

LAKE STATES FOREST EXPERIMENT STATION • U. S. DEPARTMENT OF AGRICULTURE

Lake States Pulpwood Cut Continues to Climb; Wisconsin Takes Lead in Pulpwood Production

Except for an occasional year the pulpwood harvest in the Lake States has been increasing annually at a rate of about 10 percent. This general trend continued in 1963 when the regional cut of pulpwood amounted to approximately 3,662 thousand cords, 10 percent more than the 3,342 thousand cords cut in 1962. Each of the three Lake States produced more pulpwood than the year before and Wisconsin, for the first time, was the region's leading pulpwood producing state. Leadership in Lake States pulpwood production has shifted from Michigan to Minnesota and back during the past 25 or 30 years. Substantial increases in the cut of miscellaneous dense hardwoods and the use of wood chips from mill residues helped swell Wisconsin's 1963 pulpwood pile to record proportions.

Of the total regional production, about 96 percent was roundwood and the remaining 4 percent was wood chips, slabs, and veneer cores. The overall cut of roundwood was up about 8 percent from the previous year. Hardwood roundwood was up about 9 percent, with miscellaneous dense hardwoods and white birch posting the largest gains. The cut of softwoods was up 5 percent; all species except pine showed increases. The decline of pine was general throughout the Lake States, but the cut-back was most pronounced in Wisconsin.

Although the number of Lake States pulpmills using wood chips remained the same, the quantity of chips used more than doubled over that of the previous year. In addition to the 121 thousand cords obtained from local sources, 67 thousand cords of wood chips were imported from the Western States. All imports went to Wisconsin mills.

Total 1963 pulpwood receipts at Lake States mills were approximately 4,092 thousand cords, an increase of 13 percent from the previous year. Lake States forests supplied 89 percent of the pulpwood received, Canada 7 percent, and Western States 4 percent (see table below).

The table on the reverse side shows pulpwood production, imports, and exports for the Lake States by species for 1963.

Geographic origin and destination of pulpwood received by Lake States mills, 1963

Species	Percent of pulpwood originating from:					Percent of pulpwood received by mills in:		
	Minn.	Wis.	Mich.	Canada	Other U. S.	Minn.	Wis.	Mich.
Aspen	25	36	38	1	—	26	51	23
Balsam fir	34	20	40	6	—	26	58	16
Birch	*	69	31	—	—	*	88	12
Hemlock	—	46	54	—	—	—	100	—
Pine	30	25	26	12	7	28	60	12
Spruce	42	4	15	39	—	27	59	14
Tamarack	60	26	14	—	—	—	100	—
Misc. hardwoods[1]	12	56	32	—	—	12	58	30
Slabs, etc.	—	69	31	—	—	—	100	—
Wood chips	1	41	15	—	43	1	99	—
All wood material	26	31	32	7	4	23	59	18
Previous yr. (1962)	27	31	33	6	3	23	58	19

[1] *Mostly dense hardwoods.*
* *Less than ½ of 1 percent.*

MAINTAINED AT ST. PAUL 1, MINNESOTA, IN COOPERATION WITH THE UNIVERSITY OF MINNESOTA

Production and imports of pulpwood, Lake States, 1963

(in standard cords, unpeeled)

Species and destination	Production by states[1]				Imports			
	Minnesota	Wisconsin	Michigan	Region	Other U.S.[2]	Canada	Total imports	Total receipts
Aspen								
Minn.	416,748	18,720	-	435,468	-	11,000	11,000	446,468
Wis.	16,255	591,819	268,528	876,602	-	110	110	876,712
Mich.	-	2,086	393,622	395,708	-	2,823	2,823	398,531
Total	433,003	612,625	662,150	1,707,778	-	13,933	13,933	1,721,711
Balsam fir								
Minn.	72,167	-	-	72,167	-	4,645	4,645	76,812
Wis.	29,659	60,375	85,182	175,216	-	-	-	175,216
Mich.	-	206	35,435	35,641	-	13,288	13,288	48,929
Exported[3]	526	-	-	526	-	-	-	-
Total	102,352	60,581	120,617	283,550	-	17,933	17,933	300,957
Birch, white								
Minn.	117	-	-	117	-	-	-	117
Wis.	49	50,358	13,652	64,059	-	-	-	64,059
Mich.	-	-	8,984	8,984	-	-	-	8,984
Total	166	50,358	22,636	73,160	-	-	-	73,160
Hemlock								
Minn.	-	-	-	-	-	-	-	-
Wis.	-	52,117	61,948	114,065	-	-	-	114,065
Mich.	-	-	-	-	-	-	-	-
Total	-	52,117	61,948	114,065	-	-	-	114,065
Pine								
Minn.	144,352	936	-	145,288	-	44,373	44,373	189,661
Wis.	63,242	168,919	90,015	322,176	85,237	6,390	91,627	413,803
Mich.	-	-	84,054	84,054	-	-	-	84,054
Total	207,594	169,855	174,069	551,518	85,237	50,763	136,000	687,518
Spruce								
Minn.	144,130	-	-	144,130	-	12,898	12,898	157,028
Wis.	98,756	19,325	64,322	182,403	-	158,850	158,850	341,253
Mich.	-	-	23,768	23,768	-	54,777	54,777	78,545
Exported[3]	12,276	-	-	12,276	-	-	-	-
Total	255,162	19,325	88,090	362,577	-	226,525	226,525	576,826
Tamarack								
Minn.	-	-	-	-	-	-	-	-
Wis.	13,295	5,669	3,157	22,121	-	-	-	22,121
Mich.	-	-	-	-	-	-	-	-
Total	13,295	5,669	3,157	22,121	-	-	-	22,121
Misc. dense hdwds.								
Minn.[4]	49,746	-	-	49,746	-	-	-	49,746
Wis.[4]	-	227,131	7,880	235,011	-	-	-	235,011
Mich.[4]	-	-	123,190	123,190	-	-	-	123,190
Exported[3]	973	5,832	-	6,805	-	-	-	-
Total	50,719	232,963	131,070	414,752	-	-	-	407,947
Total roundwood								
Minn.	827,260	19,656	-	846,916	-	72,916	72,916	919,832
Wis.	221,256	1,175,713	594,684	1,991,653	85,237	165,350	250,587	2,242,240
Mich.	-	2,292	669,053	671,345	-	70,888	70,888	742,233
Exported[3]	13,775	5,832	-	19,607	-	-	-	-
Total	1,062,291	1,203.493	1,263,737	3,529,521	85,237	309,154	394,391	3,904,305
Slabs, etc.								
Minn.	-	-	-	-	-	-	-	-
Wis.	-	22,665	10,352	33,017	-	-	-	33,017
Mich.	-	-	-	-	-	-	-	-
Exported[3]	-	-	-	-	-	-	-	-
Total	-	22,665	10,352	33,017	-	-	-	33,017
Wood chips								
Minn.	963	-	-	963	-	-	-	963
Wis.	-	63,775	22,926	86,701	67,392	-	67,392	154,093
Mich.	-	-	-	-	-	-	-	-
Exported[3]	-	12,140	-	12,140	-	-	-	-
Total	963	75,915	22,926	99,804	67,392	-	67,392	155,056
All wood material								
Minn.	828,223	19,656	-	847,879	-	72,916	72,916	920,795
Wis.	221,256	1,262,153	627,962	2,111,371	152,629	165,350	317,979	2,429,350
Mich.	-	2,292	669,053	671,345	-	70,888	70,888	742,233
Exported[3]	13,775	17,972	-	31,747	-	-	-	-
Total	1,063,254	1,302,073	1,297,015	3,662,342	152,629	309,154	461,783	4,092,378

1/ Vertical columns of figures under box heading "Production by States" presents the amount of pulpwood cut in each state.
2/ Mostly Western States.
3/ Pulpwood shipped to mills outside of Region.
4/ Some balsam poplar in Minnesota, mostly dense hardwoods in other States.

JULY 1964

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Research Forester (Forest Economics)

U. S. FOREST SERVICE

RESEARCH NOTE LS-49

LAKE STATES FOREST EXPERIMENT STATION • U. S. DEPARTMENT OF AGRICULTURE

Leaf Blight of Boxelder Attributed to 2,4-D Spray Drift

During the past decade, boxelder "blight" has been a major concern to people involved with tree plantings throughout much of the Northern Great Plains and neighboring parts of Canada. That it is caused by 2,4-D spray drift has been shown by the studies reported here.

The blight became evident on boxelder in North Dakota about the early 1950's, and later a similar condition was noticed on the foliage of other tree species, especially Siberian elm, American elm, and green ash. Symptoms developed each year in late May or early June and sometimes again in August or early September after a short period of recovery. In dry years damage was not as severe or widespread.

The disease apparently affects only the leaves — or in severe cases the branch tips. The leaves become dwarfed and cupped and have frilled margins (fig. 1). Chlorophyll develops a grainy appearance as the leaves become chlorotic. The younger leaves are damaged much more than the older leaves.

Although blight damage seems to be only temporary, the unhealthy appearance of the distorted foliage and uncertainty as to the ultimate effect of repeated damage have contributed in large part to a decline in the former popularity of boxelder as a windbreak species or a shade tree.

Some early investigations were made to determine whether a disease organism — possibly trans-

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FIGURE 1. — Typical blight symptoms on 2-0 boxelder seedling.

mitted by an insect — was involved. No relationship was found.

Several circumstances associated with the onset of the blight indicated a possible connection with crop spraying with 2,4-D for weed control. The blight had become noticeable at about the same time as spraying for weed control had become widely practiced. Time of spraying in early June and occasionally in late summer coincided with the appearance of the blight. The light damage and scattered incidence during dry years could be accounted for by the less intense weed control activities necessary in these years. The damage symptoms were not unlike those that had been described for certain agricultural crops. New leaves were more severely damaged than the older leaves, which is characteristic of the action of 2,4-D. Lastly, the occurrence of the blight at some distance from the actual spraying operation would presuppose travel of the spray for some distance. Studies have shown that aerial spray drift may move as far as 10 miles or more from the source.

To test the theory that drift was the cause, several different approaches were used. Certain plants, known as indicator plants, are very sensitive to 2,4-D in the atmosphere and indicate its presence by developing typical foliage malformations. Two of these plants — cotton and grape — were grown adjacent to a planting of boxelder seedlings in the Bottineau Nursery, Bottineau, N. Dak., in 1959. Plants of both indicators developed abnormal foliage typical of 2,4-D damage within 10 days of the first sign of boxelder blight. The test was repeated in 1960 with the same results.

2,4-D persists in the tissue of plants in an active form for periods of a few days to several weeks, depending on the plant species. In cotton foliage, 2,4-D has remained active for at least a month after the initial application. It was not known how long boxelder might retain the herbicide in active form.

With this in mind, three tests were selected to detect the presence of 2,4-D in extracts of the abnormal boxelder and cotton leaves:

1. Extracts of the abnormal foliage were applied to healthy plants. If 2,4-D were present, similar malformations should develop in the healthy foliage. Extracts from healthy plants should not induce malformation in healthy foliage.
2. One lot of cucumber seeds was germinated in an extract medium of blighted leaves and another lot in an extract of healthy leaves. Since the primary roots of cucumbers are extremely sensitive to growth inhibitors — such as 2,4-D — less growth would be expected in the abnormal extract than in the extract from healthy leaves.
3. The extract from abnormal foliage was tested with a chemical reagent known as chromotropic acid. If 2,4-D were present, a purple color would develop. No color reaction should develop with an extract from healthy foliage.

Results of the above tests of abnormal cotton and boxelder foliage collected in 1959 and 1960 were positive for 2,4-D except for the colorimetric test of the boxelder foliage collected in 1960. An explanation for this might be that the test was not quite sensitive enough to detect the quantity of 2,4-D present.

From the above results it must follow that boxelder foliage is as susceptible to damage by minute dosages of 2,4-D as the foliage of cotton and grape. To verify this, minute quantities of 2,4-D were applied to healthy boxelder leaf buds, and the least quantity that would produce malformation was noted. This proved to be approximately one-hundredth of a microgram. (One million micrograms equal one gram and about 28 grams equal one ounce.) Therefore, juvenile leaf growth of boxelder was sensitive to as small quantities of 2,4-D as reported for cotton by other investigators.

That the malformations induced in the boxelder leaves were identical to those found on blighted boxelder in the field can be considered as additional evidence that 2,4-D is the cause.

The results of this investigation supported the view that 2,4-D from spray drift is the cause of boxelder blight. Similar damage to leaves of Siberian and American elms and green ash strongly suggests that these species are also being affected by 2,4-D.

Although it is not known to what extent 2,4-D spray drift may damage or impair the growth of these trees, there is good reason to believe that normal photosynthesis is reduced — the destruction of chlorophyll being indicated by the chlorotic condition — and therefore the manufacture of carbohydrates essential for growth is in turn reduced. If food reserves are restricted over a period of years, trees may eventually suffer permanent damage.

Several states have already had to face this problem of spray drift damage to susceptible crops and have undertaken investigations of ways to reduce hazards involved with aerial application.

In view of the results of this study,[1] it is recommended that applicators use sprays of lowest volatility where possible and seek to minimize drift by using the latest techniques in equipment and application.

[1] *For a more detailed discussion of the study the following reference should be consulted: Phipps, Howard M. The role of 2,4-D in the appearance of a leaf blight of some Plains tree species. Forest Sci. 9: 283-288. 1963.*

July 1964

HOWARD M. PHIPPS
Research Forester

U. S. FOREST SERVICE

RESEARCH NOTE LS-50

.AKE STATES FOREST EXPERIMENT STATION • U. S. DEPARTMENT OF AGRICULTURE

A Cubic-Foot Volume Table for Unpeeled Pine Poles

Red and jack pine poles are important products from the forests of northern Minnesota. Considerable flexibility of thinning practices is made possible by the wide range of pole sizes presently used; these vary from 4 to 9 inches in top diameter and 10 to 45 feet in length. This range in sizes is troublesome. however, when numbers of poles must be converted to a single unit of measure as is sometimes necessary in cruising, appraising, and scaling timber. The cubic-foot volume table presented here provides a common unit of measure for a wide range of pole sizes.

To develop this table, the diameters of 190 red pine and 149 jack pine poles were measured at the butt end, at 10-foot intervals along the stem, and at the top. They were measured in the mill yard of the Wheeler Lumber Bridge and Supply Co. in Cass Lake. Minn., on five separate occasions, thus permitting a sample of poles cut by different operators and from a wide geographic area of northern Minnesota. The cubic-foot volume including bark was computed for each pole by Smalian's formula. A scatter diagram of cubic-foot volume plotted over the product of top diameter in inches (D) times total length (L) in feet (hereafter called DL) showed volumes curving upward with increasing values of DL. Also, variation increased in the larger sizes. Plotting the data on logarithmic paper resulted in a straight line with uniform variation for all values of DL. Therefore, the data were transformed to logarithms for the regression analysis.

A separate analysis for each species showed the two regression coefficients were not significantly different. Although the means of these two regressions were significantly different (at the 5-percent confidence level) the magnitude was less than 0.2 of a cubic foot. This difference scarcely justified separate volume tables for the two species. Therefore, they were combined to obtain the volume equation:

$$\text{logarithm } V = 1.4719 \ (\text{logarithm } DL) - 2.2964$$

where V equals volume and DL equals the product of top diameter outside bark in inches times the length in feet. The standard error of estimate for the logarithm of volume is $\pm$ 0.05066, which is $\pm$ 12.4 percent in terms of cubic-foot volume.[1] Ninety-seven percent of the variation in volume among the poles sampled is accounted for by the formula.

Because of the nature of logarithms, the formula tends to under-estimate volumes, the magnitude depending on the standard error of the estimate.[2] The correction for this regression was computed to be 0.68 percent and has been added to the volumes in table 1.

Product specifications used in this study (table 2) could undoubtedly be modified somewhat without seriously affecting the vol-

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[1] *This procedure underestimates the lower limits of error slightly. A more accurate value can be obtained by dividing the volume by 1.124 (the antilog of 0.05066).*

[2] *Spurr, Stephen H. Forest inventory. 476 pp. Ronald Press Co., New York. 1952.*

ume predictions, but major changes would probably require a new equation.

For some purposes it is desirable to convert the volume to equivalent cords. This conversion can be accomplished by dividing the cubic-foot volume of the poles (obtained by using the table or formula) by 92, which is the average number of cubic feet per cord of solid wood (79) plus bark (13).[3]

[3] *Gevorkiantz, S. R., and Olsen, L. P. Composite volume tables for timber and their application in the Lake States. U.S. Dept. Agr. Tech. Bul. 1104, 51 pp. 1955.*

TABLE 1. — *Cubic-foot volume (including bark) of unpeeled red and jack pine poles*

Length (feet)	Top diameter outside bark (inches) 4	5	6	7	8	9
10	1.1	1.6	2.1	2.6	3.2	3.8
12	1.5	2.1	2.7	3.4	4.2	5.0
14	1.9	2.6	3.4	4.3	5.2	6.2
16	2.3	3.2	4.2	5.2	6.4	7.6
18	2.7	3.8	5.2	6.2	7.6	9.1
20	3.2	4.4	5.8	7.3	9.0	10.7
22	3.7	5.1	6.7	8.5	10.3	12.2
25	4.4	6.2	8.2	10.2	12.4	14.8
30	5.8	8.2	10.6	13.3	16.2	19.3
35	7.3	10.2	13.3	16.7	20.3	24.2
40	9.0	12.4	16.2	20.3	24.8	29.5
45	10.6	14.7	19.3	24.2	29.5	35.0

TABLE 2. — *Product specifications used in this study*

Product	Length	Maximum crook or sweep[1]	Top diameter inside bark Min.	Top diameter inside bark Max.	Min. circumference over bark 6 feet from butt
	Feet	*Inches*	*Inches*	*Inches*	*Inches*
Building poles	10 and 12	1.0	5	7.5	None
Building poles	14 and 16	1.5	5	7.5	None
Building poles	18 and 22	2.0	5	7.5	None
Telephone poles	20 and 25	[2]	5	7.5	None
Telephone poles	30	[2]	5	7.5	29
Telephone poles	35	[2]	6	7.5	32
Telephone poles	40	[2]	7	8.5	36
Telephone poles	45	[2]	7	8.5	42

[1] *Deviation from centerline.*

[2] *Centerline shall not fall outside body of pole.*

October 1964

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North Central Region

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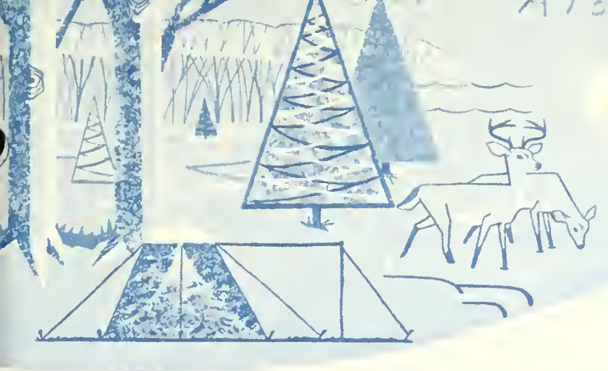

U. S. FOREST SERVICE

RESEARCH NOTE LS-51

LAKE STATES FOREST EXPERIMENT STATION • U. S. DEPARTMENT OF AGRICULTURE

Vertical Distribution of Cones in Red Pine

A survey of cone-bearing red pines, *Pinus resinosa* Ait., in the Lake States indicates that cones in individual trees are concentrated in the middle third of the crown (fig. 1), and that vertical cone distrbution is related to certain branch characteristics. This information is important to foresters, seed collectors, and entomologists concerned with the sampling, harvesting, and protection of cones.

Twenty-two trees bearing good cone crops were sampled from two areas in Wisconsin and three in Minnesota. Alternate whorls were removed from the crowns and the following data recorded: (1) whorl height on the stem; (2) branch azimuth; (3) branch length; (4 branch base diameter; and (5) total number of conelets and cones. In addition, the total number of male flower clusters was recorded for the 14 trees sampled in Minnesota. In the older and taller trees every third or fourth whorl was selected in order to reduce the number of branches sampled.

Correlation analyses indicated that branch characteristics were related to cone production. The correlation of cone production and branch size (length times base diameter) was significant. Higher correlation coefficients, however, resulted from the regression of cone production on branch size times branch height position; all **r** values were highly significant (table 1). Cone production correlated with branch size divided by branch age resulted in lower but still highly significant **r** values.

Cone production is not related entirely to the measured physical branch factors, however. Maximum cone production per unit of branch size occurred farther up the crown than did maximum cone production per branch, thus indicating greater productivity in the younger branches. The male flowers, however, were concentrated in the bottom half of the crown (fig. 2).

The higher cone production in the younger branches and the concentration of male flowers in the older ones illustrate the relation between branch age and sexuality. Wareing[1] states that in Scotch pine young branches tend to be first vegetative or female. As they become older, they produce both female and male flowers and eventually tend to produce only male flowers. Both cone and male-flower production are also apparently less on the lower, less vigorous branches of older trees than on the lower branches of young trees. This relationship is reversed above midcrown (figs. 1 and 2).

All evidence indicates that the top of the crown is the main area of cone and seed production in

[1] *Wareing, Philip F. Reproductive development in Pinus sylvestris, In The Physiology of Forest Trees, Kenneth V. Thimann, ed. Pp. 643-655. Ronald Press Co., New York. 1957.*

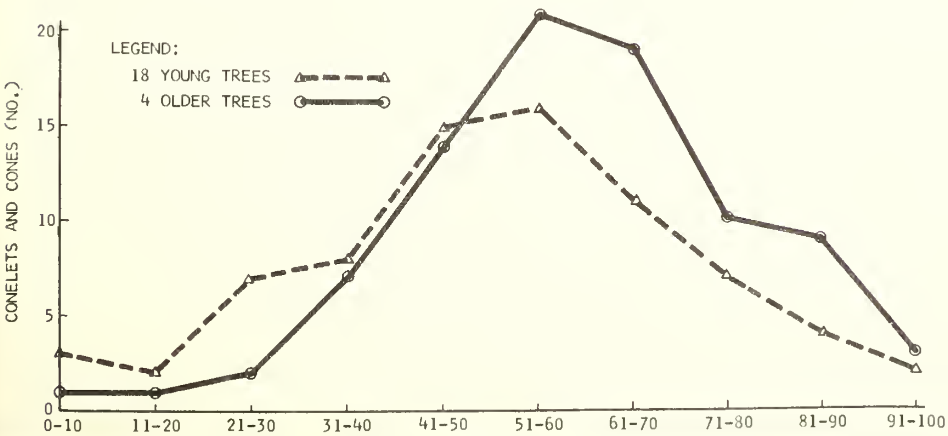

FIGURE 1. — Average number of conelets and cones per sample branch by crown tenths (6,179 conelets and cones).

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TABLE 1. — *Correlation coefficients of cone production vs. branch characteristics (averages) in 22 red pine trees in Wisconsin and Minnesota*

Area and year sampled	Stand condition	Trees	D.b.h.	Height	Age	Effective crown[1]	[2]r
		Number	*Inches*	*Feet*	*Year*	*Percent*	
Three Lakes, Wis., 1962	Open, planted	5	12	28	25	100	+0.82
Lakewood, Wis., 1962	Open, natural	3	12	35	35	88	+0.69
Echo Trail, Superior NF, 1963	Partially closed, planted	4	11	36	35	90	+0.72
Seed-production area, Isabella, Minn., 1963	Closed, natural stand	4	14	66	69	49	+0.81
Inga Lake, Isabella, Minn., 1963	Open, natural stand, jack pine understory	6	9	36	59	73	+0.86

[1] *Does not include lower stagnating and dying branches.*

[2] *The correlation coefficient of conelets and cones per branch vs. the product of branch length (feet) x branch base diameter (inches) x branch height position in the crown (percent). All individual r values are significant at the 5-percent level, 21 are significant at the 1-percent level.*

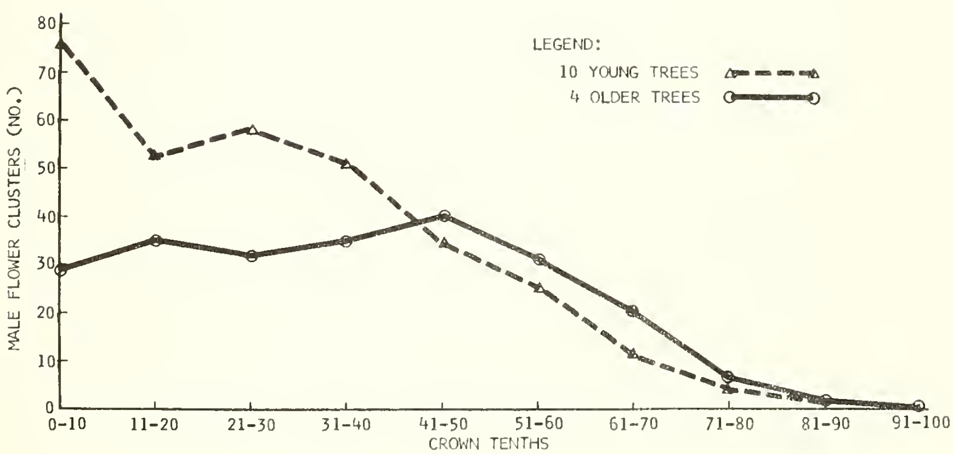

FIGURE 2. — Average number of male flower clusters per sample branch by crown tenths (11,657 male flower clusters).

the older trees. Lyons[2] has stated that the largest and most productive cones in red pine are found in the upper portion of the tree crown. Furthermore, the outer, most productive portions of the branches are higher than their points of attachment to the stem because of branch curvature.

[2] *Lyons, L. A. The seed-production capacity and efficiency of red pine cones (Pinus resinosa Ait.). Canad. Jour. Bot. 34: 27-36. 1956.*

The vertical distribution of cones has economic significance, especially in older stands. Climbers are prevented from going above a 4-inch top for reasons of safety; thus harvest of the most desirable cones is a problem. Furthermore, if effective chemical control is to be realized in older trees, mist blowers or sprayers must be powerful enough to reach the high cone-producing areas of the crown.

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Entomologist

U. S. FOREST SERVICE

RESEARCH NOTE LS-52

AKE STATES FOREST EXPERIMENT STATION • U. S. DEPARTMENT OF AGRICULTURE

Primary Wood Use by Manufacturing Firms in Duluth-Superior, 1962

The urban area of Duluth, Minn., and Superior, Wis., commonly called the Twin Ports and containing about 145,000 persons, has important manufacturing and shipping industries. Some of these industries use substantial volumes of primary[1] forest products in their operations.

Many of the surrounding counties have large timber surpluses in certain species — that is, the harvest desirable on a sustained yield basis is much greater than the current actual cut. To find out if the use of local woods could be increased, a study was made of primary wood use by manufacturing companies in Duluth-Superior during 1962. The study was part of a comprehensive economic appraisal of expansion possibilities for forest products industries in northeastern Minnesota.

Twenty-six manufacturers (all of those using significant amounts of the products) were interviewed. Results showed that in 1962 manufacturing firms in the Twin Ports used more than 1.5 million board feet of lumber, almost 400,000 square feet of plywood, and more than 500,000 square feet of hardboard and particleboard. No data were collected on wood used for repair and maintenance and secondary fabricated wood products purchased by industry.

Of the lumber used, at least one-fourth was Minnesota-grown, one-fifth or more came from Wisconsin and Michigan forests, and the remainder was primarily of western origin. Half of the lumber was procured from sawmills, with Minnesota mills supplying almost half of these direct purchases (fig. 1). Wholesalers and brokers furnished about two-fifths of the total, and Twin Ports retailers supplied the rest.

About three-fifths of the industrial lumber in 1962 was used in making salable products; all other lumber requirements were for shipping or warehousing purposes (table 1). The most common products included millwork; cabinets and fixtures; crating and boxes; and blocking, bracing, and dunnage. The most frequently used species were ponderosa pine and sugar pine for millwork; white birch, yellow birch, and white oak for cabinets and fixtures; and eastern white pine and aspen for crating and boxes.

Nearly all (84 percent) of the lumber was purchased by grade. Two-thirds of all softwood and one-half of all hardwood lumber was No. 1 common and better (table 2). For those manufacturers uncertain of the grades they bought, the grades were estimated from the buyer's specifications and requirements. White birch, eastern white pine, and aspen lumber were predominantly low-grade material. Oak was a mixture of high and low grades. Western species were essentially high-grade lumber.

Fifty-two percent of the lumber was kiln dried and another 37 percent was air dried (table 3). The only species used green were aspen, eastern white pine, and white birch employed in shipping and warehousing. Rough lumber accounted for

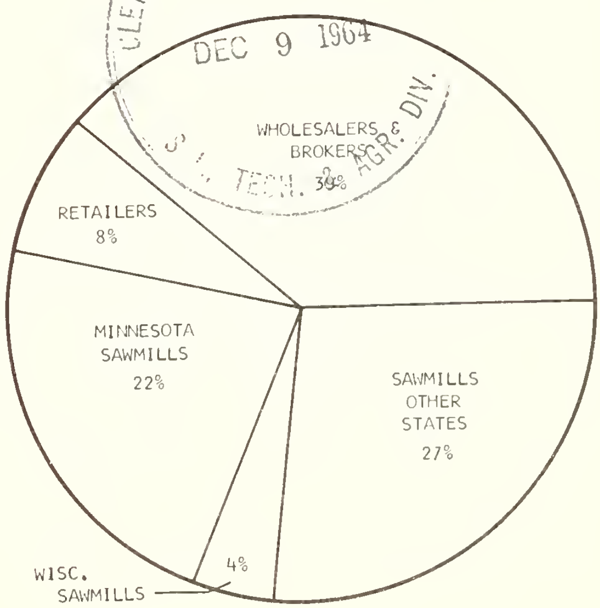

FIGURE 1. — Source of supply of industrial lumber, Duluth-Superior, 1962.

[1] *"Primary" forest products as used here include lumber, veneer, plywood, and composition boards.*

Table 1.--Lumber use in manufacturing and shipping, by product and species, in Duluth-Superior, 1962

(Thousand bd. ft.)

Species	Product: Millwork	Product: Cabinets and fixtures	Product: Flooring	Product: Patterns	Product: Signs	Product: Other	Product total	Shipping: Crating & boxes	Shipping: Blocking, bracing, & dunnage	Shipping: Skids & pallets	Shipping total
Hardwoods											
Birch	55	120	-	-	-	*	175	-	33	-	33
Aspen	-	-	-	-	-	-	-	88	24	36	148
Oak	40	56	16	*	-	*	112	-	15	-	15
Basswood	10	20	-	6	-	-	36	-	-	-	-
Maple	-	10	8	-	-	10	28	-	6	-	6
Walnut	1	20	-	-	-	-	21	-	-	-	-
Ash	-	20	-	-	-	-	20	-	-	-	-
Cherry	-	1	-	-	-	-	1	-	-	-	-
Mixed hardwood	-	-	-	-	-	2	2	-	-	-	-
Northern softwoods											
White pine	-	-	-	-	-	-	-	186	8	-	194
Jack pine	-	-	-	-	-	-	-	20	-	-	20
Mixed pine	-	-	-	-	-	-	-	1	15	-	16
Cedar	10	-	-	-	-	-	10	-	-	-	-
Spruce	-	-	-	*	-	-	*	-	-	6	6
Western softwoods											
Ponderosa pine	300	-	-	-	-	5	305	25	-	-	25
Sugar pine	110	-	-	11	-	1	122	-	-	-	-
Douglas-fir	15	-	-	-	10	18	43	7	60	3	70
Redwood	46	-	-	-	-	-	46	-	-	-	-
White fir	30	-	-	*	-	-	30	-	-	3	3
Sitka spruce	-	-	-	-	-	-	-	-	30	-	30
White pine	*	-	-	2	10	-	12	-	-	-	-
Imports											
Mahogany	31	1	-	-	-	-	32	-	-	-	-
Obeechie	-	-	-	4	-	-	4	-	-	-	-
Total	648	248	24	23	20	36	999	327	191	48	566
Percent	41	16	2	2	1	2	64	21	12	3	36

*Less than 500 board feet.

Table 2.--Lumber use in manufacturing and shipping by species and grade in Duluth-Superior, 1962

(Thousand bd. ft.)

Species	Firsts & seconds	Finish & 1/ selects	No. 1 common	No. 1 common & better	No. 2 common	No. 2 common & better	No. 3 common	No. 3 common & better	No. 4 common	Mill-run 2/	No. 5 common	Structural	Total	Percent of all species
Hardwoods														
Birch	6	69	-	-	-	-	18	100	-	15	-	-	208	13.3
Aspen	-	-	40	-	-	-	53	-	20	35	-	-	148	9.5
Oak	37	16	9	10	-	*	5	40	-	*	-	10	127	8.1
Basswood	-	-	16	-	-	20	-	-	-	-	-	-	36	2.3
Maple	8	10	-	10	-	-	6	-	-	-	-	-	34	2.2
Walnut	*	1	-	20	-	-	-	-	-	-	-	-	21	1.3
Ash	-	-	-	20	-	-	-	-	-	-	-	-	20	1.3
Cherry	-	1	-	-	-	-	-	-	-	-	-	-	1	.1
Mixed hardwood	-	-	-	-	-	-	-	-	-	2	-	-	2	.1
Total	51	97	65	60	-	20	82	140	20	52	-	10	597	38.2
Northern softwoods														
White pine	-	-	-	-	8	-	6	-	-	180	-	-	194	12.4
Jack pine	-	-	20	-	-	-	-	-	-	-	-	-	20	1.3
Mixed pine	-	-	-	-	-	-	1	-	-	-	15	-	16	1.0
Cedar	-	-	-	10	-	-	-	-	-	-	-	-	10	.6
Spruce	-	6	-	-	-	*	-	-	-	-	-	-	6	.4
Total	-	6	20	10	8	*	7	-	-	180	15	-	246	15.7
Western softwoods														
Ponderosa pine	-	60	-	240	5	-	-	-	-	25	-	-	330	21.1
Sugar pine	-	32	-	90	-	-	-	-	-	-	-	-	122	7.8
Douglas-fir	-	1	15	28	2	7	-	-	-	-	-	60	113	7.2
Redwood	-	1	45	-	-	-	-	-	-	-	-	-	46	2.9
White fir	-	-	-	33	-	-	-	-	-	-	-	-	33	2.1
Sitka spruce	-	-	30	-	-	-	-	-	-	-	-	-	30	1.9
White pine	-	*	2	-	10	-	-	-	-	-	-	-	12	.8
Total	-	94	92	391	17	7	-	-	-	25	-	60	686	43.8
Imports														
Mahogany	31	1	-	-	-	-	-	-	-	-	-	-	32	2.0
Obeechie	-	4	-	-	-	-	-	-	-	-	-	-	4	.3

1/ Hardwood select and softwood finish grades.
2/ Includes No. 4 and better hardwood.
* Less than 500 board feet.

Table 3.--Surface and moisture condition of industrial lumber used in Duluth-Superior, 1962

(Thousand bd. ft.)

Species	Rough green	Rough air dry	Rough kiln dry	Finish green	Finish air dry	Finish kiln dry	Total
Hardwoods							
Birch	15	118	15	-	-	60	208
Aspen	50	68	-	2	28	-	148
Oak	-	65	17	-	-	45	127
Basswood	-	20	16	-	-	-	36
Maple	-	16	18	-	-	-	34
Walnut	-	-	20	-	-	1	21
Ash	-	20	-	-	-	-	20
Cherry	-	-	-	-	1	-	1
Mixed hardwood	-	-	-	-	-	2	2
Northern softwoods							
White pine	-	94	-	100	-	-	194
Jack pine	-	20	-	-	-	-	20
Mixed pine	-	16	-	-	-	-	16
Cedar	-	-	10	-	-	-	10
Spruce	-	6	-	-	-	*	6
Western softwoods							
Ponderosa pine	-	-	240	-	5	85	330
Sugar pine	-	-	100	-	-	22	122
Douglas-fir	-	64	15	-	2	32	113
Redwood	-	-	45	-	-	1	46
White fir	-	2	30	-	-	1	33
Sitka spruce	-	30	-	-	-	-	30
White pine	-	-	1	-	-	11	12
Total	65	539	527	102	36	260	1/ 1,529
Percent	4	35	35	7	2	17	100

1/ Total does not include imports.
* Less than 500 board feet.

three-fourths of the 1962 consumption. Most of the finished lumber was kiln dried.

Except for three companies, the kinds of lumber bought and the procurement sources were determined by people in management positions or in business offices. In the other three firms, a foreman in the production department decided on the types of lumber needed, but purchasing agents determined the procurement source. Generally, the purchaser was familiar with the production processes of his company, and in the smaller firms he was usually closely associated with the production department.

The overall trend in industrial lumber consumption during 1958-62 was upward. During this 5-year period 11 firms noted an increasing use of lumber, 11 had no significant use changes, 1 firm had mixed trends which varied by species, and 3 companies had decreasing requirements. Companies with increasing needs for lumber from 1958-62 utilized 60 percent of the industrial lumber in the Twin Ports in 1962.

Approximately one-half of the lumber used was grown in the Lake States. Users commented on several obstacles which they felt Lake States lumber producers need to overcome if they are to gain a larger share of the local industrial market. Most often mentioned were: improper sawing and drying; undependable supplies; difficulty in locating the higher grades and large or odd dimensions; excessive costs; and inadequate promotion of local species. Two firms had discontinued using local white pine, one because of excessive shake and the other because of splintering. In addition, one of these concerns had abandoned the use of local white birch because birch could be obtained only in 8-foot lengths. Three other companies were not using Lake States-produced lumber because of excessive shake in white pine, a shortage of kiln-dried stock, and relatively high prices.

The opportunities appear limited, under current conditions of manufacture, for Lake States lumber to displace western species that fulfilled more than two-fifths of the Twin Ports industrial lumber requirements in 1962. Most of the western lumber was kiln dried No. 1 common and better. The major western species and their uses were ponderosa pine and sugar pine for high-grade millwork and Douglas-fir and Sitka spruce for blocking and bracing. High-quality white pine is a logical substitute for the ponderosa and sugar pines, but high-grade white pine stumpage in the Lake States is relatively scarce and in scattered stands. Furthermore, most sawmills have no dry kiln facilities, a necessity for suppliers to the millwork trade. Consequently, millwork manufacturers have been paying premium prices for kiln-dried western pines. Perhaps native white pine lumber could be economically upgraded by edge- or end-gluing small clear pieces together for use in millwork.

Douglas-fir and Sitka spruce were used mainly for blocking and bracing material that required large thicknesses, long lengths, and high strength properties. These requirements could not be met by material cut from small-size Lake States trees. However, lamination, end gluing, and edge gluing might provide the strength and dimensions needed for the special uses. With proper engineering of products, red pine and tamarack might become suitable substitutes for the western species in some uses.

A more immediately promising use for local species is in fabricated boxes and crates. Several firms used assembled boxes and crates made in the South or Midwest. Since this study did not examine fabricated products, the box market potential for native lumber is unknown but appears to be significant. Aspen and white pine are excellent for this purpose.

Plywood was consumed in making signs, cabinets, fixtures, crating, patterns, and truck floors. Of 393,000 square feet used in 1962, 229,000 was Douglas-fir. Hardboard and particleboard were used for items such as signs, displays, patterns, cabinets, and counter tops. During 1958-62 the industrial use trend for plywood, hardboard, and particleboard was upward in Duluth-Superior.

On the whole, the future demand for Lake States timber for industrial purposes in Duluth-Superior seems reasonably good. Use is expanding, approximately one-half of the industrial lumber comes from timber grown in the Lake States, and opportunities probably exist for local fabricators, using native lumber, to supply a larger share of the assembled wooden containers to industrial customers.

Recent Lake States Forest Survey statistics show that sawtimber volume and quality is increasing. With improved manufacturing technology, opportunities should increase for sawmills to produce a more acceptable quality of lumber.

October 1964

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U. S. FOREST SERVICE

RESEARCH NOTE LS-53

LAKE STATES FOREST EXPERIMENT STATION • U. S. DEPARTMENT OF AGRICULTURE

A Field Key to the Adult Hymenopterous Parasites of the Spruce Budworm in Minnesota

The simple key presented here was devised for field identification of the various adult hymenopterous parasites of the spruce budworm (*Choristoneura fumiferana* (Clem.)) in Minnesota. Using easily recognizable morphological characters visible through a hand lens or low-power microscope, it was designed to separate genera only. This level is adequate for certain purposes. Where precise species identification is necessary, parasites should be sent to expert taxonomists.

The species listed in table 1 are all of the hymenopterous parasites recorded from thousands of specimens reared from 1956 to 1961 in northern Minnesota. Several of the genera contain only one species in this list, so that identification to that particular genus also will indicate a particular species. A few specimens could not be identified beyond the genus because of insufficient or incomplete material. At least two, and possibly three, new species were recovered in the rearings.

Key to Adult Hymenopterous Parasites

1. Forewings with two veins or less; insects 3 mm. or less in length (Figs. 1-3) 2
   Forewings with numerous veins; insects longer than 3 mm. (Figs. 4-9) 11

2. (1) Head, thorax, and abdomen yellow; body length about 0.5 mm. ....*Trichogramma*
   Head, thorax, and abdomen not yellow; body length 1.0 mm. or greater 3

3. (2) Head, thorax, and abdomen bright green or blue; legs uniformly brown or yellow 4
   Head, thorax, and abdomen black; body may be irridescent; legs and antennae not necessarily uniform in coloration 6

4. (3) Body light yellowish green; legs uniformly yellow; antennae with yellow scape and orange or brownish filament; abdomen shorter than head and thorax combined; 2.5 mm. long ....*Psychophagus*
   Body dark brownish green; legs and antennae uniformly brown; about 3.0 mm. long .. 5

5. (4) Abdomen robust, shorter than head and thorax combined, and its length less than twice its width; abdomen shining black except basal half of first abdominal tergite metallic green ....*Amblymerus*
   Abdomen elongated, longer than or as long as head and thorax combined, and its length more than twice its width; abdomen uniformly bright or metallic green ..*Habrocytus*

6. (3) Legs nearly uniform in coloration, either white, yellow, or tan 7
   Legs marked with contrasting colors, white and black or white and brown 8

7. (6) Face below antennae black; eyes gray or black ....*Hyssopus*
   Face below antennae white; eyes purple ....*Euplectrus*

8. (6) Vertex of head rounded 9
   Vertex of head pointed ....*Copidosoma*

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9. (8) Forewing with small vein extending into membrane (Figs. 1, 2); metathoracic femora rounded 10
Forewing without vein extending into membrane (Fig. 3); metathoracic femora flattened ....*Elasmus*

10. (9) Vein in forewing membrane thick and prominent (Fig. 1); femur-tibia knee joint white ....*Tetrastichus*
Vein in forewing membrane thin (Fig. 2); femur-tibia knee joint black or brown ....*Pediobius*

11. (1) Face below antennae between eyes partly or completely white or yellow 12
Face below antennae between eyes completely black or brown 16

12. (11) Head, thorax, and abdomen black in part; dorsal abdomen completely black 13
Head, thorax, and abdomen brown; abdominal dorsum yellow or brown ......*Mesochorus*

13. (12) Metathoracic tibia black and white or black and yellow; white or yellow spot present on thoracic dorsum 14
Metathoracic tibia nearly uniform in coloration; white or yellow spot absent on thoracic dorsum 15

14. (13) Eye emarginate, and thin white markings along inner margin of eye (Fig. 10); tip of ovipositor of female curved downwards ....*Ephialtes*
Eye entire, and white markings on lower half of face (Fig. 11); tip of ovipositor of female straight. ....*Aoplus*

15. (13) Forewing with areolet (Fig. 4); (male insect) ....*Phaeogenes*
Forewing without areolet (Fig. 5); (male or female insect) ....*Exochus*

16. (11) Head and thorax black 17
Head and thorax light or dark brown 24

17. (16) Tibiae and tarsa of metathoracic legs banded white and brown 18
Tibiae and tarsa of metathoracic legs not banded 20

18. (17) Eye entire; abdomen black without markings 19
Eye emarginate (Fig. 12); abdomen black with narrow yellow bands bordering the posterior margin of each segment ......*Itoplectis*

19. (18) Forewing with areolet (Fig. 6); antennae dark brown. ....*Scambus*
Forewing without areolet; antennae black ....*Glypta*

20. (17) Dorsal abdomen completely black ...21
Dorsal abdomen brown or brown and black..23

21. (20) Forewing with areolet; eye emarginate 22
Forewing without areolet; eye entire ....*Apanteles*

22. (21) Femora, tibiae, and tarsa of metathoracic legs uniform in coloration ....*Horogenes*
Femora of metathoracic legs light brown, tibiae and tarsae dark brown ..*Coccygomimus*

23. (20) Antennae brown without markings (male or female insect) ....*Hemiteles*
Antennae brown with several control segments white, (female insect) ....*Phaeogenes*

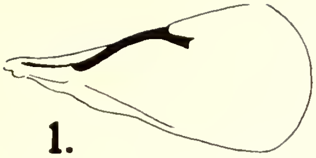
24. (16) Wing membranes transparent 25
Wing membranes pictured with opaque markings ....*Gelis*

25. (24) Antennae as long or longer than length of body 26
Antennae shorter than length of body ....*Hormius*

26. (25) Forewing with large cells only 27
Forewing with one small cell, similar to areolet (Fig. 7) ....*Meteorus*

27. (26) Eye entire; abdomen either totally black or brown with one or more yellowish segments 28
Eye with shallow emargination (Fig. 13); abdomen brown ....*Clinocentrus*

28. (27) Forewing with cells R_3 and R_4 confluent (Fig. 8) ....*Eubadizon*
Forewing with cells R_3 and R_4 separated by cross vein (Fig. 9) ....*Macrocentrus*



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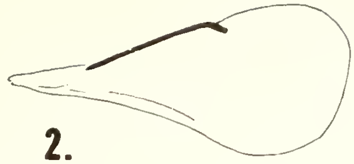

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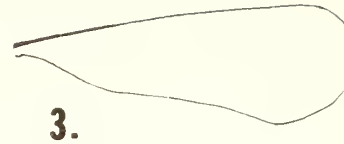

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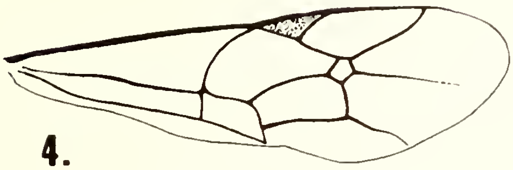

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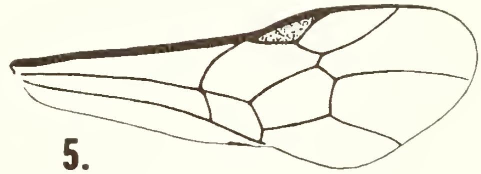

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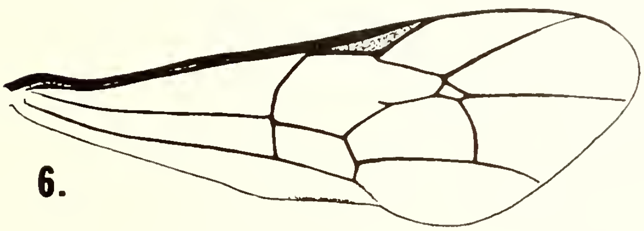

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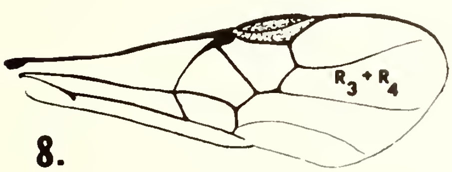

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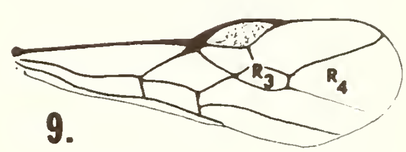

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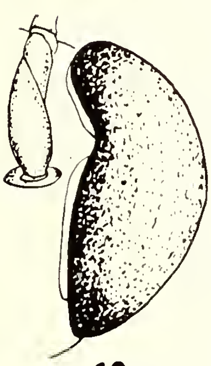

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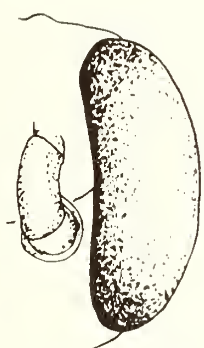

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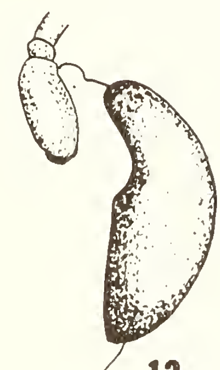

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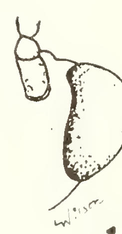

13.

FIGURES 1-9 illustrate the right forewings, and figures 10-13 the left side of head (front view).

1. *Tetrastichus*
2. *Pediobius*
3. *Elasmus*
4. *Phaeogenes*
5. *Exochus*
6. *Scambus*
7. *Meteorus*
8. *Eubadizon*
9. *Macrocentrus*
10. *Ephialtes*
11. *Aoplus*
12. *Itoplectis*
13. *Clinocentrus*

TABLE 1. *Species and type of hymenopterous parasites reared from the spruce budworm in northern Minnesota, 1956-1961*

Classification	Type of parasite
Braconidae	
Apanteles fumiferanae Vier.	Egg, larval
A. petrovae Walley	——
A. polychrosidis Vier.	Egg, larval
A. near *solenobiae* Walley	Larval
Apanteles n. sp.	——
Clinocentrus sp.	Larval
Clinocentrus n. sp.	Larval
Eubadizon gracile Prov.	Larval
Hormius sp.	——
Macrocentrus iridescens French	——
M. peroneae Mues.	Larval
Meteorus trachynotus Vier.	Larval
Elasmidae	
Elasmus sp.	Larval (hyperparasite)
Encytridae	
Copidosoma deceptor Miller	——
Copidosoma sp.	——
Eulophidae	
Euplectrus frontalis Howard	Larval
Hyssopus johannseni (Cwfd.)	Larval
Pediobius tarsalis (Ashm.)	Larval (hyperparasite)
Tetrastichus caerulescens Ashm.	Larval (hyperparasite)
T. silvaticus Gah.	Larval
Ichneumonidae	
Aoplus near *vagans* (Prov.)	Larval (?)
Coccygomimus pedalis (Cress.)	Pupal
Ephialtes ontario (Cress.)	Pupal
Exochus sp.	Larval
Gelis sp.	Larval (hyperparasite)
Glypta fumiferana (Vier.)	Egg, larval
Hemiteles sp.	——
Horogenes sp.	Egg, larval
Itoplectis conquisitor (Say)	Pupal
Mesochorus sp.	Egg, larval (hyperparasite)
Phaeogenes hariolus (Cress.)	Pupal
Scambus alboricta (Cress.)	Larval
Pteromalidae	
Amblymerus verditer (Nort.)	Pupal (hyperparasite)
Habrocytus phycidis Ashm.	Pupal (hyperparasite)
Psychophagus tortricis (Brues.)	Pupal (hyperparasite)
Trichogrammatidae	
Trichogramma minutem Riley	Egg

October, 1964

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U. S. FOREST SERVICE

RESEARCH NOTE LS-54

LAKE STATES FOREST EXPERIMENT STATION • U. S. DEPARTMENT OF AGRICULTURE

Veneer Log Production in the Lake States Continues General Decline, 1963

The veneer log harvest in the Lake States in 1963 was 50.5 million board feet. Standard veneer logs used for the better grades of veneer accounted for 43.9 million board feet; container veneer logs used for box and basket veneers made up the remaining 6.6 million board feet. Wisconsin, with a harvest of 25.2 million board feet, led the Lake States in volume of veneer logs cut. Michigan, with 15.3 million and Minnesota with 10.0 million board feet accounted for the remaining output. Detailed production data, shown in table 1, were derived from the Station's canvass of the Lake States veneer industry.

Birch, hard maple, oak, and basswood made up nearly three-fourths of the volume cut. The remainder came primarily from elm and walnut, with lesser amounts from other species.

Local timber operators shipped 5.5 million board feet of standard veneer logs to mills outside the Lake States. Three-fourths of these exports were from Michigan.

Lake States mills received 52.7 million board feet of logs in 1963. Those in Wisconsin were the principal consumers, receiving 80 percent of the volume (table 2). Nearly 45.0 million board feet came from local timber and 7.7 million from areas outside the Lake States. Timber operators in Canada shipped 5.9 million board feet to Lake States mills, while most of the remaining 1.8 million board feet came from Iowa, Illinois, Indiana, and Missouri. Birch and hard maple comprised three-fourths of the incoming shipments. Mills utilizing standard grade logs received 46.1 million board feet, and container mills the remaining 6.6 million board feet. In addition, container mills received 2,100 cords of wood for heading stock.

During World War II and for several years thereafter, the Lake States veneer industry maintained a high level of production. About 1950, production took a downturn and has been on the decline since. The loss of defense contracts, competition from substitute products and from other areas, and the scarcity of high-quality timber have all contributed to the downward trend. Fewer mills operate now than 10 or 15 years ago as shown below.

	Minn.	*Wis.*	*Mich.*	*Total*
1946				
Standard	1	23	6	30
Container	8	32	16	56
1954				
Standard	1	21	4	26
Container	8	26	19	53
1963				
Standard	2	17	4	23
Container	5	14	5	24

The peak in production was in 1948 when 117 million board feet of veneer logs were cut in the Lake States. The 1962 cut of 48 million feet was the lowest in many years. The sharpest decline has been in container grade logs. From a high of 45 million feet in 1948, production dropped to 7 million board feet in 1962 and 1963 (fig. 1). Standard grade log production reached a peak in 1946 when 74 million board feet were cut; the 40 million board feet cut in 1958 was a low point.

Michigan, for many years the leader in production, dropped behind Wisconsin in the late fifties:

	Production in million board feet for:[1]			
	Minn.	*Wis.*	*Mich.*	*Total*
1946				
Standard	2	22	50	74
Container	1	7	29	37
1954				
Standard	8	19	18	45
Container	2	8	17	27
1963				
Standard	8	22	13	43
Container	2	3	2	7

[1] *International ¼-inch rule.*

Actually, most of the production decline has been in Michigan: from a high in 1946 of 79 million feet, the cut has declined to 15 million board feet.

Table 1.--Production and imports of veneer logs, Lake States, 1963

(Thousand board feet, Int'l ¼-inch rule)

Species	Destination	Production by states[1]				Imports			Total receipts
		Minn.	Wis.	Mich.	Region	Other[2]	Canada	Total imports	
Aspen	Minn.	948	-	-	948	-	82	82	1,030
	Wis.	35	196	103	334	-	-	-	334
	Mich.	-	-	241	241	-	-	-	241
	Total	983	196	344	1,523	-	82	82	1,605
Ash	Minn.	1	-	-	1	-	-	-	1
	Wis.	149	418	51	618	10	-	10	628
	Mich.	-	-	24	24	-	-	-	24
	Total	150	418	75	643	10	-	10	653
Basswood	Minn.	1,326	-	-	1,326	-	-	-	1,326
	Wis.	1,217	3,200	519	4,936	129	1	130	5,066
	Mich.	-	5	336	341	-	11	11	352
	Exported[3]	-	1	-	1	-	-	-	-
	Total	2,543	3,206	855	6,604	129	12	141	6,744
Beech	Minn.	-	-	-	-	-	-	-	-
	Wis.	-	80	86	166	-	-	-	166
	Mich.	-	-	115	115	-	-	-	115
	Total	-	80	201	281	-	-	-	281
Birch	Minn.	644	-	-	644	-	63	63	707
	Wis.	1,756	2,839	2,419	7,014	59	1,925	1,984	8,998
	Mich.	235	370	2,417	3,022	165	1,367	1,532	4,554
	Exported[3]	-	15	216	231	-	-	-	-
	Total	2,635	3,224	5,052	10,911	224	3,355	3,579	14,259
Cottonwood	Minn.	44	-	-	44	-	-	-	44
	Wis.	125	99	-	224	326	-	326	550
	Mich.	-	-	137	137	-	-	-	137
	Total	169	99	137	405	326	-	326	731
Elm	Minn.	6	-	-	6	-	-	-	6
	Wis.	1,185	2,904	47	4,136	1	-	1	4,137
	Mich.	-	-	763	763	-	-	-	763
	Exported[3]	52	86	603	741	-	-	-	-
	Total	1,243	2,990	1,413	5,646	1	-	1	4,906
Maple, hard	Minn.	25	-	-	25	-	-	-	25
	Wis.	211	5,286	2,016	7,513	102	2,342	2,444	9,957
	Mich.	-	114	977	1,091	-	10	10	1,101
	Exported[3]	200	226	1,436	1,862	-	-	-	-
	Total	436	5,626	4,429	10,491	102	2,352	2,454	11,083
Maple, soft	Minn.	40	-	-	40	-	-	-	40
	Wis.	410	1,424	255	2,089	355	11	366	2,455
	Mich.	-	-	111	111	-	-	-	111
	Total	450	1,424	366	2,240	355	11	366	2,606
Oak	Minn.	1	-	-	1	-	-	-	1
	Wis.	1,029	7,196	402	8,627	544	59	603	9,230
	Mich.	-	6	85	91	-	-	-	91
	Exported[3]	-	5	175	180	-	-	-	-
	Total	1,030	7,207	662	8,899	544	59	603	9,322
Walnut	Minn.	-	-	-	-	-	-	-	-
	Wis.	-	-	-	-	-	-	-	-
	Mich.	-	-	-	-	-	-	-	-
	Exported[3]	294	370	1,588	2,252	-	-	-	-
	Total	294	370	1,588	2,252	-	-	-	-
Misc. species	Minn.	-	-	-	-	-	-	-	-
	Wis.	31	146	20	197	200	-	200	397
	Mich.	-	-	109	109	-	-	-	109
	Exported[3]	6	217	49	272	-	-	-	-
	Total	37	363	178	578	200	-	200	506
All species	Minn.	3,035	-	-	3,035	-	145	145	3,180
	Wis.	6,148	23,788	5,918	35,854	1,726	4,338	6,064	41,918
	Mich.	235	495	5,315	6,045	165	1,388	1,553	7,598
	Exported[3]	552	920	4,067	5,539	-	-	-	-
	Total	9,970	25,203	15,300	50,473	1,891	5,871	7,762	52,696

1/ Vertical columns of figures under box heading "Production by states" represents the quantity of veneer logs cut in each state.

2/ Central States and small amounts from New York State and Africa.

3/ Veneer logs shipped to mills outside Lake States Region.

Table 2.--Geographic origin and destination of veneer logs received by Lake States plants, 1963

Species	Percent of veneer logs originating from: Minn.	Wis.	Mich.	Other 1/	Canada	Percent of veneer logs received by plants in: Minn.	Wis.	Mich.
Aspen	61	12	22	-	5	64	21	15
Ash	23	64	11	2	-	-	96	4
Basswood	38	48	13	1	-	20	75	5
Beech	-	28	72	-	-	-	59	41
Birch	18	22	34	1	25	5	63	32
Cottonwood	23	13	19	45	-	6	75	19
Elm	24	59	17	-	-	-	84	16
Maple, hard	2	49	27	1	21	-	90	10
Maple, soft	17	55	14	14	-	2	94	4
Oak	11	77	5	6	1	-	99	1
Walnut	-	-	-	-	-	-	-	-
Misc. hdwds.	6	29	25	40	-	-	78	22
All species	18	46	21	4	11	6	80	14
Previous survey year 1962	18	41	23	6	12	5	79	16

1/ Central States and small amounts from New York State and Africa.

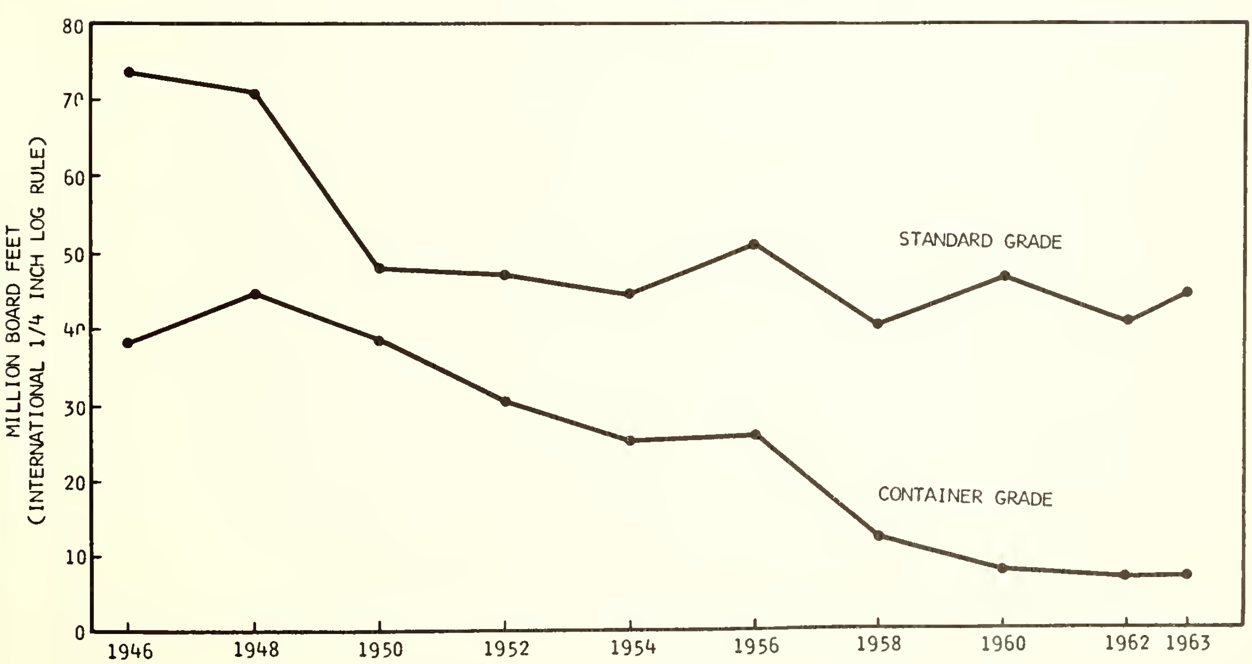

FIGURE 1. — Veneer log production, Lake States, 1946-1963.

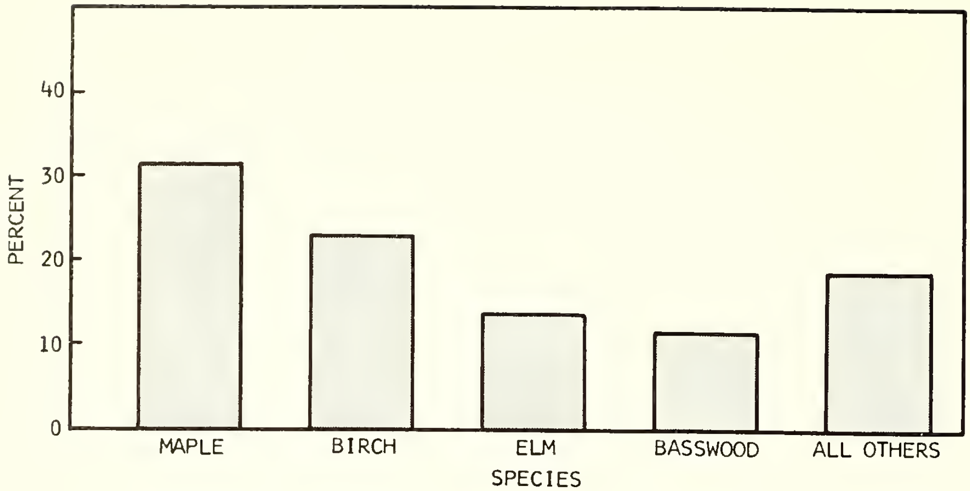

FIGURE 2. — Percent of total cut by specified species, Lake States; averages for 1946-1963.

Table 3.--Veneer log production by specified species and year by State, Lake States

(Thousand board feet - Int'l ¼-inch log rule)

Species	Minnesota			Wisconsin			Michigan		
	1946	1954	1963	1946	1954	1963	1946	1954	1963
Maple	80	1,100	890	7,620	7,780	7,050	33,570	12,060	4,800
Birch	390	820	2,640	4,120	4,200	3,220	21,460	12,310	5,050
Elm	350	1,490	1,240	8,190	6,490	2,990	9,890	2,520	1,410
Basswood	1,140	3,260	2,540	5,520	3,810	3,210	3,960	2,130	860
Other[1/]	540	3,710	2,660	3,820	4,830	8,730	9,970	5,490	3,180
Total	2,500	10,380	9,970	29,270	27,110	25,200	78,850	34,510	15,30C

1/ "Other" includes oak, ash, aspen, beach, walnut, cottonwood, and small amounts of other species.

Wisconsin's cut, although generally declining, has been about 25 to 30 million board feet. Minnesota, never a large producer, has shown a general increase over this time.

Cutting trends by species show that maple, birch, elm, and basswood have been the mainstays of the industry (fig. 2). The total cut has gone down, but these species continue to contribute about 80 percent of the production. Maple and birch together consistently account for about 50 percent of the production.

Michigan's cut of maple, birch, elm, and basswood veneer logs has fallen off sharply since 1946 (table 3). Wisconsin's cut of elm and basswood has declined, but birch and maple production has remained relatively stable. Minnesota, on the other hand, has shown moderate increases in the production of these species.

To supplement local production, some mills obtain logs from other States and Canada. Incoming log shipments fluctuate from year to year, but no sharp increase or decrease has been noted from 1946 to 1963. These imports generally range from 8 to 12 million board feet per year. Species shipped in are mostly birch and hard maple from Canada, and maple, basswood, and oak from neighboring States.

Timber operators in the Lake States ship logs not only to local mills but also to mills outside the Lake States. The principal species exported are walnut, hard maple, and elm. Mills in the Central States receive most of the logs, but some logs are sent to Canada, Japan, and European countries. Until the late 1950's, these shipments amounted to less than 1 million board feet per year. In recent years log shipments out of the Lake States have increased. Export figures on this type of material are difficult to obtain; but it is known that foreign countries, especially European countries, are in the market for elm and walnut, and an increase in procurement activities has been noted.

October 1964

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U. S. FOREST SERVICE

RESEARCH NOTE LS-55

LAKE STATES FOREST EXPERIMENT STATION • U. S. DEPARTMENT OF AGRICULTURE

Forest Type Areas by Counties, Minnesota, 1962

Aspen and birch forests occupy over one-third of the commercial forest land in Minnesota — some 6,254,000 acres (table 1). Oak and the other hardwood types are found on about one-fourth of the commercial forest area, and conifers are found on 28 percent. The remaining 11 percent (1,861,000 acres) is nonstocked.

The aspen-birch type group is widespread, covering about 40 percent of the commercial forest land in each of three survey units, Lake Superior, Central Pine, and Western (fig. 1), and 23 percent in other units. The oak type is well represented in all but the Lake Superior and Rainy River units. Ninety-six percent of the conifer type area occurs in the three northeastern units. Nonstocked commercial forest area varies from 8 percent in the Southeast to 15 percent in the Rainy River unit.

These are statistics from the Third Forest Survey of Minnesota, which was made from 1960 to 1963 by this Station and the Office of Iron Range Resources and Rehabilitation in cooperation with other public and private landowners. Detailed information on present forest resource status and trends will be presented in a summary report for the State and in publications for certain individual counties or units.

The most startling change in the statistics since 10 years ago is a reduction of nearly 2 million acres in nonstocked area (fig. 2) — half the acreage reported in 1953. While some of the difference is due to improvement in survey techniques, much of it can be credited to fire protection and natural regeneration and some to tree planting. Restocking of badly burned-over areas in northern Minnesota has been accelerated during the past decade.

Note that the charts in figure 2 were prepared on semi-logarithmic paper. This facilitates showing both large and small acreages on the same scale and correctly pictures the rate of change.

The post-fire jack pine type is smaller in all survey units than it was a decade ago, while the white and red pine type has increased markedly in all districts. This follows the expected pattern since jack pine does not reproduce itself as well as red and white pine do. Tree planting in recent years has favored red pine.

"Other conifers" show a small but consistent gain in all the survey units. The oak type made a large increase in the Central Pine Unit but lost ground in southern and western Minnesota.

The charts in figure 2 indicate a large invasion in northern Minnesota by "other hardwoods." This is considered an unfavorable trend, since conifers are more desirable than the northern hardwoods, ash, and elm in northern Minnesota.

The sampling error for Statewide forest area statistics is estimated to be about ± 0.2 percent at one standard deviation.

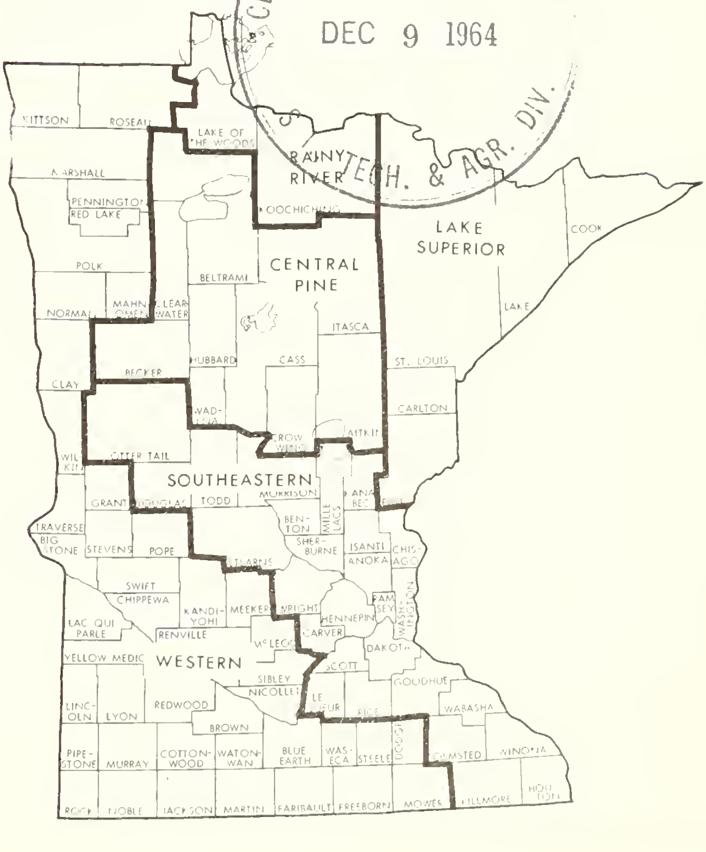

FIGURE 1. — Forest Survey Units in Minnesota.

MAINTAINED AT ST. PAUL 1, MINNESOTA, IN COOPERATION WITH THE UNIVERSITY OF MINNESOTA

Table 1.--Commercial forest land by forest cover types in Minnesota, 1962, by survey units and counties, with comparison to the 1953 survey given in parentheses[1]

(In thousand acres)

County	Total commercial forest land area[2]	Forest type[3]: White and red pine[4]	Jack pine[5]	Other conifers[6]	Oak[7]	Aspen-birch[8]	Other hdwds.[9]	Non-stocked[10]
LAKE SUPERIOR SURVEY UNIT								
Carlton	367	4	6	66	3	154	72	62
Cook	710	28	49	253	-	280	45	55
Lake	1,104	44	77	395	-	390	102	96
Pine	460	1	14	21	20	209	115	80
St. Louis	3,204	115	250	869	-	1,395	252	323
Unit total	5,845(-46)	192(+48)	396(-76)	1,604(+78)	23(+1)	2,428(+19)	586(+229)	616(-345)
Percent	100	3	7	27	*	42	10	11
CENTRAL PINE SURVEY UNIT								
Aitkin	851	4	4	158	39	255	240	151
Becker	386	12	26	20	58	146	97	27
Beltrami	993	22	57	226	13	316	184	175
Cass	1,006	58	78	87	78	497	112	96
Clearwater	368	6	16	38	12	175	78	43
Crow Wing	447	11	44	21	106	153	77	35
Hubbard	440	15	80	34	20	238	23	30
Itasca	1,412	52	55	326	12	629	239	99
Wadena	130	3	47	7	16	27	17	13
Unit total	6,033(-114)	183(+50)	407(-9)	917(+181)	354(+189)	2,436(+102)	1,067(+396)	669(-1,023)
Percent	100	3	7	15	6	40	18	11
RAINY RIVER SURVEY UNIT								
Koochiching	1,575	17	25	815	1	368	172	177
Lake of the Woods	528	4	21	185	1	108	76	133
Unit total	2,103(-16)	21(+14)	46(0)	1,000(+176)	2(+2)	476(+77)	248(+162)	310(-447)
Percent	100	1	2	47	-	23	12	15
SOUTHEASTERN SURVEY UNIT								
Anoka	62	2	-	6	10	20	15	9
Benton	27	*	-	-	8	5	11	3
Carver	24	-	-	-	5	2	15	2
Chisago	53	1	-	2	10	11	22	7
Dakota	34	-	-	-	12	3	12	7
Douglas	42	-	-	-	6	8	24	4
Fillmore	84	1	1	-	43	5	32	2
Goodhue	63	*	1	-	30	5	25	2
Hennepin	31	*	1	-	7	3	16	4
Houston	115	2	-	-	71	9	32	1
Isanti	51	3	-	3	12	12	15	6
Kanabec	155	-	-	1	36	82	24	12
Le Sueur	30	-	*	-	5	2	20	3
Mille Lacs	131	1	-	10	25	47	38	10
Morrison	200	*	3	15	44	64	54	20
Olmsted	48	-	-	-	30	4	13	1
Otter Tail	232	2	1	18	46	79	71	15
Ramsey	7	-	-	-	2	1	3	1
Rice	23	-	-	-	5	2	13	3
Scott	24	1	-	-	5	2	14	2
Sherburne	42	2	-	1	15	6	8	10
Stearns	78	1	*	2	24	14	28	9
Todd	128	1	2	11	34	40	34	6
Wabasha	52	-	-	-	24	5	20	3
Washington	27	1	-	-	6	3	15	2
Winona	96	2	-	-	56	9	27	2
Wright	42	-	-	-	10	3	26	3
Unit total	1,901(+35)	20(+14)	9(-7)	69(+38)	581(-263)	446(+71)	627(+148)	149(+34)
Percent	100	1	-	4	31	23	33	8

Table 1 (cont'd)

(In thousand acres)

County	Total commercial forest land area[2/]	Forest type[3/]: White and red pine[4/]	Jack pine[5/]	Other conifers[6/]	Oak[7/]	Aspen birch[8/]	Other hdwds.[9/]	Nonstocked[10/]
WESTERN SURVEY UNIT								
Kittson	94	-	-	1	2	82	6	3
Mahnomen	127	*	5	4	18	57	36	7
Marshall	152	-	-	11	4	123	10	4
Pennington	36	-	-	-	3	25	7	1
Polk	74	-	-	2	3	53	16	-
Red Lake	37	-	-	-	2	25	9	1
Roseau	271	2	22	27	2	83	56	79
Other counties	389	-	-	6	45	20	296	22
Unit total	1,180(-125)	2(+1)	27(-9)	51(0)	79(-72)	468(-12)	436(+38)	117(-71)
Percent	100	-	2	4	7	40	37	10
State total	17,062(-266)	418(+127)	885(-101)	3,641(+473)	1,039(-143)	6,254(+257)	2,964(+973)	1,861(-1,852)
Percent	100	2	5	21	6	37	18	11

1/ Changes by type since last survey are given only for state and unit totals. The changes for commercial forest land and nonstocked are based on 1953 statistics that were adjusted to a comparable basis with the new statistics. For the other types direct comparisons were valid.

2/ Forest land which is producing or capable of producing crops of industrial wood and not withdrawn from timber utilization. Forest tracts of less than 1 acre, and isolated strips of timber less than 120 feet wide are excluded.

3/ A classification of forest land based upon the predominant species in the present tree cover.

4/ Forests in which pine species predominate, with eastern white pine or red pine most common.

5/ Forests in which pine species predominate, with jack pine most common.

6/ Forests in which conifer species other than pine predominate.

7/ Forests in which oak and hickory species predominate.

8/ Forests in which quaking aspen, bigtooth aspen, and white birch predominate.

9/ Forests in which northern hardwoods species, lowland hardwoods species (including balsam poplar), or cottonwood predominate.

10/ Commercial forest lands less than 10 percent stocked with growing stock trees.

* Less than 500 acres.

(See next page for fig. 2)

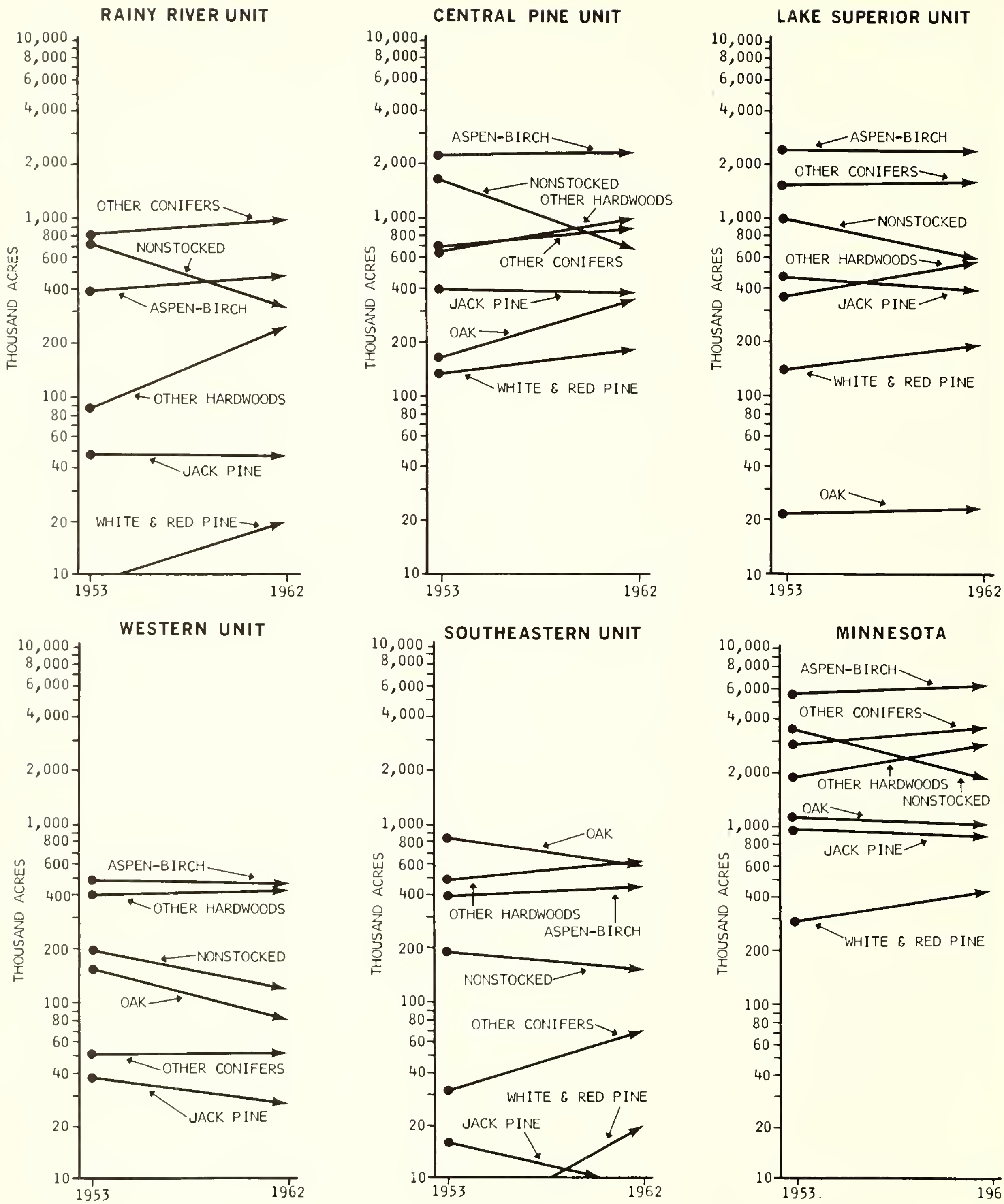

FIGURE 2. — Trends in area by forest cover types between 1953 and 1962. Charts (semi-logarithmic) cover the five Survey Units and the State as a whole.

October 1964

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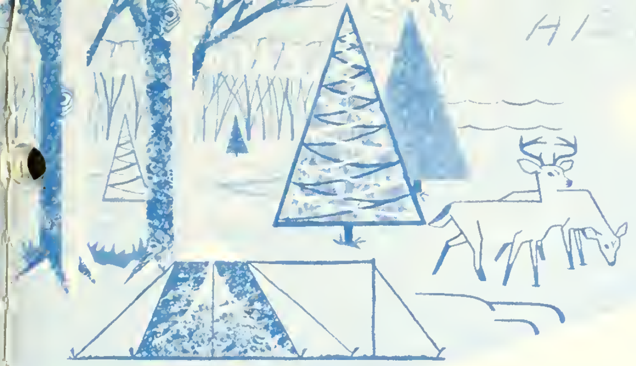

U. S. FOREST SERVICE

RESEARCH NOTE LS-56

LAKE STATES FOREST EXPERIMENT STATION • U. S. DEPARTMENT OF AGRICULTURE

The Susceptibility of Jack Pine and Lodgepole Pine and Their Hybrids to Sweetfern Rust and Eastern Gall Rust

The purpose of the study reported here was to determine the relative susceptibility of jack pine, *Pinus banksiana* Lamb.; lodgepole pine, *P. contorta* Loudon; and their hybrids to *Cronartium comptoniae* Arth., the sweetfern rust, and C. *quercuum* (Berk.) Miyabe ex Shirai, the Eastern gall rust. The sweetfern rust produces basal cankers on pine; its alternate hosts are sweetfern, *Comptonia peregrina* (L.) Coult., and sweetgale, *Myrica gale* L. The Eastern gall rust produces globose galls on pine, and its usual alternate host is red oak, *Quercus rubra* L., although occasionally bur oaks, *Quercus macrocarpa* Michx., are infected.

Since this study was completed, two additional species of *Cronartium* have been found to cause rusts on jack pine in this region. There is some question about the correct nomenclature for these two fungi at present. In this paper they are referred to by the binomial denoting their aecial stage. These are *Peridermium harknessii* Meinecke, which causes globose galls on pine similar to the Eastern gall rust,[1] and P. *stalactiforme* A. & L., which causes diamond-shaped cankers on the pine and has *Castilleja coccinea* L., the Indian paintbrush, and *Melampyrum lineare* Desr., cowwheat, as alternate hosts.[2]

So far as we were able to determine, these two rusts were not encountered in this study. The rust most likely to have been incorrectly identified is P. *harknessii,* which was later found near one of the test locations.

Lodgepole and hybrid trees were grown from seed obtained from the Institute of Forest Genetics, Placerville, Calif. The jack pine seed was obtained from the Nicolet National Forest, Wis. The seed lots are listed below:

Seed lot number	*Seed parent*	*Pollen parent*
10	*P. contorta*	*P. banksiana*
12	*P. contorta*	*P. banksiana*
15	*P. contorta*	Open pollinated
16	*P. banksiana*	Open pollinated

The seed was sown at the Hugo Sauer Nursery, Rhinelander, Wis.; and in the spring of 1953, seedlings 3 years old were transplanted at the following test sites: Pike Bay Experimental Forest, Cass Lake, Minn.; Argonne Experimental Forest, Three Lakes, Wis.; and near the Chittenden Nursery, Wellston, Mich.

The results are discussed by test areas:

Cass Lake, Minn.

Sweetfern was not present in or near the area. The sweetfern rust on the trees in this test was the result of infection in the nursery. No sweetfern rust branch cankers were found — a further indication that no infection had occurred after the trees were planted in the field. Approximately 5 percent of hybrids had sweetfern rust cankers on the main stem of the tree, whereas the jack pine were not infected (table 1).

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[1] *Anderson, G. W. The biology and control of some Cronartium rusts on jack pine. Univ. Minn. Ph. D. thesis, unpublished. 1963.*

[2] *Anderson, Neil A. Stalactiform rust on jack pine in Minnesota. Forest Sci. 6: 40-41. 1960.*

MAINTAINED AT ST. PAUL 1, MINNESOTA, IN COOPERATION WITH THE UNIVERSITY OF MINNESOTA

Table 1 — *Rust infections on jack pine, lodgepole pine, and their hybrids at Cass Lake, Minn.*

Item	Seed lot			
	10 Lodgepole pine X jack pine	12 Lodgepole pine X jack pine	15 Lodgepole pine	16 Jack pine
NUMBER OF TREES				
Total	98	76	8	78
Living but infected with sweetfern rust	2	0	0	0
Killed by sweetfern rust	3	5	0	0
Living but infected with Eastern gall rust				
On branches	20	9	1	4
On main stem	21	27	0	9
Killed by Eastern gall rust	2	0	1	0
PERCENTAGE OF TREES				
Infected with sweetfern rust	5.1	6.6	0.0	0.0
Infected with Eastern gall rust	31.6	42.0	25.0	15.4

The Cass Lake area was the only area where Eastern gall rust was present to any extent on the test trees (table 1). Various species of infected red and white oaks were present within 50 yards of the test site. Hybrid lots 10 and 12 had 32 and 42 percent of the trees infected with gall rust, while 15 percent of the jack pine, lot 16, were infected. Statistical tests comparing the number of galls on lots 10 and 16 and 12 and 16 were significant at the 1-percent level. No significant differences in susceptibility were noted between hybrid lots 10 and 12.

The results from this test planting indicate that local jack pine are more resistant to both the sweetfern rust and the Eastern gall rust than are the hybrid trees. There were too few lodgepole pine in this test to assess their resistance to the Eastern gall rust.

Three Lakes, Wis.

Sweetfern rust was the only rust of consequence in this area, as only one Eastern gall rust infection was found. A few scattered sweetfern plants were growing in the vicinity of the planting but not within the test area. In this test, nine branch cankers were noted, indicating that there had been some infection of trees after they were planted in the plots (table 2). Hybrid lots 10 and 12 had 4.9 and 3.2 percent of the trees infected with sweetfern rust, while the jack pine were free of rust.

This test did not indicate statistically significant differences in susceptibility of the hybrid lines as compared to the jack pine parent; however, the data indicate that the hybrids may be more susceptible than jack pine. The lodgepole pine appeared to be

Table 2. — *Sweetfern rust infection on jack pine, lodgepole pine, and their hybrids at Three Lakes, Wis.*

Item	Seed lot			
	10 Lodgepole pine X jack pine	12 Lodgepole pine X jack pine	15 Lodgepole pine	16 Jack pine
NUMBER OF:				
Trees	264	221	32	198
Stem cankers	7	1	5	0
Branch cankers	4	4	1	0
Trees killed	7	2	1	0
PERCENTAGE OF:				
Trees infected	4.9	3.2	21.8	0.0

more susceptible than either the hybrids or jack pine, but the numbers of lodgepole were limited.

Wellston, Mich.

Only the sweetfern rust was encountered here, and a higher percentage of trees was infected than in the other two areas. Sweetfern formed a dense ground cover on the test site, and apparently conditions were optimum for the rust. Thirty-nine branch cankers were found, which indicates field infection. Approximately 5 percent of the trees were infected when the plantation was established. From this initial amount of inoculum the disease developed until some seed lots were eliminated by the rust. Fifty-one percent of the trees from hybrid seed lot 10 and 29 percent of those of lot 12 were infected (table 3). The jack pine were free from disease. Although there were only seven lodgepole pine in this test, all had been killed.

Inoculation of jack pine seedlings indicates that first-year seedlings are more susceptible than older seedlings. When 2,121 seedlings 1 year old were inoculated with sweetfern rust, 16 per cent of the trees became infected. Inoculating 2- and 3-year-old seedlings resulted in less than 1-percent infection.[3]

Summary

The hybrid trees in this study were more susceptible to both sweetfern rust and Eastern gall rust than jack pine from a local source. Apparently this was true in both the nursery and the field. Only a limited number of lodgepole pine trees was included, but this species was very susceptible to sweetfern rust, and more susceptible to both sweetfern rust and Eastern gall rust than local jack pine.

In all three areas, more rust cankers occurred on the hybrid trees than on the jack pine of local origin. At one of the test areas only the hybrid trees had been severely damaged by the white-pine weevil, *Pissodes strobi* Peck. The hybrid trees were shorter but had darker green needles, a bushier growth habit, and thicker phloem tissue than local jack pine. The hybrids may have some

[3] *Anderson, Neil A. Studies on the effects of the Cronartium rusts on jack pine and the epidemiology of these fungi. Univ. Minn. Ph. D. thesis, unpublished. 1960.*

TABLE 3. — *Sweetfern rust infections on jack pine, lodgepole pine, and their hybrids at Wellston, Mich.*

Item	Seed lot				
	10 Lodgepole X jack pine	12 Lodgepole X jack pine	15 Lodgepole pine	16 Jack pine	Local[1]
NUMBER OF:					
Trees	51	49	7	47	42
Stem cankers	2	2	7	0	0
Branch cankers	24	11	0	0	0
Trees killed	0	1	7	0	0
PERCENTAGE OF:					
Trees infected	50.9	28.6	100	0.0	0.0

[1] *Jack pine seed from near Wellston, Mich.*

promise as Christmas trees, but they did not have the disease resistance, the form, and growth characteristic necessary to become good forest trees in the area tested.

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January 1965

U. S. FOREST SERVICE

RESEARCH NOTE LS-57

LAKE STATES FOREST EXPERIMENT STATION • U. S. DEPARTMENT OF AGRICULTURE

Seasonal Height Growth Patterns of Sugar Maple, Yellow Birch, and Red Maple Seedlings in Upper Michigan

Studies of the seasonal height growth patterns of tree species are common in the United States. Species of the northern hardwood type have been included in a few of these studies, but the height growth characteristics of northern hardwoods in Upper Michigan have not previously been reported. The results of observations in the latter area during 1959 and 1960 are presented here.

The study was conducted on the Upper Peninsula Experimental Forest, about 20 miles south of Marquette, Mich. The elevation is nearly 1,100 feet above sea level and about 450 feet above the level of Lake Superior, approximately 10 miles to the north.

Winter and summer temperatures contrast strongly. The average temperature for July is about 64° F., and the maximum for the summer is seldom higher than 90° F. The average January temperature is around 15° F., but readings of -20° F. are quite common. The average frost-free season is 93 days. The precipitation averages nearly 33 inches per year, and is distributed quite favorably, approximately 3 inches per month during the growing season. Annual snowfall averages about 100 inches per year.

Study Methods

Natural seedlings of yellow birch (*Betula alleghaniensis* Britton), sugar maple (*Acer saccharum* Marsh.) and red maple (*Acer rubrum* L.) were studied. These ranged from 0.8 to 4.6 feet tall, with 90 percent of them between 1 and 3 feet. Growth, in hundredths of feet, was measured on the dominant leader from the base of the bud scale scars to the tip of the terminal bud at approximately weekly intervals until elongation practically ceased. A final measurement was taken around the first of September.

In 1959, the study included birch under hardwood-hemlock stands of 30 and 90 square feet of basal area per acre and sugar maple under practically pure sugar maple stands of 30 and 125 square feet. In 1960, red maple was added to the study, and all samples were located in a partially-cut hardwood-hemlock stand containing about 90 square feet of basal area per acre.

Fifty seedlings (5 groups of 10) of each species under each stand condition were tagged for study. The maximum distance between any two seedlings of a group was 15 feet, and in most cases less than 10 feet. The shade conditions for groups within each stand were quite similar. All groups, regardless of stand density, received intermittent sunlight and shade during the day.

During the study a number of seedlings were lost because of injury to the growing tip, caused mostly by deer browsing and insect feeding. In 1959, 67 of the 200 seedlings tagged for study were damaged, and in 1960, 33 of 150. These seedlings are not included in the data presented here.

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Results

In 1959, sugar maple began growing around May 13. The seedlings in the open environment started growth a day or two later than those under the dense stand. The latter completed 90 percent of their elongation by May 31, a period of 18 days, but the seedlings in the open took about 24 days (fig. 1). In both environments shoot growth of the seedlings was nearly complete before the overstory trees were in full leaf. The average elongation was 0.22 feet in the open and 0.16 feet under the dense stand.

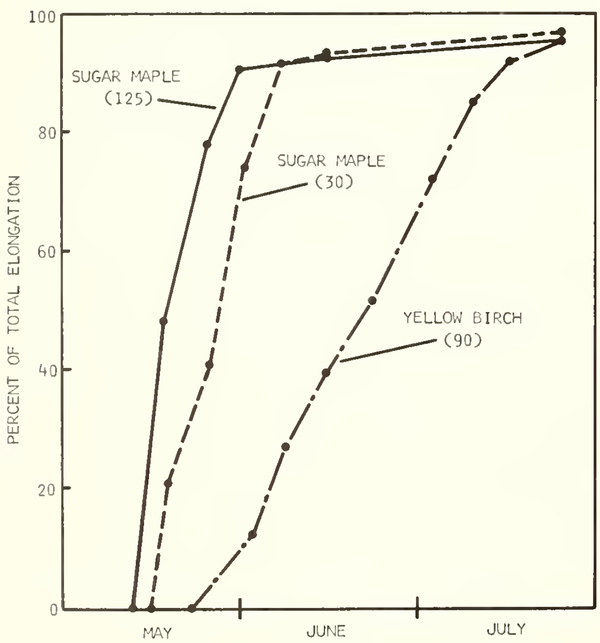

FIGURE 1. — *Seasonal height growth patterns, 1959. Stand density in square feet of basal area per acre of overstory trees is shown in parentheses.*

Yellow birch in 1959 broke dormancy about May 22, 9 days later than sugar maple. Again growth in the open commenced a day or two later than under the dense overstory. Under the dense stand the average elongation was 0.32 feet, and 90 percent of the growth was completed in 52 days. Data on the open stand are not available because deer clipped the faster growing seedlings. However, previous to the browsing in early July, the average height growth was greater under the open stand; apparently the birch would have shown the same trend as sugar maple — greater elongation and a later and longer growing period in the open.

Growth in 1960 began 5 days later than in 1959. Sugar maple commenced height growth around May 18, 2 days before red maple and 7 days before yellow birch (fig. 2). The average elongation, in feet, was 0.31 for sugar maple, 0.37 for red maple, and 0.66 for yellow birch. The growth period for sugar maple was very short, with 90 percent taking place in 17 days. That of red maple and yellow birch was more gradual, these species taking 54 and 62 days respectively to complete 90 percent of their growth.

The average height growth of both sugar maple and yellow birch under dense overstories was about twice as much in 1960 as in 1959. However, the growth patterns of each were quite similar both years (figs. 1 and 2). Furthermore, individual sugar maple seedlings showed quite uniform seasonal growth patterns even though the total elongation varied considerably. On the other hand, the growth patterns of individual red maple seedlings, even those growing side by side, showed outstanding differences. Some behaved like sugar maple with a short growing period, while others showed a slower acceleration and later climax similar to yellow birch. Seedlings which followed the latter course had the greatest elongation. Five red maples also had a second flush of growth after slowing down in early June. The most extreme example of second flushing grew as follows:

Date measured	*Periodic growth*	*Date measured*	*Periodic growth*
	(feet)		(feet)
May 25	0.16	July 6	0.39
May 31	0.23	July 14	0.41
June 9	0.05	Aug. 1	0.49
June 20	0.01	Aug. 11	0.05
June 27	0.37	Sept. 2	0.02
		Total	2.18

Note the second flush of growth after the June 20 measurement. The total growth dur-

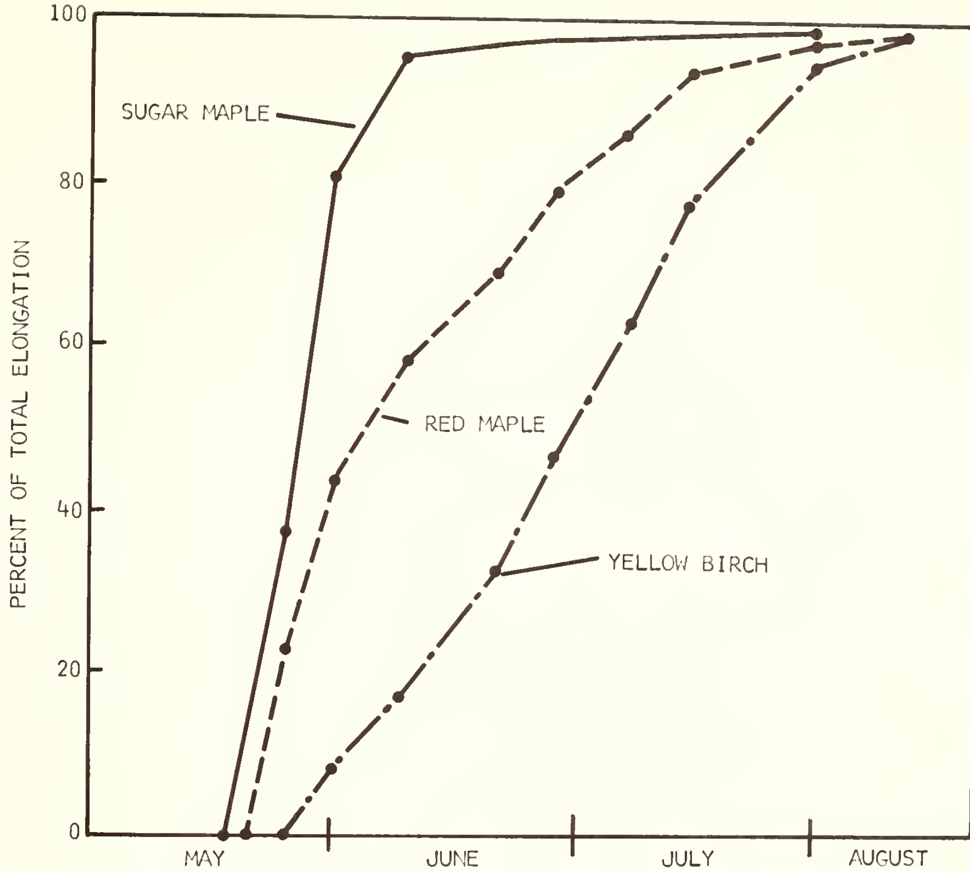

FIGURE 2. — *Seasonal height growth patterns in 1960 of seedlings growing under an overstory of 90 square feet of basal area per acre.*

ing the preceding month was quickly surpassed. The erratic growth of these red maple was not related to any apparent seedling characteristic or microclimatic factor. The seasonal courses of growth of individual yellow birch seedlings were not as uniform as those of sugar maple but considerably more so than red maple.

Discussion

There is little doubt that the sugar maple in this study made its current elongation according to the axiom that height growth of deciduous trees is made at the expense of prior-year rather than current photosynthesis. This species is putting on height growth as the leaves are unfolding, and the major portion is completed before the leaves reach full size. Kozlowski and Ward (3)[1] suggest that there may be a difference between deciduous species with regard to this phenomenon; that is, species that continue to grow all summer may begin growth using stored carbohydrates and sometime later may utilize the products of current photosynthesis. Yellow birch and red maple may follow this latter course, especially the red maples that showed the second flush of growth after practically ceasing elongation for about a 2-week period.

Although height growth is apparently controlled for the most part by heredity and only large fluctuations of the factors affecting the physiological processes will alter the seasonal patterns, the growth patterns among individual trees within a species may vary somewhat (4, 6). Kozlowski and Ward (4) found that the variations between individuals were much greater for some species than for others. The red maple of this study showed large individual differences, while the yellow birch patterns varied to a lesser extent. The patterns of the sugar maple seedlings, on the other hand, were much the same.

[1] *Numbers in parentheses refer to Literature Cited at end of Note.*

The growth patterns of the species at the Upper Peninsula Experimental Forest follow closely the patterns of the same species reported elsewhere. Kienholz (2), reporting on a number of species in Connecticut, found sugar maple made rapid early growth over a short period. The birches had a later acceleration and longer growing period; and red maple had a course midway between these species. Cook (1) and Reimer (5) also reported short growing periods in sugar maple. Kozlowski and Ward (3) in their study in Massachusetts, reported a similar pattern for sugar maple, but the growing period of their nursery-grown seedlings was nearly four times as long as the period in Upper Michigan, which is the shortest found in the literature.

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RESEARCH NOTE LS-58

LAKE STATES FOREST EXPERIMENT STATION • U. S. DEPARTMENT OF AGRICULTURE

Red Pine Needle Rust Disease in the Lake States

The needle rust (*Coleosporium asterum* (Diet.) Syd.) disease is widespread in the Lake States on young red pines. It is an inconspicuous disease that is easily observed for only 1 month (mostly June) of the year (fig. 1). It often kills the older needles, slowing growth and reducing Christmas tree values. Needle rust damage, when combined with insect injuries fatal to the new shoot, can kill young trees.

This Research Note summarizes conclusions from 3 years of research (Nicholls 1964). An article showing the experimental evidence is being prepared for publication in a technical scientific journal.

The Fungus and Its Hosts

Our observations, combined with a close study of the literature, suggest that there are at least three forms of needle rust in the Lake States. If there are several forms, this may explain the conflicting reports of host ranges in the literature (Hedgcock and Hunt 1922; Hedgcock 1916; Weir and Hubert 1916; Weir 1925).[1] Much more work will be required to clarify these host ranges.

The needle rust on red pine infects goldenrod, but not asters. Our inoculation tests have shown that jack pine and Austrian pine are also hosts to the red pine-goldenrod rust. The goldenrod we have most commonly used in our inoculation tests was *Solidago canadensis* L., but other goldenrods tested also became infected.

A second form, frequently found wild on bigleaf aster (*Aster macrophyllus* L.) has been successfully transmitted to cultivated annual asters, but it did not infect cultivated perennial asters or goldenrods. Its pine host remains unknown. The aster rust usually arrives late in the growing season, showing a few rare centers of infection that produce urediospores. These spread the rust rapidly over the Lake States, from aster to aster. A possible and intriguing explanation is that this is the western form of the rust (Hedgcock and Hunt 1922). It could be carried in by winds from the Western United States and overwinter occasionally on the rare, planted ponderosa pines of the Lake States. If this is Hedgcock and Hunt's western rust, then ponderosa pine would be a host. In 1962, ponderosa pines at Madison, Wis., were infected with needle rust, but none have been found since then — even when jack and red pines at the same site were heavily infected.

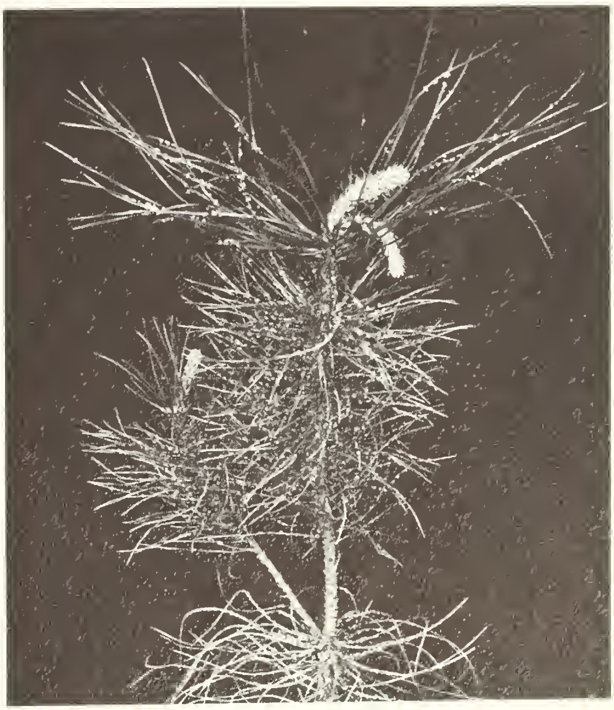

FIGURE 1. — Orange blisters on red pine needles in June are needle rust aecia. Three-year-old needles (bottom of picture) have the most blisters because they have been infected each year for 3 years. The fungus lives 3 years in the needle or until the needle dies.

[1] *Host range refers to the spectrum of plant species on which the fungus can grow.*

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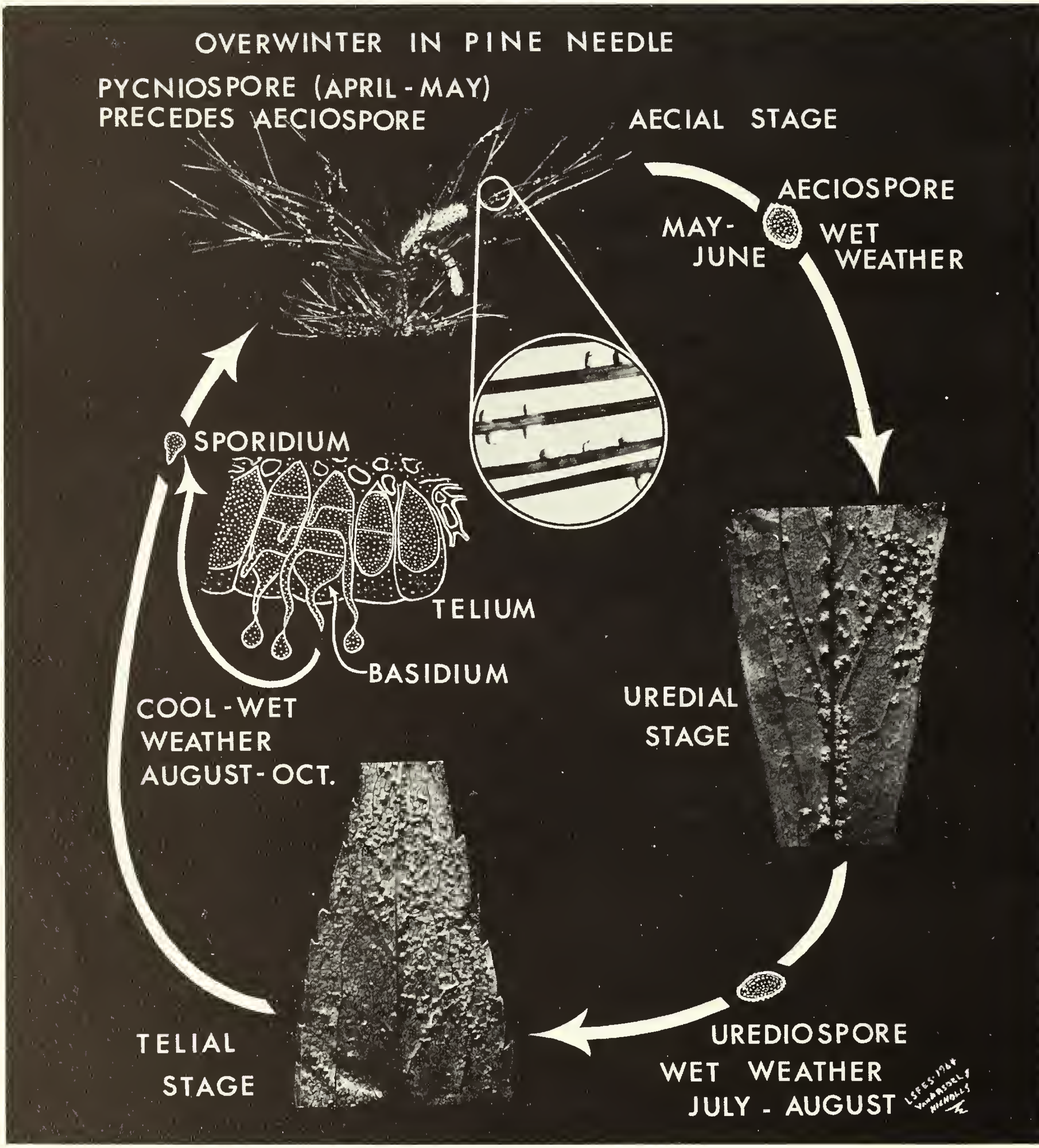

FIGURE 2. — Life cycle of *Coleosporium* on red pine and *Solidago canadensis* in the Lake States.

A third form of the rust was found in Madison, Wis., in 1961 on another species of goldenrod. This was successfully inoculated into perennial cultivated asters, but it would not infect annual cultivated asters. It infected certain goldenrods and certain asters, but not the same species that were infected by the other two forms of the rust. No pine host is known.

Coleosporium asterum (Diet.) Syd. is the name of all three forms of the rust, according to the current interpretation of the botanical rules of nomenclature (Arthur and Cummins 1962).[2] The western form of the rust (an aster rust) has larger spores than the goldenrod rust, according to Hedgcock (1916), but our Lake States aster rust has smaller spores than our goldenrod rust. We have observed a color difference between aster rust (whiter) and goldenrod (darker orange) where both hosts were growing in the same environment in the Lake States. The shapes of the urediospores differ slightly.

In our descriptions of the life cycle, environmental influences, and control possibilities, we will discuss only the red pine-goldenrod rust, which is the only life cycle we have followed through to date.

Life Cycle

The red pine-goldenrod rust must live on both pines and goldenrods and go through five spore stages to complete its life cycle. This takes 1 year. The life cycle with environmental requirements is summarized in figure 2.

Frosty-orange pycnial droplets occur on pine needles at the onset of warm weather during April and May.

Aeciospores appear on pine needles a month later, after cross fertilization of the pycnia (fig. 3 *left*). Aecia are enclosed in flat-topped columnar blisters (fig. 3 *right*) that are conspicuous for about a month in May and June. These rupture under wet conditions, releasing the orange aeciospores into the wind, which carries them to the goldenrod leaves.

The uredial stage appears 10 to 15 days after aeciospores infect the goldenrod (fig. 4). From June to August, windborne orange urediospores infect other goldenrods.

Infection of goldenrod by both aeciospores and urediospores requires wet weather (dew and other moisture) for 20 to 25 hours.

Telia start forming on goldenrod while uredia are still present on the same leaves. In cool (60° to 68° F.) wet weather of late summer or fall, teliospores produce orange-yellow sporidia in 10 to 12 hours. These are carried by the wind to pine. Since freezing kills teliospores, pine infection must occur before frost.

Needle rust lives through the winter in red pine needles and repeats the cycle the following spring. Since the rust is perennial in needles and needles usually persist at least 3 years, the rust can easily survive 2 consecutive years of unfavorable weather for spreading.

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[2] *Previously, the name approved by Arthur was* C. solidaginis (*Schw.*) *Thum.* (*Arthur 1934*).

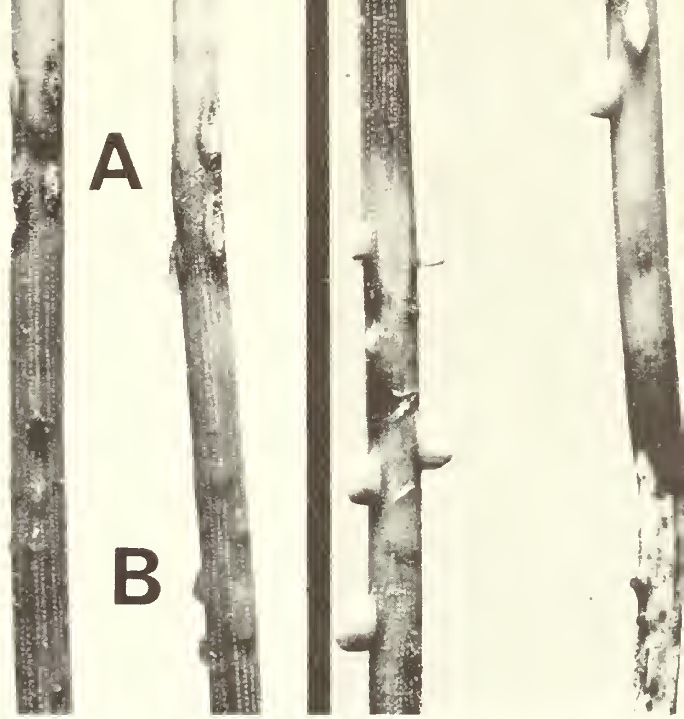

FIGURE 3. — *Left.* Two red pine needles at left show old aecial pits (A) and new pycnial droplets (B); the latter were produced by perennial growth of the fungus.
Right. Red pine needles with orange blisters containing aeciospores. Windborne aeciospores infect goldenrod under favorable conditions. Needle on right shows needle being killed by the fungus.

Possibilities of Control

Control of the disease is desirable in Christmas tree plantations and under conditions of severe infection. Four methods seem promising:

1. Preventing spore transport by —
   a. Avoiding planting sites with abundant goldenrods.
   b. Killing large concentrations of goldenrods in and adjacent to plantations with herbicides.
   c. Using plant barriers to change air currents between goldenrod and red pine as has been recommended for white pine blister rust (Van Arsdel 1961).
2. Protecting pines with fungicides during wet periods favorable to pine infection in late summer or fall. This is a promising method, but because of cost, it probably could only be applied in nurseries.
3. Reducing needle rust damage by avoiding microclimates that favor infection. Some applications follow:
   a. Herbicide applications in brushy, grassy, or weedy fields minimize local moist site conditions favoring infection, while killing alternate hosts. This elimination of brush competition also accelerates pine growth.

FIGURE 4. — *Solidago canadensis*, an important alternate host of the *Coleosporium* fungus. Inset shows a closer view of the uredia of the fungus.

b. Avoiding planting in small openings (diameter less than height of surrounding trees) keeps trees out of some of the areas that are wet and have much rust.

c. Also, avoiding any site where dew persists in the morning (such as west or north of a tree stand, on a steep west slope, or on or at the base of a steep north slope) reduces needle rust infection chances.

4. Selecting and breeding pines for resistance. This method is a possibility since some apparently resistant trees have been noted.

To summarize, useful control recommendations that we feel we can make with confidence are:

1. *Do not plant in small openings.*
2. *Do not plant just west or north of forest stands or bluffs.*
3. *Do not plant in brushy, weedy fields.*
4. *Kill brush and goldenrod in plantation areas with herbicides.*

Herbicide Recommendations

Some control of goldenrod can be obtained with 2,4-D spray on a hot, sticky day after the pine growth has hardened in late July or August. (Klingman and Shaw 1962).

Better control of goldenrod, brush, and grasses can be obtained in spring before widespread rust infection occurs. Use Dalapon, Amitrole, or Amizine when weeds are young, succulent, and actively growing.[3] General brush control is good with a 2,4-D and 2,4,5-T combination in early spring, but pine needles must be protected from spray.

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[3] *Personal communication. See Kuntz, J. E. Recommendations for weed control in forest plantations for the 1964 growing season. Wis. Conserv. Dept. Misc. Forestry Res. Rpt. 5. (Mimeographed.) 1964.*

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U. S. FOREST SERVICE

RESEARCH NOTE LS-59

LAKE STATES FOREST EXPERIMENT STATION • U. S. DEPARTMENT OF AGRICULTURE

Effect of Forest Litter on Growth of Hardwood Seedlings[1]

In the 1930's the Lake States Forest Experiment Station operated a series of large (20 feet long, 10 feet wide, 4 feet deep) lysimeters near La Crosse, Wis. The primary purpose of the experiments was to determine how different kinds of cover affected runoff, percolation, and soil loss in the Lake States' "Driftless Area," a region of flash floods and severe erosion. Detailed descriptions of the installation, treatments, and results were reported recently by Sartz.[2]

This paper reports on another aspect of the study: how forest litter affected tree growth on the lysimeters.

Stands of young hardwood trees were established by direct seeding on three of the lysimeters in 1934. The soil was a loessal silt loam (Fayette), and the species were red and white oaks (*Quercus rubra and Q. alba*) and black walnut (*Juglans nigra*). The seeds were planted just a few inches apart in rows spaced at only 16 inches. This spacing permitted 15 rows of trees per lysimeter. The upper five rows were white oak; the middle five, red oak; and the lower five, black walnut. This close spacing was used so that the trees would fully occupy the site as soon as possible. Throughout the experiment the trees were thinned whenever they began to crowd each other. The thinnings were chopped up and scattered over their respective plots.

In the spring of 1936 two of the three lysimeters were covered with a 2- to 3-inch layer of native oak leaf litter to simulate local conditions. The litter was replaced as needed to keep the cover uniform throughout the study. The third lysimeter was not mulched, but was allowed to accumulate litter from natural leaf fall.

Stand inventories were taken the fourth, fifth, sixth, and eighth years after seeding. The difference in growth rates between the mulched and unmulched trees — particularly height growth — was striking (table 1). In the fifth year after seeding (third year after the mulch treatment), the mulched black walnut, red oak, and white oak averaged 55 percent, 51 percent, and 40 percent taller, respectively. Differences in the eighth year were 42, 53, and 52 percent. However, the black walnut, which was ill-suited to the soil and site of the lysimeters, practically ceased growing after the fifth year, even on the mulched plot (table 1). Growth differences were also reflected in the thinnings. The mulched plots yielded more than twice as much material (air-dry weight) as the un-

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1 *Reported from the Station's field headquarters in La Crosse, Wis., where research is conducted in cooperation with the Wisconsin Conservation Department.*

2 *Sartz, Richard S. Water yield and soil loss from soil-block lysimeters. U. S. Forest Serv., Res. Paper LS-6, 21 pp., illus. 1963. Lake States Forest Expt. Sta., St. Paul, Minn.*

TABLE 1. — *Average diameter and height of mulched and unmulched trees*

Species and treatment	*Diameter*[1] *in inches at age of —*				Height in feet at age of —			
	4 yrs.	*5 yrs.*	*6 yrs.*	*8 yrs.*	*4 yrs.*	*5 yrs.*	*6 yrs.*	*8 yrs.*
Red oak								
Mulched	0.7	0.9	1.0	1.1	4.3	5.3	6.0	6.7
Unmulched	.6	.7	.8	1.0	2.8	3.5	4.2	4.7
White oak								
Mulched	.6	.8	.9	1.0	3.4	4.2	4.7	5.2
Unmulched	.6	.6	.7	.8	2.3	3.0	3.2	3.4
Walnut								
Mulched	.6	.6	.6	.7	2.8	3.1	3.2	3.2
Unmulched	.4	.4	.4	.5	1.8	2.0	2.2	2.1

[1] *At ground line.*

mulched plots — 18.2 and 8.5 pounds, respectively.

The faster growth probably resulted from a greater supply of available moisture: the amount of growing season infiltration averaged 3 inches more on the mulched plots.

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RESEARCH NOTE LS-60

AKE STATES FOREST EXPERIMENT STATION • U. S. DEPARTMENT OF AGRICULTURE

Relationships Between Night Breezes and Blister Rust Spread on Lake States White Pines[1]

This paper presents preliminary information on a new phase of research into the role of climate and microclimate in white pine blister rust spread. It is an amalgamation of several lines of evidence rather than a new field of study. A number of bits of evidence, such as spore transport by the countercurrents of drainage winds into swamps, forest edge breezes, and lake breezes, all hint at a larger scale picture in which certain characteristic night breezes seem to be functioning as carriers of spores from ribes leaves to white pines.

There is a body of available literature on how spore clouds disperse in winds and spread plant diseases. Such studies are mainly theoretical and are based on mathematical dispersion equations and balances between turbulent lifting and sedimentation, according to Stokes' Law of Rate of Fall. These theories, which emphasize turbulent lifting (Hirst 1959) and gravitational fall (Schrödter 1960) as the important parts of dissemination, apply more properly to day-released spores. Under daytime conditions, wind paths are not considered important in transmitting spores unless full account is taken of turbulent diffusion (Schrödter 1960).

Turbulent diffusion, however, does not disperse night-released spores to a great extent. I feel that tracing the paths of the spores themselves and the breezes that carry them is a realistic approach to the problems associated with spread of a disease whose spores are released under stable conditions.

Blister rust sporidia are released from the ribes plant at night, with a peak at 1 a.m. They are spherical and 10 to 12 microns in diameter. According to Potts (1946, 1959) in his insecticide aerosol work, this size is the lower limit of what can settle out in the air. Droplets less than 10 microns will not settle; those larger can although only those more than 25 microns will consistently settle. My own observations of blister rust spread indicate that sometimes sporidia settle; generally they do not.

A number of areas were discovered in which the pine hosts and the ribes hosts were not on the same soil types. These areas were used to observe historical rust spread. They were in sandy glaciated parts of the northern Lake States where pines grow on the sandy uplands, and the ribes are found in the organic soils in swampy potholes and lake margins. Since the white pine produces one whorl of branches each year, it was possible to date infections and see a complete history of when and where they occurred during the previous 20 years. These data permitted us to trace the paths of infection from particular ribes patches through nearby ribes-free pine stands.

Much of our evidence on the role of night breezes in the spread of rust is based on the correlation of these histories of infection and the breezes occurring in weather suitable for sporidial production, sporidial transport, and pine infection.

Swamp Edges

Observations of colored grenade smoke in cool northern Wisconsin highlands showed that thermal air currents, under temperature-inversion conditions, could explain rust distribution in nearby white pine.

Figure 1 illustrates this movement. The air on the slope is cooled by outward radiation and drains downslope into the swamp under the spruce-fir crowns. Since the tree crowns prevent outward radiation, the air is not cooled further. It is then lifted into the crowns as fresh supplies of even cooler air drain down from the open slope and slide under the warmer air beneath the trees. The reverse flow of air moves along the top of a shallow inversion layer from the crowns of trees in the swamp to the upland slope.

In our tests, smoke released in ribes-infested swamp edges under border tree crowns moved through the crowns and along the same circular path as smoke released on the open slope. Thus, these circulations could move spores from swamp ribes to hilltop pines.

In addition to the smoke patterns, there is evidence from the historical rust-spread data recorded on the pine trees. Swamp edges in northeastern Wisconsin generally have more blister rust present on the upland

[1] *Text of a paper presented at the Sixth National Conference On Agricultural Meteorology of the American Meteorological Society, Oct. 8-10, 1964, Lincoln, Neb. (Van Arsdel 1964).*

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FIGURE 1. — Smoke movements show air currents that match the spread of white pine blister rust from swamp ribes to upland white pines in northeastern Wisconsin.

pines away from the ribes than on pines near the ribes-infested swamp. The pattern is: little or no rust in small trees near the swamp, top rust in tall trees near the swamp, lower crown rust at a greater distance, and low rust on trees (including small ones) at the divide between swamps. Thus, rust-infection patterns indicated that spores moved in paths similar to those of smoke in the normal air circulation patterns found under inversion conditions.

Mountain Winds

Lloyd and others (1959), using silver-iodide tracers, traced winds down a mountain slope and onto a lake. At that point, an updraft elevated the tracers to a wind aloft that was blowing through a mountain pass and down the slope on the other side of the mountain. This movement matched the spread of rust from one side of the mountain range to the other.

Forest Edges

A number of tests, the first of which was reported at the New Haven Agricultural Meteorological Meetings in 1958, have shown that a specific air current relationship exists at the edge of a woods. Air flows close to the ground from the open area into the woods, up under the crowns in an updraft, and then back out into the open area. Rust spores travel in a warm backflow layer which extends from under the tops of the crowns out into the open, where a downdraft may eventually bring them down (Van Arsdel 1958).

For example, in a field in northeastern Minnesota, at the top of the divide from where the slope runs down to Lake Superior, we planted white pine trees in an open field surrounded by 35- to 45-foot aspens. These trees did not develop equal numbers of blister rust cankers. Those in the center of the field had 50 times as much rust as those near the edges.

A long area of heavy rust concentration in the center of the field paralleled the edges of the taller forests on two sides of the plot. Yet, alternate hosts were distributed throughout the field and the surrounding woods. The rust distribution in this field was just exactly what would be expected if the spores were all carried by air currents in two opposing cells going into the surrounding hardwoods (away from the center of the field), then up through the hardwoods and back to the center of the field where a downdraft occurred.

While we have not yet traced the air currents around this field with smoke, as we have done in some other areas, I feel that our eventual tests will show nighttime air currents matching the circulation cells I have hypothesized from the distribution of rust in the field.

Lake Breezes

We have stronger evidence that breezes developed near Great Lakes shorelines carry blister rust fungus spores. These 2-m.p.h. breezes develop as a result of the difference between the air temperatures over

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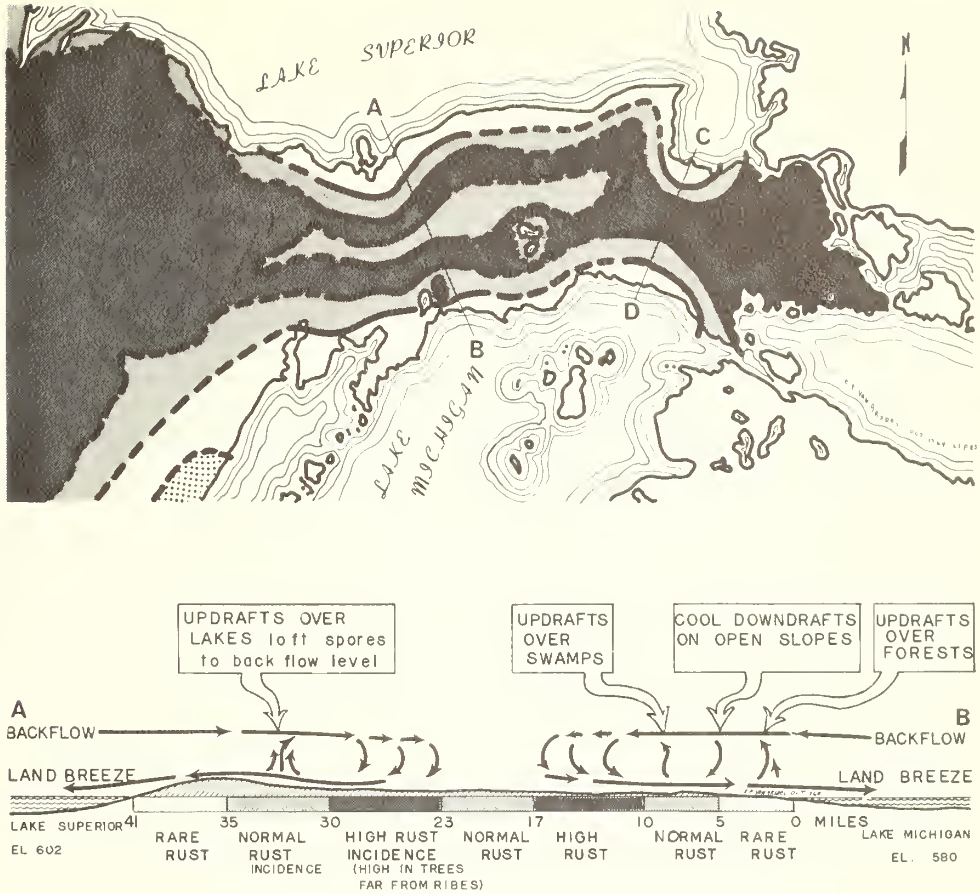
FIGURE 2.—Map (top) shows areas of types of blister rust distribution. Diagram (bottom) shows night land breezes and backflows that give this spread pattern. Shadings for rust spread zones are the same in the chart and map.



the land and the water. To test this theory, we conducted a study in the eastern part of Michigan's Upper Peninsula on the 40-mile-wide strip of land between Lakes Michigan and Superior (fig. 2). The following is a brief description of what we learned.

As the land gets cold at night, adjacent cooled air moves in a low, cold flow out over the warmer lake (see bottom portion of figure 2 for flow lines). Spores released on currant bushes less than 5 miles from the lake are usually carried out over the water by this breeze; thus pines near the lakes are seldom infected. Above this cold flow a reverse flow carries the warmer lake air back over the land. Local warm spots above the land area, such as those over swamps, forests, and small lakes, loft some spores to this backflow level. They ride the backflow to a strip 5 to 10 miles from the lake, where they are carried down by a downdraft. These spores infect pines both high in the crowns and as much as 5 miles from the nearest currant bushes.

While we have not traced the spores all the way along this path, we have watched the lake breeze and counter currents carry smoke and balloons along the way. We know the spores have 5 hours to move (before light kills them) in a 2-m.p.h. breeze, so they can go 10 miles. This movement just fits the pattern of rust infections that has occurred on the pines in the past 20 years.

Breezes around smaller lakes seem to carry spores in similar patterns. The principal evidence of this is the many cankers found in the tops of a belt of white pine trees at some distance from many of the lakes. Pines closer to these lakes and at a greater distance than this belt do not have many cankers in their tops. The distance of this heavily infected belt varies with the topography and is usually just short of the first high ridge back from the lake. The flows seem to be generated by downslope winds, which are reinforced by the temperature difference between the land and water. Downslope winds are carried out over the lake. Near the center of the lake they ascend to a higher level and return shoreward until they reach the belt near the top of the hill where pines are infected and the major downflow begins.

Land Divides and the Lake Superior Basin

In a variety of directions from Lake Superior's shores, surveys of blister rust infections show a greater amount of rust in the tops of trees at some distance from the lake than near the shore. On the flat land of eastern Upper Michigan the greater rust occurs in a zone about 12 miles from the lake. A great deal of high-crown rust is concentrated just north of the divide between the St. Croix River Valley and Lake Superior (southeast of Superior, Wis.). South of this divide, high-crown rust is rare or absent. Away from the north shore of Lake Superior and near the Laurentian Divide, there is a similar but less sharply defined distribution of much heavier rust; on the northwest side of the Divide there is less rust. The zone of high rust around the Lake Superior basin seems to indicate that rust sporidia released at night are being moved principally by nighttime circulations set up by downslope winds reinforced by lake breezes, and their countercurrents.

Other rust concentrations that occur west of Lake Superior along the Laurentian Divide through Itasca Park between the Mississippi Valley and Hudson Bay drainages suggest an interesting possibility: perhaps large-scale valley winds can influence rust distribution in somewhat the same manner as the lake breezes, although lakes are not involved.

Discussion

These lines of presumptive evidence, put together, suggest that there are important controlling breezes that spread the rust. Although we do not have the proofs, this mass of evidence indicates an area of productive research that we intend to follow vigorously. In future studies we plan to use silver-iodide tracers, wind tunnels, and tagged spores to complete the picture. Eventually, basic information on night winds and their relationships to rust spread may be applied in a practical way to help control this serious forest disease.

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July 1965

E. P. VAN ARSDEL
Principal Plant Pathologist

U. S. FOREST SERVICE

RESEARCH NOTE LS-61

LAKE STATES FOREST EXPERIMENT STATION • U. S. DEPARTMENT OF AGRICULTURE

The Importance of Fishing as an Attraction and Activity in the Quetico-Superior Area

How important is fishing as a Lake States recreational activity? Opinions on this point vary. Resort operators usually consider fishing their key attraction. Most of them believe that improved fishing is essential for improved business.[1] On the other hand, tourist industry consultants often advance the idea that the importance of fishing for resort success has been overestimated and recommend diversification of appeals and activities.[2] There is general uncertainty about what importance campers and other types of visitors attach to fishing.

Data concerning fishing in the Quetico-Superior area of northeast Minnesota and adjacent Ontario, collected as part of a broader study, may shed some light on this general question. These findings may also help to clarify the role of fishing as one of the area's recreational resources.

There are many possible ways of looking at the importance of fishing. Several of these viewpoints are represented in Table 1, which shows percentage responses of seven types of visitors to eight questions involving fishing. Responses to the first two questions (included in the table for completeness) and the sampling procedures have been previously reported.[3] Although one would expect fishing to be a particularly important recreation activity in this area, the data suggest that its importance varies considerably among types of visitors.

Variation in the role of fishing as an attraction, shown in the first three questions, was large. Motorized canoeists and boat campers, more than any other group, gave fishing as their reason for deciding to visit the Quetico-Superior area (Question A). Fishing was mentioned less often as a reason for choosing a particular spot within the area,

[1] *For example, in Wisconsin 63 percent of sample resort operators considered fishing the main attraction. "Stocking fish" was cited as a needed State action by 17 percent and was exceeded only by "more promotion." "Improving lakes" was mentioned by 5 percent, and ranked fifth. Source, I. V. Fine and Roy E. Tuttle, The Tourist Overnight Accommodation Industry in Wisconsin, Wis. Dept. of Resource Development, Madison, 1963.*

[2] *This view has been expressed at many meetings and in several newspaper reports. An example can be found in the Minnesota Tourist Travel Notes 2(1): 1, 1964. Also pages 65 and 66 of Sielaff, Richard O., The economics of outdoor recreation in the upper midwest, 330 pp., illus., Duluth: Univ. of Minn. Duluth, 1963.*

[3] *Lucas, Robert C., Recreational use of the Quetico-Superior Area, U.S. Forest Serv. Res. Paper LS-8, 50 pp., illus., Lake States Forest Expt. Sta., St. Paul, Minn., 1964. Also Lucas, Robert C., The recreational capacity of the Quetico-Superior Area, U.S. Forest Serv. Res. Paper LS-15, 34 pp., illus., Lake States Forest Expt. Sta., St. Paul, Minn., 1964.*

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Table 1.—Responses of seven types of Quetico-Superior visitor groups to eight questions concerning fishing, 1960-61[1,2]

Questions and selected answers	Canoeists		Day users (9)	Auto campers (96)	Boat campers (24)	Resort guests (57)	Private cabin users (21)
	Paddlers (64)	Motorized (21)					
	Percent of total						
A. "What characteristics of the area attracted you?" Visitors giving "fishing" as reason	16	67	33	29	48	42	14
B. "Why did you choose this lake or route?" Visitors giving "fishing" as reason	8	24	0	1	21	18	19
C. "Why did you choose to visit Canada?" (asked of those groups that did cross into Canada) Visitors giving "better fishing" as reason	7	50	0	0	33	57	33
D. "How much fishing did your group do?"							
None	8	5	33	12	8	2	5
Some	66	33	22	64	33	24	67
A lot	26	62	45	24	59	74	28
E. "What was your most important activity in the area?" Visitors naming "fishing"	8	33	44	30	46	72	43
F. "What (if anything) disappointed your group?" Visitors answering "fishing"	5	14	33	5	8	35	14
G. "What (if anything) did you particularly like?" Visitors answering "fishing"	8	33	0	1	0	9	5
H. Reaction to programs "to increase fish numbers"							
Good idea	70	78	100	59	67	78	88
Bad idea	12	12	0	12	9	8	0
Don't care	18	10	0	39	24	14	12

[1] *The differences between visitor types were tested by chi-square (except for questions C and G which did not have expected frequencies large enough to meet the requirements of the test). All were significant beyond the .001 level, meaning that there was less than one chance in a thousand that a sample of this size would produce differences this large by chance.*

[2] *Figures in parentheses are numbers of sample groups.*

but the same two groups still led in giving this response (Question B). At least half of the resort guests and motor canoeists who visited Canada based their decisions on expected fishing quality (C).

The reported amount of fishing done, in subjective terms (D), varied greatly. Resort guests reported the most fishing, car campers the least. Canoeists who used motors differed sharply from those who did not. Fishing was rated as "the most important activity" engaged in by almost three-fourths of the resort guests, but by less than a tenth of the paddling canoe-trippers (E).

Satisfaction with fishing was also uneven. Visitors were not asked directly how they liked the fishing, but they were asked free-response questions about disappointments and about things particularly liked. Fishing was not a common disappointment (F), except for resort guests and the small sample of day-users. Nevertheless, complaints about fishing outnumbered disappointments over facilities, cleanliness, crowding, etc. When asked if they particularly liked anything about the area (G), only motor canoeists commonly mentioned the fishing. Scenery, lack of crowds, and several other qualities received many more favorable mentions. Among resort guests, fishing drew only about one-fourth as many favorable mentions as unfavorable. All of the other visitor types seemed fairly well satisfied with the fishing, except perhaps for day-users for whom the sample was too small to permit a firm conclusion.

Management programs to improve fishing were generally favored, but not as universally as might have been expected (H). Auto campers were least approving. The most common reason expressed for disapproval was that such programs would attract more people—or the "wrong kind" of people, such as "fish hogs."

Resort guests showed interesting contrasts in their answers. Compared with several other types of visitors, fewer of them chose the area because of the fishing, but they fished more and were least satisfied. This would support the idea that improved fishing would benefit the resort business. But it would also uphold the view that some resort guests fish a good deal, perhaps more than they plan or desire, because of a lack of alternatives. Possibly advertising that heavily emphasizes spectacular fishing produces unrealistic expectations and leads to frequent disappointment. Thus, disagreements over fishing's role in the resort business seem to stem from looking at different aspects of the problem, at least in the Quetico-Superior area.

These conclusions apply only to the Quetico-Superior, which is atypical because of the wilderness qualities of the area and the relative magnitude of different types of visitors; but investigation might show broadly similar conditions in more typical areas.

July 1965

ROBERT C. LUCAS
Geographer

THE FOREST SERVICE CREED

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U. S. FOREST SERVICE

RESEARCH NOTE LS-62

LAKE STATES FOREST EXPERIMENT STATION • U. S. DEPARTMENT OF AGRICULTURE

Botanical and Commercial Range of Red Pine in the Lake States

Accurate maps showing the distribution of important tree species are valuable to foresters, botanists, wildlife specialists, land managers, and others. Although the general botanical ranges for our principal tree species have been well known for some time, new information continues to develop. Commercial ranges, however, have not previously been mapped very precisely, and artificial extensions of ranges generally have not been mapped at all. For these reasons, range maps of the principal Lake States forest tree species have been prepared[1] and that for red pine (*Pinus resinosa* Ait.) is presented here (fig. 1).

Accuracy depends in part on the scale of the map being used. On this map, it is not practical to separate out isolated stands except when they are some distance from the main range. Accordingly, the main range boundary is so drawn as to include several outliers near the edge of the principal distribution. To complete the southern portion of the range in the Lake States area, one verified outlier in Illinois has been shown.

In the silvical characteristics reports for Lake States tree species, commercial ranges were mapped but they were based on the following broad definition: "Commercial range is defined as the distribution of the species as a major or important component in the type, now or in the past, regardless of whether it is now being utilized." In this Note, commercial ranges are defined on a wood volume basis and are indicated for each county that presently has at least 1,000 cords of red pine (fig. 1). Counties with 10,000 to 99,000 cords and those with at least 100,000 cords of red pine are specially designated. The commercial range is based primarily on published reports of the Forest Survey, supplemented for completeness by unpublished data from the same source.

The map of botanical range is based on published reports[2] as modified by the observations of qualified foresters and botanists.[3] A supplemental map (fig. 2) shows the plots used in making the distribution map. These plots were derived from actual herbarium specimens or from other reliable sources.

Within its natural range in the Lake States, red pine grows most commonly on level to gently rolling, very well-drained, sandy soils or gravels, although it also occurs less frequently on rocky areas, occasionally on heavy soils, and rarely in swamps. It grows both in extensive pure stands and in mixture with a number of tree species, the most common of which in the Lake States are jack pine, paper birch, the aspens (quaking and big-tooth), eastern white pine, red oaks (northern red, black, and northern pin), balsam fir, and the spruces (white and black).

[1] *A report on jack pine has already been published in this series (U.S. Forest Serv. Res. Note LS-15, 1963).*

[2] *Fassett, Norman C. Preliminary reports on the flora of Wisconsin V. Coniferales, Wis. Acad. Sci., Arts, and Letters Trans. 25: 177-182, illus., 1930. Also, Rudolf, Paul O. Silvical characteristics of red pine, U.S. Forest Serv., Lake States Forest Expt. Sta., Sta. Paper 44, 31 pp., illus., 1958.*

[3] *Information in this Note has been reviewed by Dr. E. J. Little, Jr., U.S. Forest Service; Dr. Gene A. Hesterberg and staff members, Michigan Technological University; Dr. Thomas Morley, University of Minnesota; Dr. E. G. Voss, University of Michigan; and staff members of the National Forests in the Lake States, the Michigan Department of Conservation, the Minnesota Department of Conservation, and all Lake States Forest Experiment Station Divisions and field units.*

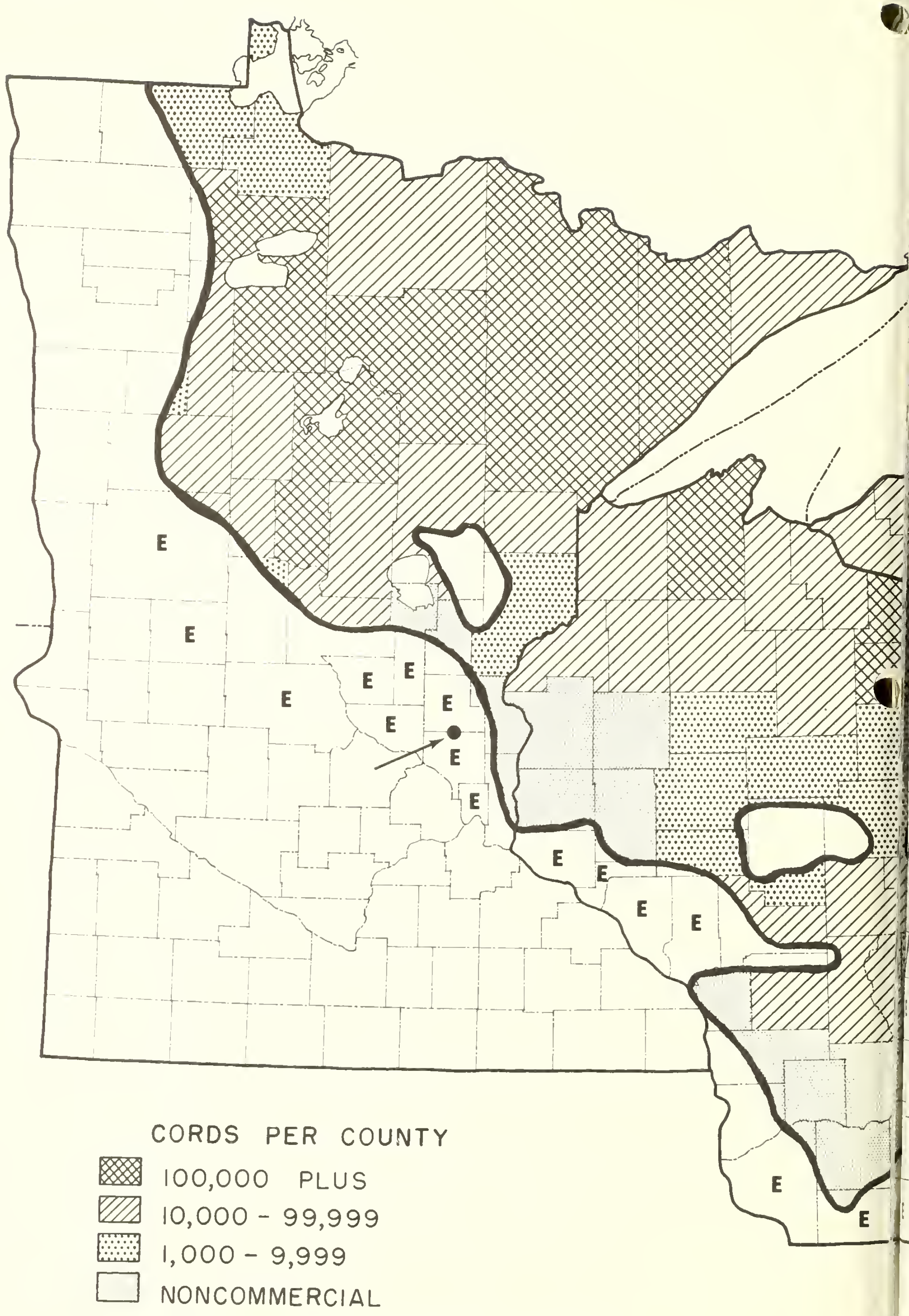
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FIGURE 1. — Botanical and commercial range of red pine in the Lake States. The botanical range includes the areas within the heavy line. Arrows point to isolated stands at some distance from the main range. The commercial range includes all counties within the botanical range that have at least 1,000 cords of red pine.

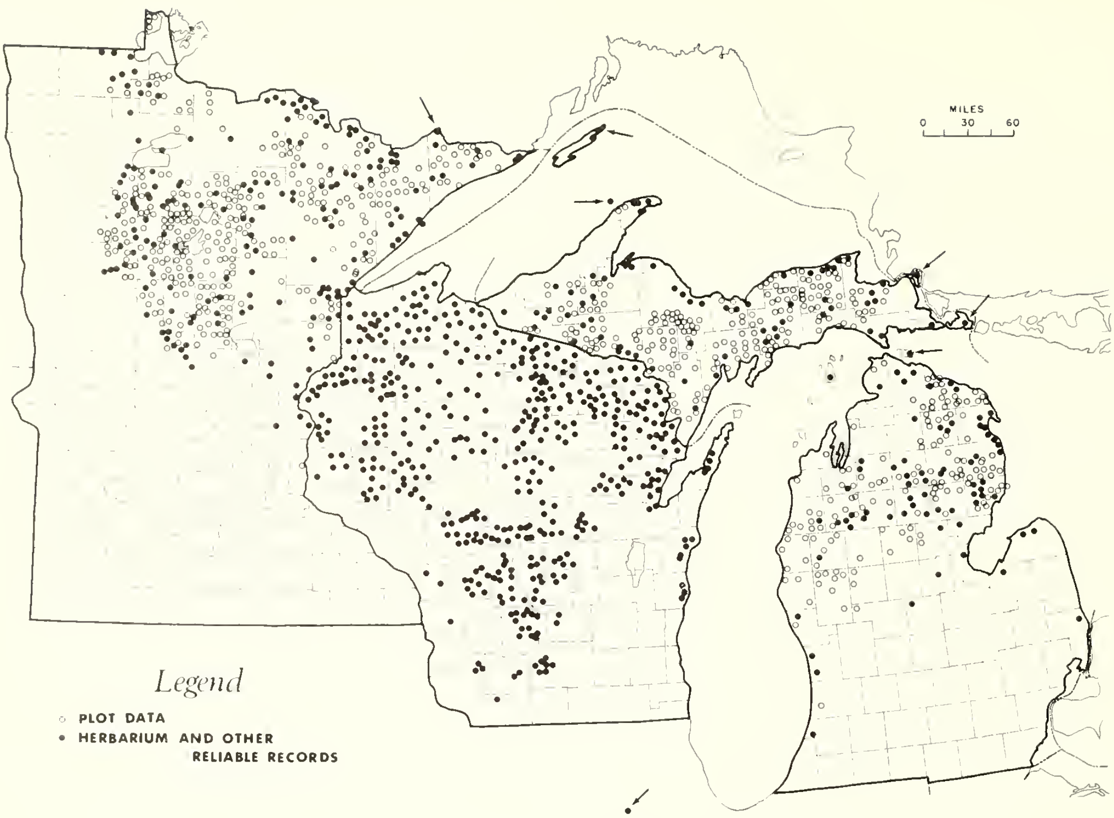

FIGURE 2. — Locations in which native *Pinus resinosa* is known to occur, according to herbarium and other reliable records based on identifiable plant material* or plot data. The latter were obtained from the Forest Survey, National Forest Timber Survey, State inventory plots, and cutting records.

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*Includes material from (1) the following herbaria: Cranbrook Institute of Science, Michigan State University, Milwaukee Public Museum, University of Michigan, University of Minnesota (Duluth), University of Minnesota (Minneapolis), University of Wisconsin (Madison), and University of Wisconsin (Milwaukee); (2) seed collection records of the Lake States Forest Experiment Station and Michigan State University; (3) superior tree records of the Lake States Forest Experiment Station; (4) seed production areas on record at the Lake States Forest Experiment Station; (5) a vegetational survey made by Dr. Egolfs Bakuzis of the University of Minnesota, and (6) Fassett 1930 (see footnote 2) for most of the Wisconsin locations.

The natural distribution of red pine is outlined on the map (fig. 1). Planting, however, is beginning to extend the range and eventually may blur the outlines of the natural range. Where planting has been extensive enough to develop at least 100 acres per county of established stand, it has appeared in Forest Survey statistics. Data were also obtained from nursery distribution records and other State forestry sources. Stands of this extent beyond the known botanical range are shown by an "E" in the counties involved. Planting within the botanical distribution may increase the commercial range.

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Lake States Forest Experiment Station
JOHN W. ANDRESEN, Head Department of Forestry, Southern Illinois University[4]

July 1965

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[4] *During the period when this paper was written, the second author was Associate Professor at Michigan State University.*

U. S. FOREST SERVICE

RESEARCH NOTE LS-63

LAKE STATES FOREST EXPERIMENT STATION • U. S. DEPARTMENT OF AGRICULTURE

Botanical and Commercial Range of Eastern White Pine in the Lake States

Accurate maps showing the distribution of important tree species are valuable to foresters, botanists, wildlife specialists, land managers, and others. Although the general natural ranges for our principal tree species have been well known for some time, new information continues to develop. Commercial ranges, however, have not previously been mapped precisely, and artificial extensions of ranges generally have not been mapped at all. For these reasons, range maps of the principal forest tree species have been prepared[1] for the Lake States (Michigan, Minnesota, and Wisconsin), and that for eastern white pine (*Pinus strobus* L.) is presented here (fig. 1).

Accuracy depends in part on the scale of the map being used. On this map, it is not practical to separate out isolated stands except when they are some distance from the main range. Accordingly, the main range boundary as drawn may include several outliers near the edge of the principal distribution.

In the silvical characteristics reports for Lake States tree species,[2] commercial ranges were mapped, but they were based on the following broad definition: "Commercial range is defined as the distribution of the species as a major or important component in the type, now or in the past, regardless of whether it is now being utilized." In this Note, commercial ranges are defined on a wood volume basis and are indicated for each county that presently has at least 1,000 cords of eastern white pine (fig. 1). Counties with 10,000 to 99,000 cords and those with at least 100,000 cords of white pine are specially designated. The commercial range is based primarily on published reports of the Forest Survey, supplemented for completeness by unpublished data from the same source.

[1] *Other published reports in this series are for jack pine (U.S. Forest Serv. Res. Note LS-15, 1963) and red pine (U.S. Forest Serv. Res. Note LS-62, 1965).*

[2] *See Lake States Forest Experiment Station, Station Paper 67, which includes a list of silvical reports.*

The natural range is based on published reports[3] as modified by the observations of qualified foresters and botanists.[4] A supplemental map (fig. 2) shows the plots used in making the distribution map. These plots were derived from actual herbarium specimens or from other reliable sources.

Within its natural range in the Lake States, eastern white pine grows most commonly on level to gently rolling, well-drained to excessively well-drained sandy soils, although it also occurs on heavier soils and less frequently on rocky areas or swamps. In the Driftless Area of southwestern Wisconsin and adjacent States, the outliers usually are found on steep, rocky slopes on acidic soils (commonly sandstone, and sometimes quartzite). It grows both in pure stands and in mixture with a large number of tree species, the most common of which in approximate order of frequency are the aspens (quaking and bigtooth), red maple, paper birch, balsam fir, white spruce, northern white-cedar, red pine, black spruce, sugar maple, and red oaks (mainly northern red, but also some black oak). Associates vary geographically and according to site conditions. For example, in Michigan, yellow birch and eastern hemlock are common associates in addition to the other species listed.

[3] *Fassett, Norman C. Preliminary reports on the flora of Wisconsin V. Coniferales, Wis. Acad. Sci., Arts and Letters Trans. 25: 177-182, illus., 1930. Also, Wilson, Robert W., Jr., and William E. McQuilkin. Silvical characteristics of eastern white pine. U.S. Forest Serv. Res. Paper NE-13, 28 pp., illus. 1963.*

[4] *Information in this note has been reviewed by Arthur W. Bloomer, Michigan Department of Agriculture; Drs. Edward Flaccus and Paul Monson, University of Minnesota, Duluth; Jacob Licke, Walker, Minn.; Dr. E. L. Little, Jr., U.S. Forest Serv., Washington, D. C.; Dr. Thomas Morley, University of Minnesota, Minneapolis; Lawrence Ritter, St. Paul, Minn.; Kenneth Robert, Wisconsin Department of Agriculture; Dr. E. P. Van Arsdel, Lake States Forest Experiment Station, and staff members at all field units of the Station; Dr. Edward Voss, University of Michigan; and staff members of all National Forests and Conservation Departments in Michigan, Minnesota, and Wisconsin.*

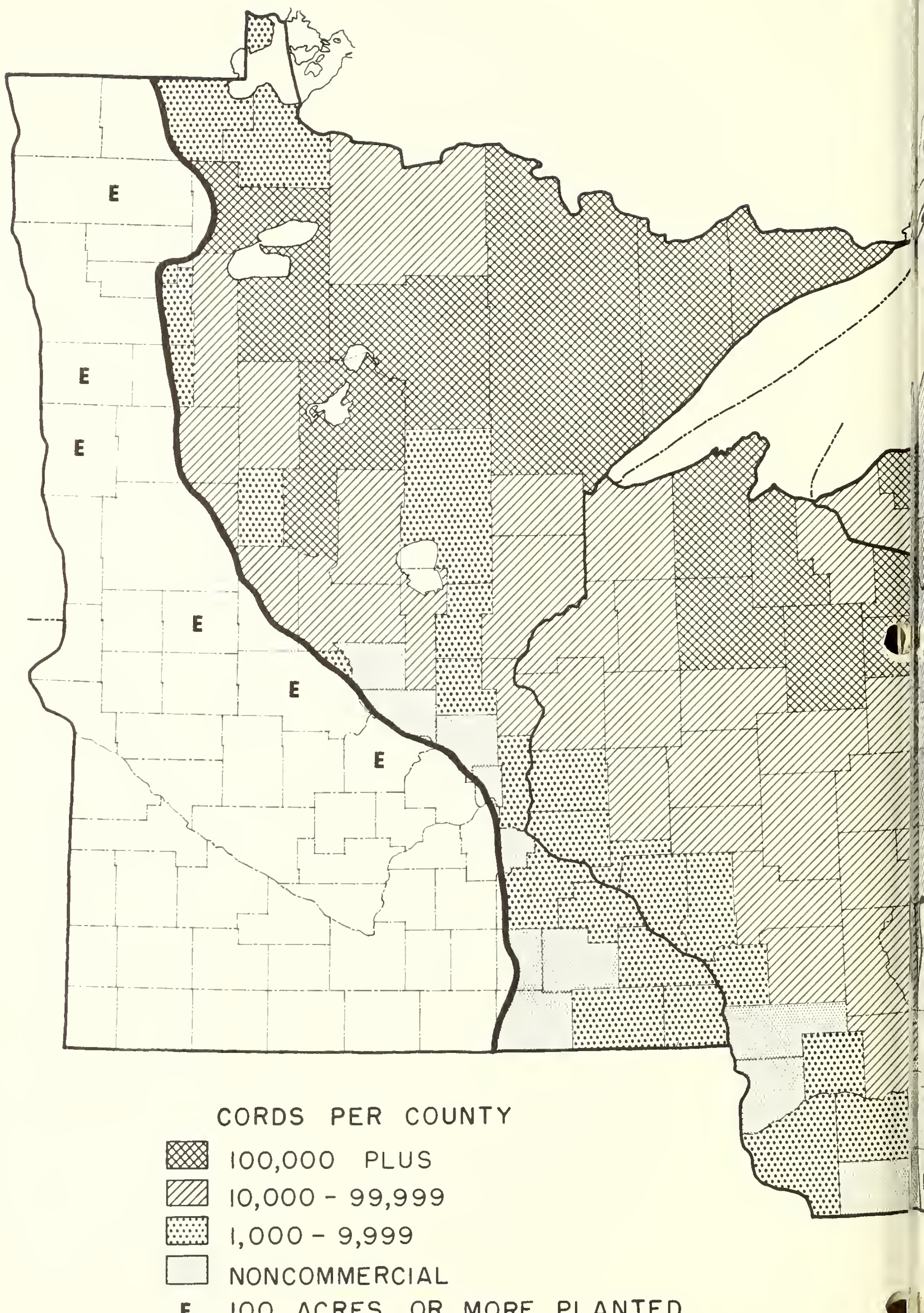
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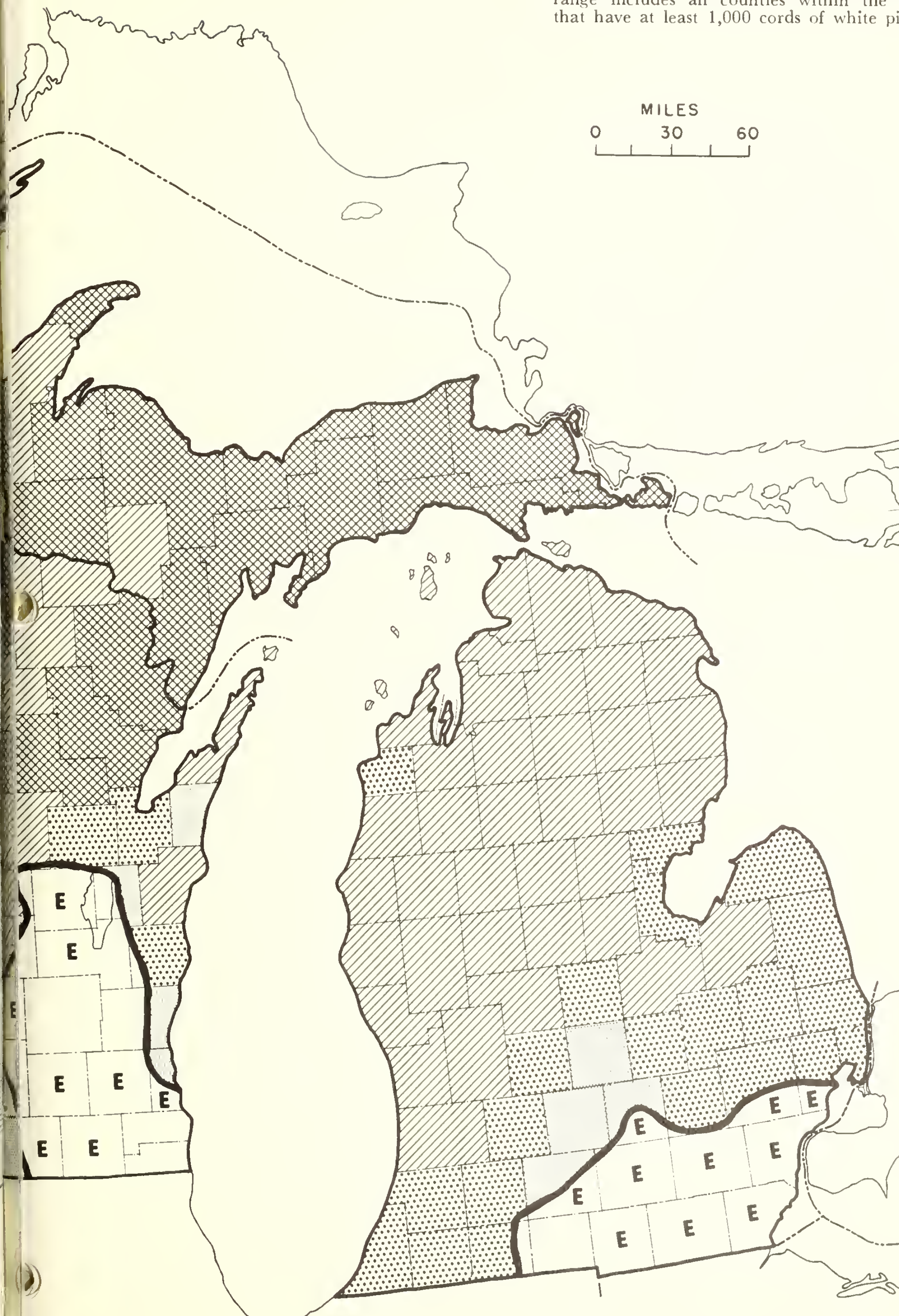
FIGURE 1. — Botanical and commercial range of eastern white pine in the Lake States. The botanical range includes the areas within the heavy line. The commercial range includes all counties within the botanical range that have at least 1,000 cords of white pine.



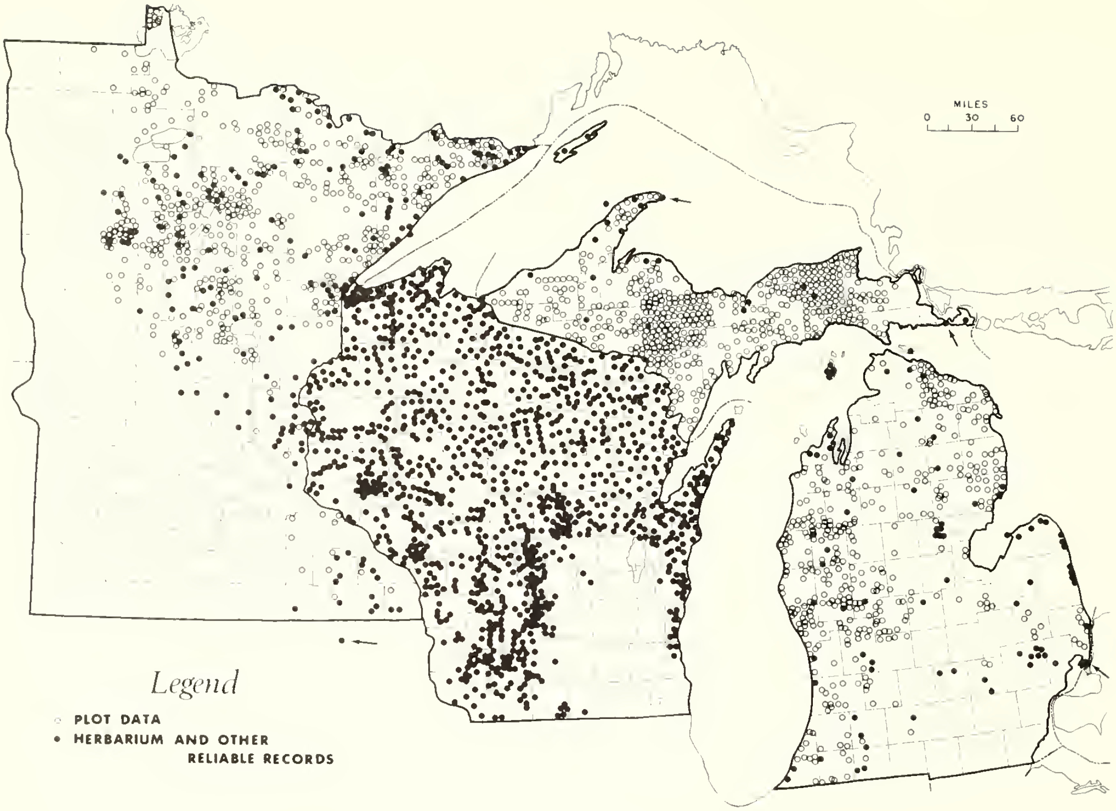


FIGURE 2. — Locations in which native *Pinus strobus* is known to occur, according to herbarium and other reliable records based on identifiable plant material* or plot data. The latter were obtained from the Forest Survey, National Forest Timber Survey, State inventory plots, and cutting records.

*Includes material from (1) the following herbaria: Cranbrook Institute of Science, Michigan State University, Milwaukee Public Museum, University of Michigan, University of Minnesota (Duluth), University of Minnesota (Minneapolis), University of Wisconsin (Madison), and University of Wisconsin (Milwaukee); (2) seed collection records of the Lake States Forest Experiment Station and Michigan State University; (3) superior tree records of the Lake States Forest Experiment Station; (4) seed production areas on record at the Lake States Forest Experiment Station; (5) a vegetational survey made by Dr. Egolfs Bakuzis, of the University of Minnesota; and (6) Fassett 1930 (see footnote 3) for most of the Wisconsin locations.

The natural distribution of eastern white pine is outlined on the map. Planting, however, is beginning to extend the range and eventually may blur the outlines of the natural range. Where planting has been extensive enough to develop at least 100 acres per county of established stand, it has appeared in Forest Survey statistics. Data have also been obtained from nursery distribution records and other State forestry sources. Stands of this extent beyond the known botanical range are shown by an "E" in the counties involved. Planting within the botanical distribution may increase the commercial range.

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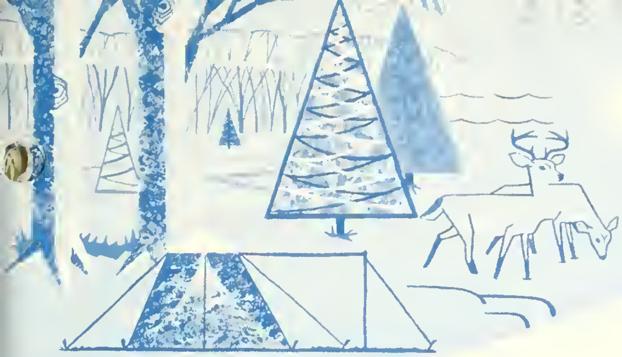
July 1965

[5] *While this paper was being prepared, the junior author was Associate Professor at Michigan State University.*



U. S. FOREST SERVICE

RESEARCH NOTE LS-64

LAKE STATES FOREST EXPERIMENT STATION • U. S. DEPARTMENT OF AGRICULTURE

A Test of Seeding Depth for Jack Pine and Red Pine

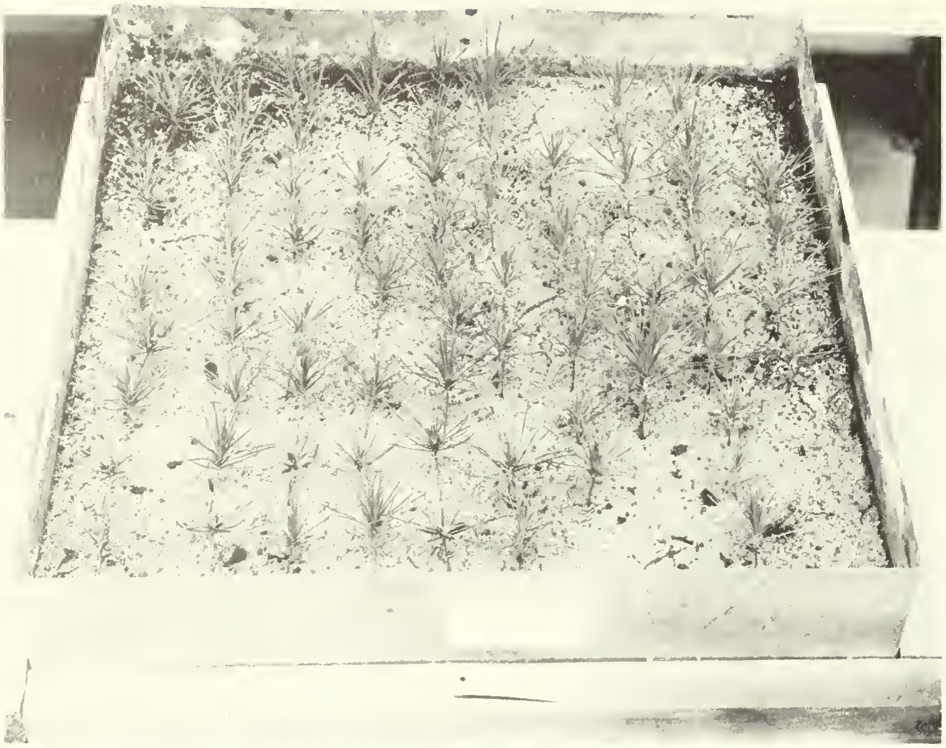
Direct seeding of jack pine (*Pinus banksiana* Lamb.) and red pine (*P. resinosa* Ait.) shows promise of being a successful regeneration technique in the Lake States (Roe 1963, Day 1964). Seedlings have been established on many small-scale trials when the seed was protected from birds and rodents and broadcast-sown on a prepared surface or spot-seeded on selected seedbeds. Direct seeding on larger areas, however, has not always been as successful—particularly with red pine.

Some of these variable results are undoubtedly caused by adverse environmental conditions, such as extreme fluctuations of temperature and moisture. Also, surface-sown seed is exposed to possible movement by wind and water. When the seed is covered with a thin layer of soil, it is better protected against the elements, and it has more moisture available for germination (Fraser and Farrar 1953, 1955). If the seed is planted too deep, however, severe losses will result (Stoeckeler and Jones 1957).

Optimum depth may vary under different growing conditions, but the critical depth (below which seedling establishment is sharply curtailed) is more consistent. A test of southern pines showed that optimum depth is slightly deeper in the field than in the greenhouse, but the critical depth is essentially the same in both places (Shipman 1963).

This study tested the effects of seeding depth on the germination and establishment of jack and red pine in a greenhouse. Groups of 50 seeds of each species were sown on one-square-foot seed flats (fig. 1) at depths of 0, 0.2, 0.4, 0.6, and 0.8 inch. The soil was a fine loamy sand. Each seeding depth was repeated four times in a completely randomized design. The seed was taken directly from cold storage (41° F.) and sown without pretreatment. Laboratory germination averaged 97 percent for jack pine and 87 percent for red pine.

The seed flats were maintained in the greenhouse for 50 days with temperatures ranging between 65° and 85° F. A photoperiod of 18 hours was provided by extending the natural daylength with artificial light. Surface-sown seeds, of course, were the only ones exposed to any substantial quantity of light during germination. Each seed flat received 0.5 inch of water on Mondays and Fridays to approximate the normal amount of precipitation in northern Minnesota during the growing season. Watering twice a week caused the soil surface to be alternately wet and dry, similar to conditions encountered in the field.



F-511486

Figure 1. — One-square-foot seed flats were sown with 50 red pine (left 5 rows) and 50 jack pine (right 5 rows) seed. The seeds in this flat were covered with 0.2 inch of soil. This resulted in the highest number of established seedlings for red pine. Jack pine seedling establishment here was not significantly better than that from seed sown on the surface.

Counts were made periodically to record the progress of germination and mortality and the total number of seedlings established. Germination of the surface-sown jack pine seed started in 5 days, red pine in 11 days. The 0.2-inch sowing depth delayed the appearance of the first seedlings an average of 6 additional days for both species. The 0.4-inch sowing depth added still another 4 days. At the 0.6-inch depth very few seedlings became established, and they were delayed an additional 3 days—an average of 13 days after the germination of surface-sown seed. Only one seedling (red pine) was established from seed covered with 0.8 inch of soil, and it appeared 31 days after the first surface-sown seed had germinated.

Seedling mortality, recorded as a percent of the viable seed sown, was low for all treatments. It averaged 5.5 percent for both jack and red pine seedlings originating from surface-sown seed. It was less than 2.5 percent for seed covered with 0.2 and 0.4 inch of soil and none was recorded for either species at sowing depths of 0.6 or 0.8 inch (but few seeds germinated when planted at the latter two depths).

The observed mortality was caused by damping off, but this does not account for total seedling losses. At the end of the test it was found that some of the seedlings from covered seed died before emerging from the soil. It is possible that those from deeply sown seed simply ran out of energy before they could emerge.

The average tree percents 50 days after sowing are shown in figure 2. Trend lines connect the averages and their 95-percent confidence intervals between seeding depths. At seeding depths of 0, 0.6, and 0.8 inch, where the confidence bands overlap, there is no significant difference between species. But at depths of 0.2 and 0.4 inch the mean tree percent was significantly higher for red pine than for jack pine.

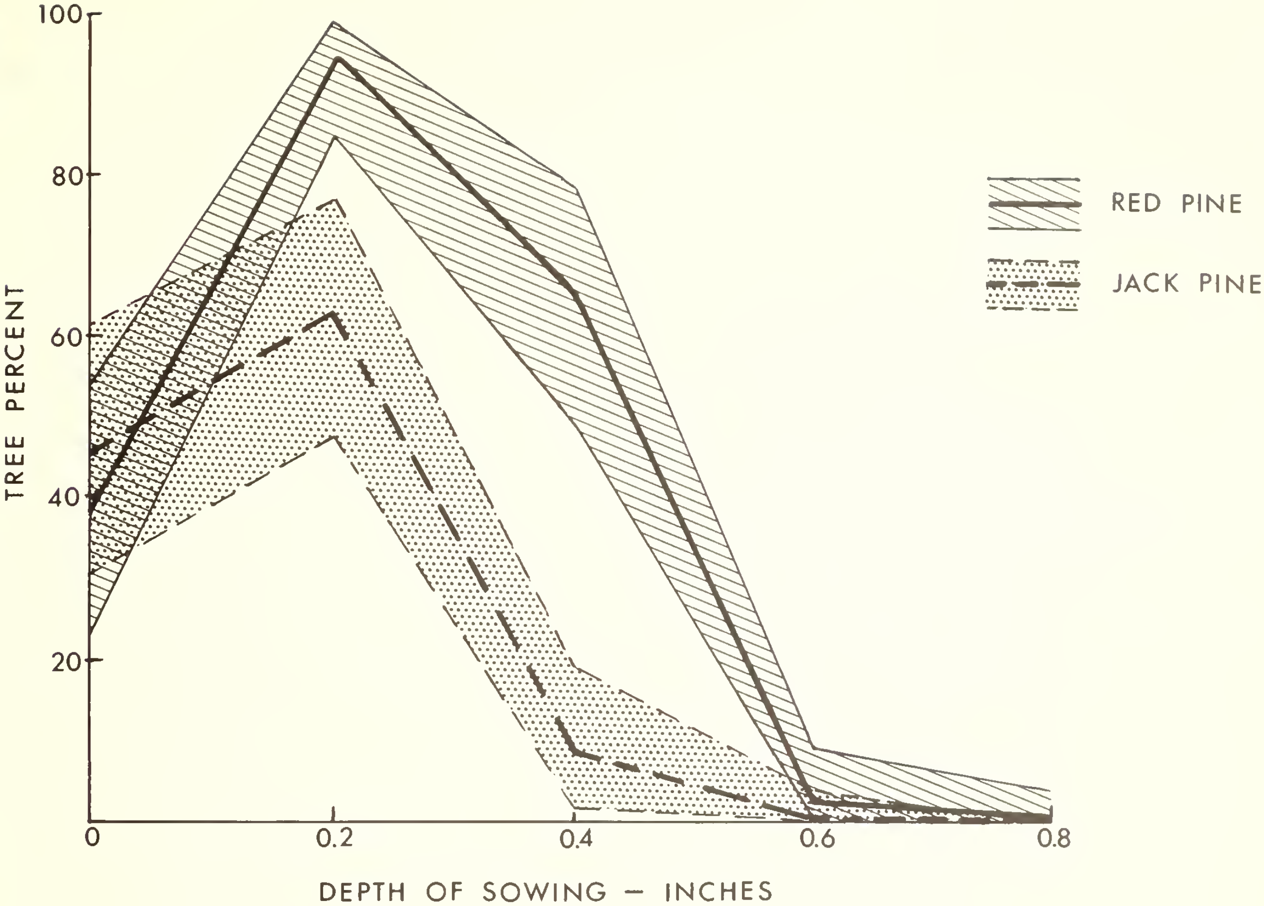


Figure 2.—Average tree percents and 95-percent confidence intervals for jack and red pine 50 days after sowing. Trend lines connect the means and their confidence limits between seeding depths. Depths where the confidence bands overlap indicate no significant difference.

Red pine tree percent increased from 38 when sown at the surface, to 94 when sown at a depth of 0.2 inch. The 0.4-inch depth resulted in an average tree percent of 65, not significantly higher than the 38 percent for surface-sown seed. Seeding depths of 0.6 and 0.8 inch failed, for all practical purposes.

Jack pine tree percent averaged 46 for surface-sown seed and 63 for a seeding depth of 0.2 inch, but the difference was not significant. A seeding depth of 0.4 inch proved to be very poor with an average tree percent of only 8. The 0.6- and 0.8-inch depths were essentially complete failures.

This study shows that critical seeding depth is between 0.4 and 0.6 inch for red pine and 0.2 and 0.4 inch for jack pine. Furthermore, it indicates that covering the seed may be very beneficial for red pine but is of questionable value for jack pine.

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July 1965

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U. S. FOREST SERVICE

RESEARCH NOTE LS-65

LAKE STATES FOREST EXPERIMENT STATION • U. S. DEPARTMENT OF AGRICULTURE

Lake States Pulpwood Production Levels Off–1964

The steady upward trend in Lake States pulpwood production so much in evidence in recent years faltered slightly in 1964. The total production was 3,628,000 cords, 1 percent less than the all-time high recorded in 1963. The slight drop was primarily due to a rather sizable decline of 60,000 cords in Wisconsin's pulpwood operations compared with 1963. Minnesota's cut, on the other hand, remained about the same, while Michigan registered a modest gain of about 25,000 cords.

Of the total pulpwood produced in the region, about 96 percent was roundwood; the remaining 4 percent was wood residues supplied by sawmills and other wood-using plants. Although residues, most of which had been chipped before shipment to pulpmills, were somewhat less than for the previous year, it is becoming apparent that the use of such material for pulping is likely to increase in each of the three Lake States.

Of all the species cut for pulpwood in 1964, only aspen, birch, and pine were cut in larger quantities than in the previous year. The aspen cut continues to climb; it accounted for nearly one-half of the total regional pulpwood cut in 1964, and in Michigan it accounted for more than 50 percent of the total pulpwood harvest. Species that declined the most were balsam fir, spruce, and hemlock—dropping 18, 4, and 4 percent, respectively.

Total 1964 pulpwood receipts at Lake States mills were approximately 4 million cords, a decrease of 2 percent from the previous year. Michigan and Minnesota receipts were up 7 percent and 2 percent, respectively, while those of Wisconsin were down 7 percent. Lake States forests supplied 90 percent of the pulpwood received, Canada 7 percent, and Western States 3 percent—very little change from last year (Table 1).

Table 1.—Geographic origin and destination of pulpwood received by Lake States mills, 1964

Species	Percent of pulpwood originating from:					Percent of pulpwood received by mills in:		
	Minn.	Wis.	Mich.	Canada	Other U.S.	Minn.	Wis.	Mich.
Aspen	26	35	39	*	—	26	49	25
Balsam fir	37	23	35	5	—	27	57	16
Birch	*	52	48	—	—	—	77	23
Hemlock	—	47	53	—	—	—	100	*
Pine	31	25	29	7	8	32	52	16
Spruce	47	4	13	36	*	29	59	12
Tamarack	60	25	15	—	—	—	100	*
Misc. hardwoods[1]	11	54	35	—	—	11	58	31
Residues	2	37	23	—	38	3	96	1
All wood material	26	31	33	7	3	23	57	20
Previous year (1963)	26	31	32	7	4	23	59	18

[1] *Mostly dense hardwoods.*
* *Less than 1 percent.*

Minnesota was the largest supplier of spruce, balsam fir, pine, and tamarack pulpwood; Wisconsin, the largest supplier of paper birch and miscellaneous hardwoods; Michigan the largest supplier of aspen and hemlock; and the Western States the source of most mill residues.

Table 2 on the reverse side shows pulpwood production by State and species, and imports and exports for the Lake States for 1964.

Table 2.—Production and imports of pulpwood, Lake States, 1964
(In standard cords, unpeeled)

Species and destination	Production by states 1/				Imports			
	Minnesota	Wisconsin	Michigan	Region	Other U. S. 2/	Canada	Total imports	Total receipts
Aspen								
Minn.	431,180	15,500	-	446,680	-	8,160	8,160	454,840
Wis.	19,487	585,959	249,334	854,780	-	-	-	854,780
Mich.	-	1,582	425,156	426,738	-	1,914	1,914	428,652
Total	450,667	603,401	674,490	1,728,198	-	10,074	10,074	1,738,272
Balsam fir								
Minn.	64,935	-	-	64,935	-	2,582	2,582	67,517
Wis.	25,112	57,382	56,225	138,719	-	-	-	138,719
Mich.	-	-	28,454	28,454	-	11,103	11,103	39,557
Exported 3/	37	-	275	312	-	-	-	-
Total	90,084	57,382	84,954	232,420	-	13,685	13,685	245,793
Birch, white								
Minn.	-	-	-	-	-	-	-	-
Wis.	254	41,215	20,050	61,519	-	-	-	61,519
Mich.	-	-	18,487	18,487	-	-	-	18,487
Total	254	41,215	38,537	80,006	-	-	-	80,006
Hemlock								
Minn.	-	-	-	-	-	-	-	-
Wis.	-	51,602	58,553	110,155	-	-	-	110,155
Mich.	-	-	10	10	-	-	-	10
Total	-	51,602	58,563	110,165	-	-	-	110,165
Pine								
Minn.	165,367	500	-	165,867	-	47,116	47,116	212,983
Wis.	38,462	167,097	90,328	295,887	54,499	-	54,499	350,386
Mich.	-	-	107,209	107,209	-	-	-	107,209
Total	203,829	167,597	197,537	568,963	54,499	47,116	101,615	670,578
Spruce								
Minn.	148,587	-	-	148,587	-	4,752	4,752	153,339
Wis.	95,677	19,601	49,589	164,867	491	148,598	149,089	313,956
Mich.	-	-	21,430	21,430	-	46,181	46,181	67,611
Exported 3/	11,989	-	889	12,878	-	-	-	-
Total	256,253	19,601	71,908	347,762	491	199,531	200,022	534,906
Tamarack								
Minn.	-	-	-	-	-	-	-	-
Wis.	12,102	4,956	2,920	19,978	-	-	-	19,978
Mich.	-	-	18	18	-	-	-	18
Total	12,102	4,956	2,938	19,996	-	-	-	19,996
Misc. dense hdwds.								
Minn. 4/	43,244	-	-	43,244	-	-	-	43,244
Wis.	257	214,057	18,867	233,181	-	-	-	233,181
Mich.	-	-	127,008	127,008	-	-	-	127,008
Exported 3/	1,150	8,175	-	9,325	-	-	-	-
Total	44,651	222,232	145,875	412,758	-	-	-	403,433
Total roundwood								
Minn.	853,313	16,000	-	869,313	-	62,610	62,610	931,923
Wis.	191,351	1,141,869	545,866	1,879,086	54,990	148,598	203,588	2,082,674
Mich.	-	1,582	727,772	729,354	-	59,198	59,198	788,552
Exported 3/	13,176	8,175	1,164	22,515	-	-	-	-
Total	1,057,840	1,167,626	1,274,802	3,500,268	54,990	270,406	325,396	3,803,149
Residues, softwood								
Minn.	-	-	-	-	-	-	-	-
Wis.	19	11,502	5,113	16,634	79,527	-	79,527	96,161
Mich.	-	-	-	-	-	-	-	-
Exported 3/	-	-	-	-	-	-	-	-
Total	19	11,502	5,113	16,634	79,527	-	79,527	96,161
Residues, hardwood								
Minn.	2,883	2,883	-	5,766	-	-	-	5,766
Wis.	1,791	53,540	36,979	92,310	-	-	-	92,310
Mich.	-	-	2,561	2,561	-	-	-	2,561
Exported 3/	-	8,369	2,000	10,369	-	-	-	-
Total	4,674	64,792	41,540	111,006	-	-	-	100,637
All wood material								
Minn.	856,196	18,883	-	875,079	-	62,610	62,610	937,689
Wis.	193,161	1,206,911	587,958	1,988,030	134,517	148,598	283,115	2,271,145
Mich.	-	1,582	730,333	731,915	-	59,198	59,198	791,113
Exported 3/	13,176	16,544	3,164	32,884	-	-	-	-
Total	1,062,533	1,243,920	1,321,455	3,627,908	134,517	270,406	404,923	3,999,947

1/ Vertical columns of figures under box heading "Production by States" present the amount of pulpwood cut in each State.
2/ Mostly Western States.
3/ Pulpwood shipped to mills outside of Region.
4/ Some balsam poplar and dense hardwoods in Minnesota, mostly dense hardwoods in other States.

July 1965

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Market Analyst

U. S. FOREST SERVICE

RESEARCH NOTE LS-66

LAKE STATES FOREST EXPERIMENT STATION • U. S. DEPARTMENT OF AGRICULTURE

Super-Spruce Seedlings Show Continued Superiority

White spruce (*Picea glauca* Moench.) seedlings, selected on the basis of superior nursery performance, have maintained their height growth advantage over average 2-2 nursery stock after 7 growing seasons in the field. The "super-spruce" also show less damage from late spring frost than the average stock.

In the spring of 1956, 357 outstanding 2-2 white spruce seedlings were lifted from the transplant beds of the Consolidated Papers Inc. nursery near Monico, Wis. The seedlings were originally grouped into 18-, 19-, and 20-inch classes and were about 1 foot taller than the average 2-2 seedling. Average seedlings from the same bed were randomly selected and paired with each of the outstanding seedlings. These 357 pairs were planted in a permanent test plantation on a nearby Consolidated Papers Inc. Experimental Forest.

Total height and height growth were measured at the end of the 1961 and 1962 growing seasons. At the time of the 1962 height measurements the presence or absence of 1962 frost damage to the terminal shoot was noted. In 1964, following a late spring frost, damage to all new shoots was scored. In the frost damage scoring each tree was assigned to one of five frost damage grades: Grade 1 with 0-20 percent of the new shoots damaged; Grade 2 with 21-40 percent new shoots damaged; Grade 3 with 41-60 percent damaged; Grade 4 with 61-80 percent damaged; and Grade 5 with 81-100 percent damaged.

Since differences between 18-, 19-, and 20-inch classes of "super-spruce" could not be shown, the three classes were grouped for the analyses. Results of all measurements are shown in table 1. Mortality as of 1962 is based on all 357 pairs, but height, height growth,

TABLE 1. — *Height, frost injury (275 living pairs), and survival (357 pairs) of super- and average spruce seedlings field planted in 1956*

Seedling group	Height 1963	Height growth 1961	Height growth 1962	Frost injury[1] 1962	Frost injury[1] 1964	Total mortality 1956-1962
	Feet	Feet	Feet	Percent	Percent	Percent
Super-spruce	3.80	0.64	0.62	11	56	16
Control	2.59	.49	[2].50 (.43)	20	66	12
Least significant difference at .01 level	.27	.06	.06	8	6	[3]

[1] *The 1962 data are the percent of trees with the terminal shoot damaged. The 1964 data are the average percent of all new shoots injured by the 1964 spring frost.*

[2] *Includes only trees with no 1962 damage to terminal. Number in parentheses includes all trees.*

[3] *No significant difference.*

and frost damage data are based on the 275 pairs in which both trees are living.

In 81 percent of the living pairs the selected "super-spruce" seedling was taller than the control, and the "super-spruce" as a group were more than a foot taller than the controls. Moreover, in both 1961 and 1962 the outstanding seedlings made greater height growth than the controls. This suggests that the "super-spruce" should retain their superiority for some time to come.

In 1962 twice as many control trees as selected trees showed frost damage to the terminal shoot. In 1964 the control trees also showed greater overall frost damage to all new shoots. Undoubtedly, this repeated frost damage will have an adverse effect upon tree form.

There are small negative but significant correlations between height and frost damage within both the "super-spruce" group ($r = -.59$ with 273 degrees of freedom) and the control group ($r = -.46$ with 273 degrees of freedom). There is no obvious explanation for these correlations. Perhaps both height and frost damage are related to a third variable such as date of flushing. This would require further investigation. It is clear from table 1, however, that the "super-spruce" do not owe their superiority to reduced frost damage. For even when the frost-damaged control trees are eliminated from height growth computations, the "super-spruce" are out-growing the controls.

In any event, the data indicate that selecting rapid-growing seedlings yields rapid-growing saplings and, whether this growth advantage is maintained or not, the selected seedlings should produce better formed trees through reduced frost damage.

October 1965

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U. S. FOREST SERVICE

RESEARCH NOTE LS-67

LAKE STATES FOREST EXPERIMENT STATION · U. S. DEPARTMENT OF AGRICULTURE

Alinement Chart for Numbers of Trees - Diameters - Basal Areas

The chart given here eliminates or simplifies many calculations involving relationships among numbers of trees, diameters, and basal areas.[1] If any two of these variables are known or can be estimated, the other can be found. This chart has many applications in forestry, both in the field and in the office. Some examples are given below.

Estimating Average Stand Diameters. — If the number of trees and basal area per unit of area are known (the unit of area can be an acre, a 10th-acre plot, or any other sized area), the diameter of the tree of average (mean) basal area can be simply estimated.

Place one end of a straightedge on the NUMBER OF TREES scale, for example 220 trees per acre, and the other end on the BASAL AREA scale, say on 90 square feet. The average diameter is read off the DIAMETER scale at the point where the straightedge crosses — 8.7 inches in this example.

Estimating Basal Areas. — If the number of trees of a given average diameter is known, their basal area is readily found. Aline the straightedge on the NUMBER OF TREES and DIAMETER scales and read off the BASAL AREA scale. The basal area for 400 trees averaging 6 inches in diameter is 78.5 square feet. Note that this same answer tells us that the basal area in 40 trees is 7.85 square feet; in 4 trees, 0.785 square feet. For the basal area of one 3.9-inch tree, find the basal area for 1,000 trees, 83 square feet, and divide by 1,000. Thus, one 3.9-inch tree has a basal area of 0.083 square feet. Any convenient number of trees can be used in this manner to find the basal area of a single tree or a group of trees of any diameter.

Estimating Diameter and Basal Area Growth. — If future values of any two variables can be estimated, then the third can be found. One use of this is to estimate stand diameter growth (the increase in diameter of the tree of average basal area). For example, after thinning a red pine stand to 90 square feet of basal area we have 220 trees averaging 8.7 inches in diameter. Over the next 10 years these 220 trees are expected to grow in basal area to 135 square feet, with no mortality. Thus, in 10 years the average diameter would be 10.6 inches (220 trees, 135 square feet), a growth of 1.9 inches.

Conversely, past ring counts may have indicated a future 10-year average diameter growth of 1.9 inches in this stand, from 8.7 to 10.6 inches. Knowing the present number of trees (220) would enable us to estimate the future basal area as 135 square feet if there is no mortality, a growth of 45 square feet (135-90).

This technique only approximates actual stand diameter and basal area growth. It applies best to stands with a narrow and even distribution of diameter classes, such as a well-spaced plantation.

Estimating Numbers of Trees To Be Cut In Thinning. — Another use of this chart is to estimate how many trees must be cut to thin to a given basal area (assuming a cut from above and below that does not change the diameter of the tree of average basal area by cutting). To illustrate, a stand averaging 10.6 inches in diameter with 220 trees and 135 square feet of basal area per acre is to be thinned back to 90 square feet. A stand with 90 square feet in 10.6-inch trees would have 147 trees. Thus, about 73 trees per acre would have to be cut to thin the stand back to 90 square feet.

Other applications of this chart may come to mind, but these examples illustrate its use in several problems commonly encountered in timber management.

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[1] *The formula used in constructing this chart was:*

$$BA = \frac{\pi}{144} \left(\frac{D}{2}\right)^2 N$$

$$BA = 0.005454\ D^2N$$

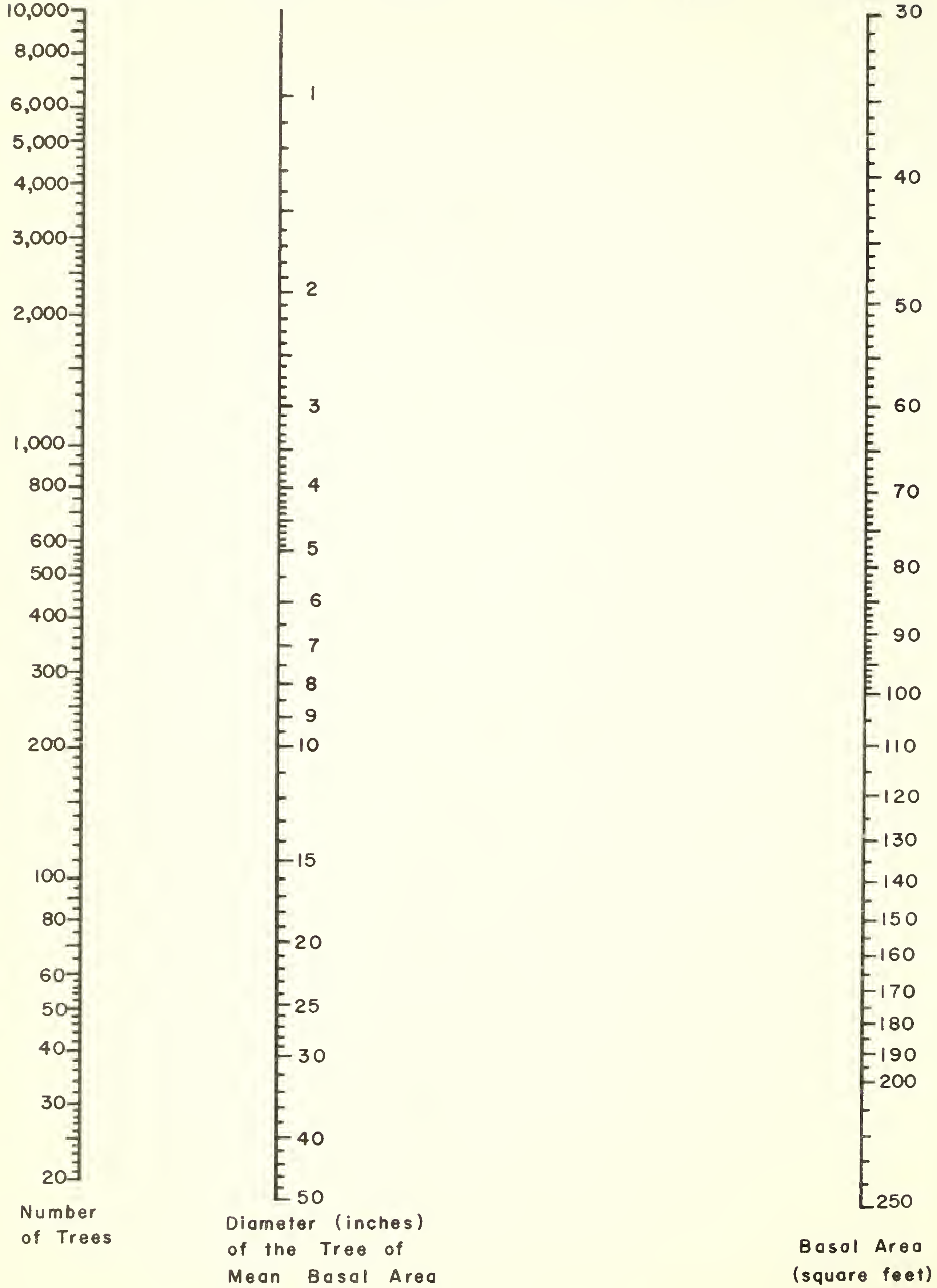
where BA *is total basal area in square feet,* D *is tree diameter breast high in inches, and* N *is number of trees on an area of known size.*

OCTOBER 1965

ALLEN L. LUNDGREN
Economist

MAINTAINED AT ST. PAUL 1, MINNESOTA, IN COOPERATION WITH THE UNIVERSITY OF MINNESOTA

NUMBER OF TREES - DIAMETER - BASAL AREA CHART



U. S. FOREST SERVICE

RESEARCH NOTE LS-68

LAKE STATES FOREST EXPERIMENT STATION • U. S. DEPARTMENT OF AGRICULTURE

Outdoor Recreation Surveys: Length-of-Stay Bias and Its Correction by Computer

Simple random samples of recreationists taken at recreation sites may not provide representative, unbiased estimates of visitor characteristics. This problem has been pointed out before, and a computational procedure to remove the effect of the bias has been suggested.[1] A computer program to make the adjustment is reviewed in this Note.

The bias arises in on-site surveys[2] because the probability that a camper, swimmer, or other recreationist will fall in the sample and be interviewed is a function of how long he is in the campground, near the beach, and so on. Campers who stay only 2 days, for example, are only one-tenth as likely to be sampled as campers who stay 20 days. Where activities or attitudes are the main interest, this sampling of *visitor-days* may be appropriate. If the survey is made to estimate characteristics of *visitors*, however, the summarized responses must be corrected for sampling bias.

Past recreation surveys carried out onsite have not been corrected for length-of-stay bias. This is unfortunate because uncorrected surveys overestimate length of stay and all factors associated with it. For example, we know that people who live farther from a site generally visit it less often but for longer periods than do local people. Thus an on-site sample of visitors overrepresents these more distant people, who may also be better paid, more educated, have different attitudes, spend more, and so on.

No completely satisfactory way of avoiding this bias in the original data collection is available.[3] Because the bias is a simple function of length-of-stay, however, correction for it is quite straightforward. If each interview is weighted by the inverse of the length of stay, the bias disappears.[4] This weighting

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1 *Lucas, Robert C. Bias in estimating recreationists' length of stay from sample interviews. Jour. Forestry 61: 912-914. 1963. The problem was also recognized in Standards for Traveler Studies, prepared by the Western Council for Travel Research, University of Utah, Salt Lake City, 1963, p. 23; but it was assumed that bias could only be corrected by arbitrary adjustments.*

2 *Redefining the population of interest by taking a sample from a registration list or at an area entrance or exit point avoids this bias since each recreationist can then enter the sample only once on each visit. If the target population is defined as visitors, other procedures are necessary, such as removing registrations on second and subsequent visits.*

3 *One possible way would involve first asking a respondent his intended length of stay, and then accepting or rejecting him for interviewing by some randomizing process proportionate to the inverse of his stay. Every tenth 10-day visitor could be interviewed, every fifth 5-day visitor, and so on. This would appear to work but it seems clumsy. Another would require taking a 100-percent sample (a census) of a part of the study area for a portion of the study period. This cluster sampling would be less sensitive to possible variation over time and area, however.*

4 *To be precise, the amount of time the recreationist is present during the period of the day on which sampling occurs should be used. A camper who arrives after dark and breaks camp early the next morning, for an extreme example, has zero probability of being interviewed in most surveys. However, this refinement is difficult to make in most situations, and appears to add little accuracy.*

scales down the overrepresented longer stays relative to the underrepresented shorter stays. Sampling with replacement is necessary; if a party falls in the sample a second time, it should be included — either by duplicating the previous interview or by reinterviewing. If it is desired to have the total number of observations after weighting be the same as the number in the original, unweighted data, a constant multiplier can be incorporated into the weighting factor.

While computing an average length-of-stay requires only a simple count of the observations for each possible stay, computing other sample characteristics that must be corrected for a length-of-stay bias involves tabulating the frequency of each response within each length-of-stay. As the number of possible responses to a question, the number of questions, and the number of interviews all increase, the mechanical procedures of listing and calculating by hand become overwhelming.

A computer program prepared at the Lake States Forest Experiment Station, designated LSWTFREQ, can more efficiently provide the type of information suggested above: weighted frequency distributions with weights determined by some critical variable, here the length-of-stay. In addition to specifying these weights, the program user can select another variable so that separate frequency distributions will be printed within each value of this "classification" variable. For example, the user might obtain a frequency distribution, corrected for a length-of-stay bias, of distances traveled for each of several recreationist income classes.

The program is general in that it can be applied to other sorts of weightings and other types of studies, provided the bias or required adjustment can be keyed to the value of some recorded characteristic of the sampled population. For example, this characteristic might be size of firm, acres of land owned, or distance from a market. In each case, the variable could be used to adjust for varying sampling intensities within the several strata defined by the values of this weighting variable.

The only critical programmed restriction is that only integer codes with a maximum value of 100 can be processed.[5] The program is written in FORTRAN 60, specifically for the CDC 1604 computer of the Numerical Analysis Center of the University of Minnesota. It can be used with minor modifications on most computers with the following characteristics:

(1) A FORTRAN 60 or FORTRAN II or compatible compiler capable of utilizing —
  (a) Two-dimensional arrays,
  (b) A variable data format (not in source program),
  (c) An input variable as the limit of an implied DO LOOP for reading the remainder of that input record;

(2) Core storage of 32,000 data words in addition to the compiler storage requirement.

A detailed description and listing of the program is available from the Biometrical Section of this Station.

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[5] *Measurements coded by alphanumeric or other multiple punch combinations must be changed to this form.*

October 1965

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U. S. FOREST SERVICE

RESEARCH NOTE LS-69

LAKE STATES FOREST EXPERIMENT STATION · U. S. DEPARTMENT OF AGRICULTURE

Yellow and Paper Birch Seeds Germinate Well After 4 Years' Storage

Little is known about the longevity of birch seeds, which are actually winged nutlets. Only a few studies have considered the storage life of yellow birch (*Betula alleghaniensis* Britt.) and paper birch (*B. papyrifera* Marsh.) seed. Storage at room temperature for 1 year resulted in decreased seed viability in both species.[1] After 18 months yellow birch seed lost all viability, while that of paper birch still germinated well.[2] However, most tree seed will retain its viability longer if it is stored at low temperatures. Redmond and Robinson reported that yellow birch seed stored at 32° F. remained viable after 27 months,[3] and storage of a single lot of yellow birch seed at 40° F. for 12 years resulted in 44 percent germination (original germination unknown).[2] The following results show that yellow and paper birch seed can be stored for at least 4 years without loss of viability.

Twelve seed lots each of yellow and paper birch were collected in the fall of 1960, dried at room temperature for a week or more, and stored in tightly closed bottles at 36° to 40° F. The germination of most lots was tested during December 1960 and January 1961. One hundred unstratified seeds from each lot were placed on moist Perlite in petri dishes and maintained in a greenhouse at about 70° F. for 30 days — the normal period used for birch germination tests. The second series of tests was performed during November 1964, four years after the seed was placed in storage. In 1964 the natural daylength was extended with fluorescent and incandescent light to 20 hours. Other test conditions were the same as before.

1 *Joseph, H. C. Germination and vitality of birch seeds. Bot. Gaz. 87: 127-151. 1929.*

2 *U. S. Forest Service. Woody-plant seed manual. U. S. Dept. Agr. Misc. Pub. 654, 416 pp., illus., 1948.*

3 *Redmond, D. R., and Robinson, R. C. Viability and germination in yellow birch. Forestry Chron. 30: 79-87. 1954.*

In 1961 germination of the yellow birch seed lots ranged from 5 to 84 percent with an average of 39.3 percent (table 1). Seed from only half of the trees germinated satisfactorily (30 percent or higher). In 1964 germination of the same lots ranged from 16 to 98 percent and averaged 60.6 percent, while seed from only two trees had less than 30 percent germination. Two seed lots (1899-5 and 1900-5) remained essentially unchanged, but seed of the other 10 trees had better germination than in 1961.

The nine paper birch seed lots tested in 1961 ranged from 1 to 58 percent germination and averaged 36.6 percent. Two of these lots (1903-1 and 1904) germinated very poorly, 1 and 6 percent respectively. After 4 years of storage, germination percentages for these nine lots ranged from 42 to 99 and averaged 78.4 percent. All lots of paper birch seed thus germinated better after storage than when fresh. The increase in germination varied with individual seed lots and was often substantial. The three previously untested lots all had very good germination in 1964.

The fact that none of these seed lots decreased, and most increased, in viability during the 4 years of storage is of biological significance and of practical importance to growers of birch planting stock. No definite reason for the increased germination was discovered, but the following circumstances may have had some effect. Seed of paper birch tree no. 1903-1 showed the largest increase in germination — from 1 to 86 percent. The seed was collected earlier from this tree than from the five other trees in the same stand and may not have been fully ripe at the time of collection. The storage allowed time for after-ripening of the seed and could have provided proper conditions for overcoming any embryo dormancy present in the seed. This could conceivably account for some of the increased viability of other lots as well. The long-day treatment the seed lots received in 1964,

TABLE 1. — *Germination percentage after 30 days; yellow and paper birch seed collected in 1960*

Yellow birch			Paper birch		
Tree number	Germination percent		Tree number	Germination percent	
	Jan. 1961	Nov. 1964		Jan. 1961	Nov. 1964
1899-1	21	33	1802-S[1]	58	79
1899-2	5	16	1802-N[1]	..	83
1899-3	15	46	1903-1	1	86
1899-4	10	55	1903-2	53	87
1899-5	84	87	1903-3	46	81
1900-1	70	81	1903-4	57	85
1900-2	81	98	1903-5	31	42
1900-3	61	72	1903-6	29	69
1900-4	49	85	1904	6	78
1900-5	24	26	1905	48	99
1900-6	21	63	1946-G[2]	..	76
1900-7	31	65	1946-T[2]	..	76
Average	39.3	60.6	Average	36.6	78.4[3]

[1] *Seed from two separate stems of same tree.*
[2] *Lot G collected from ground, lot T from tree itself.*
[3] *Averages of the 9 trees tested in 1961 and of all 12 trees are identical.*

but not in 1961, could also have increased the germination precentages, since long photoperiods are known to promote germination of unstratified birch seeds.[4]

[4] *Vaartaja, O. Photoperiodie response in germination of four speeies of* Betula. *Can. Dept. Agr., Forest Biol. Div., Bi-monthly Progr. Rpt. 15(3): 2. 1959.*

How much longer these seed lots will maintain their viability is unknown, but on the basis of these tests it appears safe to keep seed of yellow and paper birch for at least 4 years, provided the seed is stored in tightly closed containers at temperatures of 36° to 40° F.

October 1965

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RESEARCH NOTE LS-70

LAKE STATES FOREST EXPERIMENT STATION • U. S. DEPARTMENT OF AGRICULTURE

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Frost Penetration and Trafficability in Two Peats as Affected by Snowpack and Surface Mosses[1]

Unfrozen peat soils are notoriously poor surfaces for supporting vehicular traffic. In the Lake States, logging operations on peatlands are almost always delayed until winter; then light bulldozers snowplow temporary winter roads, so that they can freeze into hard roadbeds.

To follow the regime of peat-soil freezing and thawing under conditions of snowpacking and snow removal, as well as in undisturbed snow, two swamps about 6 miles south of Rhinelander, Wis., were selected for study during the winter of 1953-54. One was a shallow forested woody peat 1 to 2 feet deep; the other was a forested spaghnum peat 6 to 10 feet deep.

These swamp types, when not frozen, are non-trafficable for all conventional wheeled vehicles, and for all except very light tracked vehicles like weasels, bombardiers, and light crawler tractors.

Site Descriptions

The forested woody peat site had a thin mat of live surface mosses. Successive layers below this were 6 inches of coarse black peat, 6 inches of fine black woody peat, up to 18 inches of fine-textured dark brown peat, and finally a dark yellowish-brown, coarse, sandy soil. This site supported a heavy growth of black spruce 20 to 24 feet tall and tamarack 30 to 35 feet tall, with a scattering of white pine and alder near the edge of the swamp.

The forested sphagnum peat site was covered with a thick layer of coarse, undecomposed or only slightly decomposed sphagnum mosses to a depth of 18 to 24 inches. The surface cover included a growth of leatherleaf, blueberry, and Labradortea, and a scattered stand of stunted 3- to 8-foot-tall black spruce and 4- to 12-foot-tall tamarack.

The presence of shallow water tables, along with the capillary rise, is a factor that keeps peatlands soft and reduces their trafficability. It is also a factor that delays hard freezing. Water tables on selected dates during the winter 1953-54 varied as follows in number of feet below the surface at each site:

Forested woody peat		*Forested sphagnum peat*	
December 4	1.20	December 10	1.68
December 15	1.00	January 15	1.64
January 25	1.04	February 10	1.76
February 10	1.04	March 4	1.42
March 31	1.06	April 5	.62
April 9	.78	April 7	.00
April 23	.43	April 16	.00
April 28	.69	April 28	.20

Temperature Conditions

Average monthly air temperatures (mean of maximum plus minimum) in degrees Fahrenheit in standard Weather Bureau instrument shelters during the study period and the normal temperatures (based on Weather Bureau records to that date) were as follows:

Month	*During study period*	*Normal*
November	35.8	29.7
December	20.5	16.8
January	10.6	10.5
February	24.0	12.8
March	24.4	26.8
April	41.2	40.1
May	46.9	53.2

There were 165 days with freezing weather, and on 31 days the temperature dropped to 0° F. or lower. Cumulative degree days below 32° F. were as follows on the first and sixteenth of each month:

Month	*1st of month*	*16th of month*
December	74	185
January	435	741
February	1,093	1,254
March	1,327	1,515
April	1,608	1,532

The peak of degree days of cold was 1,662 on April 4; by April 30 thawing had progressed so far that the value for degree days was only 1,358.

[1] *Credit is due John L. Thames, Robert Tobiaski, and Edmond I. Swensen of the U.S. Forest Service for assistance in some field aspects of this study and to the Waterways Experiment Station, U.S. Corps of Engineers, Vicksburg, Miss., for financing part of the study.*

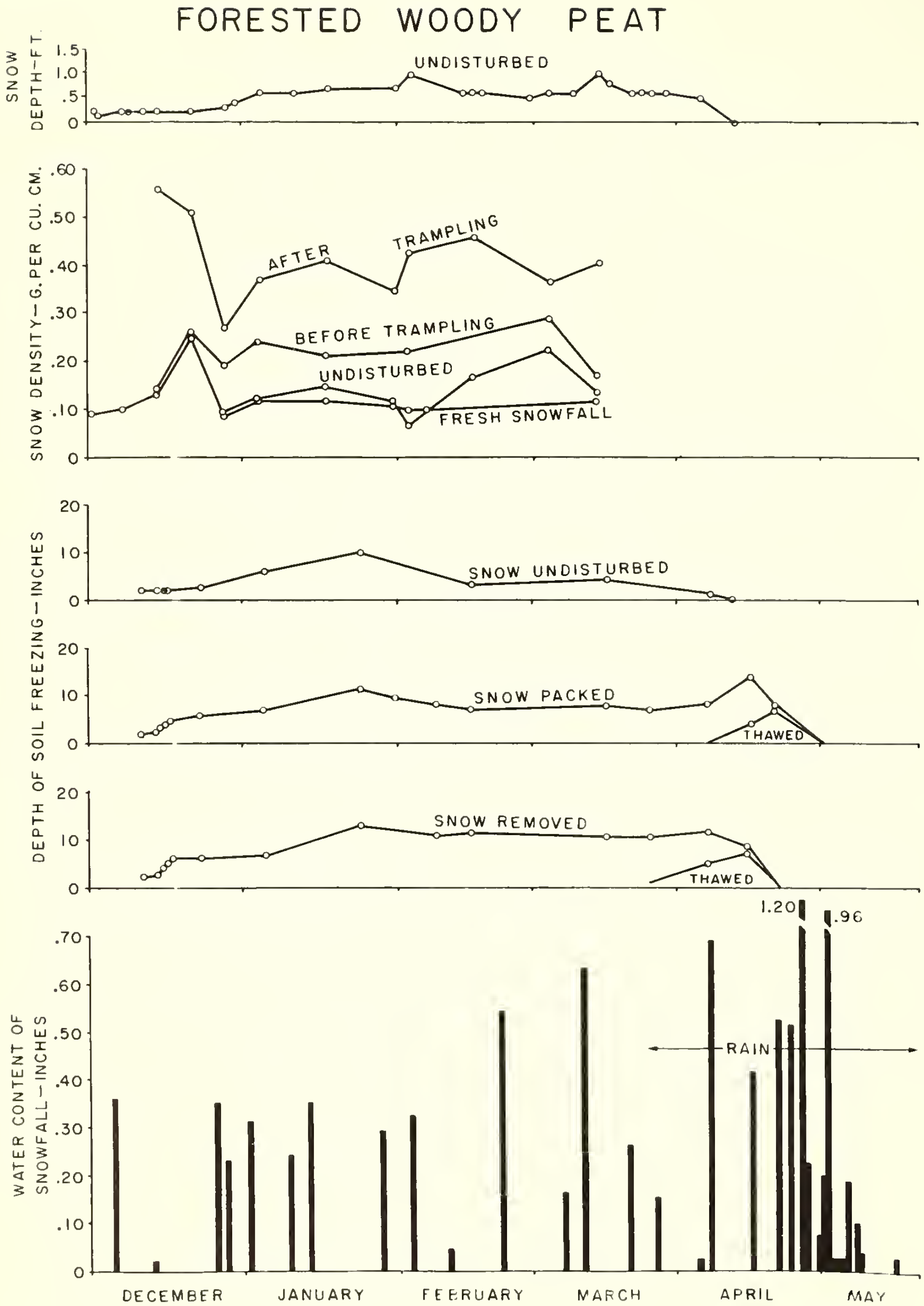

FIGURE 1. — Depth of soil freezing in a shallow forested woody peat as related to snowpack before and after treatment. All precipitation was in the form of snow except for late March, April, and May rains. The timber was medium - site black spruce and tamarack near Rhinelander, Wis.

Instrumentation and Snow Treatment

The snow treatments were started in early December and were carried until the end of the following May. Colman Fiberglas units with thermistors were placed in duplicate stacks at depths of 1½, 4½, 7½, and 10½ inches under the surface of the peat in each site. The units were installed in adjacent comparable areas where snow was (1) undisturbed, (2) packed by trampling after each snowfall, and (3) removed all winter long by shoveling. The instruments were read several times a week from early November before freezeup until the soil was thawed in spring.

The 15½-pound Lake States frost penetrometer was used to obtain supplemental direct readings.

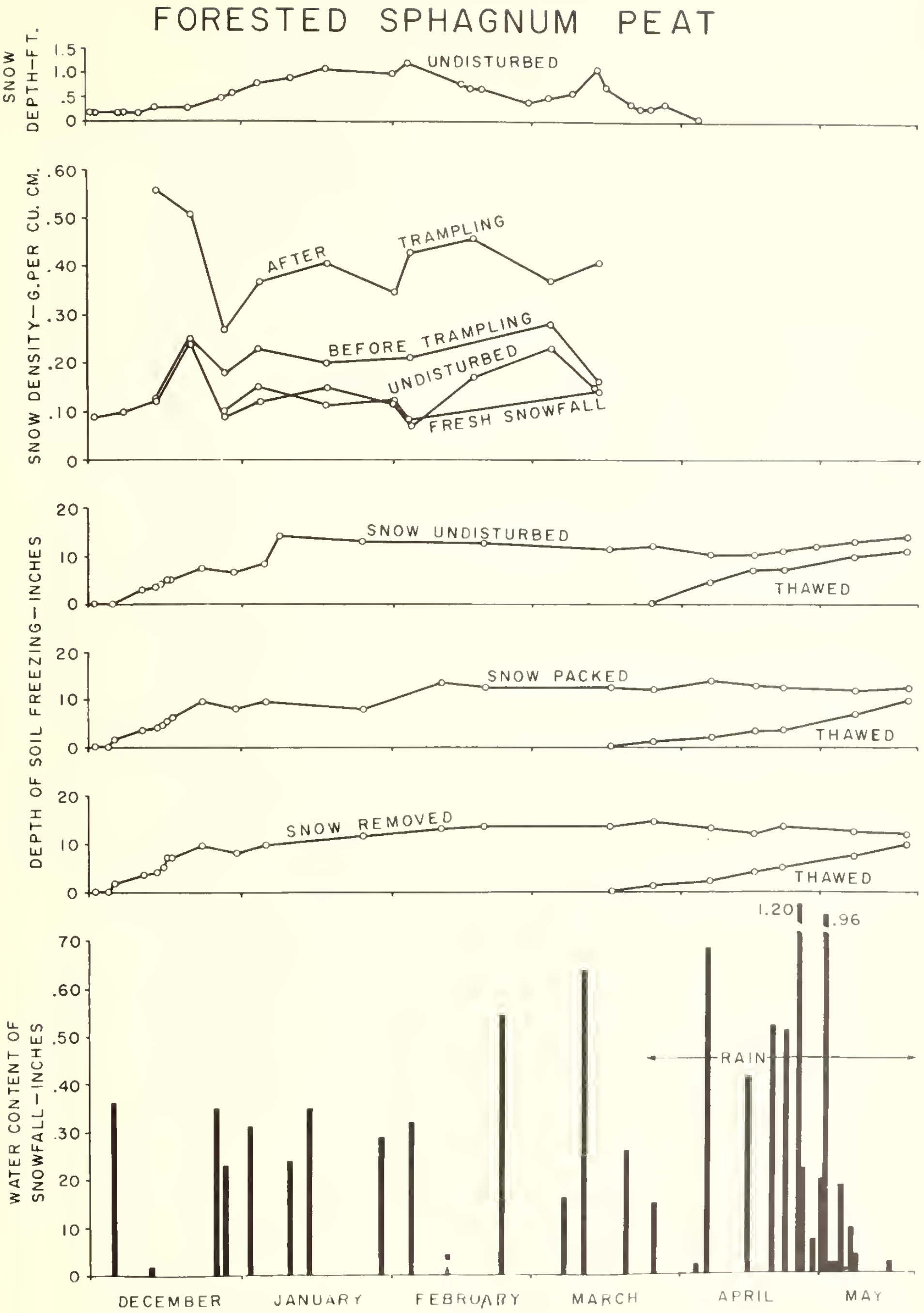

FIGURE 2. — Depth of soil freezing in a fairly deep forested sphagnum peat as related to snowpack before and after treatment. The timber was poor-site stunted black spruce and tamarack near Rhinelander, Wis.

These data were further supplemented by observations in several other swamps where logging operations were underway and where light bulldozers had been used to snowplow and pack temporary winter roads.

Results

The results of the study on these two organic soil sites are given in figures 1 and 2. In spite of spring rain and warming air temperatures, soil freezing under undisturbed snow on the sphagnum moss site lasted into the end of May; at that time 3 inches of frost were still present 11 to 14 inches below the surface. On the woody peat site, soil freezing had completely disappeared by April 12. Some thawing occurred from below in the sphagnum peat, but not in the woody peat.

In the woody peat, soil freezing was prolonged about 12 days in the area with snow removed (compared with undisturbed snow condition) and 20 days where it had been packed. In the sphagnum moss peat, some soil freezing persisted until the end of May under all conditions.

In both peats, where snow had been packed or removed, thawing occurred from below and also from the surface down (zones marked "thawed" in figs. 1 and 2). The persistence of frozen soil in the forested sphagnum peat for 6 to 7 weeks longer than in the forested woody peat is attributed largely to the substantial insulating value of the 18- to 24-inch loose mat of sphagnum moss.

Discussion

The depth of freezing on peatlands can be rather deceptive, in terms of trafficability, unless consideration is given to the character, hardness, and density of the frozen layer. In an undisturbed snow condition and with a snowpack of the type here observed, considerable freezing occurred under the snowpack. But on the sphagnum peat site it occurred in a weak, rather crumbly-to-honeycomb structure of loose sphagnum moss with a low bulk density and very little bearing strength. Wheeled vehicles attempting to cross it would break through the crust, spin their wheels, and bog down. However, light-to-medium crawler tractors or bulldozers were able to travel on such swamps for a few passes, regardless of whether or not the swamps were frozen.

Snowpacking improved trafficability considerably — but an extra 4 weeks or more was required to achieve any real amount of bearing strength, and vehicles tended to get stuck unless care was taken to smooth the roadbed.

Snow removal hastened freezing somewhat. Light passenger vehicles and pickup trucks without loads were barely able, on January 13, to travel on peatlands 3 days (or 71 degree-days below 32° F. after treatment) after complete snow removal by bulldozers, which also packed the surface and stripped off some surface sphagnum. About 10 days after treatment (or 370 degree-days below 32° F.) a logging truck could negotiate the swamp roads, but it was February 6 (584 degree-days of freezing) before a 1953 2-ton Chevrolet truck with dual wheels could make repeated trips over the roads with 4½-cord loads of pulpwood.

Marked improvement in rate of hard freezing was made in a sphagnum peat by removing the surface 20 inches of loose, partly frozen, surface sphagnum moss with spades to expose the darker colored, more decomposed, denser peat lying about 4 inches above the water table. This freshly exposed zone froze into a 5-inch-thick, hard, dense, roadbed of good bearing strength in early January, 8 days (and 172 degree-days below 32° F.) after treatment. It was very much superior in hardness and bearing strength to adjacent areas where the snow had been removed by shovels and the sphagnum moss was left intact.

December 1965

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U. S. FOREST SERVICE

RESEARCH NOTE LS-71

LAKE STATES FOREST EXPERIMENT STATION • U. S. DEPARTMENT OF AGRICULTURE

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The Performance of Eight Seed Sources of Ponderosa Pine in the Denbigh Experimental Forest, North Dakota

The area presently designated as the Denbigh Experimental Forest was established in 1931 as a location where large-scale afforestation could be tested in the Northern Great Plains. More than 40 species of trees have since been planted on 270 acres within the forest, which is located at an elevation of 1,486 feet in the sand hills of McHenry County in north-central North Dakota. The major soil type there is a Valentine fine sand.

The early planting, begun in 1933, was completed in 1940. Ponderosa pine (*Pinus ponderosa* Laws.), one of the most extensively planted species, was used in 48 plantations. The planting stock came from numerous seed collections from four broad geographic areas: western Montana, eastern Montana, the Black Hills of South Dakota, and western Nebraska. Because the seed sources were not fully identified in all plantings, only eight seed sources (see Fig. 1) in 10 plantations were selected for comparison in this report.

Although the ponderosa pine stock in the 10 plantations was not established as provenance studies (several planting techniques and various cultural treatments were used, which may have introduced some differences in survival and growth), the results indicate that some seed sources have obviously fared better than others in the Northern Great Plains environment. This paper is meant to give Northern Plains foresters and nurserymen some indication of which of the eight seed-collection areas are likely to provide the most suitable stock.

The comparisons, shown in table 1, involve two basic features — survival and growth characteristics — which were measured with different sampling procedures. The details are discussed in the following sections.

Survival

Survival was calculated in 1959 and 1960 for the period since 1941 (to offset to some degree the effects of the varied planting and cultural techniques). The survivals were determined from 31- to 100-percent samples, depending upon the sizes of the plantations.

The highest survivals were recorded for the Custer National Forest and Glendive, Mont., sources, as well as the source from the southern half of the Black Hills National Forest (sources I, III, VI, and VII). As is indicated, however, height growth for sources VI and VII was relatively poor. The trees from the western Nebraska seed source showed the poorest survival.

Growth Characteristics

Although some of the variations in the characteristics recorded in table 1 can perhaps be attributed to site conditions or nonuniform cultural practices, the data seem to indicate that genetic variation does exist among the eight seed sources. Comparisons of these characteristics were obtained in 1959 and 1960, when superior trees were selected and evaluated in the plantations. Since the primary purpose of this measurement project was to select individual superior trees, varying numbers of trees were selected from each plantation. Tree age from seed ranged from 25 to 30 years when the measurements were

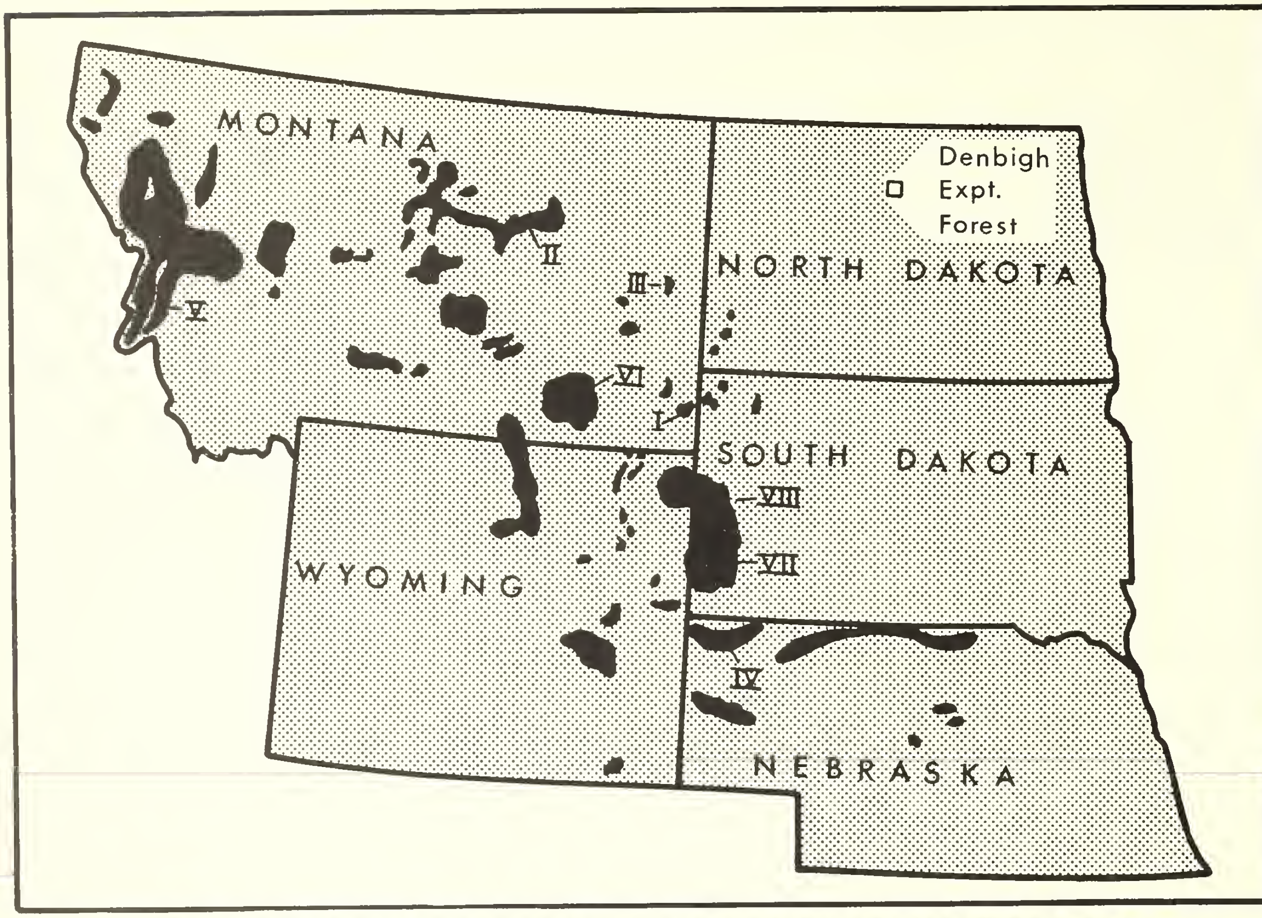

FIGURE 1. — Natural stands (black areas) of ponderosa pine in Montana, North Dakota, South Dakota, Wyoming, and Nebraska. Roman numerals indicate collection points.

taken. The growth characteristics are compared and discussed in the following paragraphs:

Height and diameter growth. — The collections are arranged in the table in descending order of "Average annual height growth," since height is the most heritable indicator of vigor. Diameter is more strongly influenced by environmental factors, but in this study annual diameter growth fell into almost exactly the same order as annual height growth. The three collections with the best height and diameter growth rates are all from eastern Montana, as was the case in the survival results.

Branch habit. — A significant factor in Plains plantings is branch habit because heavy branches indicate good resistance to wind, ice, and snow damage. As the table indicates, this factor varies by collection with no particular relationship to other traits such as general vigor or height growth. Collections I and II — both from eastern Montana — had the largest percentages of coarse branches.

Foliage density. — Resistance to winter desiccation damage, length of needles, shade tolerance, and other factors that influence needle retention all contribute to foliage density. The collections having the highest percentage of trees with dense foliage (Collections I and VI) are from the two Montana divisions of the Custer National Forest. The parent stands are about 100 miles apart and at about the same elevation. It is interesting

TABLE 1. — *Survival and growth characteristics of eight seed sources of ponderosa pine growing in the Denbigh Experimental Forest, North Dakota*[1]

Seed source no. and collection location[2]	Pct. survival since 1941, calculated in 1959-60	Growth Characteristics								
		Avg. annual height growth (ft.)	Avg. annual diameter increase (in.)	Branch habit (pct.)			Foliage density (pct.)			No. trees sampled
				Coarse	Medium	Fine	Dense	Medium	Light	
I Long Pines Div., Custer National Forest, Montana	100	0.69	0.176	50	33	17	78	15	7	210
II Jordan, Mont. (8 to 15 miles north)	72	0.65	0.169	58	22	20	4	55	41	84
III Glendive, Mont. (5 to 8 miles south)	86	0.65	0.146	38	32	30	5	60	35	127
IV Western Nebraska	55	0.59	0.142	47	40	13	6	51	43	67
V Bitterroot National Forest, western Montana	73	0.58	0.143	35	33	31	24	41	35	132
VI Custer National Forest, Montana[3]	100	0.58	0.136	25	33	42	45	42	13	53
VII Southern half of Black Hills National Forest, South Dakota[4]	94	0.53	0.115	30	45	25	30	38	32	366
VIII Black Hills National Forest, South Dakota	58	.46	.116	38	39	23	5	46	49	67

[1] *Tree age from seed varied from 25 through 30 years and average total height varied from 11.5 through 18.6 feet.*
[2] *Seed source locations and their relative distances from the Denbigh Experimental Forest can be seen on figure 1.*
[3] *Presumably from the Ashland Division.*
[4] *Designated as the Harney National Forest at the time of collection.*

to note that Collections II and III have a very low percentage of dense trees, although the parent stands are only about 150 miles north of the sources of Collections I and VI. Perhaps differences in elevation are responsible, since the northern stands are approximately 1000 feet lower than the two Custer National Forest sources.

Other performance-related factors. — Resistance to winter desiccation was not recorded because evaluations were made in midsummer when injury was generally not evident. However, Stoeckeler and Rudolf[1] reported that trees from the Black Hills in South Dakota and from western Nebraska suffered 7.0- and 16.3-percent average defoliation in comparison with 4.1- and 4.8-percent average defoliation on trees from the Glendive, Mont., source and from Medora, N. Dak. (In the table, Collections IV and VIII show low percentages of dense trees, which may be related to a high incidence of winter desiccation.)

The possible effects of altitude on seed sources are indicated in the marked differences in responses between Collections VII and VIII. Geographically these two seed sources are located very close to one another, but there may be two or three thousand feet difference in elevation between their sites. Unfortunately, precise elevation data are lacking for these two collections.

It is also significant that Collection V from the Bitterroot National Forest seemingly is quite well adapted, in spite of the fact that the collection area is some 800 miles west of the planting site and a minimum of 2000 feet higher in elevation. It is, however, within 2° of the same latitude as the planting site.

Summary

Although the data are by no means conclusive, this comparison strongly suggests that different geographic races of ponderosa

[1] *Stoeckeler, J. H., and Rudolf, Paul O. Winter injury and recovery of conifers in the upper midwest. U.S. Forest Serv., Lake States Forest Expt. Sta., Sta. Paper 18, 20 pp., illus. 1949.*

pine do exist in the eastern outliers of the species and that these races respond differently when planted in a Plains environment. Until more positive results of current research concerning the adaptability of ponderosa pine seed sources to the Great Plains region are available, Great Plains nurserymen should probably collect their ponderosa pine seed from eastern Montana sources for North Dakota plantings.

December 1965

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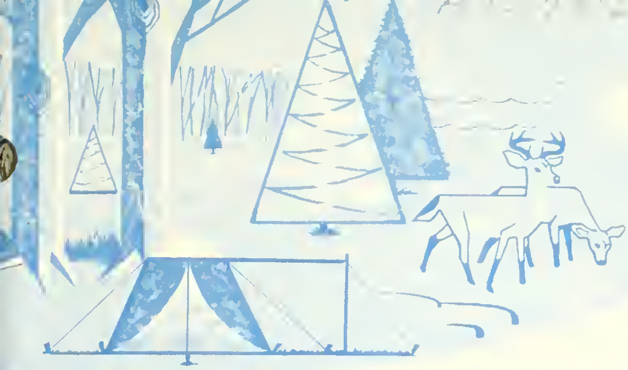
THE FOREST SERVICE CREED

The Forest Service of the U.S. Department of Agriculture is dedicated to the principle of multiple use management of the Nation's forest resources for sustained yields of wood, water, forage, wildlife, and recreation. Through forestry research, cooperation with the States and private forest owners, and management of the National Forests and National Grasslands, it strives — as directed by Congress — to provide increasingly greater service to a growing Nation.



U. S. FOREST SERVICE

RESEARCH NOTE LS-72

LAKE STATES FOREST EXPERIMENT STATION • U. S. DEPARTMENT OF AGRICULTURE

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Influence of Temperature and Early Spring Conditions on Sugar Maple and Yellow Birch Germination in Upper Michigan

For many years, workers at the Upper Peninsula Experimental Forest have observed sugar maple germinates protruding through the snow in the spring. They have also noted that yellow birch germination is always later than that of sugar maple. This Note documents the ability of sugar maple to germinate beneath a snow cover and indicates variations in temperature requirements for germination of sugar maple and yellow birch.

Sugar maple seed matures in early fall and is dispersed during leaf drop. Yellow birch seed also matures in early fall, but it is dispersed gradually throughout the winter months (Benzie 1959). In this climate, yellow birch seed is often windblown for great distances on top of the snow crust that occurs after mild thaws. Cross sections cut through the snowpack in late winter reveal concentrations of yellow birch seed on these crusts, which are formed at different depths.

Temperature requirements for germination of yellow birch seed may vary with the time of seedfall (Tubbs 1964); those seeds naturally stratified early in the season germinate early in the spring while those stratified later germinate in midsummer. Observations on the time of germination have shown that the bulk of the natural seedfall germinates in early June.[1] Recommendations for laboratory germination tests are for alternating temperatures of 50°+ and 90° F. (U.S. Forest Serv. 1948).

Sugar maple has often been observed germinating at stratification temperatures (U. S. Forest Serv. 1948) of 41° F.; recommended test procedures specify temperature alternation either of 50° and 77° or 68° and 86° F.

During April 1964 several locations in mature northern hardwood stands were visited while snow still remained over appreciable areas. On April 30 one location was selected for photographs. Pictures of the snow surface, leaf surface, and area directly under the previous year's leaf litter were taken from exactly the same camera position (figs. 1-3). The pictures show that sugar maple seeds germinate beneath the snow under a leaf layer where, according to Geiger (1959), temperatures may be only slightly above freezing and relatively uniform. Yellow birch seeds, on the other hand, are usually found in the snow cover where dormancy-breaking conditions may not be as favorable.

Also during April 1964, seeds of yellow birch and sugar maple, collected the previous fall and stratified for 90 days, were germinated in petri dishes placed in incubators. Incubator temperatures were 34°, 41°, 50°, and 68°F. Total numbers of seeds tested were 1,602 for birch and 317 for maple. The test was run for 30 days. Results were as follows:

Temperature (°F)	Percent germination[1]	
	Yellow birch	Sugar maple
34	0	87
41	6	35
50	14	8
68	9	2

[1] Percent of filled seed.

This collection of observations indicates that sugar maple germinates best under very low temperatures and, in natural environments, will germinate under a snow cover. Yellow birch, on the other hand, germinates best under more moderate temperatures, and these seedlings do not appear until after the sugar maple seedlings, which are able to utilize early season moisture supplies and growing space. In some circumstances, however, yellow birch seedlings attain greater height than sugar maple when both start from seed (Tubbs 1963).

[1] *Unpublished data on file at Lake States Forest Experiment Station.*

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U.S. Forest Service.
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December 1965

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Associate Plant Physiologis

F-51315
FIGURE 1 (top). — Yellow birch conelet bract and seeds litter surface of melting snow o April 30 in a northern hardwood stand on th Upper Peninsula Experimental Forest. Th overstory is composed primarily of suga maple of seeding age, but seldom are mapl seeds observed on top of or within the sno cover even after a bumper seed crop. Righ arrow indicates yellow birch seed; left on points to bract.

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FIGURE 2 (middle). — Removing the snow fro the exact spot shown in figure 1 to the top c the previous fall's leaf layer reveals no see of any species. The leaves are compressed int a soggy mat, which is often partially froze Spring ephemerals have pushed through th mat (arrow).

F-51315
FIGURE 3 (bottom). — When the top leaf laye shown in figure 2 is removed, the ability c sugar maple to germinate underneath a sno cover in early spring is revealed. Arrows poi to germinated seed. In those areas sampled c the Experimental Forest, the bulk of the suga maple seed was found under a layer of lea whereas yellow birch seed occupied the top the snow as illustrated in figure 1.

U. S. FOREST SERVICE

RESEARCH NOTE LS-73

LAKE STATES FOREST EXPERIMENT STATION • U. S. DEPARTMENT OF AGRICULTURE

St. Paul Campus, University of Minnesota, St. Paul, Minn 55101

Botanical and Commercial Range of White Spruce in the Lake States

Accurate maps showing the distribution of important tree species are valuable to foresters, botanists, wildlife specialists, land managers, and others. Although the general natural ranges for our principal tree species have been well known for some time, new information continues to develop. Commercial ranges, however, have not previously been mapped precisely, and artificial extensions of ranges generally have not been mapped at all. For these reasons, range maps of the principal forest tree species have been prepared[1] for the Lake States (Michigan, Minnesota, and Wisconsin), and that for white spruce (*Picea glauca* (Moench) Voss.) is presented here (fig. 1).

Accuracy depends in part on the scale of the map being used. On this map, it is not practical to separate out isolated stands except when they are some distance from the main range. Accordingly, the main range boundary as drawn may include several outliers near the edge of the principal distribution.

In the silvical characteristics reports for the Lake States tree species,[2] commercial ranges were mapped, but they were based on the following broad definition: "Commercial range is defined as that portion of the natural range in which the species grows to commercial size and is a major or important species in the type." In this Note, commercial range is defined on a wood volume basis and is indicated for each county that presently has at least 1,000 cords of white spruce (fig. 1). Counties with 10,000 to 99,000 cords and those with at least 100,000 cords are specially designated. The commercial range is based primarily on published reports of the Forest Survey, supplemented for completeness by unpublished data from the same source.

The natural range of white spruce is based on published reports[3] as modified by the observations of qualified foresters and botanists.[4] A supplemental map (fig. 2) shows the plots used in making the distribution map. These plots were derived from actual herbarium specimens or from other reliable sources.

Within its natural range in the Lake States, white spruce grows best on loamy soils but will also grow well on moist sands and on clays that are neither especially wet nor exceptionally dry. Pure stands more than a few acres in extent are rare in the Lake States, except in plantations. White spruce usually grows with a large number of tree species, the most common of which in the Lake States (in approximate order of frequency in Forest Survey plots) are balsam fir, paper birch, quaking aspen, red maple, northern white-cedar, black spruce, white pine, yellow birch, black ash, balsam poplar, and American elm. Associates vary geographically and according to site conditions. For example, in Michigan sugar maple and eastern hemlock are common associates, in addition to the other species listed.

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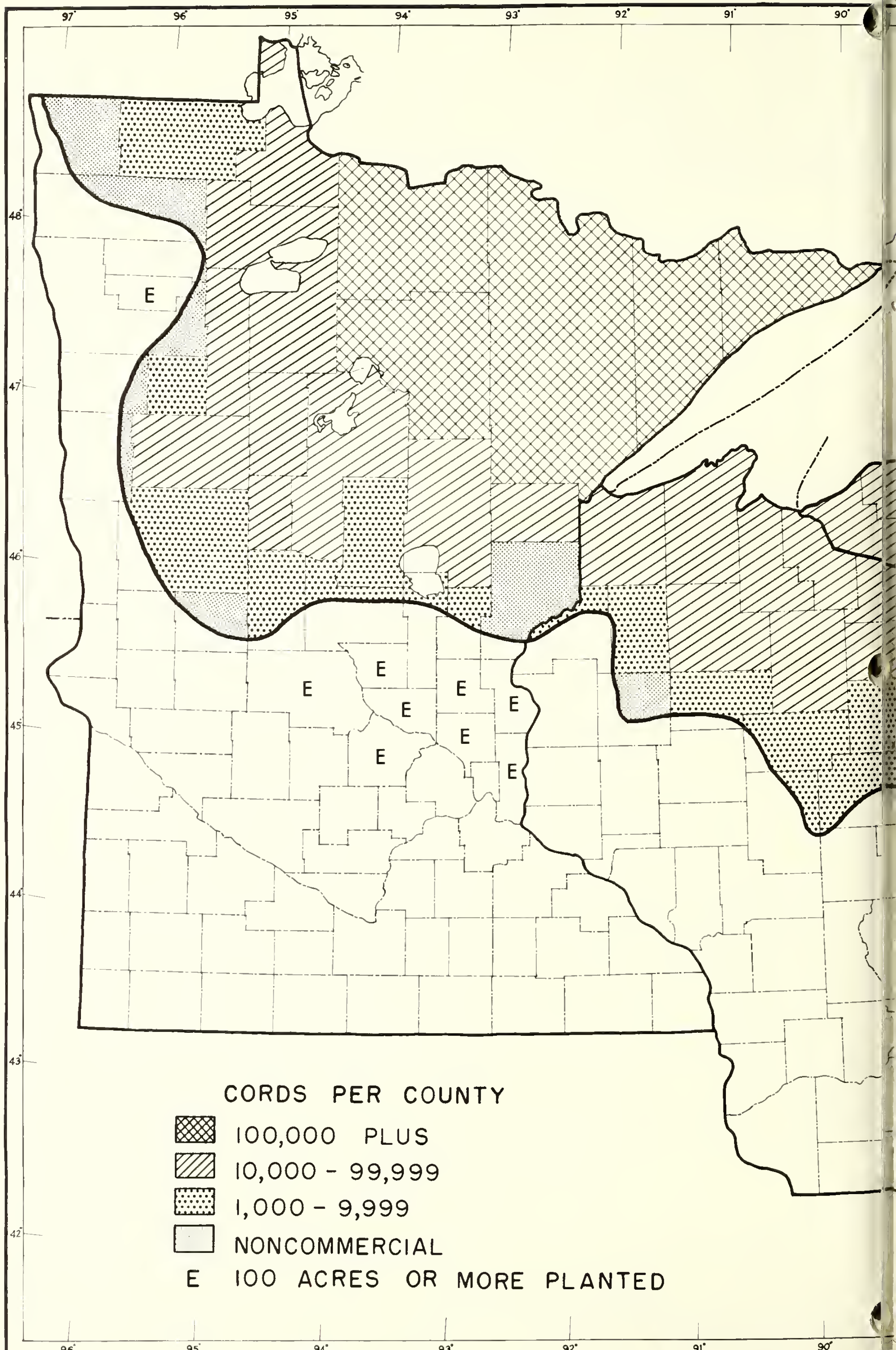
1 *Other published reports in this series are for jack pine (U.S. Forest Serv. Res. Note LS-15, 1963), red pine (U.S. Forest Serv. Res. Note LS-62, 1965), eastern white pine (U.S. Forest Serv. Res. Note LS-63, 1965), and black spruce (U.S. Forest Serv. Res. Note LS-74, 1965).*

2 *See Lake States Forest Experiment Station, Station Paper 67, which includes a list of silvical reports.*

3 *Dodge, C. K., Miscellaneous papers on the botany of Michigan. Publ. 31, Biol. Series 6, Mich. Geol. and Biol. Survey, 1921. Fassett, Norman C., Preliminary reports on the flora of Wisconsin, V. Coniferales, Wis. Acad. Sci., Arts and Letters, Trans. 25:177-182, illus., 1930. Nienstaedt, Hans, Silvical characteristics of white spruce, U.S. Forest Serv., Lake States Forest Expt. Sta., Sta. Paper 55, 23 pp., illus., 1963.*

4 *Information in this Note has been reviewed by Drs. Edward Flaccus and Paul Monson, University of Minnesota (Duluth); Dr. Thomas Morley, University of Minnesota (Minneapolis); Dr. Edward G. Voss, University of Michigan; staff members of all Divisions and Field Units of the Lake States Forest Experiment Station; and staff members of all National Forests and State Conservation Departments in Michigan, Minnesota, and Wisconsin.*


97°
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E
E
CORDS PER COUNTY
100,000 PLUS
10,000 - 99,999
1,000 - 9,999
NONCOMMERCIAL
E 100 ACRES OR MORE PLANTED

FIGURE 1. — Natural and commercial range of white spruce in the Lake States. The natural range includes the areas within the heavy line. Arrows point to isolated stands at some distance from the main range. The commercial range includes all counties within the natural range that have at least 1,000 cords of white spruce.

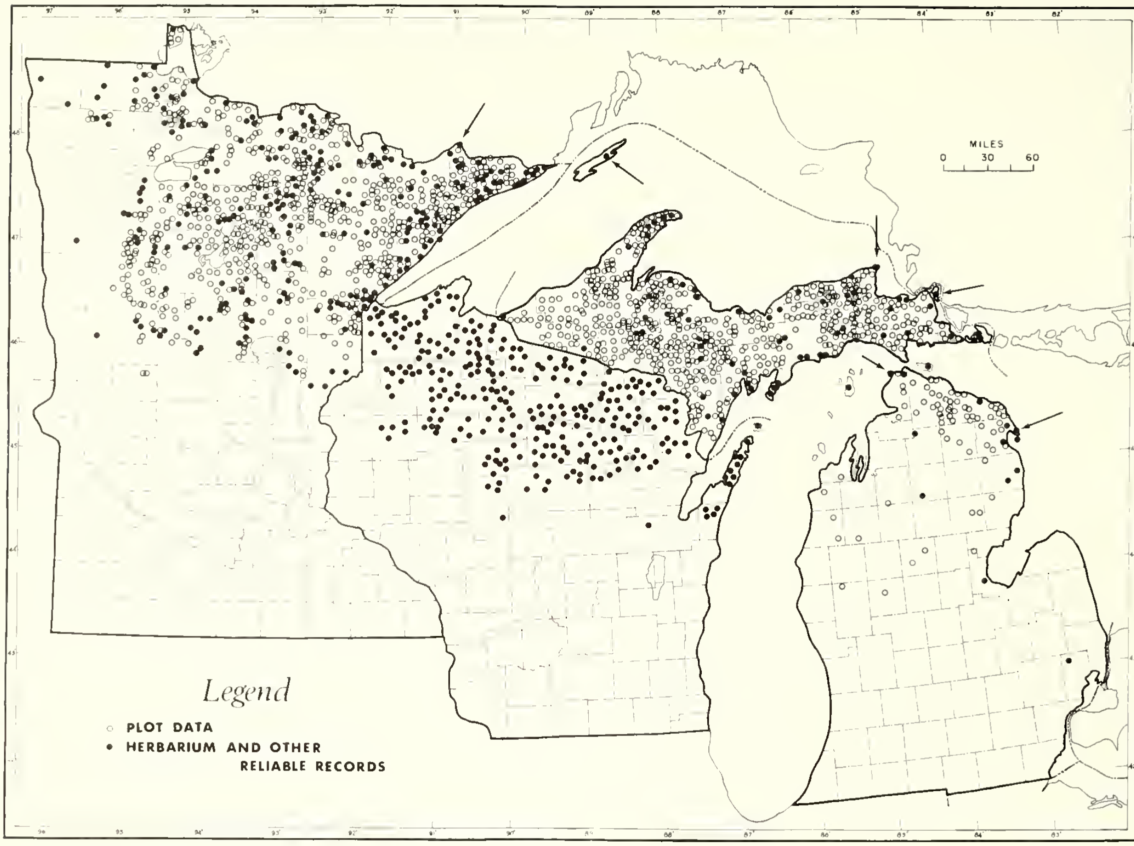

FIGURE 2. — Localities from which native white spruce is represented in established herbaria or other valid records.*

* Includes material from (1) the following herbaria: Cranbrook Institute of Science, Michigan State University, Milwaukee Public Museum, University of Michigan, University of Minnesota (Duluth), University of Minnesota (Minneapolis), University of Wisconsin (Madison), and University of Wisconsin (Milwaukee); (2) seed collection records of the Lake States Forest Experiment Station, the University of Minnesota, and Michigan State University; (3) superior tree records of the Lake States Forest Experiment Station; (4) seed production areas on record at the Lake States Forest Experiment Station; (5) a vegetational survey made by Dr. Egolfs Bakuzis, of the University of Minnesota; and (6) Fassett, 1930(see footnote 3), for most of the Wisconsin locations.

Although the natural distribution of white spruce is outlined on figure 1, planting is beginning to extend the range and eventually may blur the outlines of the natural range. Where planting has been extensive enough to develop at least 100 acres per county of established stand, it has appeared in Forestry Survey statistics. Data have also been obtained from nursery distribution records and other State forestry sources. Stands of this extent beyond the known botanical range are shown by an "E" in the counties involved. Planting within the botanical distribution may increase the commercial range.

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December 1965

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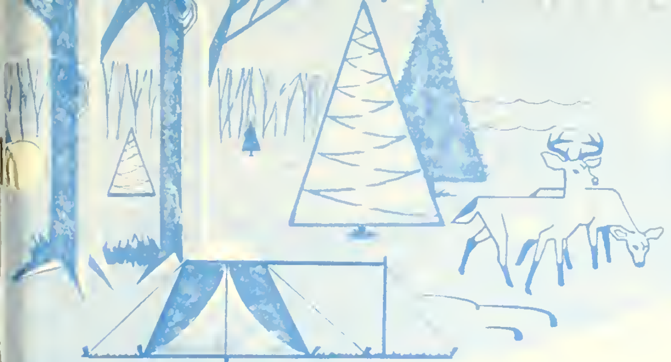

U. S. FOREST SERVICE

RESEARCH NOTE LS-74

LAKE STATES FOREST EXPERIMENT STATION • U. S. DEPARTMENT OF AGRICULTUR
St. Paul Campus, University of Minnesota, St. Paul, Minn 55101

Botanical and Commercial Range of Black Spruce in the Lake States

Accurate maps showing the distribution of important tree species are valuable to foresters, botanists, wildlife specialists, land managers, and others. Although the general natural ranges for our principal tree species have been well known for some time, new information continues to develop. Commercial ranges, however, have not previously been mapped precisely, and artificial extensions of ranges generally have not been mapped at all. For these reasons, range maps of the principal forest tree species have been prepared[1] for the Lake States (Michigan, Minnesota, and Wisconsin), and that for black spruce (*Picea mariana* (Mill.) B.S.P.) is presented here (fig. 1).

Accuracy depends in part on the scale of the map being used. On this map, it is not practical to separate out isolated stands except when they are some distance from the main range. Accordingly, the main range boundary as drawn may include several outliers near the edge of the principal distribution.

In the silvical characteristics reports for the Lake States tree species,[2] commercial ranges were mapped, but they were based on the following broad definition: "Commercial range is defined as that portion of the natural range in which the species grows to commercial size and is a major or important species in the type." In this Note, commercial range is defined on a wood volume basis and is indicated for each county that presently has at least 1,000 cords of black spruce (fig. 1). Counties with 10,000 to 99,000 cords and those with at least 100,000 cords are specially designated. The commercial range is based primarily on published reports of the Forest Survey, supplemented for completeness by unpublished data from the same source.

The natural range is based on the available published reports[3] as modified by the observations of qualified foresters and botanists.[4] A supplemental map (fig. 2) shows the plots used in making the distribution map. These plots were derived from actual herbarium specimens or from other reliable sources.

Within its natural range in the Lake States, black spruce grows on both mineral and organic soils. Most commonly it grows on peat bogs and muck-filled seepages and stream courses. On the Laurentian Shield in northeastern Minnesota and in a few areas in Upper Michigan it is common on mineral soil sites, usually on gravelly and bouldery loams and shallow soils over bedrock. Pure stands are common on the organic soils and sometimes develop on the mineral soils, also. Under some

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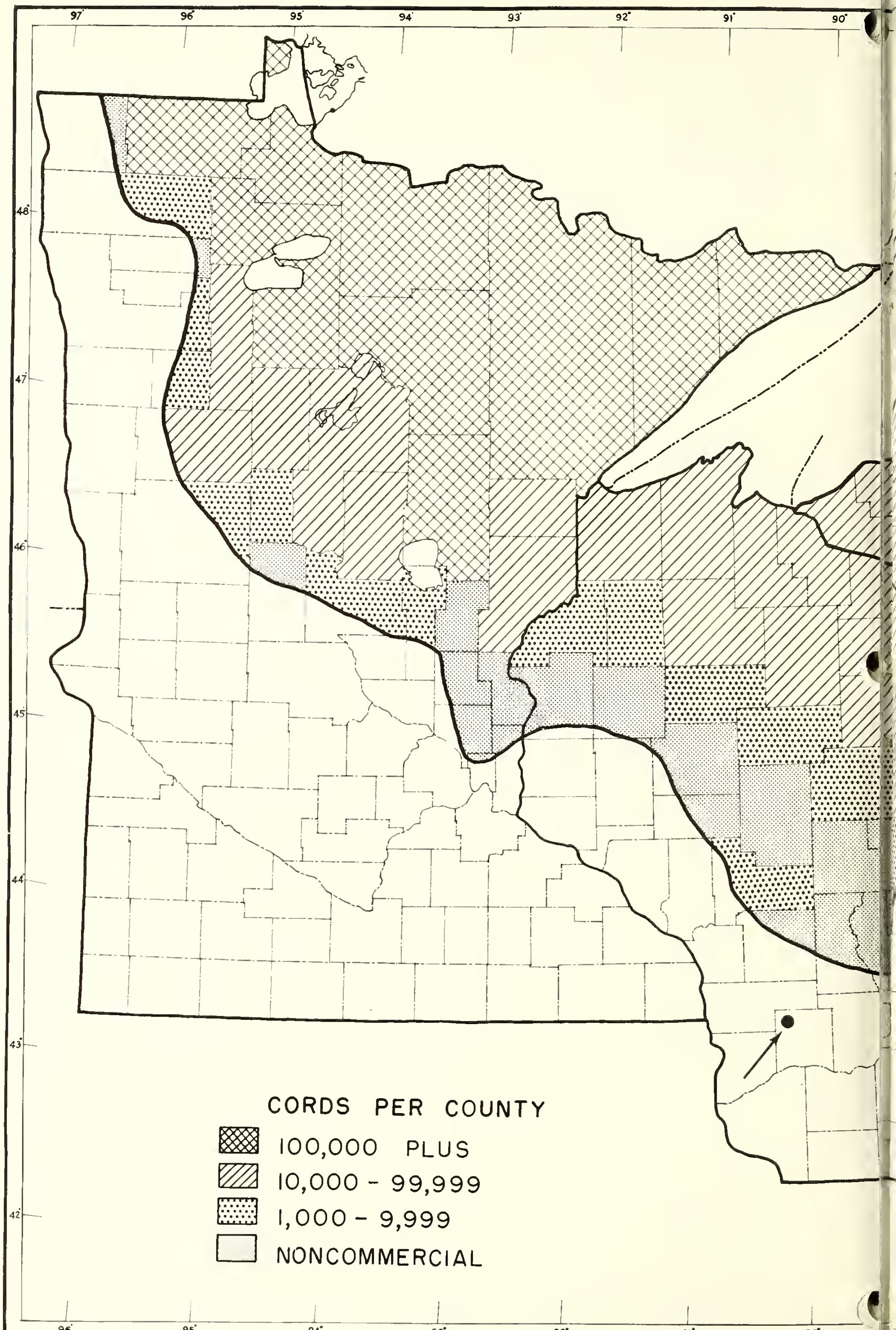
1 *Other published reports in this series are for jack pine (U.S. Forest Serv. Res. Note LS-15, 1963), red pine (U.S. Forest Serv. Res. Note LS-62, 1965), eastern white pine (U.S. Forest Serv. Res. Note LS-63, 1965), and white spruce (U.S. Forest Serv. Res. Note LS-73, 1965).*

2 *See Lake States Forest Experiment Station, Station Paper 67, which includes a list of silvical reports.*

3 *Dodge, C. K., Miscellaneous papers on the botany of Michigan, Publ. 31, Biol. Series 6, Mich. Geol. and Biol. Survey, 1921. Fassett, Norman C., Preliminary reports on the flora of Wisconsin. V. Coniferales, Wis. Acad. Sci., Arts and Letters, Trans. 25: 177-182, illus., 1930. Heinselman, M. L., Silvical characteristics of black spruce, U.S. Forest Serv., Lake States Forest Expt. Sta., Sta. Paper 45, 30 pp., illus., 1957.*

4 *Information in this Note has been reviewed by Drs. Edward Flaccus and Paul Monson, University of Minnesota (Duluth); Dr. Thomas Morley, University of Minnesota, (Minneapolis); Dr. Edward G. Voss, University of Michigan; Dr. John W. Andresen, Southern Illinois University; staff members of all Divisions and Field Stations of the Lake States Forest Experiment Station; and staff members of the National Forests and State Conservation Departments in Michigan, Minnesota, and Wisconsin.*



CORDS PER COUNTY
100,000 PLUS
10,000 - 99,999
1,000 - 9,999
NONCOMMERCIAL

FIGURE 1. — Natural and commercial range of black spruce in the Lake States. The natural range includes the areas within the heavy line. Arrow points to isolated stand that is some distance from the main range. The commercial range includes all counties within the natural range that have at least 1,000 cords of black spruce.

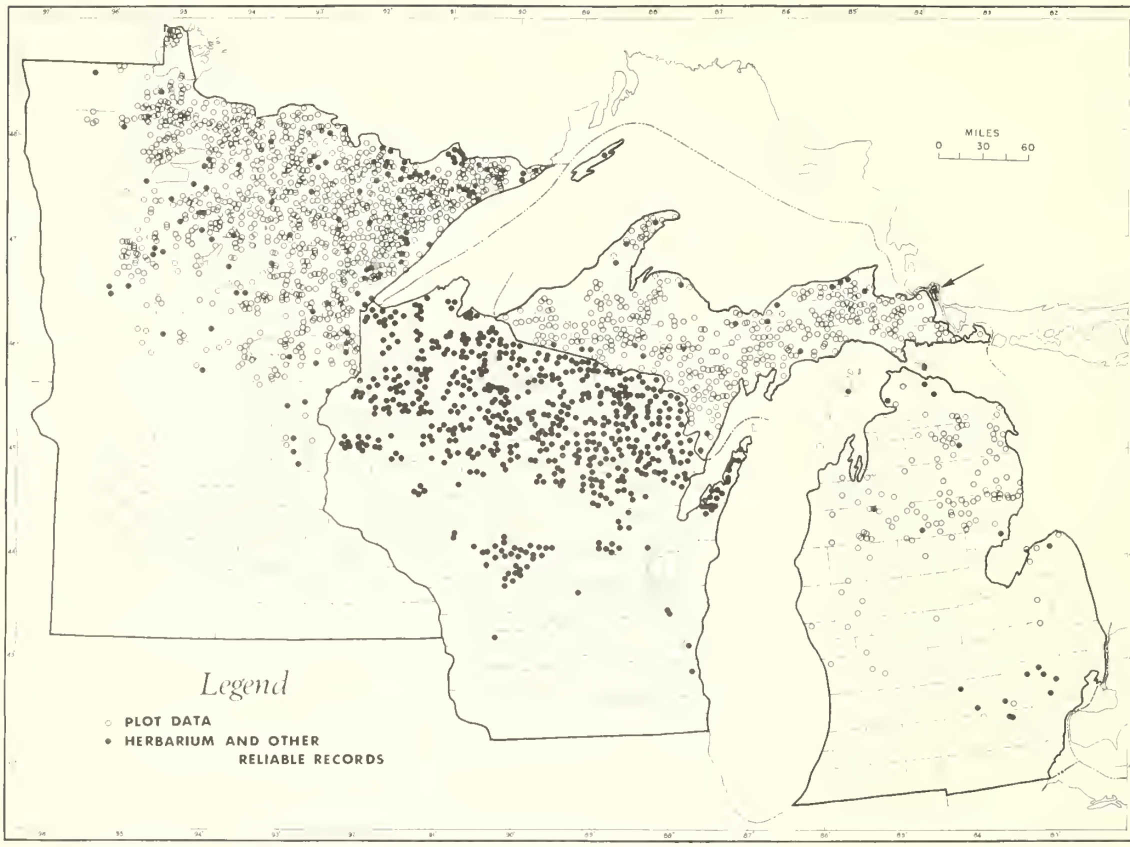


FIGURE 2. — Localities from which native black spruce is represented in established herbaria or other valid records.*

* Includes material from (1) the following herbaria: Cranbrook Institute of Science, Michigan State University, Milwaukee Public Museum, University of Michigan, University of Minnesota (Duluth), University of Minnesota (Minneapolis), University of Wisconsin (Madison), and University of Wisconsin (Milwaukee); (2) seed collection records of the Lake States Forest Experiment Station, the University of Minnesota, and Michigan State University; (3) superior tree records of the Lake States Forest Experiment Station; (4) seed production areas on record at the Lake States Forest Experiment Station; (5) a vegetational survey made by Dr. Egolfs Bakuzis of the University of Minnesota; and (6) Fassett, 1930 (see footnote 3), for most of the Wisconsin locations.

bog conditions extensive pure stands of stunted trees, often over 100 years old, may develop. Frequently, however, black spruce grows with one or more associates, the most common of which (in approximate order of frequency on Forest Survey plots) in the Lake States are balsam fir, tamarack, northern white-cedar, paper birch, quaking aspen, white spruce, eastern white pine, red maple, jack pine, and yellow birch. Associates vary geographically and according to site conditions. For example, in Michigan sugar maple and eastern hemlock are fairly common associates, in addition to the other species listed. On bogs, tamarack is the most common associate.

The natural distribution of black spruce is outlined on the map. Planting of black spruce has not been extensive, although it is increasing. There is little probability, however, that artificial regeneration in the Lake States will blur the outlines of the natural range in the forseeable future, as it may for white spruce and the pines.

December 1965

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