SPECIAL CIRCULAR 96 DECEMBER 1960

COMPARATIVE GROWTH OF EIGHT CONIFERS IN A PLANTATION IN MAHONING COUNTY, OHIO

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OHIO AGRICULTURAL EXPERIMENT STATION
Wooster, Ohio

CONTENTS

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JOHN AUGHANBAUGH

This report describes one of the oldest and finest mixed conifer plantings to be found throughout any of Ohio's northeastern counties. Established during the spring of 1919, it covers approximately nine-tenths of an acre whereon eight different species of trees were represented. The following conifers had been planted at the Mahoning County Experiment Farm near Canfield:

Japanese red pine—*Pinus densiflora* Sieb. & Zucc.
Austrian pine—*Pinus nigra* Arnold.
Ponderosa pine—*Pinus ponderosa* Laws.
Red pine—*Pinus resinosa* Ait.
Scotch pine—*Pinus sylvestris* L.
Douglasfir—*Pseudotsuga menziesii* (Mirb) Franco.
Baldcypress—*Taxodium distichum* (L.) Rich.
Canada hemlock—*Tsuga canadensis* (L.) Carr.

The plantation comprises a rectangular unit of 18 blocks of 1/20th-acre each. Bounded on two of its sides by tilled farm land, it abuts also on a tract of native hardwood timber. Figure 1 depicts the various tree and row spacings, and the arrangement and composition of each component block.

Mahoning County, bordering on Pennsylvania, lies wholly within the glaciated portion of the State of Ohio. Hence the soil type underlying this stand was derived from glacial till, and is technically termed Canfield silt loam. The afforested site is well-drained, gently rolling terrain facing to the northwest on the Allegheny Plateau, at an elevation of 1170 feet above sea level.

HISTORY OF CULTURAL TREATMENTS

The first recorded treatment of this plantation was done in the spring of 1941 by forester Jacob Ulmer[1]. He reported: "Blocks 1 to 13 inclusive were thinned, pruned and otherwise culturally improved. The remaining blocks of Douglasfir, Japanese red pine, cypress and hemlock were given no assistance, for their condition was too poor to merit the effort." Consequently today, there remain no living Douglasfir, cypress, or Japanese red pine, and no more than a few hemlock survivors—the outcome, no doubt, of competition from the more thrifty of the planted pines and voluntary hardwoods.

Ulmer treated the tract as a unit, irrespective of its separate blocks. He applied, according to forestry terminology, a light 'crown thinning from below'. His opinion was: "Due to the fact that the stand went so long without attention, care was taken not to treat it severely, for the trees in general lacked sufficient crown to withstand a heavy thinning." So his improvement cut had consisted mostly of inferior trees, and those under 20 feet in height. On occasions he removed a large crooked dominant, to prevent breakage of potential crop trees if subsequently cut. Unwanted voluntary hardwoods overtopping the planted stand were felled, girdled, or poisoned.

Thirteen years later, in March of 1954, the Department of Forestry, Ohio Agricultural Experiment Station, placed three permanent 1/10th-acre study plots in this same plantation (Fig. 2). The trees on those plots were measured and marked for treatment, but little intensive work resulted before their re-measurement the spring of 1959. By then every pine had been hand-pruned to approximately 7 feet above ground. Not until 1959, however, had potential crop trees (240-310 per acre) been selected, each tree banded with white paint, and then high-pruned with pole-saws to 17 feet or higher. Thinning of a varied degree followed, to release the chosen crop trees and promote their best development (Tables 4, 5, and 6). They were liberated, too, from encroachment of hardwoods, particularly on the borders adjacent to the woodlot.

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[1]Ulmer, Jacob S., 1941. Report of the cultural thinning of the experimental conifer planting at the Mahoning County Experiment Farm, Canfield, Ohio. Survey of the Forest Resources of Ohio (Mahoning County).

TABLE 1.—1941 SUMMARY, AFTER TREATMENT

(Data on per acre basis)

Age 22 yrs. **Canfield Plantation** **Computations by Jacob Ulmer**

Block	Species	Spacing Feet	Trees No.	Survival %	Basal Area Sq. Ft.	Volume (Smalian Formula) Cu. Ft.	Volume (Smalian Formula) Cords[1]	Av. Ht. Feet	Av. Dia. Inches	Remarks
1	Am. red pine	4 × 4	1340	46.5	184.7	2850	22.3	31.0	5.1	Very heavy stand
2	Am. red pine	6 × 6	800	62.5	147.9	2334	18.2	31.6	5.7	
	Am. red pine	6 × 6	340	53.1	81.3	1669	13.0	33.2	6.6	Red pine outgrew the ponderosa
3	Ponderosa pine	alt. rows	160	21.6	28.1	582	4.6	32.9	5.6	
4	Austrian pine	4 × 4	780	27.1	140.3	2305	18.0	30.1	5.7	
5	Austrian pine	6 × 6	300	23.4	66.1	1097	8.6	28.6	6.2	Demolished plot[2]
	Am. red pine	6 × 6	60	10.0	66.1	77	0.6	26.2	4.2	Scotch pine outgrew the
6	Scotch pine	alt. rows	420	65.6	135.7	2883	22.5	42.9	7.7	Am. red pine
7	Ponderosa pine	4 × 4	980	34.0	111.0	1608	12.6	27.9	4.5	
8	Ponderosa pine	6 × 6	620	48.4	89.9	1276	10.0	27.5	5.1	
	Am. red pine	6 × 6	380	59.4	79.6	1384	10.8	34.5	6.1	Red pine outgrew the ponderosa
9	Ponderosa pine	alt. rows	200	31.0	18.4	261	2.0	28.0	4.1	
10	Scotch pine	4 × 4	900	31.2	179.5	3950	30.9	43.7	6.0	Very heavy stand
11	Scotch pine	6 × 6	560	43.7	132.4	2896	22.5	42.5	6.5	
	Scotch pine	6 × 6	340	53.0	104.4	2388	18.7	44.9	7.4	Scotch pine outgrew the
12	Am. red pine	alt. rows	100	15.6	10.2	326	2.5	38.0	4.1	Am. red pine
	Am. red pine	6 × 6	420	65.6	128.0	1876	14.7	29.2	7.4	No Douglasfir cut
13	Douglasfir	alt. rows	100	15.8	0.3	1	.01	5.7	0.7	

[1]Based on a standard cord of 128 cu. ft.

[2]No trees cut in 1941. One Scotch pine (the largest on the whole area) had been planted in the center of this block. It developed so rapidly as to suppress the Austrian pines.

EARLY GROWTH COMPARISONS BY SPECIES AND SPACING

Ulmer in 1941 had carried out a complete stand inventory. Moreover, he charted it on coordinate paper, and indicated thereon the position of every tree and whether it was to be cut or left. Nowadays though, as a result of the mortality and the felling, one discerns neither the former tree-spacings nor the original block-boundaries.

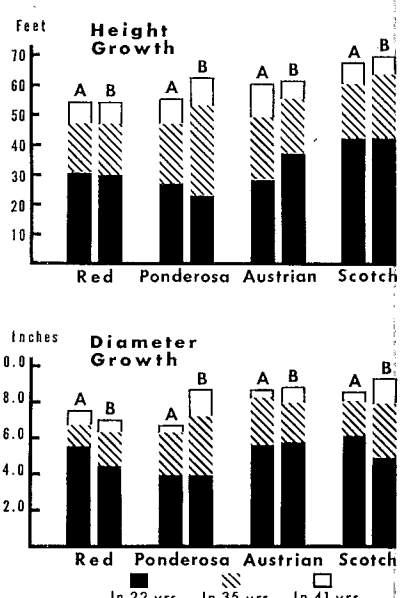
Ulmer's remarks on the subject of spacing were:

> "In pure blocks, the 6 × 6 feet spacings have developed a decidedly better stand than did the 4 × 4 feet spacings. This was reflected in higher survival and greater diameter growth. Height data showed but slight variation.

FIG. 1
COMPOSITION OF THE PLANTING
1919

1 Red Pine Ponderosa Pine 6 x 6 Alt. Rows	2 Red Pine 6 x 6	3 Red Pine 4 x 4
6 Red Pine Scotch Pine 6 x 6 Alt. Rows	5 Austrian Pine 6 x 6	4 Austrian Pine 4 x 4
7 Red Pine Ponderosa Pine 6 x 6 Alt. Rows	8 Ponderosa Pine 6 x 6	9 Ponderosa Pine 4 x 4
12 Red Pine Scotch Pine 6 x 6 Alt. Rows	11 Scotch Pine 6 x 6	10 Scotch Pine 4 x 4
13 Red Pine Douglasfir 6 x 6 Alt. Rows	14 Canada Hemlock 6 x 6	15 Jap. Red Pine 4 x 4
18 Douglasfir 6 x 6	17 Douglasfir 4 x 4	16 Baldcypress 4 x 4

FIG. 3
COMPARATIVE GROWTH OF PINES
AT CANFIELD AND WOOSTER



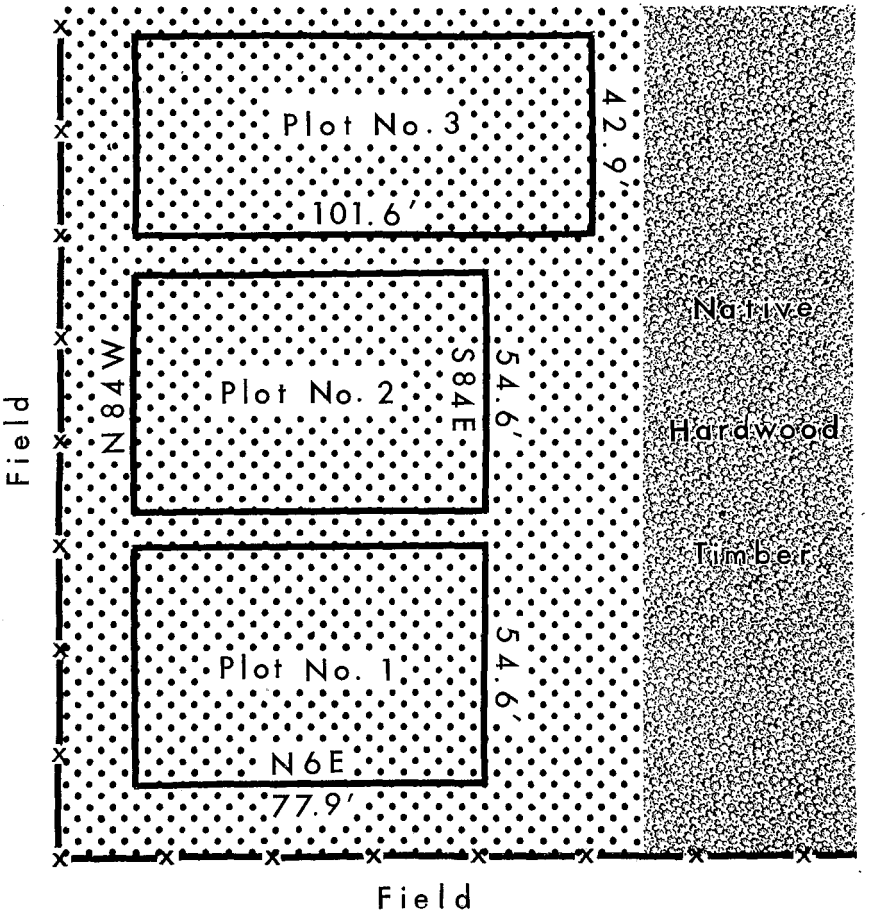
A--Mahoning County Experiment Farm
B--The Secrest Arboretum

In mixed alternate-row blocks, where the failure of one species resulted in 6 × 12 feet spacing and an almost pure stand, the predominant species evinced even better development. So it may be said that a spacing greater than 6 × 6 feet would have been more desirable."

FIG. 2

PERMANENT STUDY PLOTS

1954 – Today



His comments are borne out by the data. Table 1 indicates that, following an elapse of 22 growing-seasons:

Red pine outgrew the ponderosa pine when mixed with it in alternate rows at 6 × 6 feet spacing (Blocks 1 and 7).

Scotch pine outstripped the red when mixed with it in alternate rows at 6 × 6 feet spacing (Blocks 6 and 12).

Red pine practically eliminated its Douglasfir associate (Block 13).

Scotch pine, in almost all instances, led the others in both diameter and height growth.

In survival percent, the red pine surpassed the ponderosa, Scotch, and Austrian in the order named.

PLANTATION YIELD TO DATE

Evidence points to this as being an unusual plantation. Consider the pines, for instance—they are straight-boled, of slight taper, and have self-pruned remarkably well. A carpet of needles and duff 2 to 4 inches deep now covers the ground, and no undergrowth exists except the red-

Table 2
MEAN GROWTH RECORDS[1/]
(Data on per acre basis)

Year	Age	Trees	Basal Area	Av. D.B.H.[2/]	Av. Height	Cu. Ft. Volume	M.A.I.[3/]	P.A.I.[4/]
1941	22	718	91.3	4.8	31.4	1654	75.2	–
1954	35	637	165.9	6.9	51.3	4776	136.4	240.0
1959	41	610	194.4	7.6	59.0	6914	168.6	427.6

1/ Regardless of species. Blocks (Fig.1 and Table 1) grouped together to arrive at 1941 data. Permanent plots 1,2 and 3 (Fig.2 and Tables 4,5 and 6) are grouped together to arrive at the 1954 and 1959 data.

2/ Average diameter at breast height (4.5 feet above ground).

3/ Mean yearly growth rate, gotten by dividing the volume present by the number of growing-seasons to date.

4/ Periodic annual increment, gotten by dividing the periodic volume increase by the number of growing-seasons.

berried elder (*Sambucus pubens* Michx.) which is common. Despite the meager assistance accorded it, this woods illustrates some rather meaningful object lessons in forest tree planting.

Table 2 traces its development at ages 22, 35, and 41 years (before treatment). Taken as a whole, its basal-area almost doubled in amount during the 41 growing-seasons denoted by the records. The wood volume of its growing-stock more than quadrupled.

In March of 1959 there remained 610 pines per acre having a mean breast-high diameter of 7.6 inches, overall height 59 feet, and yearly increment 168.6 cubic feet! Nevertheless, stocking so excessive may, and it is presumed in this instance does, denote much wastage of the site potential on stems not apt to mature.

The tabular data evidently portray an overstocked stand. It could hardly be otherwise when 610 pines having 194.4 sq. ft. of cross-section are crowded onto one acre. Live crown lengths on a majority of the

TABLE 3

HEIGHT AND DIAMETER GROWTH BY SPECIES [1]

Species	Diameter Breast High (Inches)			Total Height (Feet)		
	22 yrs.[2]	35 yrs.[3]	41 yrs.[3]	22 yrs.	35 yrs.	41 yrs.
Scotch pine	6.2 (2.9–9.1)	8.1 (4.1–13.0)	8.6 (4.1–14.1)	42 (28–49)	60 (55–63)	67 (40–76)
Austrian pine	5.6 (2.9–10.8)	8.2 (6.1–10.5)	8.7 (7.0–11.5)	28 (14–41)	49 (47–50)	60 (46–68)
Am. red pine	5.4 (3.3–7.8)	6.7 (5.8–8.7)	7.5 (6.2–9.2)	31 (24–37)	47 (40–48)	54 (48–61)
Ponderosa pine	4.0 (2.1–6.4)	6.3 (3.7–9.6)	6.7 (3.7–10.5)	27 (17–35)	47 (41–52)	55 (35–65)
Douglasfir[4]	0.7 (0.5–1.0)	—	—	6 (5–6)	—	—
Canada hemlock[5]	—	—	7.2 (3.2–12.3)	—	—	45 (25–60)

[1] Averages of all the tree measurements taken to date, irrespective of individual blocks or plots.

[2] Data from 13 of the original planted blocks, taken the spring of 1941 by forester Jacob S. Ulmer.

[3] Data from the 3 permanent tenth-acre sample plots of the O.A.E.S; Forestry Dept; taken in 1954 and 1959.

[4] None measured after 1941 because there were no survivors.

[5] Not present in the permanent plots. Data based on only 8 trees.

NOTE: Mean values are listed first, the data dispersion in parentheses

trees represent as little as 20 percent of their total height. The obvious silvicultural need was that each potential crop tree be allotted additional space for its adequate development. Accordingly, about half of the pines comprising a third of the basal-area were removed in 1959 (Tables 4, 5, and 6).

TABLE 4.—Plot No. 1—RED PINE and AUSTRIAN PINE
(Data on per acre basis)

Age (Yrs.)	Trees (No.)	Basal Area[4] (Sq. Ft.)	D.B.H.[5] (Inches)	Height[6] (Feet)	Volume (Cu. Ft.)	M.A.I.[7] (Cu. Ft.)
		Red Pine—Pinus resinosa Ait.				
35	590	97.750	5.5	43	1905.1	54.4
41	280 (Cut)	49.520	5.7	50	1265.9	----
	200 (C)[1]	65.430	7.7	56	2106.2	----
	70 (T)[2]	14.510	6.2	51	432.6	----
	40 (D)[3]	4.180	4.4	38	64.9	----
Before Treatment	590 (Total)	133.640	6.5	52	3869.6	94.4
After Treatment	270 (Total)	79.940	7.4	55	2538.8	----
		Austrian Pine—Pinus nigra Arnold				
35	120	43.760	8.2	48	1171.7	33.5
41	20 (Cut)	7.950	8.5	63	291.6	----
	80 (C)[1]	35.520	9.0	60	1208.0	----
	20 (T)[2]	6.530	7.7	60	227.8	----
	0 (D)[3]	----	--	--	----	----
Before Treatment	120 (Total)	50.000	8.7	60	1727.4	42.1
After Treatment	100 (Total)	42.050	8.8	60	1435.8	----
		Plot Total—Combined Species				
35	710	141.510	6.0	46	3076.8	87.9
41	300 (Cut)	57.470	5.9	51	1557.5	----
	280 (C)[1]	100.950	8.1	57	3314.2	----
	90 (T)[2]	21.040	6.5	53	660.4	----
	40 (D)[3]	4.180	4.4	38	64.9	----
Before Treatment	710 (Total)	183.640	6.9	53	5597.0	136.5
After Treatment	370 (Total)	121.990	7.8	56	3974.6	----

[1]Crop trees, pruned to 17 feet above ground. [2]Trainers. [3]Dead standing trees. [4]Cross sectional area at 4½ feet. [5]Diameter at breast height (4½ feet above ground). [6]Total height, measured with hypsometer. [7]Average yearly growth (mean annual increment).

TABLE 5.—Plot No. 2—RED, AUSTRIAN, and PONDEROSA PINES

(Data on per acre basis)

Age (Yrs.)	Trees (No.)	Basal Area[4] (Sq. Ft.)	D.B.H.[5] (Inches)	Height[6] (Feet)	Volume (Cu. Ft.)	M.A.I.[7] (Cu. Ft.)
		Red Pine—Pinus resinosa Ait.				
35	20	7.070	8.0	51	195.8	5.6
41	0 (Cut)	----	--	--	----	----
	20 (C)[1]	8.070	8.6	56	245.2	6.0
Before Treatment	20 (Total)	8.070	8.6	56	245.2	6.0
After Treatment	20 (Total)	8.070	8.6	56	245.2	6.0
		Austrian Pine—Pinus nigra Arnold				
35	110	40.260	8.2	50	1119.8	32.0
41	40 (Cut)	14.410	8.1	55	444.6	----
	60 (C)[1]	29.440	9.5	63	1066.8	----
	10 (T)[2]	3.070	7.5	62	113.7	----
Before Treatment	110 (Total)	46.920	8.8	60	1625.1	39.6
After Treatment	70 (Total)	32.510	9.2	63	1180.5	----
		Ponderosa Pine—Pinus ponderosa Laws.				
35	500	106.910	6.3	47	2817.0	80.5
41	210 (Cut)	41.530	6.0	55	1281.0	----
	230 (C)[1]	69.630	7.5	58	2385.1	----
	30 (T)[2]	7.850	6.9	57	257.9	----
	30 (D)[3]	2.730	4.1	36	57.3	----
Before Treatment	500 (Total)	121.740	6.7	55	3981.3	97.1
After Treatment	260 (Total)	77.480	7.4	58	2643.0	----
		Plot Total—Combined Species				
35	630	154.240	6.7	48	4132.6	118.1
41	250 (Cut)	55.940	6.4	55	1725.6	----
	310 (C)[1]	107.140	8.0	59	3697.1	----
	40 (T)[2]	10.920	7.1	58	371.6	----
	30 (D)[3]	2.730	4.1	36	57.3	----
Before Treatment	630 (Total)	176.730	7.2	56	5851.6	142.7
After Treatment	350 (Total)	118.060	7.9	59	4068.7	----

[1]Crop trees, pruned to 17 feet above ground. [2]Trainers. [3]Dead standing trees. [4]Cross sectional area at 4 ½ feet. [5]Diameter at breast height (4 ½ feet above ground). [6]Total height, measured with hypsometer. [7]Average yearly growth (mean annual increment).

TABLE 6.—Plot No. 3—SCOTCH PINE

(Data on per acre basis)

Age (Yrs.)	Trees (No.)	Basal Area[4] (Sq. Ft.)	D.B.H.[5] (Inches)	Height[6] (Feet)	Volume[7] (Cu. Ft.)	M.A.I.[8] (Cu. Ft.)
35	570	201.880	8.1	60	7119.3	203.4
41	280 (Cut)	99.010	8.0	65	3808.0	----
	240 (C)[1]	119.560	9.6	70	5006.4	----
	40 (T)[2]	11.140	7.1	66	450.2	----
	10 (D)[3]	0.920	4.1	50	27.8	----
Before Treatment	570 (Total)	230.630	8.6	67	9292.4	226.6
After Treatment	280 (Total)	130.700	9.2	70	5456.6	----

[1]Crop trees, pruned to 17 feet above ground. [2]Trainers. [3]Dead standing trees. [4]Cross sectional area at 4 ½ feet. [5]Diameter at breast height (4 ½ feet above ground). [6]Total height, measured with hypsometer. [7]Total volume outside bark. [8]Average yearly growth.

SPECIES PERFORMANCE RECORDS

So rare a mixed stand as this calls for a detailed comparison of its component species. Table 3, wherein is listed their status at ages 22, 35, and 41 years, points up the brief specific summaries to follow:

Scotch pine. This European species has consistently taken the lead in height, diameter, and volume growth. Its overall height at present averages 67 feet, its diameter 8.6 inches, but one noteworthy tree reaches to 76 feet in height and has a breast-high diameter of 14.1 inches.

Of the successful pines here represented, the form of the Scotch falls below the standard of excellence set by the others, and yet it is above average for this notoriously erratic species. Among its various geographic races or varieties, the northern 'Riga' strain *(Pinus sylvestris rigensis* Loud.) is considered most promising for Ohio.

Austrian pine. Ranking second in status is another exotic, one that foresters frequently under-rate. On this site it did well when mixed with the red and ponderosa pines. For example, in Plot 2 (Table 5) the Austrian at 41 years averaged 60 feet in height and 8.8 inches d.b.h., the red 56 feet in height, and 8.6 inches d.b.h., the ponderosa 55 feet in height and 6.7 inches d.b.h.

Suited to the heavy calcareous soils, Austrian pine is a good tree for windbreaks in western Ohio.

Red pine. Its inability to express dominance at an early age makes the timely thinning of red pine essential, so as to avert losses from growth stagnation in overcrowded stands.

The red pine's stem-form usually is excellent, but here it self-pruned somewhat better than did any of its companion species.

Unfortunately, however, because of its susceptibility to injuries from the European pine shoot moth *(Rhyacionia bouliana* Schiff.) and pine sawfly *(Neodiprion sertifer* Geoff.), foresters no longer consider the red pine an important tree to plant in northern Ohio.

Ponderosa pine. The ponderosa (western yellow or bull) pine of Rocky Mountain origin obviously thrives under these Canfield, Ohio soil, moisture, and climatic conditions. Yet in the past six years its growth rate has declined. Being very shade intolerant, its status will likely improve following the selective treatment of the stand.

COMPARISON WITH THE SECREST ARBORETUM

There exists an interesting similarity between the performance records of these particular pines at Canfield and those representative of the well-known Secrest Arboretum at Wooster. The two localities have analogous soil types, so presumably their site indices for tree growth would differ but little. Growth within the plantation typifies Canfield silt loam soil, that within the Arboretum the strikingly similar Wooster silt loam. Both soil series are of glacial origin, of medium texture, permeable, usually well-drained, and particularly suited to tree growth. From a strict comparative standpoint, the Wooster, having a bit the less clay in its subsoil, permits of course of a better tilth and drainage.

Now, note the relative standings of the pines in those habitats situated so far apart. The chart (Fig. 3) indicates that Scotch pine holds the topmost position in both, and is followed by Austrian. The red and ponderosa pose as close contenders, with the former ranking third at Canfield and fourth at Wooster.

Next, scrutinize the bar-graphs portraying the performance records of these pines. In general, their periodic growth trends exhibit mutual correlations. That is especially true of the Scotch, red, and Austrian pines. The ponderosa, as a result, perhaps, of dissimilar seed source, shows the greater variation.

Timber growth data possessing a correlation with soil types, or with other environmental factors, could be of considerable practical value. A good woodland yield table reflects both a meaningful and a readily measurable site index factor. In fact, it must in order to predict with accuracy the returns forthcoming under different local conditions. An urgent need exists in Ohio and elsewhere for silvicultural aids in determining the quality of planting sites for preferred species. Just as farmers employ modern techniques to evaluate their tilled-land productivity from its soil characteristics, its slope and erodibility, so let them assess their potential wood yield when timber is their crop to be managed at an intensity level comparable to that of a field crop.

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