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SCOTS PINE IN EASTERN NEBRASKA: A PROVENANCE STUDY

by Ralph A. Read

ABSTRACT

Seedling progenies of 36 rangewide provenances of Scots pine (Pinus sylvestris) were established in a field test in eastern Nebraska. Results in growth and other characteristics after 8 years reveal that (1) southern origins bordering the Mediterranean grow slowly to moderately fast and remain dark green in winter, (2) central European origins grow very fast and turn yellowish green in winter, (3) northern origins grow slowly and turn very yellow in winter. Southern origins are therefore recommended for Christmas trees; fast growing central European origins are recommended for windbreaks; and the northern origins recommended as special-purpose ornamentals.

Key words: Pinus sylvestris, provenances, growth, Christmas trees, windbreaks, ornamentals.

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Scots Pine in Eastern Nebraska:

A Provenance Study

by

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[1]Central headquarters maintained at Fort Collins, in cooperation with Colorado State University; research reported here was conducted at Lincoln, in cooperation with the University of Nebraska.

PREFACE

The provenance study described in this Paper is one of a dozen experimental plantations of various tree species established on the Horning State Farm near Plattsmouth, Nebraska, which is administered by the Department of Horticulture and Forestry of the University of Nebraska. The USDA Forest Service, through its Rocky Mountain Forest and Range Experiment Station work unit at Lincoln, cooperates with the Nebraska Agricultural Experiment Station on this research.

The purpose of this work is to find and develop better adapted genetic tree materials for use in all kinds of plantings, environmental and commercial, throughout Nebraska and the Central Plains. These provenance studies of different species provide basic materials of known origin for evaluation of adaptability, for study of genetic variation, and for selection, propagation, and breeding for resistance to disease and insect pests.

The diversity of tree planting materials under study at this and many other locations in the Plains was made possible through cooperation in a Regional Tree Improvement Project (NC-99, formerly NC-51) of the North Central State Agricultural Experiment Stations.

Credits are due Jonathan W. Wright, Professor of Forestry, Michigan State University, for initiating the Regional study and providing the planting stock, and to Walter T. Bagley, Associate Professor of Horticulture and Forestry, University of Nebraska, for cooperation in planting and maintenance of the plantation.

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Scots Pine in Eastern Nebraska: A Provenance Study

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Scots pine (Pinus sylvestris L.) has become an important exotic in the United States in the last 20 years because of its greatly increased use for Christmas trees. It has been planted in this country since colonial times, but until recently has seen limited use in the Eastern Great Plains. More people are growing Christmas trees on a commercial basis in the Plains States now, and conifers are being used more generally for landscaping along highways, around rural and urban homes, and for windbreaks.

This increase in demand has brought up questions concerning the origin of seed sources, especially of planting stock to be used for Christmas trees. Experiences with planting stock purchased from commercial producers have resulted in plantations containing a large percentage of off-color yellow trees. Such trees are not readily marketable as Christmas trees. Although many Christmas tree growers now spray their trees with plastic paint to give them a uniform green color, this operation is an added expense passed on to the consumer. Planting stock of selections which stay fairly green have become available recently in limited amounts from some nurserymen.

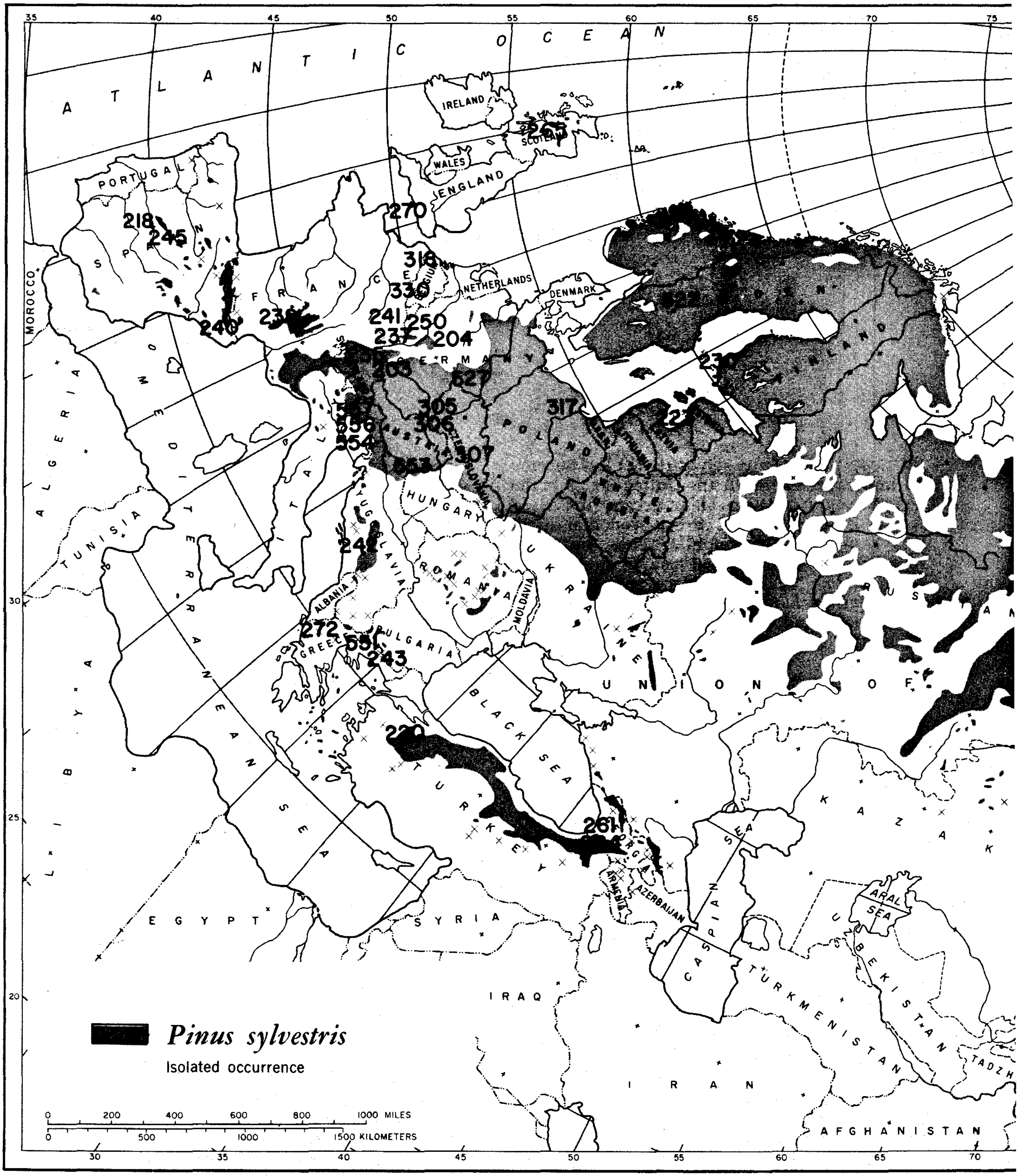
The performance of early plantings of Scots pine in the Eastern Plains was not recorded in detail, although many old trees 40 to 60 feet tall and 24 to 30 inches d.b.h. are still to be seen on farmsteads. Several plantations, labeled variety riga, were established in the 1920's on sandhills in the Nebraska National Forest. These grew well for 40 years before succumbing to an infestation of turpentine beetles. Generally, however, the full value of Scots pine as a tree for the Plains has been overlooked, because performance has been judged on relatively few and mostly unknown seed origins.

A cooperative Regional Tree Improvement Project (NC-51) of the North Central State Agricultural Experiment Stations made it possible to test, for the first time, a wide range of Scots pine origins for adaptability and growth in Nebraska. This Paper reports the results of that field study 8 years after it was established in 1959 in eastern Nebraska.

Past Work

Scots pine is the most widely distributed species of pine in the World (Critchfield and Little 1966). It grows in natural stands throughout Europe and northern Asia from southern Spain to Greece and Turkey, north to Finland, and east to Manchuria (fig. 1). It occurs on a great variety of soils and in regions of diverse climates, from 38° to 70° north latitude, and from 5° west to 135° east longitude.

Reports concerning the nature of genetic variation in this species are not entirely in agreement. Langlet (1959) contended that variation is clinal, based upon seedling characters of Swedish provenances and 17-year height data in European plantations. Khalil (1969), King (1965), Ruby (1967), Wright and Bull (1963) and Wright et al. (1966b) considered the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Pinus sylvestris
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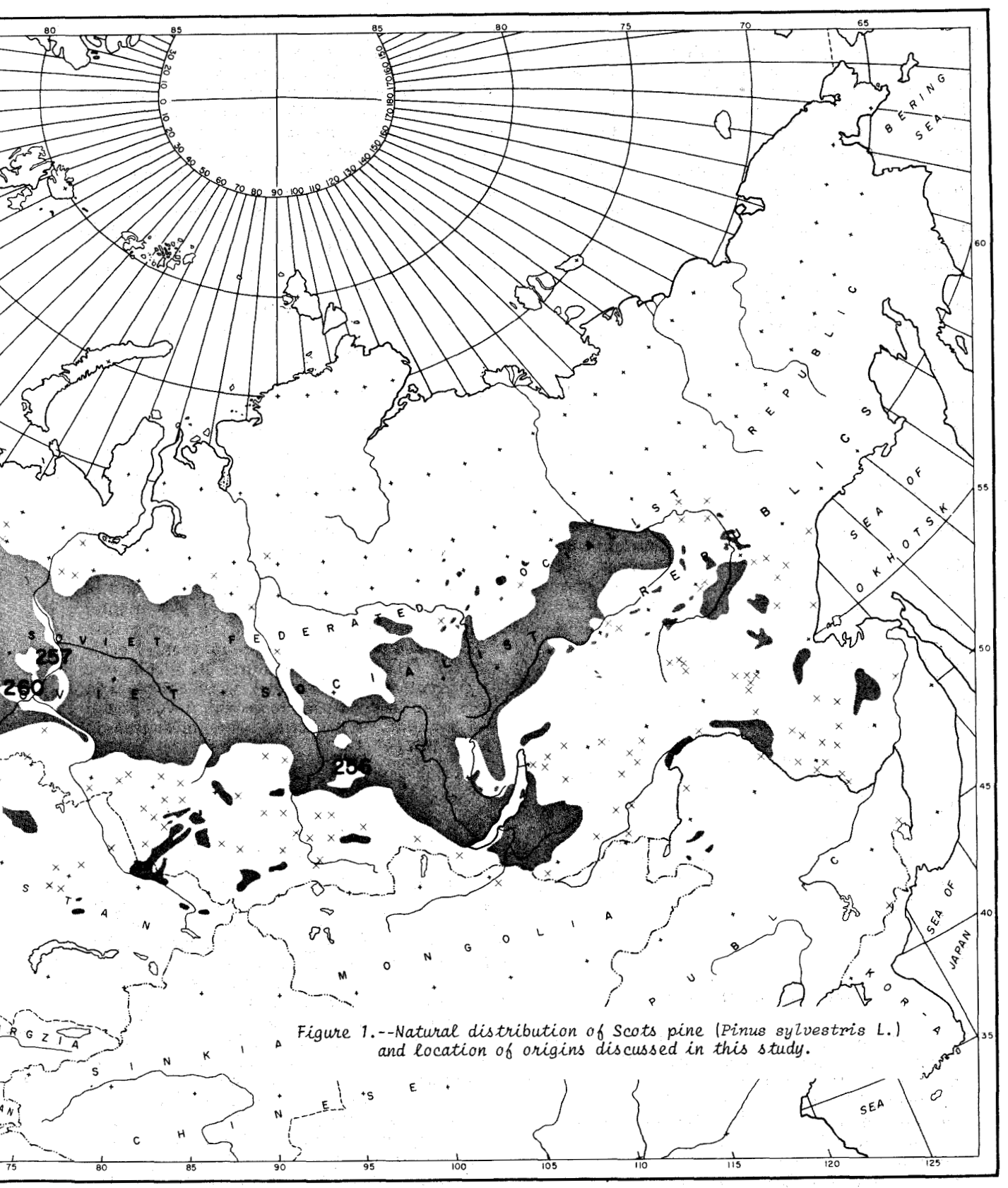

Figure 1.--Natural distribution of Scots pine (Pinus sylvestris L.) and location of origins discussed in this study.

variation as ecotypic or discontinuous. Wright's analysis was based upon 3-year seedling growth of 122 range wide origins in Michigan and upon 5- to 7-year field performance of these origins in various plantations in the North Central States. Garrett (1969), on the other hand, concluded that 5-year field results of 83 origins in northern Michigan seem to agree more closely with the clinal variation concept, with no well-defined breaks among origins in height and foliage characteristics. Ruby's (1967) detailed study of cone and seed characters of the parental populations and needle data of Wright's progenies grown in Michigan, indicated the existence of distinct regional groups or identifiable entities.

In their analysis of 17 field plantations in the North Central States at 5 to 7 years age, Wright et al. (1966b) grouped the origins by varieties as determined by multivariate analyses (Wright and Bull 1963). The choice of variety names was suggested by Ruby (1967). Several variety x plantation interactions were significant, but these were small compared with main effects. They found that Central European origins grew fastest, and Scandinavian and Siberian origins slowest. Origins from the most southerly latitudes remained darkest green, while origins from far north turned yellow. Winter foliage color differences by variety were essentially the same in the 10 widely scattered plantations from which data were available. The southern varieties, however, suffered winter injury in plantations in Minnesota and Michigan. Susceptibility to European sawfly was greatest on the tallest or fastest growing origins from central Europe (Wright et al. 1967).

Although performance in the Nebraska plantation has been similar in some respects to other north-central plantations, there are differences in growth, hardiness, and flowering by certain origins which are of importance in choosing the best seed sources for the Plains.

Materials and Methods

Seedlings of 36 origins (table 1, fig. 1) from a larger number under study by Michigan State University, Department of Forestry, were field planted in eastern Nebraska in 1962. Two-year-old seedlings from the Michigan nursery were shipped to Nebraska by air freight in 1961, and were grown for one additional year as transplants in a USDA Forest Service nursery in central Nebraska before being field planted.

The provenance plantation is 20 miles south of Omaha, near Plattsmouth, Nebraska, on the Horning State Farm experimental area operated by the Department of Horticulture and Forestry, University of Nebraska. This location, at 96° west longitude and 41° north latitude, is about the same latitude as many of the southern origins tested. The site is near the top of a gentle east-facing slope of silt loam soil derived from loess, which had been cultivated for a number of years in row crops. The layout consists of 14 tree rows, 500 feet long, on the contour. There are seven replications of two rows, and 36 randomly located four-tree plots in each replication. Trees are 7 feet apart, in rows 14 feet apart.

The 2+1 transplant stock was planted by machine during April 1962 on previously disked land. A 20-inch-wide band on both sides of each tree row was sprayed soon after planting with simazine at a rate of 4 pounds per acre for weed control (fig. 2). Plantation failures were replanted from extra lineout stock during the first two seasons. Maintenance through the first 6 years consisted of weed control with simazine in the tree rows and mowing between rows. Thereafter, only mowing was necessary.

Tree heights were measured at the end of each growing season, 1963 through 1969. Winter color of foliage was rated in December 1964, and checked in several subsequent years. Needle samples (two fascicles per tree from midpoint of current year's terminal) were collected in December 1964. Terminal growth development and amount of flowering were measured in spring 1967.

Results

Height Growth

The fastest growing trees, of origins from central Europe, were twice the height of the slowest growing origins at 8 years (table 2). Trees of the haguenensis variety from the Vosges Mountain region (237, 241, and 250) and from Belgium (318 and 530) were the fastest growers of the central European origins.

Trees of Scandinavian and Siberian origins grew slowest, followed by the southern origins. There was considerable variation in growth of southern origins. Greek sources 272 and 243, for example, differed by over 3 feet in total height. The relative height differences, as percent of the plantation mean at 8 years, ranged from 63 to 130 percent. These differences were of essentially the same magnitude as they were at 4 years of age.

Table 1.--Data on seed origin locations and geographic varieties of Scots pine tested in eastern Nebraska

Michigan State University origin number	Country	Latitude	Longitude	Elevation	Geographic varieties[1]
		Degrees N.	Degrees E.[2]	Feet	
		NORTHERN			
256	Siberia	56.7	96.3	1100	*altaica*
230	Finland	60.5	22.4	150	*septentrionalis*
522	Sweden	60.9	16.5	700	*septentrionalis*
265	Scotland	57.1	4.9W	640	*scotica*
257	U.S.S.R. Urals	56.8	65.0	500	*uralensis*
260	U.S.S.R. Urals	57.0	61.4	600	*uralensis*
223	U.S.S.R. Latvia	57.5	25.8	-	*rigensis*
		CENTRAL EUROPEAN			
317	Northern Poland	53.7	20.5	650	*polonica*
527	East Germany	50.9	13.7	1700	*hercynica*
204	West Germany	50.8	9.7	1300	*hercynica*
307	Czechoslovakia	49.9	17.9	800	*hercynica*
305	Czechoslovakia	49.0	14.7	1300	*hercynica*
306	Czechoslovakia	49.2	14.0	1500	*hercynica*
553	West Hungary	47.7	16.6	1000	*pannonica*
270	England	51.2	0.8W	200	*scotica X?*
318	Belgium	51.2	5.0	-	*haguenensis*
530	Belgium	50.0	5.0	1000	*haguenensis*
250	West Germany	49.4	7.6	1300	*haguenensis*
241	Northeast France	49.1	7.4	800	*haguenensis*
237	Northeast France	48.8	7.8	500	*haguenensis*
235	Northeast France	48.2	7.2	2300	*haguenensis*
203	South Germany	48.2	8.3	-	*hercynica*
554	North Italy	46.0	11.2	2400	*"Italy"*
556	North Italy	46.3	11.3	3200	*"Italy"*
557	North Italy	46.3	11.0	2600	*"Italy"*
		SOUTHERN			
261	U.S.S.R. Georgia	41.7	42.7	3600	*armena*
264	U.S.S.R. Georgia	41.8	43.5	5200	*armena*
220	West Turkey	40.0	31.3	4700	*armena*
243	North Greece	41.5	24.3	5800	*rhodopaea*
551	North Greece	41.3	23.4	4900	*rhodopaea*
272	Central Greece	39.9	21.2	4500	*rhodopaea*
242	Yugoslavia	43.9	19.4	4000	*illyrica*
239	South France	45.3	3.7	3300	*aquitana*
240	South France	42.6	2.1	5000	*aquitana*
245	Central Spain	40.7	4.2W	4800	*iberica*
218	Central Spain	40.3	5.2W	3700	*iberica*

[1]Wright et al. 1966b.
[2]All east except as noted.

Figure 2.--The Scots pine provenance plantation 1 year after establishment in eastern Nebraska (weeds controlled by means of a 40-inch-band chemical spray over the tree rows).

Table 2.--Growth and needle characteristics of Scots pine origins in eastern Nebraska

Michigan State University origin number	Height		Spring growth initiation (4 to 0)[1]	Winter foliage color (0 to 9)[2]	Needle length
	8-year total	Percent of plantation mean			
	Feet				mm
		NORTHERN			
SIB 256	7.4	63	4.0	0.3	59
FIN 230	7.6	64	3.0	1.6	49
SWE 522	8.2	69	3.6	1.4	53
SCO 265	10.7	91	1.7	5.6	64
URA 257	10.1	86	3.9	1.4	64
URA 260	10.4	88	3.8	1.3	64
LAT 223	11.1	94	2.4	1.6	60
		CENTRAL EUROPEAN			
POL 317	13.5	114	2.2	3.0	79
GER 527	14.3	121	2.6	3.7	71
GER 204	13.0	110	1.9	4.4	76
CZE 307	14.1	119	2.2	4.0	84
CZE 305	13.4	114	1.9	3.9	87
CZE 306	13.0	110	2.1	4.0	70
HUN 553	13.2	112	2.0	4.4	87
ENG 270	13.4	114	2.3	5.4	74
BEL 318	14.7	125	2.1	4.6	85
BEL 530	14.5	123	2.1	4.6	85
GER 250	14.4	122	2.0	4.9	83
FRA 241	14.2	120	1.8	4.4	88
FRA 237	15.3	130	2.0	5.0	92
FRA 235	13.3	113	2.2	6.0	77
GER 203	12.3	104	2.1	4.3	63
ITA 554	12.2	103	2.2	5.7	66
ITA 556	11.9	101	2.1	4.6	66
ITA 557	11.3	96	1.9	4.7	62
		SOUTHERN			
GEO 261	10.6	90	2.1	6.3	69
GEO 264	11.3	96	2.1	6.1	63
TUR 220	11.6	98	2.3	7.0	67
GRE 243	12.0	102	2.2	6.3	48
GRE 551	11.0	93	1.9	6.0	54
GRE 272	8.6	73	2.3	5.3	55
YUG 242	11.9	101	2.0	4.9	72
FRA 239	11.5	97	1.6	7.1	54
FRA 240	8.6	73	1.0	7.0	47
SPA 245	9.7	82	1.1	8.3	53
SPA 218	9.2	78	1.1	8.0	56

[1]4 = earliest; 0 = latest.
[2]0 = yellowest; 9 = darkest green.

Total height curves for groups of origins of similar growth (fig. 3) show that southern and northern origins grew slowest and generally at about the same rate. The far north origins of Finland and central Siberia were the slowest. A few southern origins, particularly from Greece, Turkey, and Georgia S.S.R., grew moderately fast, about equal to the slowest central European sources. The curves also show that the fastest growing origins in the nursery continued to grow fastest, and the smallest transplants continued to be the slowest growers after 8 years.

Analyses of variance of height data by years showed increasing significance among origins throughout all replications. Relative height growth of the various origins was essentially the same in this Nebraska plantation as in Michigan (Wright et al. 1966b).

Spring Growth

Northern varieties started growth earliest in the spring; southern varieties were last (table 2). Height growth in spring 1967 was well advanced by May 8-9 on all origins from Sweden, Finland, Latvia, and Siberia. All bud scales had sloughed and the new needles, mostly longer than 1 centimeter, were distinct from the base to tip of shoot. The Scottish origin was the exception. Height growth started later and in this respect was more like some of the southern origins.

Height growth started much later on some, but not all, southern origins. Origins 218 and 245 from Spain and 240 from southern France were especially late in starting growth. Buds had scarcely begun to swell and elongate on May 8-9, appearing still in winter condition. Some southern origins from Greece and Turkey, however, were moderately advanced in growth, but not so much as the far north origins. All origins of central Europe were intermediate, and there was no apparent pattern based on their geographic source.

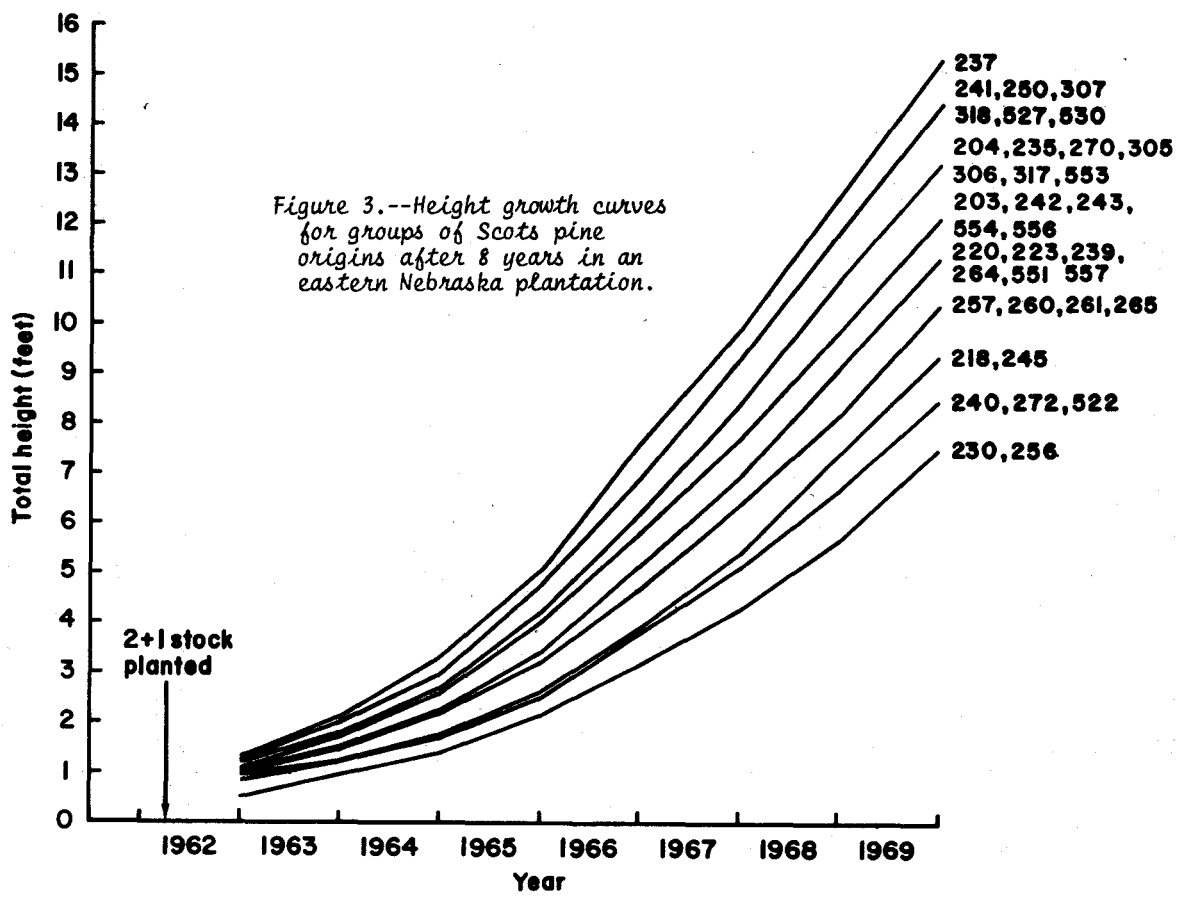

Figure 3.--Height growth curves for groups of Scots pine origins after 8 years in an eastern Nebraska plantation.

Needle Color and Length

Foliage color during the growing seasons was not strikingly different among origins, although it ranged between medium and dark green. Among the more northerly origins, needle color changed annually from green to yellow, usually starting during October after several days of cold, sunny weather. The green generally returned during March and April.

Winter foliage color ranged from yellow to dark, bluish green, rated on a scale from 0 to 9 (table 2). There was essentially no variation in winter color of individual trees from year to year. All trees of Scandinavian and Siberian origins turned various shades of yellow, and were consistent in color change each winter. Here again the Scottish trees were different among the northern origins. Although foliage color was not as dark green as most southern origins, they were not yellowish green.

All trees of origins from Spain, southern France, and northwest Turkey remained dark green or bluish green. Central European origins were generally intermediate in color, with some sources remaining fairly green, while others turned yellowish green. None of the origins showed any effects of winter desiccation and foliage burn, a condition which is evidently quite common some years in the northern Plains.

Needle length ranged from about 50 mm. on the origins from Scandinavia, southern France, Spain, and Greece to about 90 mm. on many of the central European origins. The slowest growing origins had the shortest needles, and the fastest growing origins of central Europe had the longest needles. This confirms Ruby's (1967) observation of seedling materials of these origins grown in Michigan.

Flowering Patterns

A few ovulate strobili were seen on less than 1 percent of all trees in 1966 (after the fifth field season). Abundant flowering began on many origins in the spring of 1967—66 percent of all trees produced ovulate and 17 percent staminate strobili. Staminate strobili were generally produced at a much lower level than ovulate on all sources (table 3). Flowering started in the Michigan nursery when nine 2-year-old seedlings produced small amounts of pollen (Wright et al. 1966a).

Ovulate flowering on the origins, except for the Scottish, was sparse. Although over half the trees of these origins had started to produce conelets, there were very few on each tree. Central European sources produced the most ovulate strobili on more trees. Southern origins were intermediate in ovulate cone production; cones were abundant only on source 239 of southern France. Cone production on origins from Turkey, central Greece, and central Spain was as sparse as on the far north origins.

Fast-growing origins from Belgium and others of the haguenensis variety had the highest percentage of pollen-producing trees. Just a few trees of other origins produced abundant pollen. The Scandinavian and Siberian origins had practically none. Others not producing much pollen were from Spain, Greece, Scotland, and England. Staminate strobili on the smaller trees were invariably on the terminal shoots, while on the larger trees they were predominantly in the lower crown. Ovulate strobili were usually at midcrown.

Application of Results

The 36 origins tested can be grouped by classes of height growth rate and winter foliage color (table 4). The extremes of growth are: Slow (less than 1 foot per year) and Very Fast (more than 1.75 feet per year). From this table, the most desirable origins can be selected for specific purposes.

None of the origins with the dark green color desired for Christmas trees fell into the fast growth class. The origins of best color grew medium slow to medium fast—from 1.0 to 1.5 feet per year. This is probably fortunate because trees which grow too fast must be sheared heavily to shape them for Christmas trees. The slower growing trees need less shearing, and have less tendency to produce multiple leaders and extreme numbers of lateral branches.

The best origins for Christmas tree color in Nebraska are from southern France, Spain, and Turkey (239, 240, 218, 245, and 220). Of these, 239 and 220 grow slightly faster than the others. In addition, the Scottish origin (265) is recommended because of its overall desirable characteristics of growth, color, and later growth initiation.

Results to date indicate that fast-growing origins may be well adapted for general use in windbreaks, where foliage color is not important. Origins of the haguenensis variety of Belgium (318 and 530) and nearby Vosges Mountains in France and Germany (237, 241, and 250) appear ideal for this purpose. They grow nearly as fast as broadleaf species such as green ash and honeylocust, and should be used more often in windbreaks to provide yearlong effectiveness and beauty.

Table 3.--Occurrence and abundance of flowering in Scots pine origins, 6 years after planting in eastern Nebraska

Michigan State University origin number	Ovulate strobili		Staminate strobili	
	Occurrence among all trees	Average per tree	Occurrence among all trees	Abundant trees
	Percent	Number	Percent	Number
		NORTHERN		
SIB 256	29	2	0	0
FIN 230	65	9	0	0
SWE 522	56	5	7	0
SCO 265	79	21	0	0
URA 257	50	3	4	0
URA 260	50	5	8	0
LAT 223	61	9	11	0
		CENTRAL EUROPEAN		
POL 317	74	29	11	1
GER 527	89	18	36	0
GER 204	82	33	15	1
CZE 307	78	13	18	1
CZE 305	73	24	4	0
CZE 306	57	34	24	0
HUN 553	78	22	9	0
ENG 270	68	17	4	0
BEL 318	100	91	56	6
BEL 530	86	23	36	2
GER 250	93	48	44	3
FRA 241	76	28	24	0
FRA 237	86	28	29	2
FRA 235	79	12	14	0
GER 203	93	26	21	0
ITA 554	71	43	21	2
ITA 556	67	33	14	0
ITA 557	77	45	27	1
		SOUTHERN		
GEO 261	72	18	25	3
GEO 264	54	13	21	1
TUR 220	37	6	15	0
GRE 243	68	20	32	2
GRE 551	54	15	4	0
GRE 272	12	3	4	0
YUG 242	44	25	32	1
FRA 239	82	52	32	1
FRA 240	75	14	14	0
SPA 245	32	12	11	1
SPA 218	43	4	0	0

Table 4.--Growth rate and winter foliage color groupings of Scots pine origins after 8 years in eastern Nebraska

Height growth rate (8-year basis)	Winter foliage color			
	Yellow	Yellow green	Green	Blue green
Very fast (more than 1.75 feet per year)		527 East Germany 241 France 307 Czechoslovakia	237 France 318 Belgium 530 Belgium 250 Southwest Germany	
Fast (1.50 to 1.75 feet per year)		317 Poland 305 Czechoslovakia 553 Hungary 306 Czechoslovakia 204 Central Germany 203 Southwest Germany	270 England 235 France 554 Italy 556 Italy 243 Greece 242 Yugoslavia	
Medium fast (1.25 to 1.50 feet per year)	223 Latvia 260 West Siberia 257 West Siberia		557 Italy 264 Caucasus 261 Caucasus 551 Greece 265 Scotland	220 Northwest Turkey 239 France
Medium slow (1.0 to 1.25 feet per year)	522 Sweden		272 Greece	245 Spain 218 Spain 240 France--Pyrenees
Slow (less than 1.0 foot per year)	230 Finland 256 Central Siberia			

The northern varieties, which turn yellow in winter, may have special ornamental value in creating color contrast in landscaping. Other studies have shown that additional origins from northern Siberia change to golden yellow in midwinter. These golden types, when combined in planting with the dark green materials of southern Europe, can be used to create striking ornamental effects.

The time of growth initiation in spring has a bearing on the time of shearing. Early shearing in relation to terminal growth development causes a profusion of lateral buds near top of the sheared terminal, resulting in an undesirable flush of growth, which must be thinned for proper shaping. Delayed shearing tends to reduce this, producing fewer laterals. Since southern origins are last to start spring growth, shearing of them should be delayed several weeks, in comparison to origins which begin and complete growth much earlier.

The fact that northern origins begin height growth 2 to 3 weeks before the southern is important for planning controlled pollinations among the different origins, since development and receptivity of ovulate strobili depends on terminal shoot elongation. Development of staminate strobili is also closely related to initiation of terminal shoot growth in the spring. Controlled crosses of northern varieties with pollen of southern varieties will therefore require collection and storage of pollen a year in advance.

Individual trees of superior crown form have been noted within almost all origins tested (fig. 4). These trees are now being used in an intensive selection and breeding program to provide superior genetic materials for seed production orchards by means of grafting and controlled pollination. Improved planting stock from these orchards will not be available for at least 10 years, however. In the meantime, Christmas tree growers, landscape nurserymen, and windbreak tree planters can help influence present programs and can obtain better performance in their plantings by specifying the seed origins desired for certain purposes.

Figure 4.--Individual tree of origin 305, from Trebon, Czechoslovakia, shows excellent crown form and height (13 feet) after 8 years in the field.

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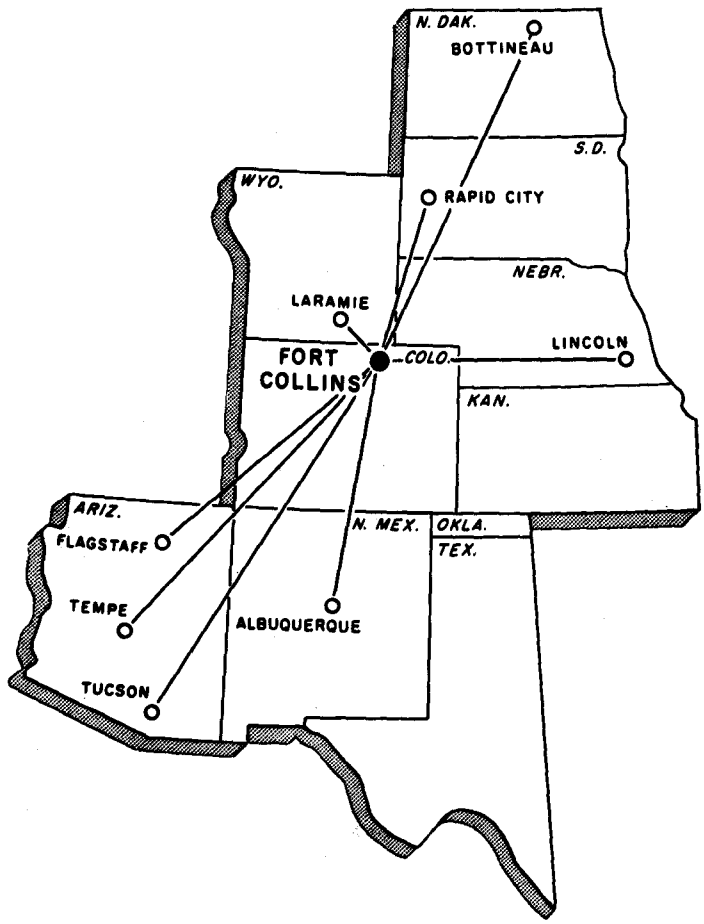
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COLO.
KAN.
ARIZ.
N. MEX.
OKLA.
TEX.
FLAGSTAFF
TEMPE
ALBUQUERQUE
TUCSON