RESEARCH PAPER NC-8
DECEMBER 1966

PROMISING CONIFERS for WESTERN IOWA

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Promising Conifers for Western Iowa

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Foresters and landowners have little information to guide them in selecting or recommending suitable tree species for windbreak and forest plantings on the uplands of western Iowa. Hardwood species generally are not suited to the calcareous soils and climatic conditions of this area. So we established a study in 1949 to find coniferous species that could be successfully grown here. Eleven out of 24 coniferous species planted appeared to be adapted to local conditions. Furthermore, the degree of success for most of the promising species was correlated with depth to free carbonates in the soil.

Western Iowa has wide variations in temperature (+96 to —22 degrees Fahrenheit), almost continuous drying winds, and an annual precipitation of 30 inches. Most rainfall occurs as heavy thundershowers during the 160-day growing season. Thus, it is poorly distributed and periods of extended drought are common.

Ida soils occupy the upper slopes, and Monona soils are found on the lower slopes of the study area. The Ida soils are classified as Regosols, and Monona soils as Brunizems. Monona soils are distinguished from Ida soils by a thicker and darker A horizon, and a developed B horizon. Moreover, calcareous loess generally occurs at depths greater than 40 inches in Monona soils. Ida soils are droughty and have unleached calcareous loess near the soil surface.

The Study

In 1949, 19 coniferous species were planted in each of 3 blocks (table 1). Each block had twenty 1/10-acre plots.[1] Eastern redcedar from Nebraska and Oklahoma seed sources and each of the other 18 species were planted in separate plots. Seedlings were planted at a 6- by 6-foot spacing. In succeeding years, an effort was made to attain full stocking of the plots by replacing the trees that died. Often stock of different seed origin was used in replacing trees (table 2). Species that failed after two or more trials were replaced with other species. Five additional species were planted in 1950 and 1952. Weed competition was controlled to a limited degree by handhoeing and mowing during the first 3 years.

Linear regression analyses were used to investigate the effect of depth to free carbonates on survival and height growth of the most promising species.[2]

[1] *Established cooperatively with Ed Banks, landowner, and the Forestry Department, Iowa Agricultural Experiment Station, Iowa State University.*

[2] *Dr. W. H. Scholtes (Agronomy Department, Iowa State University) prepared detailed maps of soil type, topsoil thickness, and depth to free carbonates for the study area.*

Table 1.—*Species of conifers planted from 1949 to 1952*[1]

Common name	Scientific Name
Northern white-cedar	Thuja occidentalis L.
Douglas-fir	Pseudotsuga menziesii (Mirb.) Franco
White fir[2/]	Abies concolor (Gord. & Glend.) Lindl.
Eastern redcedar[3/]	Juniperus virginiana L.
One-seed juniper[4/]	J. monosperma (Engelm.) Sarg.
Rocky Mountain juniper	J. scopulorum Sarg.
European larch	Larix decidua Mill.
Japanese larch[4/]	L. leptolepsis (Sieb. & Zucc.) Gord.
Austrian pine	Pinus nigra Arnold
Eastern white pine	P. strobus L.
Jack pine	P. banksiana Lamb.
Japanese red pine[4/]	P. densiflora (Sieb. & Zucc.)
Lodgepole pine	P. contorta var. latifolia Engelm.
Pitch pine	P. rigida Mill.
Ponderosa pine	P. ponderosa Laws.
Red pine	P. resinosa Ait.
Scotch pine	P. sylvestris L.
Shortleaf pine	P. echinata Mill.
Swiss Mountain pine	P. mugho Turra var. rostrata Hoopes
Table-Mountain pine[4/]	P. pungens Lamb.
Virginia pine	P. virginiana Mill.
Black Hills spruce	Picea glauca var. densata Bailey
Norway spruce	P. excelsa Link
White spruce	P. glauca (Moench) Voss

1/ Unnumbered species were planted in 1949.
2/ Planted in 1952.
3/ Separate plots were established for eastern redcedar from Nebraska and Oklahoma seed sources in 1949.
4/ Planted in 1950.

Table 2.—*Seed sources used by species from 1949 to 1951*[1]

Species	Seed Source		
	1949 Plantings	1950 Plantings	1951 Plantings
Northern white-cedar	Beltrami County, Minnesota	Beltrami County, Minnesota	Warroad, Minnesota
Douglas-fir	Pike National Forest, Colorado	Pike National Forest, Colorado	Lincoln National Forest, New Mexico
Eastern redcedar	Nebraska National Forest, Nebraska	Nebraska	Anselmo, Nebraska
Eastern redcedar	Oklahoma	Oklahoma	Unknown
One-seed juniper	No plantings	San Isabel National Forest, Colorado	San Isabel National Forest, Colorado
European larch	Unknown	Central Europe	Unknown
Japanese larch	No plantings	Japan	Japan
Austrian pine	Vienna, Austria	Unknown	Unknown
Eastern white pine	Manistee National Forest, Michigan	Nicolet National Forest, Wisconsin	Nicolet National Forest, Wisconsin
Jack pine	Gen. Andrews State Forest, Willow River, Minnesota	Jackson and Clark Counties, Wisconsin	Nicolet National Forest, Wisconsin
Japanese red pine	No plantings	Japan	Unknown
Lodgepole pine	Pike National Forest, Colorado	Routt National Forest, Colorado	Routt National Forest, Colorado
Pitch pine	Unknown	New England	Unknown
Ponderosa pine	San Juan National Forest, Colorado	Nebraska National Forest, Nebraska	Nebraska National Forest, Nebraska
Red pine	Baudette, Minnesota	Massey, Ontario	Wisconsin
Scotch pine	College Park Madison Wisconsin	Unknown	Denmark
Swiss Mountain pine	Denmark	Denmark	Denmark
Table-Mountain pine	Pennsylvania	Pennsylvania	Pennsylvania
Virginia pine	eastern Tennessee	Pennsylvania	Unknown
Black Hills spruce	Denver, Colorado	Denver, Colorado	Denver, Colorado
Norway spruce	Vienna, Austria	Vernon County, Wisconsin	Sweden
White spruce	Chequamegon National Forest, Wisconsin	Chequamegon National Forest, Wisconsin	Chequamegon National Forest, Wisconsin

1/ Seed origin is important. It can make the difference between success or failure of a tree plantation. We do not know which seed sources would provide the best stock for planting in western Iowa. Seed sources from other localities might have survived and grown better than those that were actually used.

Table 3.—*Height and survival by species, year of planting, and major causes of mortality*[1]

Species	1949 Plantings (12-year results): Average height	1949 Plantings (12-year results): Survival	1950 Plantings (11-year results): Average height	1950 Plantings (11-year results): Survival	1951 Plantings (10-year results): Average height	1951 Plantings (10-year results): Survival	Major causes of mortality
	Feet	Percent	Feet	Percent	Feet	Percent	
Northern white-cedar	12.6	36	9.8	51	6.8	53	1949--Poor stock, winter drought injury, and rabbits
Douglas-fir	6.0	8	5.5	25	6.0	56	1949 and 1950--Poor stock
Eastern redcedar (Neb.)	12.6	33	12.0	91	11.9	88	1949--Poor stock
European larch	17.5	35	15.2	57	13.2	47	1949--Poor stock 1950 and 1951--Stock leafing-out
Austrian pine	12.9	35	12.6	79	10.1	59	1949--Poor stock and rabbits
Eastern white pine	14.2	42	13.8	70	13.3	64	Winter drought injury and rabbits
Jack pine	17.2	36	15.1	70	13.4	78	1949--Poor stock
Lodgepole pine	7.2	40	6.7	37	3.6	44	1949--Poor stock 1950 and 1951--Rabbits and hogs
Pitch pine	14.6	28	13.7	43	10.3	7	1949--Poor stock, winter drought injury, and rabbits
Ponderosa pine	12.6	25	11.9	84	9.4	87	1949--Poor stock and rabbits
Red pine	12.8	21	10.7	54	9.4	43	1949--Poor stock and winter drought injury
Scotch pine	14.6	2	12.7	47	10.6	83	1949--Poor stock 1950--Rabbits
Black Hills spruce	5.8	6	5.7	69	4.3	50	1949--Poor stock and weed competition
Norway spruce	4.2	1	6.3	37	6.8	25	1949--Poor stock, winter drought injury, and weed competition
White spruce	7.8	60	7.4	45	5.7	42	Winter drought injury, weed competition, and gophers

1/ Survival percentage = $\frac{\text{total number of trees living in replicated plots}}{\text{total number of trees planted in replicated plots}} \times 100$

Average total height = average total height of surviving trees in replicated plots

Suitable Species After 12 Years

Survival and mean height of 10-, 11-, and 12-year-old plantings were calculated for the 15 species that survived (table 3). Unfavorable weather and poor planting stock caused low survival of most species planted in 1949.

Species suitability ratings are based on present survival, height growth, and vigor, and on potential for producing forest products. The 11 most promising species are described individually.

Eastern redcedar from a Nebraska seed source survived and grew better than any of the species grown on exposed upper west- and northwest-facing slopes. These Ida soils have less than 2 inches of topsoil and pH ranges from 8.1 to 8.6 in the upper 9 inches with lime concretions present at the soil surface.[3] In 1949, 1-2 planting stock with a poor top-root ratio failed, but vigorous 2-0 stock in 1950 and 1951 gave excellent results.

Scotch pine also is very tolerant to high-lime soils. Results of the 1951 plantings show that Scotch pine survived and grew well when vigorous 2-0 stock was used (table 3). Scotch pine behaved like eastern redcedar on exposed sites where free carbonates were present at the soil surface. Graded stock (4 to 7 inches in height) with a good top-root ratio was planted in 1950. During the fall and winter (1950-1951) rabbits seriously injured 66 of the trees necessitating replacing them.

Austrian pine is tolerant to high-lime soils. It also survived and grew well on west, northwest, north, and northeast exposures. The very small stock planted in 1949 gave poor survival while the larger stock planted in 1950 and 1951 gave good results.

Ponderosa pine performed exceedingly well on exposed upper slopes as well as on more favorable sites. Soil pH to a depth of 9 inches ranged from 8.2 to 8.5 on areas of poor growth and from 6.4 to 7.4 on areas of good growth. In 1949, 2-2 stock with a poor top-root ratio failed. Good 2-1 stock in 1950 and 2-1-1 stock in 1951 gave excellent survival.

Jack pine grew from 1.0 to 1.8 feet annually for 12 years since planting. During the first 7 years, jack pine and European larch had the fastest growth rates among the species studied. Trees planted on the middle one-third of slopes survived and grew better than trees planted on the upper one-third of an exposed northwest-facing ridge. Small 2-0 planting stock used the first year gave 38-percent survival. Larger 2-0 stock in 1950 and 1951 gave at least 70-percent survival.

European larch grew faster than any of the species planted. It averaged 1.5 feet annually over the 12-year period since planting. During the last 4-year period (1957-1960) it grew 2.3 feet per year. European larch grew well on calcareous soils with pH values up to 7.8, but it is sensitive to poor surface drainage and soil compaction.[4] European larch grew best on a northeast aspect on Brunizem intergrade soil. Survival tended to be lower on exposed west and northwest aspects than on north aspects. The 2-0 stock planted in 1950 and 1951 gave 57- and 47-percent survival,

[3] *Soil pH determinations were made in 1956 with a Coleman glass electrode pH meter.*

[4] *McComb, A. L. The European larch: its races, site requirements, and characteristics. Forest Sci. 1(4): 298-318, illus. 1955.*

respectively. In both years, buds on the planting stock had burst before planting. Survival probably would have been greater if dormant stock had been planted.

White pine survived and grew best on a plot having Brunizem intergrade soil located on the lower one-third of a northeast-facing slope. The upper 12 inches of soil in this plot was slightly acid. Calcareous loess occurred at more than 36 inches below the soil surface. During the last 4 years, white pine grew about 2.5 feet annually on this plot. In this study, good survival and growth resulted from the use of vigorous 2-2 stock planted on favorable sites.

Red pine survived and grew best (2.0 feet annually during the last 4-year period) on a plot having Brunizem intergrade soil that was located in a covelike position on the lower one-third of a northeast-facing slope. Soil pH ranged from 6.2 to 6.7 in the upper 9 inches of soil on the good growth plot. Calcareous loess was present at a depth of over 36 inches. Small 3-0 stock used in 1949 gave poor results, but larger 2-2 stock planted in 1950 and 1951 gave better results.

Northern white-cedar survived and grew well when good stock was planted. Good results were obtained in 1950 with planting stock that was 8 to 14 inches tall and with 3-0 stock in 1951. Older stock (8-0) with a poor top-root ratio planted in 1949 failed. Northern white-cedar, which is shallow rooted, probaby would have failed on calcareous Ida soils, but by chance it was not planted there. A spring examination of drought injury in 1956 showed that northern white-cedar suffered extensive dieback and mortality on two plots mapped as having Brunizem intergrade soils. Mortality undoubtedly would have been even more severe on droughty Ida soils. Drought injury was more severe on an exposed northwest-facing plot than on a more protected northeast-facing plot. No damage was recorded on a third plot located in a covelike position on the lower one-third of a northwest-facing slope.

Black Hills spruce and *white spruce,* typically slow-starting species, have overtopped the weeds on protected slopes. These two species have survived well and are beginning to grow nearly 1 foot per year on Brunizem intergrade soils, but they have failed completely on calcareous Ida soils. The best spruce sites are located along drainageways on the middle and lower one-third of north- and northeast-facing slopes. Results were good on favorable sites when vigorous 2-0 Black Hills spruce and 2-2 white spruce stock was used.

Unsuitable Species After 12 Years

Norway spruce and *Douglas-fir* have been classified as unsuitable but both are borderline cases. Two of the three Norway spruce plots were established on exposed sites with Ida soil. Nearly all the trees on these plots died. But Norway spruce survived and grew nearly as well as Black Hills and white spruce on Brunizem intergrade soils. Douglas-fir was considered unsuitable because of slow growth, but this species is now growing more rapidly, and vigorous 3-0 stock planted in 1951 has survived satisfactorily. Survival and growth were best on the lower third of a northeast-facing slope.

Eastern redcedar (Oklahoma seed source), *Japanese larch, one-seed juniper, shortleaf pine, Swiss pine, Virginia pine,* and *white fir* exhibited such poor survival that they must be considered unsuitable for planting in this area.

Rocky Mountain juniper, like eastern redcedar (Nebraska seed source), performed well on adverse sites, but during the moist 1960 and 1961 growing seasons juniper blight killed all the trees. The disease was caused by *Phomopsis juniperovora* Hahn.

Lodgepole pine grew less than 1 foot in height per year. Because of this slow rate of growth and because of the unhealthy appearance of the surviving trees, it is considered a poor risk for planting in western Iowa.

Pitch pine, Japanese red pine, and *Table-Mountain pine* performed like white pine and red pine. However, because of their poor form these species must be considered less suitable than red and white pines.

Depth to Free Carbonates

Survival and growth for most species were correlated with depth to free carbonates. Eastern redcedar (Nebraska) and Scotch pine were the outstanding exceptions. Neither survival nor growth of these two species was significantly affected by depth to free carbonates. Eastern redcedar and Scotch pine survived and grew well even when free carbonates were within the top 12 inches of soil.

Survival of ponderosa pine, jack pine, and European larch was not greatly affected by the presence of carbonates, but the other six promising species were.

Height growth was significantly depressed when carbonates were at or near the soil surface for the following species: Austrian pine, ponderosa pine, jack pine, red pine, and probably eastern white pine and European larch.

Austrian pine and ponderosa pine grew best when the carbonates were 14 inches or more below the soil surface (fig. 1).

White pine failed completely on Ida soils that had free carbonates within 30 inches of the soil surface. Red pine survived and grew satisfactorily (more than 1 foot a year) where the depth to free carbonates was at least 30 inches below the soil surface. Red pine survival and height growth declined rapidly with decreasing depths to free carbonates. During severe winters, extensive dieback of white pine, red pine, and northern white-cedar is associated with high-lime soils. These species grew well on Brunizem soils that had more than 30 inches of lime-free soil. Wilhite investigated drought injury and death of red pine in relation to site in Iowa. He found that at least the upper 12 inches of soil should be noncalcareous for satisfactory growth of red pine.[5] We found that 30 inches of noncalcareous soil were required for satisfactory growth in western Iowa.

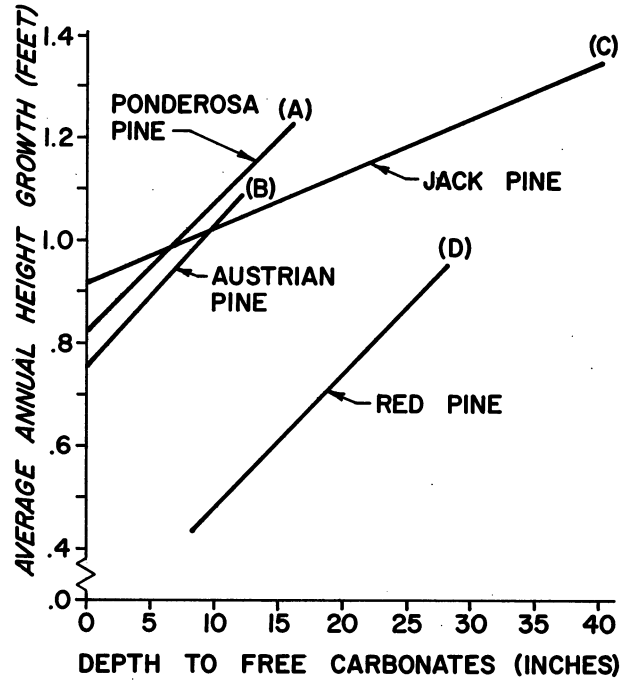

Fig. 1.—Significant relations of mean annual height growth to depth to free carbonates by species on Ida soils with less than 2 inches of topsoil.

[5] *Wilhite, L. P. Drought injury and death of red pine* (Pinus resinosa *Ait.*) *in relation to site. (Master of science thesis on file at Iowa State Univ.) 1960.*

Initial survival of Black Hills spruce and white spruce was satisfactory when vigorous stock was planted. However, the trees gradually became chlorotic and died where carbonates occurred at depths of less than 16 inches from the surface. The poor growth rate and chlorotic condition of the spruces during the growing season appear to be related to mineral deficiencies that may be associated with highly calcareous soils.

Planting Recommendations

A species selection guide was prepared to help choose the right species for planting in western Iowa (table 4). Species selection was based on the best information we have on each species' capacity to survive and grow satisfactorily on calcareous soils and exposed sites. If a species is not adapted to the local climate or site, it may fail completely or growth and vigor of the species may be greatly reduced.

Many failures in this study resulted from the use of poor planting stock. Acceptable stock grades for some of the promising species are described by Limstrom in U.S. Department of Agriculture Handbook 274, page 24.[6] The "preferred" stock will probably perform better on adverse sites in western Iowa than the other stock grades.

Table 4.—*Species selection guide for western Iowa*

Planting site class	Great soil group and soil series	Depth to free carbonates	Species to plant in order of preference
		Inches	
1. Droughty soils; well-drained calcareous silt loam soils with low moisture-holding capacity. Surface soil less than 2 inches thick.	Regosol-Ida	0-14	All aspects: eastern redcedar, Scotch pine
		14-24	All aspects: ponderosa pine, Scotch pine, Austrian pine, eastern redcedar
2. Deep, well-drained silt loam soils; calcareous loess occurs at depth of about 20 to 24 inches. Surface soil usually more than 2 inches thick.	Regosol-Brunizem intergrade	24-30	North and east aspects and coves: European larch, ponderosa pine, Scotch pine, Austrian pine, jack pine South and west aspects: ponderosa pine, Scotch pine, Austrian pine, jack pine
3. Deep, well-drained silt loam soils; surface layer 2 to 6 inches thick and slightly acid.	Brunizem-Monona	30-36	North and east aspects and coves: eastern white pine, red pine, European larch, white spruce, Norway spruce, northern white-cedar[1/] South and west aspects: ponderosa pine, Scotch pine, Austrian pine, jack pine

1/ The spruces are recommended for minor drainageways.

After the trees have been planted, the plantations must be protected from rodents, livestock, fire, and weed competition. Weed control can be achieved by chemical or cultural means during the first 2 or 3 years. These measures will give the best assurance of establishing a successful plantation.

[6] *Limstrom, G. A. Forest planting practice in the Central States. U.S. Dep. Agr. Handb. 247, 66 pp., illus. 1963.*

Some Recent Research Papers of the North Central Forest Experiment Station

Forest Tree Improvement Research in the Lake States, 1965, by Paul O. Rudolf. U.S. Forest Serv. Res. Paper NC-1, 54 pp. 1966.

Estimating Investment Returns from Growing Red Pine, by Allen L. Lundgren. U.S. Forest Serv. Res. Paper NC-2, 48 pp., illus. 1966.

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