A Seed Source Study of Ponderosa Pine for the Great Plains Region

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Introduction

Conifers give permanence and greater winter effectiveness to shelterbelts. One of the most promising conifers in the Great Plains region, according to past experience, is ponderosa pine *(Pinus ponderosa* Laws). But survival is variable, spotty, and often quite low. Also, form, growth rate and resistance to insects and diseases vary between trees and races. Since some of this variability may reflect origin, a study has been initiated to test the adaptability of various seed sources of ponderosa pine for shelterbelt use in the Great Plains Region. The study was designed primarily by Hans Nienstaedt and David H. Dawson of the Lake States Forest Experiment Station, with cooperation from Ralph Read of the Rocky Mountain Forest and Range Experiment Station.

Before discussing the details of the study, it may be helpful to review some background and to point out how such a study would be beneficial for tree planters in the Great Plains.

Background

One need not travel very far in the Great Plains region to realize that shelterbelts and windbreaks have been planted very extensively. Such planting began with the westward migration of pioneers in the mid 1800's.

Most early settlers realized that some form of wind barrier was essential to give them the protection to which they were accustomed. As a result they set out trees—usually wild seedlings dug from river bottoms near their homes. Through the years of settlement, tree planting efforts continued, encouraged by legislation and the accumulating experience of landowners.

The most significant impetus to Plains forestry, however, was the Prairie States Forestry Project, initiated in 1935. Shelterbelts were planted over the Plains States from Texas to the Canadian border. In the 8 years of the Forestry Project more than 200 million trees and shrubs were planted in shelterbelts that extended 18,600 miles. Tree planting is still continuing at a significant rate; in the fiscal year of 1960 a total of 35,366 acres were planted, with the concentration of plantings in North Dakota, South Dakota, and Nebraska.

Early in the settlement years, tree planters felt that conifers should be important components of shelterbelts. Foresters and horticulturists estimated that conifers would be superior to deciduous trees in drought and cold resistance, longevity, and general usefulness. Consequently, conifers were used in shelterbelts and afforestation attempts from a very early date.

Reports of surveys of the shelterbelts in 1944 (Munns and Stoeckeler 1946) and in 1954 (Read 1958) have emphasized the important of conifers in the belts and viewed ponderosa pine as one of the best-suited conifers in the present plantings. Eastern redcedar *(Juniperus virginiana* L.) and Rocky Mountain juniper *(Juniperus scopulorum* Sarg.) were also used extensively in shelterbelts; however, these species do not grow very tall—particularly in the northern Great Plains. Considerable use is also made of white and blue spruces *(Picea glauca* [Moench.] Voss and *P. pungens* Engelm.), but they do not seem to be as drought resistant as ponderosa pine.

In addition to the ponderosa pine that have been planted in shelterbelts and are therefore available for observation, various test plantings of the species have indicated that there are variations in the adaptability of different seed sources. Plantings such as those in the Nebraska National Forest and in the Denbigh Experimental Forest at Denbigh, N. Dak., include a limited number of seed sources which appear to be responding differently to the Plains environment. For example, Bates and Roeser in 1926 reported that trees grown from seed of New Mexico and, apparently, of Colorado origins are both unsuited to planting in the Nebraska Sand Hills. Best results were obtained from material collected in the Black Hills of South Dakota and from natural stands in the Nebraska Pine Ridge area. Recently the plantations growing in the Denbigh Experimental Forest, which represent 10 geographic sources, were sampled and evaluated for characteristics valuable for shelterbelt usage. Although these plantings were not replicated, and their treatment was not uniform, considerable differences in performance and traits between individual trees and between seed sources were apparent.

Other early trials in which ponderosa pine appears

to be reasonably well adapted to Plains conditions include those at South Dakota State University, at Brookings, North Dakota Agricultural Experiment Station at Dickinson, the Northern Great Plains Field Station at Mandan, N. Dak., and the Dryland Field Station (ARS) Akron, Colo.

Objectives of the Present Study

In recognition of the need for a tall-growing, adapted conifer in shelterbelts and as a result of the encouraging performance of ponderosa pine in the Great Plains and the indication that seed sources varied in their adaptability to plains conditions, the Lake States Forest Experiment Station, in cooperation with the Rocky Mountain Station, initiated a study in 1960 to test ponderosa pine in the Great Plains.

The study has three objectives:

(1) To find the ponderosa pine seed source or sources best adapted for shelterbelt use in the different regions of the Great Plains.

(2) To determine the range and distribution of variation in drought resistance, winter hardiness, and other characteristics of silvical and morphological importance, and to interpret these variation patterns in terms of the evaluation of the species and their implications in regard to the improvement of the species. An evaluation of characteristics which determine adaptation to use in shelterbelts, will be particularly important.

(3) To provide plant material and data for progeny tests, within-stand variation studies, and hybridization research.

Seed Sources and Sampling Procedure

The objectives emphasize the adaptive variation in ponderosa pine that might be important in determining its usefulness in shelterbelt plantings. No provision has been made, therefore, to sample seed source variation within the entire range of the species. The collection areas were chosen from regions which most closely resemble the climatic conditions in the Great Plains, with emphasis on effective precipitation.

Precipitation in the potential planting area ranges from about 16 inches per annum to the northwest in North Dakota to about 32 inches in Kansas and Oklahoma to the southwest. In the north this is mostly summer rainfall; toward the south it becomes more uniformly distributed throughout the year.

The range of ponderosa pine extends east into the plains of Nebraska and South Dakota for a considerable distance. Other eastern extensions of the species are found in southwestern North Dakota. All such extensions have been sampled. Based on past experiences with ponderosa pine planting on prairie sites, collections sampled not only these areas but also the Montana-Wyoming area. A Bitterroot National Forest source has performed well at Denbigh; hence, some western Montana collections were included. Also some stands from New Mexico and Colorado were sampled in view of the development of these sources in older Nebraska plantings.

Eighty potential collection areas were sampled. In addition we are arranging for 6 collections from the droughtier areas of Idaho, Washington, Oregon, Nevada, California, and Arizona, in order to bring the study in closer correlation with other studies now progressing.

The goal of the collections has been to sample as wide a variation as possible from stands growing in the drier portions of the range. Where several collections have been indicated for a large body of pine, the points of collection were chosen because of marked variation in site and elevation. In the Black Hills, for example, collections were made from six locations ranging from 3,400 to 6,500 feet, and from soils derived from crystalline rock and from limestone.

Each stand sample consisted of at least a bushel of cones from a minimum of 10 trees. To guard against the possibility that the seed would represent half-sibs among the collection trees, the trees chosen were not growing in the immediate vicinity of each other. They were, however, growing on the same general site and approximately the same elevation. Isolated trees were not used. Trees were picked at random, without selection for superior form or vigor. Each tree was marked, assigned a number, and its location recorded.

Because the production of cones from some of the stands is anything but prolific and regular, the cones have been collected over the 4-year period between 1960 and 1964.

Experimental Procedures

It would be highly desirable to combine single-tree progeny tests and seed source testing into a single study, with individual tree identity maintained in the field. The magnitude of such an undertaking, however, puts it beyond our reach in terms of manpower and financial resources. Composite seed samples will therefore be used.

There are two major experimental phases of the study: (1) the nursery phase, and (2) the field planting phase.

The Nursery Phase

The nursery phase of the study is similarly divided into two distinct operations: (1) raising stock for field plantings, and (2) raising stock for measurements.

Stock for field planting will be grown at the Bessey Nursery, Halsey, Nebr. and the Towner Nursery at Towner, N. Dak. Standard nursery procedures are being used. The stock for field planting will be 2-1 transplants, grown from seed composited to make up a stand sample.

The nursery testing phases of study involve growing 3-year seedlings, and recording data during each of the three growing seasons. Replicated nursery test plots will be established at Towner, N. Dak. and Halsey, Nebr. With measurements of plants growing at two different localities, the value of nursery measurements will be many times increased.

Stock will be seeded in the spring of 1965 in ten randomized blocks. A plot will consist of 1 row of 10 plants each. The rows will be sown across standard 48-inch nursery beds at a spacing of 12 inches between the plots. It requires 800 feet of nursery beds for the 80 seed sourcs. One hundred seed will be placed in each row. At the start of the second growing season. rows will be randomly thinned to 10 plants per row.

First-year measurements will include germination data, number of cotyledons, height measurements, and color variation. If there appears to be significant variation between seed sources, certain other morphological and taxonomic characteristics of the young seedlings should be scored. Among the characteristics which might be studied are: (1) length and width of primary needles, (2) serrations of primary needles, (3) the occurrence of bloom on primary needles, (4) the position of primary needles, whether appressed or divergent, (5) the time and position at which secondary needles occur, (6) the development of epidermis and hypodermis in primary needles, (7) the size of cells in primary needle tissue, (8) the relative size of vacuole and protoplasm, and, (9) the development of hypocotyl tissue, particularly the epidermis.

Second- and third-year measurements will include winter desiccation injury, height and caliper measurements, number of side branches and leaders, and phenological data. Methods of scoring stages of bud swelling, bud opening, and early elongation will be developed. The morphological and anatomical characteristics of the secondary needles will be scored the third season. We are also aware of the need of root evaluation studies on the third-year seedlings. We are expecting to develop separate studies to cover items such as the total soil volume penetrated by the root system of an individual plant, the depth and lateral penetration, the number of active secondary roots, and regrowth potential.

The Field Plantings

The field testing will be a joint effort of the Lake States Forest Experiment Station, the Rocky Mountain Forest and Range Experiment Station, several NC-51 cooperators, and the Forest Nursery Station at Indian Head, Saskatchewan. The basic design for the tests will be randomized blocks with 4-tree plots and 15 replications.

It is hoped that each NC-51 cooperator involved in the study will agree to establish one set of plots of this magnitude at a location selected by the cooperator. The Lake States Station will establish two such sets of plots and the Rocky Mountain Station three. In addition, the two experiment stations will each establish one planting with 36-tree plots and five replications in order to have sufficient plant material for further study in 20 to 30 years. These will be planted immediately adjacent to one of the sets of four-tree plots.

Measurements will be scheduled the first, fifth, and tenth year after planting. After the first year, survival counts will be made and fail spots replanted with stock lined out in a nursery. Fifth-year measurements will include height growth to the nearest 1/10 foot; number of branches per whorl; branch angle and branch length; needle retention based on oldest whorls on the tree; needle arrangement scored on measured branches; needle length and fascicle length; bloom on measured branches; and crown width. Between the fifth and tenth year, observations should be made every spring for winter desiccation. In addition, the plantings will be checked every spring and fall and examined for insect, disease, and other injury, as conditions warrant.

Measurement intervals after the 10th year and data to be taken then will be decided upon according to the results of analyses made up to that time.

Statistical analyses will be handled by computer. The development of a general computer program for the handling of seed source studies is scheduled for the near future, and details of the analysis will be provided then.

Other Studies

In a study of this nature there will, of course, be material available for numerous other studies of variation. For example, although wood quality characteristics are not of particular importance in Great Plains plantings, they might be studied in the available material. Detailed studies may also be made of differential disease and insect resistance factors that become evident in the plantings.

Individual tree progeny tests are encouraged. We feel that there is a very good chance that the results with the 3-year-old plants will indicate which stands should be included in the progeny tests. Because of the nature of the plant material assembled for this study, an excellent opportunity exists for evaluating resistance to injurious agents and determining the factors that cause the resistance.

Summary

A study designed to test the adaptation of *Pin us ponderosa* for use in Great Plains shelterbelts has been started by the Lake States Forest Experiment Station and the Rocky Mountain Forest and Range Experiment Station. The study includes the testing of some 80 sources of seed from stands growing in the eastern, limited-precipitation, areas of the native range of the species. The test will include evaluation of material in the nursery and the field, and will furnish material for progeny tests, within-stand variation tests, and studies relating to differential drought, frost, insect, and disease resistance factors. Seed has been collected from 79 stands. Nursery planting of seed for production of field planting stock and seedlings for measurement in the nursery will begin in the spring of 1965. In addition to the originating stations, several NC-51 cooperators and the Forest Nursery Station at Indian Head, Saskatchewon, will participate in the field phases of the study.

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