STUDIES TO DETERMINE HOW TO RE-ESTABLISH PONDEROSA PINE ON MINE SOIL IN EASTERN MONTANA[1]

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Abstract.--Natural stands of Ponderosa pine were studied to determine their regeneration strategies. The natural stands are uneven aged, with regeneration established at approximate five-year intervals. Seedlings developed best in protected microsites. Soils were not critical for seedling development, although best development was observed on sandy soils with a pH of 7 ± 1.

Seed was collected from 50 trees in six widely separated stands. This seed was used to establish tests to measure genetic control of survival and to determine appropriate seedling handling, planting and plantation maintenance. Survival was under moderate genetic control. Estimate of heritability ranged from .2 to .4. Surviving seedlings from specific parent trees ranged from 50% to 80% after five growing seasons.

Best time to plant was late fall (Oct. - Nov.). Watering was necessary in July of the first growing season. Of critical importance was protection of the planted seedlings from rodents, rabbits, porcupine, deer and cattle. Vexor net, placed on seedling and fencing, appeared to provide the needed animal protection. Seedlings also needed protection from competing vegetation. Herbicides were effective in controlling competing vegetation in our study area. Plantations need fire protection; two test plots were destroyed by fire in the summer of 1986.

INTRODUCTION

Pinus ponderosa Laws. var. scopulorum Engelm. occurs naturally from eastern Montana south to New Mexico, trans-Pecos Texas and northern Mexico, west to eastern Nevada and east to central Nebraska (Schopmeyer 1974). Ponderosa pine stands in eastern Montana, Wyoming, and both of the Dakotas are underlain by rather extensive deposits of coal. In mining operations these stands are destroyed. Ethics as well as federal and state regulation require that the areas disturbed because of mining activities be returned to a state of native vegetation "similar" to that found on the site before mining. Although ponderosa pine does not typically represent a large proportion of the native vegetation, it too must be re-established along with other indigenous vegetational species.

There have been few documented attempts to re-establish conifers, specifically ponderosa pine and junipers (Juniperus spp.), in the north and central Rocky Mountains. Because of this dearth of information, I will limit my statements and observations to the publications I have found and my own experiences since 1979, when the Western Energy Company contacted the School of Forestry and asked for help in re-establishing ponderosa pine on its Rosebud Mine at Colstrip, Montana. The work reported here represents personal efforts as well as those of a number of my graduate students.[3]

Our first study examined existing vegetation and attempted to determine how natural communities of ponderosa pine reproduced; at the same time, we collected seed to provide seedlings for outplanting trials. The objectives of the trials were to determine if survival mechanisms were

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under genetic control and to determine appropriate techniques for establishment of ponderosa pine on mine soils. Root system development was studied on seedlings that had been established for six years.

RESULTS AND OBSERVATIONS

Natural Regeneration and Stand Structure

Richardson (1981) sampled 12 stands of ponderosa pine within a five-mile radius of Colstrip, Montana. Her objectives were to describe natural regeneration strategies of ponderosa pine and provide baseline data on the ecology of those stands.

She observed that the age structure of the sampled stands was basically uneven-aged, that is, a minimum of at least three age classes was observed. Although some regeneration occurred every year, it generally appeared to be cyclic, with significant regeneration occurring every five to seven years. Annual regeneration was usually found on mineral soil in shaded and protected sites, while the cyclic regeneration had a wider distribution. The cyclic regeneration was found on favorable microsites and in lesser quantities on the duff layer and on sites made harsh by poor land use practices such as overgrazing. Soil pH (7 ± 1) had little if any effect on regeneration. Stands and regeneration within stands were limited to cooler sites with some source of moisture, i.e., north-to-east-facing, gullies, draws, rocky knobs and rocky buttes.

Stands appeared to grow better on coarse-textured soils; although some were found on fine-textured soils. Encroachment of pine stands on fine-textured soils was observed on sites that had been disturbed, usually by overgrazing. Prairie grasses seemed to have a competitive edge on fine-textured soils. Fire scars on trees indicated that fire was a part of stand development. Richardson dug up a number of seedlings and found that in all cases the tops were an inch or less in length, while the roots ranged from 12 to 16 inches.

Out-planting Trials

Seed for out-planting was collected from 6 of the 12 stands sampled by Richardson (1981). Collections were made from at least 50 trees per stand. Seed was hand-extracted and labeled according to stand and individual tree. This allowed us to maintain seed in packets containing only open-pollinated families (one common parent). This seed, either combined or family identified, was used for all out-planting. All seedlings were auger-planted using a four-inch auger.

Before we could attain our final objective--"a healthy, established ponderosa pine tree"--numerous questions needed to be answered. Meyn et al. (1975) attempted to establish ponderosa pine on the Rosebud mine using local seed, bare-root seedlings, different mulches and fertilizer regimes. All of the seedlings were dead within three years. The speculated causes of mortality were poor planting and/or vegetative competition (DuPuit 1978). Consequently, we decided to use as natural a system as possible. The questions we attempted to answer were:

1. Was there genetic control of survival and, if so, what was the mechanism?
2. Could stands be established by direct seeding?
3. What kind of and age of seedling stock (bare root vs. container) could result in stand establishment?
4. When was the best time of year for planting?

Progeny Test

A progeny test was established to determine if there were any kind of genetic control of survival. Isozyme analysis was used to evaluate the amount and distribution of genetic variation in the six stands from which seed had been collected (Woods 1982). We found that six randomly selected open-pollinated families would provide a good sample of possible genotypes (Woods et al. 1983, Woods et al. 1984); however, to be conservative, we selected 15 families per stand. The progeny test was in a five-tree plot, with a randomize block design. After five years, we found an overall average of 50% survival, while some families had as high as 80%. There was a significant difference between families. The survival mechanism was not identified, but survival heritability was estimated to be .35. The high heritability estimate means that selection and breeding for survival would be practical. Moisture stress was also taken by family and was found to be significantly different between families, and heritability was estimated to be .44 (Riley 1984).

Out-planting Test

A series of out-planting tests were used to develop planting and plantation maintenance techniques. All tests were replicated and had from 500 to 3000 seedlings. These seedlings were grown from bulked seed--a random mix of seed from all sampled stands and all trees within stands. We compared direct seeding to planting and found that planting was superior. The difference was so great that no statistical analysis was needed. When fall and spring planting were compared, the best results occurred in the fall. When bare-root seedlings were compared to containerized seedlings (1 1/2" x 8"), the containerized stock gave the best results in most cases. Some 3-0 bare-root stock performed well for three years, but were dead after five years. Shade cards were tested as a means of protection, but they did not appear to be worth the added expense and installation time (Vance and Running 1985).

It is imperative that vegetation competition be controlled. Chemical control of competition gave spectacular results: Seedlings in treated plantations had growth rates double those of seedlings in untreated plantings (Baumbauer and

Blake 1984). Animal damage was also an immediate problem. Rodents ate the seed in the direct-seeded plot and rabbits, deer and cattle caused damage in all plantations. The cattle were controlled by fencing. The rabbit and deer damage was controlled by protecting the seedlings with a degradable plastic net tubing (Vexar). In 1986, all plantings where the seedlings were not above the grass and vegetation were destroyed by grasshoppers. To date, no means of controlling grasshoppers has been discovered.

The addition of water during planting did not increase survival. However, a heavy watering during the first summer after planting seemed absolutely necessary to insure any kind of survival. A number of seedlings were dug up one year after planting and examined for mycorrhizae infections. All had well developed mycorrhizal roots.

Schopmeyer (1974) recommended that ponderosa pine var. scopulorum seed needs stratification. We found that stratification was not needed, and stratification in fact reduced seed germination (Woods and Blake 1981). Although fire is part of the natural ecology of native ponderosa pine stands (Richardson 1981), seedlings have only limited resistance to fire. In 1986, a wild fire destroyed all but six trees in two blocks of the progeny test. Most of these trees were two to three feet tall and represented a sizable investment. Some thought must be given to protecting tree plantations once they are established.

Studies of root growth were started in 1986. Results will be reported in these proceedings by K. Thamarus.

RECOMMENDATIONS

1. Use only local seed or seed that has been tested in the area to be planted.
2. Containerized seedling stock does work if properly grown and planted. Bare-root stock may work, but further testing is needed to determine where and how to use it.
3. Fall planting on north-facing slopes gives the best results.
4. Heavy watering during the first summer after planting is needed, usually the middle of July.
5. Competing vegetation must be controlled until the trees are above the competing vegetation.
6. Plantations must be protected from rodents, rabbits, deer, cattle, insects, diseases and fire.

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