INTENSIVE SEED ORCHARD MANAGEMENT - A MINNESOTA EXAMPLE

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ABSTRACT.--The St. Francis Seed Orchard was established in 1985, and consists of two, three-acre grafted orchards. One is comprised of 15 white pine clones putatively resistant to blister rust, and the other contains 40 Scots pine clones selected for timber quality. These orchards are intensively managed including cover cropping, mowing, mulching, gopher control, soil sampling, fertilization, irrigation, and pest monitoring. Changes in management with time are also discussed.

Additional Keywords: *Pinus strobus*, *Pinus sylvestris*, *Cronartium ribicola*

INTRODUCTION

The economics of applied tree improvement have been well studied and documented (Carlisle and Teich, 1975; Davis, 1967; Porterfield, *et. al*., 1975; Talbert, *et. al*., 1985; and many others). Almost without exception, these analyses conclude that tree improvement is an excellent investment. Tree improvement is often the best choice in a range of forest management options. To realize the potential of genetic improvement however, requires substantial commitment of manpower and resources.

Unfortunately, many northern tree improvement programs have attempted to achieve real genetic gain without the corresponding budgetary commitment. Rather than obtain agricultural land, seed orchard sites are often carved out of existing forest land. Although the land base is inexpensive, the site preparation costs needed to create a good orchard site are prohibitive (Jett, 1986). All too often, the result is an inadequately prepared site.

Another alleged cost cutting measure is the so-called "progeny test/seedling seed orchard". If the test/orchard is intensively managed (which it must be to maximize seed production), the data may be meaningless because of unexplained genotype-by-environment interactions. If it is managed like a progeny test, seed production is delayed, and it may be impossible to convert the test to an orchard. When the test/orchard is planted on an inadequately prepared site, heroic efforts are often needed to salvage the project.

Rather than being an inexpensive method, the test/orchard can be very costly due to inaccurate data, delayed seed production, and conversion difficulties. Put simply, good progeny testing is not compatible with good seed orchard management. The folly of the progeny test/seedling seed orchard is described by Hamilton (1984).

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In 1985, the Minnesota Department of Natural Resources determined that all future tree improvement efforts would separate progeny testing and seed production. Furthermore, seed orchard management would become intensive, consistent with the goal of maximum seed production.

That same year, the St. Francis Seed Orchard was established. This orchard contains two, three-acre clonal orchards. One orchard is comprised of 15 white pine (Pinus strobus L.) clones putatively resistant to blister rust (Cronartium ribicola Fischer). The other has 40 scots pine (Pinus sylvestris L.) clones selected for superior timber qualities. The scots pine plus trees were selected from seed sources shown to be adapted to Minnesota conditions in provenance tests. The St. Francis Orchard is intensively managed, serving as a model for applied tree improvement in Minnesota.

THE SITE

Located at longitude 93 40 W, latitude 45 25 N (Figure 1), the climate at the orchard is somewhat milder than that of the parent trees. Moving orchards south of the origin of the parent trees is an accepted technique that often results in less pollen contamination and increased seed production (Jett, 1986; Richmond and McKinley, 1986). Average annual precipitation is 32 inches. From December to February the temperature mean is 13 degrees F, while the June-August average is 68 degrees F.

The soils on the orchard are very homogeneous, classified as Zimmerman fine loamy sand. These soils are deep and well-drained, with an eroded "A" horizon. The water table fluctuates depending on precipitation. In the extremely dry year of 1987, water was obtained from a sand point well at 21 feet.

The topography is slightly rolling to flat. Prior to seed orchard establishment the site was used as a hayfield. The nearest source of foreign pollen is over one quarter mile away.

The site was chosen for several reasons. First, it is located in a low blister rust hazard zone. There is no reason to expose valuable orchard trees to high blister rust hazard. Second, the site was already cleared. Site preparation costs were minimal. Third, light textured soils are known to be conducive to cone and seed production. Moderate drought stress appears to stimulate flowering (Dewers and Moehring, 1970; Shoulders, 1967). Also light textured soils are less susceptible to soil compaction caused by repeated equipment travel. Maintaining healthy trees is a key factor in the production of regular, abundant cone crops.

SITE PREPARATION

In August of 1984, the two orchard areas were sprayed with Roundup, followed by double disking after the grass was killed. This treatment did produce good conditions for tree planting the following spring. However, it also created conditions for rapid invasion of annual weeds. In the future on similar sites, preparation will concentrate on the immediate planting spot, leaving an established grass cover intact.

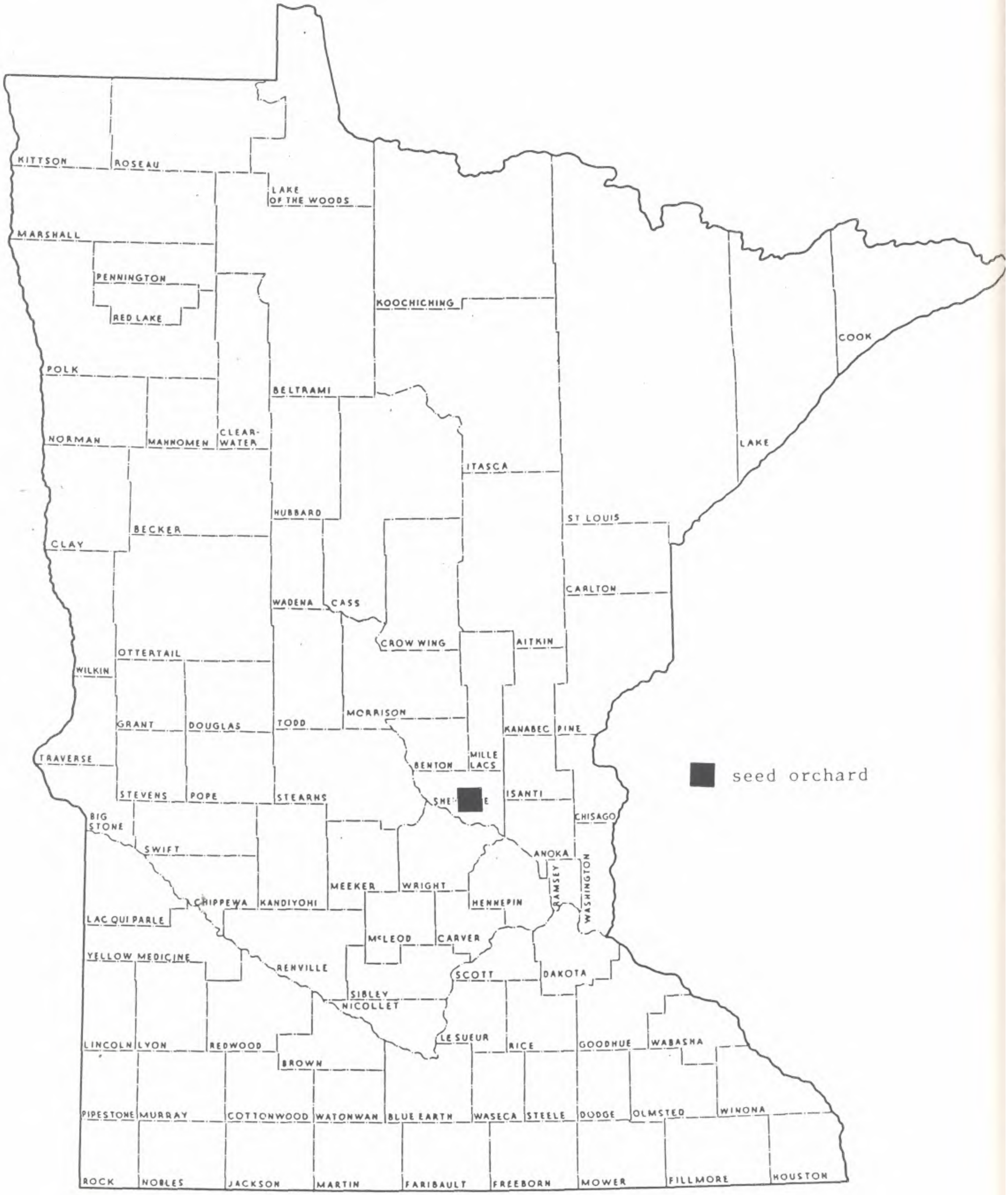

Figure 1. Location of St. Francis Seed Orchard

ESTABLISHMENT AND MANAGEMENT

At present, both orchards are managed according to the same schedule. As the orchards mature, this schedule will no doubt be refined to reflect differences in species biology.

1985. Due to uncontrollable circumstances, the first trees were not planted until May 15-16. The grafts were flushed out and actively growing. Laid out at 15 x 20 feet spacing, over 400 white pine and 100 scots pine grafts were planted according to a randomized design. Because of adequate precipitation, first year survival was excellent.

On such open sites, pocket gophers (*Geomys bursarius*) are a commonly occurring pest. Untreated, the gophers tunnel under the soil surface feeding on tree roots, and leaving soft mounds of soil. Small trees can be killed by pocket gophers. However, gophers are easily controlled by baiting artificial burrows with poisoned grain. A tractor drawn burrow builder creates the burrows and deposits the grain through a hollow tube. Burrows are made at regular intervals across the orchard, with a double ring around the perimeter. This treatment is most effective when timed to coincide with high gopher activity, usually in May.

Because of the severe site preparation, the orchard was inundated with annual weeds by mid-summer. The principal culprit was ragweed (*Ambrosia artemisiifolia* L.). This problem was solved by first disking down the weeds, then sowing a perennial grass cover in September. Two separate seed mixtures were used to determine if one might be better than another. The mixtures were as follows:

white pine

creeping red fescue	50 %
perennial ryegrass	13 %
red top	15 %
Park Kentucky bluegrass	20 %
Dutch white clover	2 %

@ 60 lbs/acre

scots pine

perennial ryegrass	13.3 %
Park Kentucky bluegrass	33.4 %
smooth bromegrass	22.2 %
timothy	11.1 %
sand dropseed	13.3 %
birdsfoot trefoil, Empire	6.7 %

@ 50 lbs/acre

The seed was applied by a grain drill, and became established in the fall of 1985.

At this time the white pine orchard contained 17 clones. The scions for grafting these clones had been obtained from two different sources, A and B. At some unknown time in the past, A had shared some material with B, who used it in controlled coatings. Along the way aliases were assigned. Finally, when scions were given to the DNR for grafting, the complete identity of the clones was not known.

As it turned out, five clones received from source B were related to a single clone (P327) obtained from source A. Clone P327 must exhibit strong resistance (tolerance?) and be a good general combiner. It has been used in many full sib crosses, which then apparently exhibited tolerance (resistance?). One of the related clones turned out to be a selfed progeny of

P327. P327 showed up in four other clones as either a male or female parent. A sixth clone had a better than even chance of containing P327, because that cross had been made with a three clone pollen mix, one of which was 327. If P327 is high in general combining ability, the selected progeny probably has 327 as the male parent.

In a three-acre wind pollinated seed orchard containing 17 clones, the presence of six related clones was intolerable. This situation created an unacceptable risk of inbreeding depression. Thus it was decided to eliminate the five related clones obtained from source B. The clone derived from the pollen mix would be kept, in hopes that it might not be related. This decision would result in the loss of over 100 ramets, slightly more than one quarter of the orchard. An expensive lesson like this lends additional support to the development of a regional record keeping system (Stine, 1987).

1986. In late March, the established grafts were pruned to remove rootstocks. Soil testing and analysis were started in April to determine fertility levels. The initial results were:

nitrogen	2 lbs/acre
phosphorus	70 lbs/acre
potassium	80 lbs/acre
pH	5.6
organic matter	1.38%

Soils were sampled to a depth of two feet, with four individual samples plus a composite sample per orchard. There was little variation from sample to sample, although fertility levels were slightly lower in the scots pine orchard.

In late April, the related white pine clones were removed and partially replaced with 32 ramets from two new clones. All trees in both orchards were mulched with black plastic to control weeds and conserve soil moisture.

A late spring frost in May caused some damage to the white pine, the scots pine emerging unscathed. Later than month gopher bait was applied to continue control of pocket gophers.

In June, the orchard was fertilized with 100 lbs/acre of ammonium nitrate (34-0-0). This treatment helped the white pine recover from the frost damage and generally greened up the orchard. By this time the cover crops in both orchards were well established.

Both seed mixtures worked well. The white pine site was dominated by creeping red fescue, the scots pine was primarily bluegrass. The dark green color of the bluegrass in the scots pine orchard made a more attractive appearance. However, the cost of this mixture was $ 0.40 more per pound than the mixture used on the white pine. The increased seed cost of about $20/acre is probably not justified.

With the cover crops established, vegetation control simply involved mowing the orchard and trimming around the trees. This was done in June. Also that month the soils were resampled, with results similar to the April test. By mid-July in a warm, wet summer, mowing and trimming was again required. Mowing was done with a brush hog and trimming was done with a "weed eater".

The soils were sampled again in August, with no change in results. These samples confirmed that fertility levels did not vary over the course of a growing season. Because of low potash levels, 100 lbs/acre of potassium sulphate (0-0-52) was applied in early September.

Also in September, pocket gophers were observed re-invading the orchard. Repeated equipment travel during the course of orchard management operations collapsed the artificial burrows, allowing the gophers to return. A second application of poisoned bait was necessary to eliminate the gophers.

1987. As needed, grafts were pruned to remove rootstocks in early April. Later that month the soils were sampled, giving results similar to 1986. With such consistent soil analyses, it is now possible to design a regular fertilizer regime. Until the onset of flowering, 100 lbs/acre of ammonium nitrate will be applied. The 1987 soil survey revealed that essentially none of the potassium applied in 1986 remained. On such light textured soils, much of the added potassium will leach out until the tree roots expand. As such, further additions of potassium will be delayed several years. When the orchard trees are 5-6 feet tall, 100 lbs/acre of potassium sulphate will be added in the late summer. These fertilizer applications should result in vigorous trees capable of producing large seed crops.

In late April, 80 white pine grafts were planted, and over 300 were added to the scots pine orchard. All newly planted trees were mulched with black plastic. The 1987 additions brought the white pine orchard up to 350 ramets and 15 clones. The scots pine orchard now contains 400 ramets and 40 clones.

An infestation of cottony aphid (pine bark adelgid) on the white pine was sprayed with Malathion in May. Permanent tags were affixed to each tree. Ammonium nitrate and gopher bait was applied as previously described.

In June the orchard was mowed and trimmed. A road right-of-way was laid out for the future construction of an all-weather road into the orchard.

An entrance sign was erected in July to identify the orchard and explain its purpose. By this time, a severe drought was adversely affecting the newly planted grafts. After a winter with very little snow, soil moisture was low at the start of the growing season. Annual precipitation was at least six inches below normal. Rainfall recorded at Zimmerman (8 miles northeast) was only 5.28 inches for the period May 1-July 17. As an emergency measure, trees were hand watered from a fire unit.

Because of the drought, no mowing was needed in July. The grass will be cut in August if necessary. There are about 30 replacement scots pine grafts available to replant trees killed by the dry weather. This will be done in September.

THE FUTURE

The intensive management schedule outlined above will be followed on an annual basis, until the trees begin to flower regularly. The basic intent is to get the orchard trees established and growing as fast as possible. Tree height has been shown to be more important than age for onset of flower production in loblolly pine (Schmidtling, 1969). Similar observations have been made in other conifers. With vigorously growing trees, the time to seed production can be reduced.

Once the trees begin to flower, management emphasis will shift toward stimulation of increased flowering. Two management practices appear to have the most promise. Supplemental nitrogen fertilization about the time of bud initiation has been shown to increase flower production the following spring in many different conifers (Barnes and Bengtson, 1968; Brinkman, 1962; Day, et. al., 1972; Ebell, 1972; Schmidtling, 1971; and many others). The second practice is subsoiling. First used to ameliorate compacted orchard soils, subsoiling also has been shown to stimulate flower production (Jett, 1986).

A recent study in a white pine seed orchard indicated that late May fertilization was best for male flower stimulation, while late June to early July was best for female flowers. The fertilizer used was a mixture of N-P-K, but was primarily ammonium nitrate (Schmidtling, 1983). There is little data available for scots pine, but it seems safe to assume that it will respond to ammonium nitrate as do many other hard pines.

Most, if not all of the research on subsoiling has been done with southern pines. However, it seems reasonable that subsoiling should be effective in white and scots pine as well.

By the early 1990's, both orchards should be flowering. At that time, both orchards will receive supplemental nitrogen in the form of ammonium nitrate. Rates of at least 200 lbs/acre will be used initially. As the trees grow larger, higher application may be needed.

Subsoiling will proceed more slowly because of unknown responses. Operational trials will be set up to determine the timing and extent of subsoiling to achieve a positive result.

As noted earlier, the soils on the St. Francis are deep and well drained. In most years, there is sufficient rainfall during the growing season to sustain the trees. The expected response from these soils is an increase in flowering due to moderate drought stress. However, in the severe drought year of 1987, the trees did suffer serious moisture stress. Plans are being made to set up a more permanent irrigation system to avoid similar problems in the future. This irrigation system will also have other benefits. One study in loblolly pine indicated that adequate moisture early in the growing season followed by dry conditions resulted in increased flower production (Harcharik, 1983). It is also possible to apply fertilizers and pesticides through the irrigation lines. The principal concern with irrigation is cost. It is simply very expensive to set up, maintain, and operate an irrigation system in a seed orchard. It remains to be seen if irrigation can be justified economically in the St. Francis Orchard.

As seed crops begin to develop, control of cone and seed insects will be a critical aspect of seed orchard management. White pine is particularly vulnerable to two pests; the white pine cone beetle (Conophthorous coniperda) and the white pine cone borer (Eucosma tocullionana). These insects have completely destroyed large cone crops in white pine orchards in North Carolina.[1] Potential pests of scots pine cones and seed are unknown at this time. Regular monitoring will be required to detect the presence of damaging insects so that control measures can be implemented in a timely fashion.

SUMMARY

Applied forest tree improvement has been a widely accepted means of increasing forest productivity for more than 30 years. Successful programs have at least one area of agreement: Seed orchards must be intensively managed.

Recognizing this fact, the Minnesota Department of Natural Resources decided in 1985 to intensify management of Division of Forestry seed orchards. That same year, the St. Francis Seed Orchard was established using state-of-the-art management practices.

These practices include soil sampling and analysis, mulching, fertilization, mowing, irrigation, and pest control. Use of such practices should result in the production of early, regular, and abundant seed crops.

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