In discussing ways of doing the job of tree improvement, he used sketches of six "schemes" that have been proposed for obtaining seed from desirable trees.

The first scheme consisted of picking the most desirable stand in a forest area and collecting all the seed needed for planting from this stand. The rest of the schemes are based on individual tree selection. As this would narrow the genetic base on which future stands are built, he felt that foresters should consider it very carefully. In selecting a desirable stand, there were many advantages, but also many disadvantages.

The most popular scheme, based on individual tree selection, is the seed orchard. The low cost seed is the main advantage, but there are many disadvantages.

The other schemes he discussed were mass hand pollinations, mass rooting of cuttings, continuous seed tree selection, and "jumbo" seedling selection at the nursery. In summary, he pointed out the jobs everyone could do:

1. Help in stopping negative selection.
2. Preserve the best material we find.
3. Help promote some local scheme of getting seed from the best trees.
4. Don't sell nature's "natural selection" short.
5. Keep abreast of the present work the foresters are doing in tree improvement and help, if possible.
6. Need for intensive study on the subject.
7. Nurserymen could help by finding ways to bring down the cost of handling small lots of seeds.

Mr. Silen's paper follows:

A SPECIES IMPROVEMENT PROGRAM

by
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In order to move quickly into this subject, it is assumed that almost everyone here is in agreement that species improvement based on genetics is desirable. On that basis we can start right out talking about the fields of activity where improvement can be made; what we know about ways to improve trees; and how the job can be done if we all aim our efforts the same general direction.

Talking about tree improvement based on genetics is a little absurd until two other steps are taken. Both of these are the proper activities of the average forester and forest worker. The first of these steps is to reverse the process of negative selection in the conventional forest practices. How can we be really serious about forest genetics when we all are aware that the bulk of the cones collected for our nursery-grown seedlings come from the trees whose main attribute is that they are easy to harvest - small, limby, and squat, - or are chosen on the basis of how they look to the squirrels. The bulk of the natural regeneration still comes from the dregs left behind after the best trees are taken for logs. Reversing the present processes of negative selection is so obvious that one would expect to find no opposition to it in forestry today. Yet any proposal to change present practices is almost certain to raise costs, and you meet opposition right away when selection of trees for seed collection is seriously proposed.

The second of these steps is one for the foresters and forest owners. This is deciding what kind of tree they want most and the location of the best specimens of the trees having the traits they want.

Let me give you an example of the kind of trouble one can run into in trying to pick superior material. We were instructed to pick the best tree on each plantation when we re-measured the old Douglas fir heredity study. This study was begun in 1915, so the trees are over 40 years old. There were 6 plantations in it originally, all identically laid out, all progeny rows from single wind-pollinated parents, all individually tagged and measured. At about 3,500 trees per plantation, this totals a whopping 21,000 trees. The best trees from so large a 40-year-old population should be rather superior stuff. Choosing them was not particularly difficult either, since they were all measured. Yet I feel a little reluctant to go out on a limb and say they are better than average. On 4 of the 5 plantations now remaining I would not have to go more than 200 feet from the border of the plantation to find not one, but dozens of trees the same age that are taller by some margin and one-third larger in diameter than the best in the plantation. What was involved here was due to suppression in the 7 x 7 spaced plantation.

I think part of the difficulty here is that we naturally look first for fast growth in Douglas fir as our most desirable character. Naturally, this is where I looked first. But the evidence, both from agriculture and the little we have from forestry is that the genetic control over growth is relatively small, compared with environmental controls - small but probably quite important for us.

List of traits in trees now thought to be inherited:

Morphological	Wood	Physiological
Growth rate	Specific gravity	Bud bursting time
Form class	Spiral grain	Flowering time
Sweep	Resin content	Cone production
Lean	Fibril angle	Needle size retention
Stem undulations	Fiber length	Rooting strike
Limb size	Wood checking	Grafting strike
Limb angle		Resistance to insects
Number of limbs		Resistance to disease
Crown shape		Resistance to cold
Crown density		Resistance to grazing
Leaf length		

It is obvious from the list that most of the characters besides growth rate have commercial implications, especially those having to do with bole quality, wood quality, cone production, and various types of resistances. However, the list narrows down in Douglas fir when you consider those which would represent improvement over the average tree one would expect to find in a repeatedly thinned stand under management. The minus characters like sweep, lean, stem undulations, large limb size, spiral grain, evidence of susceptibility to disease, etc. would almost certainly be taken out in thinnings. How much we would be able to improve Douglas fir in growth rate, bole form, limb size, higher specific gravity, fiber length, and resistance to insects and disease over this kind of an average tree is still a very much studied question. One of the bigger pieces in this jigsaw puzzle is the obvious fact that environment also controls these factors to an undetermined extent. We see the control of growth rate by moisture supply everywhere in the forest, for instance. In casting around for a pure example of the effect environment has on many of these characteristics, we are lucky enough to have a rather good one in the region.

If we want to show the genetic effect of a certain character, we like to do it under a controlled environment. Conversely, to show pure environmental effects, we use identical genetic material - a clone of trees propagated by cuttings from the same tree. At Corvallis today there is a clone of 12 Douglas fir trees which originated as rooted cuttings from a single limb of one tree on the Campus. These trees were rooted in 1938 and are now in their 17th growing season. The variation from tree to tree, all due to environment, is surprisingly large. In height growth, they range from 8 to 28 feet, a variation almost as great as might be found in the surrounding stand. Diameters range from 2.8 to 7.4. Limb angle varies considerably from the top to the bottom on the same individual. They vary from tree to tree from 51 degrees to 75 degrees if measured at the fourth whorl. Trees of similar age in the surrounding stand vary considerably more. The number of limbs per whorl and limbs between whorls varies as much between the trees in the clone as out in the forest. Our records show them to burst their buds rather close together - all within a week. In the surrounding stand similar-sized trees burst over a month-long period.

Ability to take successful grafts appears to depend more on tree vigor than identical understock. Out of 7 of the clone trees, one had 100% success with limb grafts; another 47%. Mortality of grafted stock also followed poor vigor. Three of the trees have sinuous leaders; 9 have straight ones. Needle characteristics on all the clone trees are very similar. The clone is a demonstration that some characters, like bud bursting date, or needle characteristics, are fairly tightly controlled by genes in spite of environmental differences. Other characteristics, like growth, are more dominated by the environment. Even so, the many clones of poplar have amply demonstrated that it is possible to raise the growth rate by genetic means.

It is no wonder that picking superior trees is difficult when site enters in so strongly. Returning to our original question, "How much would we be able to improve Douglas fir over an average good tree?" That depends on how tightly controlled genetically the trait is. Where most of the variability is due to site differences, the answer is "not much." We could expect considerable improvement among the characteristics which are tightly controlled by the genes. Resistances to disease, insects, and cold in most plants would be examples of tightly controlled characters. Usually these are controlled by only a few genes. Complex characteristics, like growth, are controlled by scores or even hundreds of genes in some plants.

With species having well-defined problems, the improvement from forest genetics has real promise. There is little doubt that a white pine, which is resistant to the blister rust, will eventually be developed. This is probably true for the other five needle pines of commercial value. Other possibilities are development of weevil-resistant sitka spruce, silver fir and alpine fir resistant to the woolly aphid, and lodgepole pine resistant to the mountain pine beetle. The Institute of Forest Genetics is amply demonstrating the feasibility of bringing the genes of fast growth and drought resistance into ponderosa pine from its faster growing near relatives. Frost resistant hemlock and Douglas fir can surely be found for the area of Western Washington devastated by last year's "deep freeze."

I personally feel that more accomplishments will be made by the forest geneticists working in the fields of breeding for resistance and for specialized products such as pulp than anywhere else.

Up to now we have been talking about ways in which trees can be improved. How can the job be done? The methods are essentially very simple. I have outlined six schemes that have been prepared. I could call them "systems" or "formulae" or glorify them in some other way. You will remember them better if I call them simply "schemes." Taking a tip from Tore Arnborg, I have sketched these schemes as they make their cycle from forest to nursery and back to forest.

Only one of the schemes is based on selecting stands; the other five being based on selection of individual plant, or tree. This one is the "Improved natural seed collection area." It consists of picking the most desirable stand in a forest area and collecting all the seed needed for planting from this stand. The stand can be 1, 50, or 500 acres and the forest area of any size up to a million acres. The "improved" part of the scheme consists of cutting out all the undesirable trees, until a rather open stand is left to increase cone production. I do not know who originated the scheme - probably the first forester to do a conscientious thinning job. Although the geneticists talk of the thinning as "roughing out the bad pollen parents," they mark the same trees any forester would - deformed, slow growing, defective, and trees with extra large limbs.

The scheme has its disadvantages. It would take a real statistician to show an improvement over the run-of-the-mill seed the first generation. It might be more expensive to collect and require waiting for a good seed crop at that stand and thus slow the planting program for the area. Its advantages are that it assures adapted seed of good quality for the area. It is simple and flexible. It preserves a good cross-section of our present gene pool for the next generation. I like the improved natural seed collection area scheme because it could answer our biggest problems - indiscriminate movement of planting stock and negative selection. What could be a greater immediate step than to have several such collection areas in each forested drainage of, say, 20,000 acres?

All the rest of the schemes are based on individual tree selection. As such, each narrows the genetic base on which future stands are built to the extent to which they limit the number of trees serving as parents. This is something foresters should consider very carefully because, unlike farm crops, their crop will pay off if it can grow without further labor. It must stand the gaff of everything a predatory, voracious, and often harsh environment can thrust upon it. When I consider the successive destructive agents that hit the experimental forest I was on during a short five years it would seem folly to put all eggs in one basket. We had a heavy, wet snowfall in 1950 that carried down a maze of old trees across every canyon.

In 1951 we had a five-month drought. During the same winter winds up to 90 miles per hour hit the area. An upsurge in the beetle population followed quickly on the heels of these two events. All the time the steady attrition of butt and trunk rots were taking their toll. Numerous trees fell victim to all these factors, but the resistive element to every one of those lived through as an intact stand. What combination of events would occur the next five years no one can tell, but the present forest is adapted for it. No doubt the day of the specialized product will soon be in the forest with its narrow genetic base. Will it be adapted to stand everything that comes along during the next century?

The most popular of the schemes based on individual selection is the seed orchard. I believe a good share of you had a chance to see the film shown by Tore Arnborg during his recent visit. The sketch is essentially the same as his, showing the selection of 20 to 30 trees in a million-acre tract. From these trees scions are cut and grafted to nursery seedlings. These are transplanted in a well-spaced, systematically arranged orchard on good farm land and pruned to grow into bushy trees to produce lots of seed at low collection cost. The seedlings from these seeds will be used to restock all the clearcuts of the million-acre area. The advantages of this scheme are considerable. Low cost seed, combining the qualities of the selected parents, is cited as one. The orchards are at low elevations on flat ground where machine collection methods can be used. The present efforts in the region should certainly be encouraged.

The disadvantages are all concerned with gaps in our knowledge about seed orchards. The chance one takes with a narrow genetic base has been discussed. Another problem is contamination from outside pollen. Nobody knows how serious this is. I am certain from my own studies that dissemination of great amounts of Douglas fir pollen for considerable distances from stands is common in the Willamette Valley. Obviously, contamination from outside pollen becomes more and more serious the farther the orchard is located from the planting area. Still another problem is the great variability we have in elevational and environmental zones on any one million-acre block in the Northwest. A single kind of seed orchard planting stock may not be as suitable for our conditions as for the more uniform conditions in Sweden, where the first seed orchards originated. As a final problem, the details of seed orchard practice have not been completely worked out. The great range in flowering dates of Douglas fir on even a small area raises questions as to time of pollination and flower receptivity in the orchard trees. Even the arrangement of clones to insure cross pollination is not easy to work out. In all probability these problems can be solved.

Several other schemes are also based on selection of individual trees. These are mass hand pollinations, mass rooting of cuttings, continuous seed tree selection, and "jumbo" seedling selection at the nursery.

The mass hand pollination scheme, which is receiving a large-scale trial at the Institute of Forest Genetics, is more applicable to ponderosa pine than Douglas fir. It is based on the idea that a species of medium growth rate like ponderosa pine can pick up factors for growth from its more rapid growing and hardier relatives. The Institute has repeatedly shown this as a possibility. In this scheme, native pines of good form and cone production are hand pollinated with pollen from related pines of better growth characteristics. The seed is collected and resulting seedlings are planted in nearby plantations. The advantages are that the qualities of both parents are known with certainty. Of course, the problem of a narrow genetic base is still a disadvantage. Cost of seed would be high, but Dr. Righter felt this could be brought down to reasonable levels. The application of this to Douglas fir is not as promising because Douglas fir has no faster growing relatives.

As very outstanding trees become known in our forest, the question keeps arising - Why not root cuttings from them on a mass scale for outplanting? This would have the advantage of complete genetic duplication of the outstanding trees. They could be mixed and varied in any proportion into the stands for the product desired. It is hard to see any disadvantage except cost. However, no one has yet found a cheap method of rooting our western trees into planting stock on a mass scale.

Still another possibility is the relatively untried scheme of reserving a few of the best trees on every clearcut. I like to call this "continuous plus tree selection." The timber manager generally becomes so familiar with each setting after road locations are run, landings scouted, and cutting boundaries marked, that he usually has an intimate knowledge of any outstanding or plus trees on that area. These would be reserved through logging and cut to collect the first cone crop that appeared. Seedlings from this seed would be used on this and immediately adjacent clearcuts. The advantages are that the very best element of our present stands would be preserved more completely than in any of the other schemes. The job would mesh with other forestry activities, and the men most familiar with each area would control the next crop. Disadvantages would be extra costs of handling the smaller lots of seeds during collection and through the nursery. There might be a year or so delay in planting up some areas - a real disadvantage in the coast ranges. It would still be difficult to prove that real improvement was being made over run-of-the-mill seed.

Almost every nursery is running some kind of a selection program on "jumbo" seedlings. A typical one is being set up at the Bend Nursery, where a few selections of outstanding seedlings are made each year from seedlings intended for major Sub-Regions of Region 6. These are planted in coves around the nursery reserved for such stock. The plan from here is a little indefinite. Probably the best of this material will end up in appropriate seed orchards over the region. Seed may eventually be collected from such stock after mass hand pollination or even wind pollination. Seedlings will be sent to appropriate planting areas. The advantage of the program is the excellent condition for choosing outstanding stock from large populations and the simplicity of the plan. The disadvantages are the difficulties of keeping enough out-planting areas on hand for the vast areas served by most nurseries. Cost is another. However, the possibilities of this kind of selection are enormous once we gain a little more knowledge of what seedling characteristics mean in terms of tree characters.

In summarizing the field of species improvement, there is some part of the job each of us can do:

1. All of us can help in stopping the negative selection - our biggest problem in tree improvement. As of August 23, 1956, we are slipping behind, not going ahead. Our heritage of a magnificent pool of genes is being squandered in our seed collection, timber cutting, and planting habits.

2. A good share of us can help by preserving the best material we find. It won't be easy to recognize, because environment greatly affects all the characteristics we are choosing. Don't worry about making lots of mistakes - the best of experts are no better off here than you are.

3. Help promote some local scheme of getting seed from the best trees you have. You don't need a seed orchard right now. Other simple plans have real advantages.

4. Don't sell nature's "rough and tumble school of natural selection" short. No geneticist will ever be able to duplicate the selection for survival that the trees already have. Remember you are taking a risk when you shift the gene compliment in favor of some specialized tree.

5. Keep abreast of the present work the foresters are doing in tree improvement and help us out if you can. It's a tremendous job. I don't expect to see as much progress in developing a better growing, better form Douglas fir, as I do in getting resistant species where the problems are better defined, such as with white pine.

6. The schemes I have shown you are all relatively unproven. The seed orchard seems to be particularly adapted to conditions in Sweden, where it was preceded by a decade of intensive genetic studies. The mass hand pollination scheme followed two decades of genetic studies in California. We have had no similar period of intensive study. Any of the schemes shown may have a place, but it may well be that something quite different from any of these may develop to fit Northwest conditions when we have 5 to 10 years of intensive study of the subject.

7. And talking strictly to the nurserymen, one of the big items in their cooperation between foresters to accomplish the goal of tree improvement is development of cheap methods to handle small lots of seed in the nursery. A real bottleneck in our genetics work is that for a long time we will be interested in small seed lots so that seedlings can more accurately fit the area of collection. Few watchdogs of the purse will accept the present added cost of handling small seed lots through the nursery. If you can bring these costs into line, you will be doing more for forest tree improvement than most of us.

(End of Paper)

Mr. Silen had mentioned a clone of 12 Douglas fir trees at Corvallis, which originated as rooted cuttings from a single tree. In answer to questions from the group, he explained that the cuttings were taken around February; they had good form; and the old horticultural rule is to take cuttings from the bottom of the tree.

Chairman Deffenbacher declared a recess, and the group went to the Hemlock Mess Hall for lunch.

The meeting resumed at 1:15 P.M. The first speaker for the afternoon was Mr. L. T. Webster, Supervisor of Forestry, State of Washington.

Mr. Webster traced the history of the organization since its first meeting on January 17 and 18, 1949. He mentioned Charles Spark's efforts to get nurserymen's meetings started in this area. He stressed the importance and the tremendous responsibility of the nurserymen in the picture of managing our resources. With the rise in the demand for wood fibre, the type of trees produced by the nurserymen, he said, is the type of trees we need for pulp products.

Mr. Webster's paper follows: