SOME SUGGESTIONS FOR PLUS-TREE SELECTION AND SEEDLING SEED ORCHARDS

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For maximum genetic improvement of our forest trees it is the genus--not the species--that constitutes an individual genetic-improvement problem requiring research. The breeders of agricultural crops, such as wheat, corn, tobacco and cotton, did not start with a single wild species: their foundation stocks were ancient mixtures whose ancestry is still open to debate; and to these stocks they are still adding wild types for the improvement of particular characteristics. Similarily, maximum forest tree improvement will require the creation of new genotypes that combine not only as many as possible of the desirable characters available in natural populations but also the desirable characters of artificial polyploids, and mutants obtained by irradiation, chemical means or other means yet to be discovered.

PLUS-TREE SELECTION

There are three possible uses for plus trees (1) for the establishment of clonal and/or seedling seed orchards; (2) for immediate use in planting where clonal propagation is practical; and (3) for use in selective breeding and hybridization. Although uses 1 and 2 may fully justify the selection of plus trees, in my opinion the ultimate importance of progeny-tested (elite) selections will be their use in long-term breeding programs. Therefore plus trees should be established in small clonal plantings for two-parent progeny tests and for the preservation of germplasm for selective breeding.

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Geneticists have no magic formula for determining whether or not a plus tree is actually a superior genotype: this must be determined by adequate progeny tests. Such progeny tests may be made by geneticists or they may be made by silviculturists with the advice and guidance of geneticists. The search for, and the selection of plus trees for forest requirements--characteristics such as growth rate, timber form, freedom from diseases and insects, and resistance to or recovery from snow and ice breakage--can be handled most effectively by foresters who have sufficient local experience to recognize plus trees in the course of their regular duties. If a tree is not sufficiently outstanding to strike the attention of the experienced forester ho is subconsciously looking for such trees while engaged on other work, it probably is not a plus tree. Selection of plus trees for use requirements (superior wood characteristics) will require the cooperation of forest-products technicians, but the forester should be aware that local industries may have some knowledge of quality variation in the species they are processing.

Brown and Goddard (2) have presented the silvical considerations necessary for the selection of plus phenotypes of the southern pines. Their suggestions apply equally well to plus-tree selection of our northeastern conifers where natural stands or plantations of a single species are available. Since plantations of our native hardwoods are extremely rare,, selections will have to be made in uneven-aged mixed stands. Such selections will require a high degree of local experience with the species to estimate the effect of the immediate environment on the individual tree.

Theoretically there are several ways to increase the efficiency of plus-tree selections:

1. Limit selections to one or two important characters. If additional superior characters are required, such selections should be made separately.
2. Decrease the environmental variation in the sample by selecting in even-aged stands or plantations with similar density of stocking and on similar sites. This will be possible for our Northeastern conifers but will seldom be possible for native hardwoods.
3. Base the estimate of growth rate on current periodic growth rather than on total growth where the early stand history is unknown® The suggestion by Brown and Goddard (2) to base the estimate of growth efficiency of southern pines on the relationship between basal-area increase and crown size (length - mean radius) should be considered for Northeastern conifers. It would not appear to be feasible for hardwoods.
4. Increase the selection differential, the difference between the plus tree and the mean of a part or of all of the stand. Where practicable, determine the normal frequency distribution of the particular character in the stand and confine selection to trees that are two or three standard deviations above the mean.
5. Select a large number of plus trees. The objective should be at least 140 to 50 plus trees per species.
6. Since the tree is the product of its inherent potentialities and its environment, it is obvious that character-environment correlations would be very helpful. Such correlations will not be available, but the silviculturist who has had wide experience with a particular species has at least a mental estimate of the character-environment correlations for such important characters as growth rate and stem form.

IMPROVEMENT OBJECTIVES

Superior growth rate and timber form are certainly of primary importance for all of our important timber species. Selection should be made for these characters alone (see 1 above) but with the minimum requirement that the plus trees show no evidence of disease or insect damage. Superior timber form as used in this discussion is limited to straightness and concentricity of the bole, and--for most species, minimum taper.

The inclusion of early natural pruning and such crown characteristics as branch angle and number and diameter of branches as limiting selection criteria may unduly and unnecessarily complicate the immediate selection and improvement program. The production of clear timber in the shortest possible rotation will require exceptionally fast-growing trees and the application of artificial pruning as soon as the trees reach the minimum size at which pruning can be started most profitably and without reducing the vigor of the tree. The use of improved stock will certainly justify management practices of sufficient intensity to include pruning to at least one and possibly two log-lengths.

Although I would not include crown characters as limiting criteria of timber form, some (such as small number of branches) may be listed as additional desirable characters for particular species. Selection for crown structure in regard to lumber quality, particularly knottiness, would involve several characters, including branch angle, number and diameter of branches, and distance between branches, Campbell's studies (3) indicate that:

> "...broad-sense heritability of crown characteristics may be very low in wild populations of Douglas fir. This suggests that intensive selection for phenotypic plus trees, where crown characteristics are being considered, is extremely inefficient in species such as Douglas fir which are found growing on many sites within a relatively small geographic range."

This may also apply to our important Northeastern conifers. And for hardwoods it will be very difficult to evaluate crown characters in mixed uneven-aged stands.

In my opinion, pest resistance is equally as important as growth rate and timber form for the species listed alphabetically in table 1 Selection for apparent resistance to any pest, whether or not it is now a serious problem in forest management, can be justified for future improvement breeding,

Selection for resistance to a particular pest should be for this character alone, Inferior growth or timber form should not disqualify a tree except in cases where some aspect of growth rate is known, or suspected, to affect susceptibility. Pathologists and entomologists are in the best position to find and recognize apparently resistant trees in the course of their field work.

There are additional selection objectives for specific uses of our native and introduced species; for example, desirable Christmas-tree characters, high sugar content in the sap of sugar maple, wood characteristics or qualities such as figured wood, high or low density, particular fiber dimensions, percentage of cellulose or lignin, It will be advisable to set up such selection objectives in special categories for which minimum requirements for other characters such as growth rate and timber form should not be made too restrictive,

The evidence for short pollination distances among forest trees point to the probability of relatively close genetical relationships between trees in a "limited neighborhood" (panmictic unit). It therefore may be advisable to select only one plus tree from within a limited neighborhood in natural stands to avoid the possibility of too close relationship between selections. This would not be the case In plantations derived from bulked seed.

Brown and Goddard (2) recommend the selection of southern pines in stands between 25 and 50 years of age. For our northeastern timber species, the most effective selection probably can be made in stands between the midpoint and end of rotation age. This does not mean that exceptional younger trees should not be selected.

Table 1.--Suggested list of tree species and pests to be considered in selection for resistance

Tree Species	Pests
Abies balsamea	Spruce budworm Wooly aphid
Picea abies	White-pine weevil Gall aphid
Picea glauca	Spruce budworm Gall aphid
Pinus resinosa	Shoot moth
Pinus strobus	White-pine weevil Blister rust Needle blight
Pinus taeda	Fusiform rust Tip moth
Acer saccharum	Dieback
Castanea dentata	Chestnut blight
Fagus americana	Beech scale-Nectria
Fraxinus americana	Dieback
Liquidambar stryaciflua	Sweetgum blight
Platanus acerifolia	Canker stain
Platanus occidentalis	Anthracnose
Populus balsamifera, deltoides grandidentata, tremuloides	(1/)
Prunus serotina	Gum spot Black knot
Quercus alba	Oak wilt
Quercus rubra	Oak wilt Dieback
Ulmus americana	Dutch elm disease Phloem necrosis

1/ Cankers (Cytospora, Dothichiza, Hypoxylon, Septoria), Melampsora rust, spring dieback, twig and trunk borers. Selection should be limited to individual diseases and insects.

SEED ORCHARDS

The justification for seed orchards has been greatest in regions where clear-cutting followed by planting or direct seeding is, or is expected to be, practiced over large areas Most forest geneticists admit that the improvement to be obtained through seed orchards, particularly for improved growth rate, will be relatively small as compared to the improvement from selective breeding. Even in the South it has been admitted that, "Thus the seed orchard project is somewhat of a 'crash program' to obtain as much gain as possible in as short a time as possible." (p. 6).

The plantable area of commercial forest land in the Northeast totals approximately 4.9 million acres. This includes all non-stocked forest land, and seedling and sapling areas slightly more than 10 percent stocked where local experience indicates that they may be practical to plant (7, p. 542). On the assumption that much of this acreage will be planted within the next 30 to 40 years, a crash program of seed orchards for our most important native timber species, particularly pines and spruces, is justified in this region. It then becomes advisable to consider the type of seed orchard that will provide the greatest genetical gain at costs justified by such a crash program.

Clonal seed orchards have been widely recommended both in this country and in Europe, but the extent of genetic improvement to be attained has not yet been proved; and there are at present no sound data on the cost per pound of improved seed to be obtained from such orchards Seedling seed orchards should be cheaper to install, and theoretically they should be more effective for genetic improvement than clonal seed orchards. Since my comments on clonal versus seedling seed orchards at the 1961 Conference (6) have stirred considerable interest in seedling seed orchards in the Northeast, it seems appropriate and opportune to offer some specific suggestions on their establishment.

SUGGESTIONS FOR A WHITE PINE SEEDLING SEED ORCHARD

These suggestions are for eastern white pine, with growth rate and timber form as the improvement objective, and open-pollinated seed of 40 plus trees available. The statistical models presented by Wright (8, 9) indicate that the greatest genetic gains would be obtained if seedlings derived from controlled pollinations of plus trees were used for the establishment of seedling seed orchards. But the use of seedlings from open-pollinated seed (half-sibs) would have the greatest practical appeal and should provide sufficient improvement in growth rate and timber form for a crash program. In general, the procedure suggested for the establishment of a seed orchard with seedlings from open-pollinated seed would apply also to seedlings derived from controlled pollinations of such parents.

The minimum quantity of seed required from each parent tree, for an approximate 5- to 10-acre unit of orchard, should be sufficient to provide at least 1,000 seedlings for the first (nursery) selection when the trees are lifted for out-planting. This number is based on the probability that at least 20 to 30 of the progenies will be selected (on the basis of nursery performance) for outplanting in the seed orchard. For the field planting suggested in this proposal for a 5-acre orchard, this would require 120 selected seedlings for 30 progenies, or 160 seedlings if only 20 progenies are selected for outplanting.

The figure 1,000 should be considered minimum, larger numbers of seedlings would increase the efficiency of selection. Since seed weight can have an influence on the seedling and early growth of conifers that is overcome in later years, the 1,000-seed weight (filled seed) of each plus tree should be determined at the time of extraction. If there are significant differences,, the parent trees should be classified in seed-weight categories for future reference.

The seed, kept separate by parent trees, should be sown in at least two randomized nursery replicates. Additional replication should be used if this seems advisable because of the heterogeneity of the nursery beds. Special care should be taken in seeding the beds (preferably in drills) to space the seed evenly and widely enough to permit growth in the seedbed for 3 years without thinning (seed lings in the Maryland State Forest Nursery may have to be lifted at 2 years).

The first selection should be made when the 3-year-old seedlings are lifted from the nursery beds. Selection of progenies to be outplanted in the seed orchard should be based on comparisons of the average progeny heights, within the respective seed-weight categories., and their frequency distributions. Beazley and Shiue (1, p. 325) have pointed out the added selection advantages of tests for skewness and central tendency. Only the tallest trees of the progenies should be used for outplanting in the seed orchard. The remaining seedlings (36,000+) would be available for commercial planting.

For a white pine seed orchard, I would propose that the selected seedlings be planted in "progeny squares" of 4 trees spaced 8 feet x 8 feet (to be thinned eventually to the best tree in each square). Four seedlings per progeny square will permit selection within the individual squares for growth-rate., for early and consistent flowering, and particularly for time of flowering to provide max imum panmixis in the orchard. This offers a possible advantage over a clonal seed orchard. Four trees will also provide greater assurance for successful establish. ment of one tree at each location (in each square) during the critical early years of a plantation. It is questionable whether ramets in a clonal orchard can be satisfactorily replaced after 5 or 10 years; there certainly will be a loss in flowering time by such replacements.

Assuming that 30 of the plus-tree progenies were selected for outplanting in the seed orchard, 6 squares per progeny would occupy approximately 1 acre (1.05+ acres). This would require 24 of the tallest seedlings per progeny per acre. The field arrangement of the progeny squares could be randomized in blocks; or, to decrease the chance for half-sib crosses, the field layout might follow the designs recommended for the distribution of ramets in a clonal seed orchard. In this case the progeny square would replace the ramet.

Spacing at 8 x 8 feet would be sufficient to eliminate the necessity of thinning for 15 to 20 years without sacrificing crown volume. When thinning becomes necessary, the progenies should be evaluated and those that have fallen below the average of all progenies, or have begun to show inferior timber form should be eliminated from the seed orchard.[1] It is a fair assumption that this may eliminate half the progenies.

[1] The most effective methods for weevil control must be applied to a white pine seedling seed orchard so that weevil damage will not be confounded with inherently poor timber form.

Roguing of the trees in the remaining progeny squares should be started and continued (to prevent crown reduction) until only one tree is left in each square. Theoretically, if 15 progenies were left following final roguing and progeny elimination, the seed orchard would contain 90 trees per acre--6 half-sibs of each of the 15 best progenies. When this eventually becomes too large a number of trees for maximum crown development the orchard should be reduced to the desired number of stems by further roguing. Uniform spacing cannot be expected and will not be necessary; large, eccentric crowns can be developed for maximum seed production.

There is nothing sacrosanct about the 4-tree progeny square with 8x 8-foot spacing. Closer initial spacing with more trees per progeny square would be advantageous under some conditions; for example for slower growing species, or if large numbers of plus-tree seedlings per progeny were available. For wide-crowned species, such as oaks, larger progeny squares may be advisable to provide more space per tree in the mature orchard.

Perhaps the strongest argument in favor of clonal seed orchards has been the contention that they will bloom and produce abundant seed earlier than seedlings This may be true for some species such as beech and sugar maple. Zobel (10) has reported that, in northern Europe, "Spruce seed orchards have so far been a failure in that they have not flowered adequately. In the opinion of Goddard and Brown (4), "... from current direct comparisons of strobili production of grafts and seedlings of loblolly pine, there is no valid basis for assuming 15-year-old grafts would out-produce the same age trees under comparable conditions of seed orchard management."

For Eastern white pine, the saving in time for seed production by the use of grafted stock may not be so great as anticipated. In a white pine plantation of half-sibs in the Maryland State Forest Nursery at Harmons, the seedlings started to flower when they were 4 years old from seed. State Forester Buckingham has given detailed information on these seedlings. I first saw this plantation in mid-July of this year when the trees were 6 years old from seed (see cover photos).

Inherent precocity may be inferred because the seedlings in this plantation are derived from a single parent. But run-of-nursery seedlings planted as windbreaks on this nursery area have also fruited early, and 15-year-old trees are maturing a heavy cone crop this year. It is possible that this site, although it is outside the natural range of eastern white pine, provides an environment that favors flowering. Commercial producers of agricultural seed grow many of their crops where the environment is particularly favorable for maximum seed production. The possibility that plus trees of some species may be more fruitful outside their endemic area deserves investigation if clonal seed orchards are planned, Clonal orchards can be established far outside the natural range of the species, provided the progeny tests that must accompany such orchards are carried out in the environment where the seed is to be used. Seedling orchards should be established where the seed is to be used because in this case the seed orchard itself is a progeny test. This does not rule out the search for local environments that may favor seed production.

The chance for self-pollination between the ramets of the same clone must be considered in the design of a clonal seed orchard. In a seedling seed orchard, self ing would be limited to each of the individual trees; selfing could also occur

on the individual ramets in a clonal orchard. The possibility of crosses between half-sibs (or full-sibs if the seedlings are derived from controlled pollinations) would be present in a seedling orchard but not in a clonal orchard. From research on the effective pollination and seed dispersal distances for forest trees, it can be assumed that in the natural forest there is considerable family (close) breeding among neighboring trees in successive generations. With seedlings of plus trees selected from widely separated stands and with proper arrangement of the seedlings in the seed orchard, close breeding should be less than in a natural stand. The degree of inbreeding that might occur between half-sibs in a seedling seed orchard may or may not be deleterious; for some characters it may be advantageous. This point can be determined only by controlled breeding.

It will not be advisable to prune the trees in a seedling seed orchard, to keep seed production within easy reach of collection equipment, until the final selections have been made. This will not be a serious disadvantage. Zobel (10) has reported that the question of whether early and continuous pruning increases seed production is still being debated in Europe. Some preliminary work with red pine in western Maryland indicates that conifers may still be shaped for relatively cheap cone collection when they are 20 to 30 feet in height without loss of cone production.

The relative costs and genetic gains of clonal versus seedling seed orchards can be determined most effectively by using the same plus-tree parents for the establishment of both types of orchards. I hope that in the near future such tests may be started in the Northeastern Region.

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DISCUSSION

SCHREINER I have a question on the use of the word periphysis which also is used by mycologists. Does this term as applied here to vegetative propagation have precedence over its use in mycology?

KLAEHN[1] As to precedence or preference of usage I'm not in a position to pass judgment. Some of you are familiar with Busgen and Muench, 1929 . "Life of Forest Trees." Since that time the term periphysis has been used in a number of papers, I have never found the word periphysis in American literature to refer to environmental disposition. I have never found the term cyclophysis in American literature. I found only topophysis I don't know whether we are alowed to change it or retain the term, as I did,with a reference to Busgen and Muench.

RAUP Are you sure it's the same word? Isn't it paraphysis in the fungi?

SCHREINER There are two words, paraphysis and periphysis. I expected to be called on this so I brought along the following definition from Ainsworth and Bisby's "Dictionary of the Fungi" 5th edition, 1961, p. 29. "Periphysis a hair-like projection from, or near, the ostiole of a perithecium, pycnidium, or pycnium."

VALENTINE Dr. Klaehn, these various changes you refer to could be of great importance in the type of experiment I reported, for in the clonal tests the various trees at different distances from the "parent" tree presumably are of different ages. These kind of effects, therefore, might be expected. This was checked by Mr. Brown, but he obtained no evidence for differences in leaf characters which were associated with distance of the sprout growth. This might be rather easily checked in root sprouts of beech. Have you ever observed any differences in the retention of leaves, a juvenile trait, among the root sprouts from a beech tree?

KLAEHN I have discussed this with Muckadell. He mentioned that some of the grafts he did originated from root sprouts, as well as sprouts from the lower section of the stem. The root sprouts retained the leaves as well as the grafts taken from a young tree shown here on the picture.

VALENTINE - It appeared from our data that there is not a change in the root it self in trembling aspen. This suggests that the adventitious bud that will give rise to a sprout "reverts" to a juvenile condition, at least for the traits we studied.

KLAEHN The only reference I have to this problem is the paper by Frohlich. I have it in my briefcase with me. A paper Which I got ten or fifteen days ago. Frghlich collected shoots of aspen at various distances up the main stem and grew them all in replicated environments over a period of three or four years, a terrific variation in height was noted.

SCHREINER You are speaking now of the original branches, not sucker growth at those points.

KLAEHN I speak of the original branches.

[1]The transcript of Dr. Klaehns statements was edited by Mr. Hunt.

REINES In the case of aging of tissues more specifically, reproducibility of tissues in grafting as affected. by aging have you noticed any differences in your grafts using scion material from different aged parents?

KLAEHN (Beginning inaudible) The growth of scions from old individuals is usually noticeably slower than scions from young, juvenile trees.

REINES Well, inasmuch as age of clonal parent affects rooting, would the per formance of grafted trees be a good measure of aging? Were starting a study in which the ratio between diameter of the scion and diameter of the stock and their interaction are being considered. Could this give us an indication of the effect of age on reproducibility of tissues? I was wondering whether you observed any trends in your grafting work. There is another study we have in mind. This involves an examination of wound response in trees of different ages, Have you noticed differences in healing as a consequence of age?

KLAEHN Oh, yes. There is a difference in wound healing. In a small study, I wounded red pine bark and red pine stems, 5, 6, 7 years old and likewise on Scotch pine. The next year I found that these young Scotch pines had healed completely but the wounds of the 5 and 7-year pine were still open. Apparently red pine shows reduced healing ability at an early age ... (inaudible from this point)

REINES Have you done anything toward understanding aging phenomena other than observing morphological differences? Have you made some attempt to study meristematic tissues; their physiology?

KLAEHN We started a study last spring using Abies species to demonstrate aging and location with regard to sterile and fe rtile sections, male and female sections. In an attempt to modify cyclophysis we grafted these sections on juvenile rootstocks. We hope to graft juvenile non-fertile twigs in all crown sections of a mature tree for comparison.

REINES There are some pretty fundamental problems here as to what aging is. There is a question as to whether this is an accumulation of substances or a depletion of substances. There are also some other pretty wild ideas about it. I was just wondering whether anything was being done in the area of comparing fertilized female gametes with progressively older sporophytic tissue.

KLAEHN The only thing I can say for people who are interested in the subject is that there is a very interesting paper on the aging problem written by Robbins, I can give you the reference if you want. Although he takes a neutral position, he is not against the aging theory and recognizes several factors causing aging...(inaudible)

REINES I believe Molisch did a better job many years earlier.

KLAEHN Yes, Molisch is pretty much accepted in Europe; he is not accepted by Robbins. Robbins does not agree that the decline seen is dueprimarily to the aging of the clone with an attendant loss of vigor.

REINES It has been suggested that early decline of Lombardy poplar might be due to the advanced accumulative age of the clone plus that of the clonal parent In essence, plants are being produced vegetatively which possess the weaknesses of old age.

COOK - I'd like to comment on two things that Ernie has said and one that he has left unsaid. Four and nine-tenths million acres is entirely inadequate for the scope of the "crash program" in the Northeast. I'd be willing to bet that any honest appraisal would double that figure. Forty years ago, we had 4 million acres of abandoned farmland in New York deemed to be in need of refor estation; in spite of our best efforts, we still have that much. I think you are wrong in limiting genetic gain simply to stem form; the shape and size of the crown are important in artificial pruning. If you get the wrong shape of tree, it can run the pruning cost up sharply, and that is one thing that the silviculturist is very much interested in. And in the matter of unit cost, we can grow top grade seedlings for something like 3 cents apiece, whereas grafted stock will cost at least $1.50, probably much more.

SCHREINER We can select for crown form but how much improvement will we get? We probably would have to discard some vigorous trees. From Camp bell's studies, selection for crown characters does not look too promising. It would be better to put a little more money into pruning and count on additional inherent growth rate to offset the cost of the pruning.

COOK But the cost of pruning is going to be applied to many stems per acre on many acres, so a slight additional cost per unit can run into a lot of money. It will be cheaper to get fine branching genetically than to spend money on mechanical pruning.

SCHREINER The point I've tried to make, Dave, is that we may not get maximum growth rate, or as many trees, if we include all these additional characters.

COOK - That I will debate.

SCHREINER I'll be up to Cooxrox one day and we'll debate in the woods.

KLAEHN - I have a question, Ernie; I may have misunderstood you. If you would establish a seed orchard the way you have described it, are you planning to do anything to the trees, fertilize them or prune them to stimulate flower production to get early, abundant flowering in seedling seed orchards?

SCHREINER The cultural methods I would recommend in the early years would be those that we anticipate may go into the eventual commercial plantings.

KLAEHN - When we establish a seedling seed orchard we cannot use the same orchard for progeny tests. A progeny test requires that you do nothing to the trees to influence growth or growth form You cannot prune them and I do not know whether it is correct to fertilize to get early flowering, as, for instance, re- ducing the time of normal flowering from 20 years to 10 years. You can do one thing or the other, but not both with the same plants.

SCHREINER - I agree, but thinnings will not confound the progeny test; such thin nings will also be required in the progeny tests that must accompany a clonal seed orchard. Pruning, particularly cutting back tops to stimulate flowering or to develop orchard-tree form, will end the progeny test at least for height growth. But in my opinion this will not be necessary in white pine for 20 to 25 years, approximately half the rotation. Interest in forest fertilization is increasing; as this becomes an accepted management practice, it may be applied to progeny tests.

McELWEE I have just a couple of comments, the first on the present discussion. In progeny tests for any seed orchard, as we look at it, and as you pointed out, we must test under the conditions that the trees are going to be grown commercially. Now, in your management of white pine, here in the Northeast, do you plant at 8 x 8 and thin at 15 years? Thinning 3 out of 4 trees is what this will require.

SCHREINER - No, we would not thin that heavily in practice, and such a heavy thinning, 3 out of 4, would not be applied to the best progeny squares. The poor progenies could be weeded out but the best progenies need not be thinned to a single tree at 15 years. I would expect to terminate the progeny test for growth rate after 20-25 years, about half the rotation. Are you pla nning to wait a full rotation before you rogue a clonal seed orchard?

McELWEE For certain characteristics we think we can determine the results of progeny tests in a relatively few years, say 4 to 5. This is true of certain wood properties, Now, when I think of final evaluation of what these trees are going to do under the plantation conditions, its going to have to be made at rotation age

SCHREINER For white pine, I believe half-rotation age will provide a sufficient ly sound estimate of growth-rate and form. I must admit that this opinion is based partly on my long experience with hybrid poplar tests where half-rotation age is ample to safely judge growth-rate and form.

McELWEE Well, if you can do this, I think it's legitimate, but I'm not sure we can do this with the southern pines. Now, I have another comment on Cook's question. What characteristics we're going to use will depend, of course, on the end product. We can't say at this time how much we can accomplish be- cause we don't know enough about the heritabilities, either in the broad sense or the narrow sense. In the South we're working only with those characteristics that we think cannot be adequately taken care of through our silvicultural practices. Such things as diameter growth we give less attention to because we know that through our spacing we can influence it, so we give very little weight to it. Height growth is something else because for our southern pines within the normal forestry spacings of 5 x 5, 6 x 6 and up to 10 x 10, there is little we can do to influence the height growth as compared with diameter growth. Now, however, we have some preliminary data that tends to show that diameter growth in the narrow sense heritability is a little higher than we had anticipated.

KLAEHN As for clonal seed orchards versus seedling seed orchards, nobody has yet attempted to point out in American literature the fact that clonal seed orchards may be quite something different than what we have been talking about. I have published a paper on this in 1959 in the Journal of Forestry In Europe, and as we are attempting to do in New York State, and as I teach my students, there are four basic types of clonal seed orchards. The first type, is probably what you have in the South and what we may have in a couple of years in New York State when these orchards begin to flower, is a regular seed orchard producing somewhat improved seed. We call it regular seed orchard. The second type is what we call an elite seed orchard where we have to complete the progeny testing and eliminate negative clones. When we harvest seed, in perhaps 30-4 0 years, which we can call elite seed, we will know the exact genetical gains. The third type is a conservative type of seed orchard. All we plan to do is to keep a certain strain, a certain local ecotype, alive for future seed production so that we have preserved this particular strain. They are paying considerable attention to this type in Europe because they have certain old Norway spruce, local, natural, not mixed with other material which they want to keep as straight

and as pure as possible. The fourth type, called hybrid seed orchard, is for the production of interspecific hybrid seed. We have planted out two orchards of this type in Saratoga and one in Syracuse. In this case we are dealing only with two clones. In our orchards, we have one Japanese larch and one European larch. So these two trees, propagated perhaps 50 times by grafting, hybridize. I believe this has to be considered in our discussion of seedling versus clonal seed orchards.

If you accept seedling seed orchards as the best way to do it, I still don't believe it is the best way to do it if you only want to keep a certain strain alive. There is another aspect which comes to light. That is, how are these trees pollinated, are they wind pollinated or insect pollinated? So far, nobody has discussed this matter from this point. We know that in Korea, they are doing cross pollinations, on a large scale, by hand. This will be feasible for certain species here in the United States, such as the birches, which have tremendous seed production. All of these points have to be considered before we come to a final decision.

Clonal seed orchards are not only what they are doing in the South, there is much more involved. We have to consider this because there are many people, even in this room, who have the idea that the clonal seed orchard is what they have in the South. A clonal seed orchard is more than that.

SCHREINER In my argument for seedling seed orchards I am not referring to these other types of orchards. I am not recommending seedling seed orchards for hybridization and various other purposes. My argument is for the seed orchard designed to produce seed that is a little better than run-of-mine stock to satisfy the needs of a crash program. I have always urged small clonal plantings of se lected individuals for research and to preserve good germ plasm for future breeding.

McELWEE - I want to point out to Fred that in the South we not only have these production orchards, we have several other types of orchards. First of all we have what we term our clone banks which are purely for preservation of genotypes. We also have research orchards which will be used for hybridization, not only intra- but also interspecific, which we think will offer a chance for some gain in the future.

I have a question that I want to ask Ernie or Buck. On the pictures that yot showed where we could see the female strobili, what about the pollen production of this young material?

SHREINER We have no information on male bloom. Buck wasn't expecting these young trees to flower, and I just happened to visit the nursery this summer. Although the chance for pollination is good because there are older pines in the nursery, we don't know whether these young trees have produced any male flowers.

McELWEE When we first started our seed orchards, the question revolved around the production of the female strobili, with the assumption that pollen was going to be plentiful. Now, however, we're beginning to get a little bit disturbed about whether we are going to have adequate pollination for a few years or not in these seed orchards. We have to check both sides of the fertilization picture.

GENYS - I wish to present a viewpoint related to selection of superior trees which appears to be worth consideration. On several occasions I observed that our selected superior trees are the oldest and the largest specimens, particularly among white pines. However, as we recall from history, the best white pine stands were harvested by the lumber companies with no attempt to leave superior trees . In fact, there is a strong probability that they left inferior trees. By now these left-overs are quite large specimens. It is worthwhile to consider the question stated by Mr. Cook on the field trip,"What these big trees looked like when they

were young? Perhaps, we may expect a better genetic gain by conducting tree selection in younger stands, growing from seed of primordial good trees. In general, I question the value of the old leftover trees primarily because the early lumber companies were not engaged in selecting superior trees for our tree improvement programs. If they left a few old specimens, these are not necessarily superior from the genetic point of view.

BUCKINGHAM - I take exception to this statement, I know definitely that some of our older stands were not cut because the owners refused. This is true not only in the coastal area but in western Maryland as well. The State now owns a forty-acre tract of old growth white pine and hemlock that was adjacent to one of the larger mill sites in the county. The lumber company deeded this tract to the Grand Lodge of Masons of West Virginia and Pennsylvania as a hospital site This is one example where most desirable, and easily loggable, trees were left and I am certain that there are such locations in all states in the white pine area. I also know of cases in the Savage River section of western Maryland where white pine trees were left because, in the words of some of the old camp bosses that I knew, "They (the trees) were just too big." I measured one tree that had fallen that was some 150 feet long and another that was standing, that was about 130 feet tall. So far as I could determine, these trees had no visible defects and were of excellent form.

GENYS Since Mr. Buckingham heard of cases that some better trees were left, and I heard that millions of better trees were cut with the exception of a few questionable leftovers, possibly, the case has two sides.

KLAEHN - Suppose you have a seedling orchard which is very productive. You have a number of trees in it and you get just what you want, somewhat improved white pine seed on a commercial basis. You have a good seed crop and there is no trouble at all getting the cones down. You plant it out every second or every third year. Now this white pine stand becomes older and suddenly, one day these trees reach a height too high to reach, the cones or an age when you cannot keep them any longer. What are you doing now? When material is gone and you can no longer get seed from it are you then going to start propagating these trees vegetatively to establish clonal seed orchards with them? How are you going to perpetuate this particular seed source you are harvesting for future generations?

SCHREINER Fred, you will recall that I said every plus tree should be established in small clonal plantations. To this I would add that further selection and clonal propagation of the best trees in the seedling seed orchard, before it reaches old age, would be the obvious procedure to continue improvement. We need clonal seed orchards for research, for the preservation of germ plasm and for continued improvement through breeding these need not be extensive plantings.

KLAEHN That depends on where you plaoe your emphasis.

JORANSON Ernie, it seems to me that possibly a good common sense recommendation coming out of this discussion might be that if seedling orchards are to be established, you would devote some of the replicates for each progeny type to something like a half-rotation final evaluation schedule and other replicates to a full rotation evaluation schedule. You could then incorporate some research objectives into an orchard which in general has a practical design If you could do such things early and get them in on an area-spread such as you would get in a production proposition perhaps you would go a long way.

SCHREINER Phil, thats an excellent suggestion.