REPORTS FROM THE FLOOR
ON WORK IN PROGRESS AND PLANNED IN THE NORTHEAST

INTERSPECIFIC HYBRIDIZATION IN SPRUCE, MAPLE, AND ASH AT THE NORTHEASTERN FOREST EXPERIMENT STATION

Jonathan W. Wright

Spruce.--From 1937 through 1941 and from 1948 to the present the Northeastern Forest Experiment Station has been engaged in species hybridization work in the spruces. This brief report is a summary of the accomplishments to date. Most of the data comes from our own experiments.

Judging the value of interspecific hybridization as an improvement measure requires that we determine:

1. Which species cross with each other.
2. Which of the successful crosses yield useful hybrids.
3. How to produce and use the promising species combinations.

1. There are some 40 species of spruce. Determining which species cross by the trial and error method would require some 780 different combinations--possibly 75 man-years work. For that reason it is desirable to determine the crossability pattern.

A total of 67 different species crosses have been attempted, not counting reciprocals. Most have been repeated on different trees in different years. Of these 23 crosses were probably successful and 44 crosses failed to give good seed. The results of this hybridization work as summarized in table 1 indicate that the geographic ranges of the natural species provide the best clues to their crossability.

Table 1.--Spruce species crosses which have been attempted, arranged by geographic distribution of the parents

Range of one parent	Range of the other parent			
	Europe, Siberia	China	Japan	America
Europe, Siberia	3S, 3F*			
China	3S, 7F	4S, 1F		
Japan	2S, 1F	2S, 4F	1S	
America	1S, 9F	1S, 12F	3S, 3F	4S, 4F

*F--crosses which failed; S--crosses which succeeded or probably succeeded. Numbers refer to the number of species combinations attempted.

Forty-two of the failures involve species occupying totally distinct ranges, with a range gap of several hundred to several thousand miles (e.g. Norway spruce x white spruce). Only two failures (white spruce x red spruce, Norway spruce x Serbian spruce) involve species occupying the same range. If there were not some barrier to crossing such species would have merged long ago.

Nine of the successful crosses (table 2) involve species with barely overlapping ranges and one involves species with greatly overlapping ranges. Eleven cases involve species which cross with a near neighbor or involve distant species connected by an intermediate type. Only three of the successful crosses involve species occupying widely separated ranges not connected by an intermediate. Crosses involving close neighbors gave higher seed sets and more consistent results than those involving more distant species. One old Japanese species (P. koyamai) crossed with everything on which its pollen was applied and provided most of the exceptions to the general trend.

A crossability pattern such as this is a common one in plants and animals, and it is probably safe to extend it to the many crosses which have not yet been tried. If so we need to try only a fraction of the 780 possible crosses. About 50 well-chosen species combinations should produce representatives of nearly all the hybrid types which might prove useful in the Northeast.

Table 2.--List of successful spruce crosses (order of listing does not indicate direction of the cross)

Species crossed	Remarks on geographic ranges
White x Sitka	Slight range overlap in Alaska
" x Engelmann	Slight range overlap in Alaska
" x black	Great range overlap; usually separated ecologically
" x P. jezoensis	Alaska-Kamtchatka range gap (geologically short)
Black x " "	Alaska-Kamtchatka range gap (geologically short)
Sitka x Engelmann	Slight range overlap in Alaska
Serbian x oriental	1000-mile gap, no spruce, Yugoslavia-Caucasus
Norway x "	1000-mile gap, no spruce, Yugoslavia-Caucasus
" x Siberian	Range overlap in NE Europe; doubtfully distinct
" x P. asperata	500-mile gap, no spruce, Hopei-Manchuria; P. obovata an intermediate type in Siberia
" x P. montigena	500-mile gap, no spruce, Hopei-Manchuria; P. obovata and P. asperata intermediate types
P. asperata x "	Slight range overlap in Szechuan
" " x Siberian	500-mile gap, no spruce, Hopei-Manchuria
" " x P. retroflexa	Range overlap in Szechuan; doubtfully distinct
P. montigena x "	Range overlap in Szechuan
P. balfouriana x "	Range overlap in Szechuan
P. glehnii x P. jezoensis	Range overlap on Hokkaido and Sakhalin
P. koyamai x white	P. koyamai (Japan) seems to cross with everything without regard to relative geographic ranges
" " x P. asperata	
" " x P. montigena	
" " x Norway	
" " x Serbian	
Sitka x "	Yugoslavia-Alaska range gap
White x P. asperata	Alaska-China range gap, slightly crossable

2. There is no information on the growth performance of the artificial hybrids; our own hybrids are less than 3 years old. Therefore, our growth information must come from hybrid swarms occurring naturally--swarms of white x Sitka spruce in Denmark (hybrids vigorous but of poor form) and *swarms* of white x Engelmann spruce in western Canada (hybrids intermediate) .

It is probable that most of the hybrids which are now being produced will serve mainly as prototypes for future work and not be useful in themselves. As one example, the P. asperata we have used as a parent is broad-crowned. If the hybrids with Norway spruce do show hybrid vigor, they are also likely to be too broad-crowned for forest planting. We shall then have to repeat the cross using better races of both species.

3. Seed yields have been relatively high for most of the hybrids made. Indications are that we could economically produce hybrid seed by the thousand with either hand pollination or natural crossing in suitable plantings.

Our spruce program for the next 5 years will be devoted to making as many of the promising hybrid combinations as possible, testing these and the hybrids already made, and starting racial studies on one or two of the most important species. The State of New York is growing most of our hybrid stock and it is hoped will furnish us with. planting sites when it is ready to go out. Canadian workers are studying racial and individual variation in our three native species. We may be in a position to cooperate on their studies.

Maple.--In the maples closeness of taxonomic relationship determines whether or not two species cross easily. Taxonomists have divided the genus into 13 sections based on characters of leaves, flowers, and samaras. Each section is a group of a few species which are more similar to each other than to other species; most sections are confined to a single part of the world. One of the sections includes sugar maple, black maple, and 3 or L minor species from the Southeast. Another section includes only red and silver maples, our only spring fruiting species.

There are several rare natural hybrids between species in different sections. Presumably we could make many more with intensive effort but we do not get these rare hybrids if we pollinate only a few hundred or a few thousand flowers. We do get high seed sets from crosses between species in the same section. From the practical breeding standpoint we can treat each section as a unit. The four sections containing sugar maple, red maple, Norway maple and sycamore maple respectively appear most promising for the Northeast.

We now have growth data on 6 different hybrid combinations, some about 15 years old. Two combinations exhibit probable hybrid vigor, 3 are intermediate and 1 is runty. One of the vigorous combinations is Norway maple x Acer cappadocicum.Both parents are good in form, growth rate and wood quality; the extra vigor makes the hybrids look good. The other involves boxelder and A. henryi,neither one of them worth very much.The red-foliaged hybrid may be a promising ornamental. So far the various sugar maple hybrids seem to be of no special value although they will give us a good source of variability for starting the selection of superior trees and races,

Most maples flower regularly and nearly always give a 25 to 50 percent seed set to the proper hand pollinations. However, hand pollination is laborious and we can not yet mass-produce the hybrids we have produced by the dozen.

Our plans for the next few years include testing of the hybrids already made and more detailed study of the crossability patterns and mass production possibilities within the sections most important to the Northeast. Also, we expect to intensify our work on sugar maple, the most important species. In this species we are limiting ourselves to individual tree selection (mainly for high sugar content) and to the clonal and seed testing necessary in such selection work. Our studies in sugar maple will be complementary to those in progress in Vermont and Ohio.

Ash.--A limited amount of crossing work in the ashes indicates that the species crossability pattern is governed both by similarity in characters and closeness of geographic range. Our one successful cross--of 6 attempted--is between green ash and Arizona ash. These two species are very much alike and occupy nearly overlapping ranges.

With about 40 species to choose from, we could find a good many other species-pairs which would cross with each other. But would the hybrids be useful here? So far about 15 of the 40 species have been tested, and only one of the exotics grows even half as fast as do our best native species. It appears that any really useful hybrid will be based in part at least on our native white or green ash. If so there are about seven hybrid combinations that seem both possible and worthwhile.

In both white and green ash there is considerable racial and individual variation. The outlook for selection and crossing within these species looks brighter than does the outlook for crossing different species.

On very fruitful ash trees it is possible to harvest 50,000 control pollinated seeds as the results of a single day's pollinations. But fruitful trees are rare. Better ways of stimulating flowering and fruiting are needed.

We already have racial tests underway in green and white ash. Most of our work in the next few years will be on these racial studies, and on the relationship between wood quality and geographic origin and chromosome number. As flowering material becomes available we hope to do a little on interracial crosses and on the most promising species crosses.

More detailed accounts of the species hybridization work in all three genera and on the ash racial work have already been published in papers available from the Northeastern Forest Experiment Station. Interested individuals may obtain these for the asking.

HEMLOCK PROJECT AT THE CONNECTICUT AGRICULTURAL EXPERIMENT STATION

Hans Nienstaedt

You've already heard about our chestnut project. I thought I would like to tell you a few words about our hemlock project which was started last year. Hemlock as you knew used to have a much more extensive distribution through New England and especially in our case through Connecticut. The Experiment Station thinks that by bringing hemlock back into our present poor oak stands we could increase the per acre yield and at the same time increase the quality of our oaks. Therefore, we have initiated a very comprehensive study of east -ern. hemlock.It will involve an ecological study of the species which is in charge of the Forestry Department, Dr. Jerry Olson is doing the work. I, personally, work on the genetical aspects of the problem and am at present studying the compatability between the different species. I don't know if we will get much in the way of practical results in the very near future, but I hope we eventually can develop some desirable, fast growing species hybrids.

Dr. Olson and I work together on a study of racial and ecotype variation in eastern hemlock. We have just started this project and are at present trying to get seed collections from the entire range of this species for field and laboratory experiments.

In the past winter we have been studying the photoperiodic response of 2-year hemlock seedlings and have had some very interesting results. We have not used the same technique as Scott Pauley, testing several races on the same day length. We have used one single collection at different day lengths. We have found that day length has a very distinct effect on the breaking of dormancy. Growing seedlings on 8, 12, 16, 20 hours and continuous light we get a breaking of dormancy very rapidly on 16, 20 and 24 hours of light. However, it is somewhat delayed on the shorter day lengths. With regard to terminal growth and elongation the best is again encountered on 16, 20 and 24 hours. Apparently it is best on the 4-hour night lengths, that is on the 20-hour day, This compares with European results with Scotch pine. On the long day length the plants remained actively growing for more than 4 months. Plants growing on the 8 and 12 hours day length grew much less and went back into dormancy after less than two months.

Another interesting thing we find is that the hemlock seedlings, as could be expected, require a chilling to break dormancy. However, if you grow the seedlings on a long day, 16 hours or longer, they will break dormancy without any chilling, and grow normally and reach practically the same amount of elongation, as a plant which has been pre-chilled before they were put under growing conditions.

Studying the effects of different day and night temperature combinations, we have found that a moderate constant temperature of 75 degrees will give a fairly decent growth. A constant temperature of 90 degrees will give a slower growth. On a constant temperature of 60 degrees the plants will have a terminal elongation comparable to those on 75 degrees. However, the number of side branches on the 60 degree plants is very much reduced as compared to the higher temperatures. We don't know what is involved here, but it is very interesting, and we hope to follow it up later on. Alternating temperatures between day and night we found that the best results are obtained if we have a

lower night temperature. A 60 degree night temperature with 75 degrees of day, or 60° with 90°, will give approximately the same elongation and will he much better than 60°- 45°, or 90°- 75°. Finally, we found that the seedlings will even grow on 45 degrees, constant. I think that's rather interesting, too. Well, that gives you some idea of what we have been doing. This winter we plan to make a similar experiment but expand it to include several different races of the species.

TREE IMPROVEMENT WORK AT THE BOYCE THOMPSON INSTITUTE FOR PLANT RESEARCH

Clyde Chandler

You will soon find out that I am not a trained forester. It was by chance that I got into forestry and it is certainly by chance that I am telling you today about our work at the Boyce Thompson Institute for Plant Research. My first work on tree breeding was done in Guatemala, Central America, where Cinchona was hybridized and selections were made for higher quinine content. At Boyce Thompson we have started a breeding project on larch, We have obtained seeds from various sources and started some provenance tests of the European, Japanese, American and Western larch. We have selected some very fast-growing trees from these seedlings. This phase of the work is more or less at a standstill now because we have been unable to root softwood cuttings. From approximately 50,000 cuttings taken at monthly intervals throughout the year from terminal and lateral growths on lower and upper parts of the tree only 125 produced roots. Various types of cuttings were made and may of the root inducing hormones were used. I saw Professor Larsen's work in Denmark on rooting larch cuttings and he seems to have no difficulty rooting them outside in cold frames. It seems now as though we should study the effect of light and humidity on rooting by controlling both of these factors. I was very glad that Professor Doran said yesterday that he would try to root larch for us in this country and tell us how to do it.

We have been making inter- and intraspecific hybridization pollinations and have some very fast-growing seedlings from some of these combinations. We are testing some of Professor Larsen's seedlings in this country. We have them in the nursery along with some of our hybrids which are somewhat larger at the present time. This may be due to change in climatic conditions for his stock.

We have treated seeds of the Japanese and European larch with colchicine. These seedlings are in the nursery where their growth rate is being observed. Chromosome numbers will be determined if any prove to be interesting from a vegetative point of view.

We have been selecting some columnar type male ginkgo trees and propagating them vegetatively for ornamental purposes. We feel that they may be a good substitute for the Lombardy poplar which is dying from disease.

We plan to start some experiments on parthenocarpy in larch because, even though we have no trees shedding pollen around our American Larch, embryoless seeds develop. I should like to know what really happens in this case.

I'm glad that Dr. Schreiner invited me to come to your meeting yesterday and today. I hope to carry back a lot of good ideas.

IRRADIATION STUDIES AT THE UNIVERSITY OF MASSACHUSETTS

A. D. Rhodes

I might report briefly on a project which we have at the Experiment Station at the University of Massachusetts. It's a little different than what you've been hearing here and I'm not quite sure whether this is the place or time to report on it.

We have a cooperative project with the Brookhaven National Laboratory down on Long Island to irradiate seeds and plant materials. It concerns so far just white pine and Norway spruce but we hope eventually to expand it to some of the other northeastern conifers particularly red pine. I've been talking with Hans Nienstaedt and he may be interested in doing the same thing with hemlock. We have irradiated seed in various dosages, with thermal neutrons and X-rays, which have germinated in part and are growing in our greenhouse, to determine primarily what dosages can be tolerated and what we might work with in the future. We considerably over-estimated the dosages of then. mal neutrons that the seed could take and only our lowest dosages show any germination as yet. They've only run about 2 ½ months, so it is conceivable there may be more germination but I doubt it. After we have carried on these preliminary greenhouse aspects of the work and know what dosages the seeds can tolerate, our hope then is to treat larger numbers and grow them in nursery cultivation, then set them out in the field and see what happens to them.

We also have irradiated transplants of both Norway spruce and white pine growing in the gamma field at the Brookhaven Laboratory. They are set out in the field and are actually subjected to gamma radiations from a cobalt 60 source as they grow. They were set out this spring. I havn't seen the plants yet and I don't expect much to occur until they become fairly well established.. It may be some time yet before we see results. Whether we can extend this sort of thing to include other species I don't know. The Arnold Arboretum has a good many horticultural species there I believe. We also hope to irradiate cuttings of white pine this winter - Professor Doran is carrying on that aspect of it - to determine what effect this will have on rooting capabilities.

I can't tell you a thing about the final results of our tests because its still too early. So far as the seedlings in the greenhouse are concerned most of the irradiated seed treated by thermal neutrons (what limited germination we did get) produced seedlings which apparently were very susceptible to damping off. A very high percentage of them compared with the controls died shortly after germination. As far as the X-rayed seed is concerned the seedlings showed a much greater tendency to live, and we may be able to work with these radiations to a greater extent than with the thermal neutrons.

WHITE PINE BREEDING, CABOT FOUNDATION

A. G. Johnson

I would just like to say a word about the white pine breeding that we are doing as it is related to the concept that Wright has mentioned here, that the crossability of species is correlated with overlapping ranges. That apparently holds very well for spruce and the hard pines but in the white pines it doesn't hold. There is a good reason, I think, in that the white pines constitute essentially one good species with considerable variability. We have hybrids combining Asiatic, European and North American pines. We have some individual plants now that combine the merits or demerits of 4 different species, in fact we have one old hybrid at the Arboretum that analysis has shown to be a combination of the Mexican white pine, Himalayan pine and the Japanese P. parviflora; it is a wierd thing. The white pines are widely crossable and *seem* to show patterns of variation. Thus, in our western pines we have a continuous series, almost imperceptible changes, from the northern albicaulis through flexilis down into the Mexican pines and the intermediate forms that occur in south Arizona and New Mexico, with little outlyers that differ a bit from P. monticola which seems to represent a form between flexilis and eastern white pine. Sugar pine on the west coast seems to be queer; it doesn't seem to be crossable with anything. The only cross I made with it and the only one I've heard of as successful, has been with armandi of China. This armandi x sugar pine hybrid does hold some promise of blister rust immunity; that Asiatic pine is highly tolerant if not actually immune.

DISCUSSION

(IMPROVEMENT THROUGH BREEDING AND HYBRIDIZATION)

Graves Mr. Recknagel suggested that I say something more about the in arching of the chestnut hybrids. We find that this in-arching has been very successful. We don't need to lose a single chestnut tree if it has any hardiness and any resistance, because we have developed this in-arching method of curing blight, you might say. It's about the only instance I know of curing a plant disease. When a tree has the blight we cut out the dead bark and usually one or two annual rings under the blight lesion and paint it over. If a tree has blight it nearly always sends up basal shoots, and we take those basal shoots, sharpen the ends and graft them in about the blighted area which has been cut out. In that way we restore the corimunication of the leaves with the roots, and this connection we've made with the base of the tree and the part above the blighted area continues to grow. We've been doing this every spring through April since 1937 and hundreds of trees have been restored. Some of the original inarchings we made in 1937 now are as thick as my thigh and almost a second trunk, as Dr. Diller has said. So we keep these trees for further breeding. Of course it isn't practical on a large scale with large plantations, but if the tree has rapid growth and other good characteristics such as erect growth, we can save it. There is no reason why people who have Chinese chestnut orchards should ever lose a tree, if they use

this method. It is possible to in-arch repeatedly, year after year, so that the entire trunk is nothing but a series of in-arches.

Recknagel I'd like to ask Ernie Schreiner a question on frost hardiness of these hybrid poplars. Two years ago we received 1,000 hybrid poplars from Dr. McKee at Saratoga. These were set out on a waste area near Watertown, N. Y. They grew very well on very poor soil. They were cultivated the first year but not the second. It is interesting to know that these are not frost hardy. Now I'd like to ask this question, I asked it yesterday in the field, you have had no frost damage, is that right? Now has anyone had frost damage elsewhere?

Schreiner These clones have been frost-hardy near Rumford, Maine, the original plantations now 25 and 26 years old, but some clones were not frost-hardy at Cass lake, Minnesota. I believe the answer is that at Cass Lake they get a dry spell about August and the poplars become dormant. I was there in mid-September in 1936. The poplars had put on a second period of growth and that was all frozen back by an early frost. The native aspens were acclimated and didn't put on that second period of growth when the rains came in September and the weather was still warm enough for growth. But we have had no such trouble with any of these 250 hybrid clones here in the Northeast.

Pauly I can't help but point out that adaptability to the photoperiod is involved in this matter. For example, origins of P. trichocarpa from Alaska stop height growth in Massachusetts on or about the time of the summer solstice. That is to say on June 20 or 21, in that week, and there they sit regardless of the climatic conditions or other factors influencing growth. In this area growth conditions are certainly excellent for the remainder of the season. And yet these Alaska clones do not renew their height growth activity. There is, during a drought period, a tendency for height growth to drop off appreciably but I don't think we have any record of material which has actually entered dormancy, i.e., developed a terminal bud, hardened off its wood, etc. and then started to grow again.

Schreiner I wasn't in Minnesota in August. Perhaps they didn't really become dormant, but the point is that there was a flush of growth with the September rains which was caught by the first heavy frost.

Pauley That's a very common thing, they slow down and then continue again. In this connection there is something else that I know will be of special interest to Ernie because he has done work along this line, in fact he has published a couple of papers on the effect of sod on the growth of poplars. Sod has a very inhibiting effect on growth which you can well see in any plantation which has not been cultivated in the first or second season. This year we have an experiment under way to determine the influence of sod on the time of height growth cessation in some of these clones on which we know the critical photoperiod. The clone that we have used (893) is of Oregon origin. At this latitude on cleanly cultivated areas No. 893 has gone into dormancy for the last 3 years about the middle of September. We planted a group of 30 ramets of this clone on a sod area. Prior to planting the area was rototilled but it was not touched after the planting, so the sod was able to reconstitute itself. Another group of ramets was planted in a cleanly cultivated nursery at Petersham and two others were planted, one at Weston and the other at the Arnold Arboretum. Now the only ones that I can talk about reliably are the ones that I have had under observation this summer in Petersham. All of the ramets of this clone which were grown in sod stopped their height

growth the latter part of July and have not increased in height since that time. The ones which have been cleanly cultivated in the nursery have continued their active growth and doubtless will continue until the middle of next month. The disparity in height of course is obvious. Those which are in the nursery are now almost as tall as I am, whereas the ones in the sod are about a foot in height.

This leads to another comment that I would like to insert here about hybrid vigor as it relates to day length. I think we have here a very complex business. We get an apparent heterotic effect in our Populus clonal lines of southern origin when grown at this latitude which compares very closely with the same sort of reaction that is observed in certain of our interracial or interspecific crosses. We have grown ramets of various clones under artificially elongated days and also short days. Under the long day we get delayed growth cessation and consequent great increases in height throughout the season. Analysis of our data taken on a weekly basis however does not indicate that the rate of growth in the long-day photoperiod is any greater for that material than growing it in a short day. In other words, the principal difference between the total growth for the season appears to be correlated directly with the increased length of the season rather than the increased length of the daily light period. I think this is a point of considerable importance, not only from the standpoint of tree breeding but also from a purely physiological standpoint.

Taber I would like to ask the chestnut experts why the Chinese and Japanese chestnuts have not been worked on the roots of the American chestnut to make use of the vigorous root systems of the established American chestnut.

Nienstaedt Usually you don't have too much effect between root and scion. You may possibly have a decrease of resistance if you do that. It's not likely, as I don't think it's likely you would increase the growth, except initially while the scion should draw on the longer established root system.

Taber We've had 50 years of chestnut blight, we still have sprouts, the sprouts die and resprout, but the roots stay alive and might support scions.

Nienstaedt That's probably because the root of the American chestnut has a tannin concentration which is at least twice as large as in the stem. Qualitative and quantitative differences in the tannins play an important role in the resistance to the chestnut blight. However, you have no effect up in the stem from the higher concentration of the tannin in the root.

Taber What you're saying is that the sap of the two species are not compatible. If we have resistance in the Chinese and Japanese varieties why can't we preserve that resistance to blight and use a parent root which is established and which would give more rapid growth to the scion? I'm simply asking why hasn't it been done? There must be some reason, this is not a new idea. Soper Orchards in Northumberland County, Pa., worked paragon stock on American roots as early as 1908.

Lambert A friend of mine, Luther Falkner, of Tyngsboro, Mass. has been grafting Chinese and Japanese chestnut on American and vice versa, and also oak, for the last two or three years and having some success. What we'll get out of it I don't know yet. We're watching it.

Nienstaedt I don't think it is a practical method it seems to me it would be a tough job to go around in the woods and graft on roots you have there. To get your growth that way would be costly and may not often be successful because your root stock will not be in ideal condition for grafting.

Pauley It seems to me there would be quite a few people willing to devote time and money to field grafting of chestnut if it were a feasible undertaking. We've done some field grafting of various other species. Ash and maple seem to work very nicely. We also did some work with chestnut but we didn't get any survival on that material. We were using buddings, however, put on during August. I should think that grafting on some of these old sprout stools out in the woods ought to be work.

Graves About this field grafting of the Chinese and Japanese on the American chestnut; the idea of course is to get the tall straight growth of the American chestnut, isn't it? As a matter of fact our hybrids far exceed in their growth rate the American chestnut and I don't see the practicability, as Dr. Nienstaedt said, of going into forests and grafting the Chinese and Japanese on the American chestnut.

Pauley I don't personally think that the root stock will have any effect on the improvement of this particular material. I assumed that you were going to graft some good material on it and it would afford a means only of getting material established in the woods. We have found no influence of stock on scion as far as the photoperiodic reaction is concerned. We get the same photoperiodic reaction from the scion whether it is on its own roots or whether it is on some other roots,

Nienstaedt If you think you can establish interest in a project like that I think we can supply you material for the grafting. If you personally want 50 or 100 scions, I'll be glad to furnish them next spring.

Taber What I'm thinking about is that you have a root system that covers an area of perhaps 50-1000 sq. ft., and you put one or two scions on that, certainly such a large root system would give strong growth.

Nienstaedt From that standpoint you are,certainly right. We have had the same experience. We graft on 2-year-old Chinese stock when we do cur grafting in field and the first year we get 6 feet of growth. However, as soon as crown and root is in balance again the growth slows down to normal.

Bramble I'd like to say something on field planting of chestnuts, we've done a little of that. The only demand right now for planting chestnut, and the only possibility I see in the near future, is for game food or estate planting. If you've had the experience of going out in a wooded area and planting chestnuts by the hundreds, and leaving them, you know when you come back a few years later there aren't any left. The snowshoe rabbits and other animals, particularly deer in Pennsylvania, destroy them. We must protect them from animals, which means we plant small quantities carefully protected. The reason I mention this is because we have estate plantings and I guarantee people will spend a lot of time on chestnuts, maybe because they love them, but also because it is practical for nut production.

I'd like to ask a question about inarching. Do you just use one basal shoot or use more than one for the first time?

Graves Two or three, just whatever is convenient.

Bramble I've been cutting my trees off and trying to get one of the sprouts up. I guess I ought to stop that and just inarch. That would save a lot of time because we have 10-12 foot trees in our plantation that we are losing with blight. However, our biggest problem with chestnut seedlings, the ones that are sent out commercially, is hardiness. We some times lose an entire year's planting because they die back from winter injury. In the spring they are dead and start suckering. It is very important to combine hardiness with blight resistance in anything that is being set out in the mountainous areas to replace chestnut.

Graves Is this a matter of site?

Bramble Yes, we have had some success with underplanting as well as planting on upper slopes. Whether that was site or a certain lot of hardy seedlings I can't say.

Recknagel Dr. Wright, your paper yesterday on racial variation and individual tree selection was extremely good. We have one very practical question to ask you. Jack pine, as you well know, is a desirable pulpwood in the Lake States. Our mill in Minnesota operates on up to 40 percent and more of Jack pine. But the Jack pine that grows in Minnesota and Wisconsin, I think, must be a racial variation, different from Jack pine as we have it in northern New York. Have you ever made any studies on that or anything similar that you can throw light on?

Wright Schantz-Hansen has published (Journal of Forestry, July 1952) on a well-replicated provenance test of Jack pine established at Cloquet, Minnesota in 1942. Minnesota, Michigan, Wisconsin, Alberta, Manitoba, Ontario, Saskatchewan, New Brunswick, and Maine provenances were included. Average 7-year height varied from less than 2 feet for the poorest to more than 8 feet for the best.

Bramble A number of Xmas tree growers have been stuck with Jack pine on rather large areas. On an acre you get only about 10 beautiful trees, which are blue in the winter and which don't turn yellow. In view of the wide range of Jack pine across the country there must be a strain that should be good.

Littlefield Dr. Pauley mentioned that one of his staff was working on red maple. I wonder why they happened to pick on red maple, which is quite an unimportant species in forestry.

Pauley We chose red maple not because of any great economic significance that it might have, but because we thought it would be a convenient and valuable material to work with experimentally. One of the reasons is that red maple is widely distributed in different habitats within its range. For instance, in the Petersham area of Massachusetts we find it up to the tops of the highest hills and in practically all habitats right down to floating bogs around ponds. We felt that it would be good material to study for local variability. Perhaps Bill Gabriel who is actually working with the red maple would like to add something.

Gabriel As an example of possible genetic variation in red maple, out of 18 seed collections made from scattered points in the northern half of the range of this species, a Cape Cod origin is the only one which demonstrates a double embryo condition. This collection came from an area of extremely dry, sandy soil which has been subjected to periodic fires. It is most interesting that all red maple trees in this area are of stump-sprout origin. There were no seedlings to be found anywhere. Considering the unusual

environmental conditions, the genetic implications which the double embryo seeds present are most interesting. The wide range of this species and the numerous environments associated with it holds promise of turning up important genetic variations.

Concerning the economic importance of red maple, I believe that a large part of the red maple today is of stump sprout origin and most of it is infected with heart rot. For this reason it is discriminated against by most foresters who weed it out of stands at every opportunity. It is possible that red maple ha been forced into its present status of a weed tree through continuous suppression and mistreatment. There certainly hasn't been any selection. of superior phenotypes practiced in this species for purposes of improving quality. If foresters could produce good quality red maple there is no doubt in my mind that it would find a prominent place in the wood-using industries.

Lambert In Massachusetts and probably New England red maple is the most common tree. We used to mention it as a weed tree but it is now used as pulpwood. I don't know why other uses should not be found for it.

Sehreirer The weed tree of yesterday is not necessarily the weed tree of today, I haven't any grey beard yet, but I remember when fir was considered a weed tree, and by golly, we cut the pulpwood scale if the percentage of fir was too high in purchased wood. But it wasn't many years before fir was acceptable. The weed tree of today can be the good tree of tomorrow if we really go to work on it. In regard to maple, when birch became scarce, a wood turner in Maine tried red and silver. As I recall he found the silver maple was better for dowels, but the red could be used.

Pauley I'd just like to mention in this connection the case of aspen in frequently maligned genus Populus. I think that there are a great many possibilities for aspen, and I think the forest supervisors in the Lake States would agree. I've talked to several of them and they have told me that one of the main reasons they came out of the red in the Lake States was that the post-logging aspen crop started to mature about 15 or 20 years ago.

Diller I want to comment on Dr. Bramble's remark about the winter hardiness of chestnuts. We have plantings of Chinese chestnut PI 58602 that were established spring of 1926 at Petersham and Holliston, Massachusetts, Derby and Killingly, Connecticut, 2 in New York, 3 in Pennsylvania, 1 each in Virginia, West Virginia, South Carolina, North Carolina, and Delaware, and 2 in Georgia. Those in New York withstood 25° and 40° F. below zero during the winter of 1933-34. Hank Baldwin has a 6-year-old planting of PI 58602 at Hillsboro, New Hampshire--the best tree measuring 13 feet tall this summer, and Bob Monahan has a 2-year-old planting of this same strain on Dartmouth College Forest that seems to be doing just fine. I know that on the site at Petersham these Chinese chestnuts show up as poor phenotypes, but the genetic characteristics to produce a forest-type tree are there if you plant them on the right sites. Likewise, at State College, Bill, if you get this good strain, and plant it on the right sites you'll have a Chinese chestnut that will prove winter hardy, and will develop forest-tree form. When our Division furnished State College the untried chestnut planting stock from the oriental seed we imported a few years earlier, we gave you a large collection of miscellaneous stock. No wonder they have made such a poor showing for you.

Gabriel I would like to ask a question of Dr. Graves. When you graft a shoot across a diseased part, when the grafted shoot develops the disease, can you keep grafting shoot on shoot?

Graves Yes, we do that right along; we do it several times, inarching on the inarched arch. We keep the inarch going rather than start a new inarch of a smaller diameter.