growth with a number of our species is leaf hopper. When kept under control, growth will double or triple with some maples, sophora, wisteria, koelreuteria, some oaks and certain other species.

Aside from sanitation and cultural practices to hold down weed populations, there are two basic approaches to controlling weed competition. One is soil fumigation; the other is herbicides. We have used fumigation and have nothing against this procedure. However, the complex of herbicides now available seem to make this route more feasible for us. Herbicides are treacherous, of course, and one error can be disastrous. But by working closely with our college people, herbicides have reduced hand weeding to a minimum with minimal hazard to the crop.

Lastly, control of seed-bed population is essential to producing the size plant desired. We used to shoot for a stand at digging time of around 25 or 30 plants per square foot. Now the typical stand is down around 10 p.s.f. With particularly high-value crops such as Carpathian English walnut the stand will be two or three plants p.s.f. Stand population is controlled almost entirely by seeding rate, as thinning is usually impracticable.

ROOTING OF DORMANT CONIFER CUTTINGS

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The information presented herewith is based upon my experience as a propagator at wholesale nurseries in the Northeastern U.S. The methods described are generally acceptable by most successful growing operations east of the Mississippi River. Specific references to Rhode Island Nurseries, Middletown, Rhode Island result from my recent eleven years in their employment as Production Horticulturist.

One of the keys to successful propagation is to do things at the proper time. This is true whether it involves taking cuttings, transplanting into beds, or any of the other myriad operations associated with nursery production. At Rhode Island Nurseries, between 600,000 and 750,000 units are propagated each year with a labor force of seven full-time employees in the propagation department. All cuttings are taken from plants growing in fields of the parent operation.

Propagation Methods. This discussion will concentrate on propagation of conifer cuttings taken during their dormant period. Webster's Dictionary defines dormant as; "inactive; as in a resting or torpid state."

The following plants are propagated as dormant cuttings during the winter season:

Chamaecyparis obtusa cultivars
C. pisifera cultivars
Juniperus chinensis 'Pfitzerana'
J.c. 'Hetzi'
J. communis 'Hibernica' (Syn.: *J. communis* 'Stricta')
J. squamata 'Meyeri'
J. horizontalis 'Plumosa'
Thuja occidentalis cultivars
Taxus × *media* cultivars
T. cuspidata 'Densiformis'
T. baccata 'Repandens'

The objective in producing coniferous evergreens is to take a small cutting from clean stock plants, put roots on them and four to six years later have a quality plant that may be offered to the trade for a profit.

The medium used for rooting cuttings is sharp washed sand. This medium is put in greenhouse benches which are constructed of concrete, are closed on the sides and have bottom heat available. Temperature at the base zone of the cuttings is maintained at 66 to 68°F. Several different root promoting hormones are used, depending on the plant species and the degree of "rootability." Hormones include Hormex powders number 3, 8, 30 and 45, as well as "Jiffy-Grow" in liquid form.

Cutting material is gathered from field plants in November in the Northeast. Temperatures at this time of the year dip into the low 30's in the evening and days are bright and sunny with the highs around 50 to 55°F. A killing frost can be expected as early as November 20th.

Cuttings are stored in a large cooler maintained at 38 to 45°F. Sufficient material is taken on schedule so that cuttings will be available during inclement weather. All conifer cuttings are treated in much the same manner prior to sticking. Bottom needles are either stripped from the base of the cuttings or cut away using scissors or a knife. The basal end is given a fresh, sharp cut, moistened slightly and dipped into the dry hormone. Excess powder is tapped off the cuttings and they are ready for sticking. In the case of the liquid "Jiffy-Grow," cuttings are dipped into the 4 to 1 solution for 10 seconds, allowed to dry and then are stuck in sand. About 10,000 to 12,000 cuttings can be prepared and stuck in a day by having four men in the headhouse making cuttings and two men up on the benches sticking. These cuttings will remain in the greenhouses all winter with occasional fungicidal sprays and periodic heavy drenching with water.

Dormant conifer cuttings respond best if the sand is permitted to dry slightly between watering. A heavy watering is given *once a week under normal conditions during the early rooting* schedule. Water is applied from a hand held hose until excess water drips from the bottom of the benches. Watering is done early in the morning and all foliage is dry before late afternoon. Wet foliage in a closed, heated house is an invitation to fungus and diseases during the dark, cool winter days. No top ventilation is given to the cutting houses until late February or early March when roots are established. Ventilation is then provided to retard top growth, harden the cuttings and to control development.

By early April, the houses are ventilated daily and watering must be done on a regular basis. Cuttings are allowed to develop in the benches throughout April and May while ground beds are being emptied to receive these new liners. No fertilization takes place while the cuttings are in the greenhouse benches.

Preparation for Planting. In early June, when danger of frost has passed, the cuttings are prepared for the transplant beds. All conifer cuttings are handled in a similar fashion. Plants are pulled from the sand in bunches of 10 to 20, sand is shaken from the roots, cuttings are graded, roots are trimmed *and the new growth is pruned. Cuttings are then plunged into a* solution of 1 to 40 Rapidgro (soluble fertilizer), drained, and then packed into planting boxes. These plants may be planted either by machine or by hand. Since the forced new growth is very sensitive to full sunlight, lath shade is applied over the plantings as soon as practical. Fifty percent shade is maintained over all *Taxus* cultivars for the first two summer seasons.

New Developments and Methods. Recent experimentation with plastic "Styro-Blocks," "Speedling" trays and container-rooting of dormant conifer cuttings has shown many advantages over the conventional closed bench, bottom heat method. Another factor contributing to the development of new methods is the escalating cost of energy. Most growers in the Northeast are returning to cold frame production of conifers and are scheduling around-the-year sticking. Although the rooting cycle may be lengthened to 14 or 16 months, the unit cost of production may be appreciably lower.

SUMMARY

Any system of rooting may be acceptable to any given propagation facility. Factors such as cost, labor force, available capital, turn-over time, and market demands must be carefully analyzed. There is no perfect method for every grower. Experi-

mentation is part of the challenge in propagation and only the basic techniques remain static.

DON DILLON: We have time now for a question and answer period for the papers that have just been given.

VOICE: Charlie, could you go over your juniper propagation again?

CHARLES PARKERSON: We try to do it the easiest possible way. We copy Greenleaf Nursery's system. Look for the article that Austin Kenyon wrote back in 1974, in the IPPS Proceedings (Vol. 24, p. 64). We copy him in total, except the size of our cutting is 5 inches; we use a little brown wood at the base. He said use electrical tape on your fingers — we might use masking tape on our gloves to rip off the lower leaves. We don't prune off the leaves; we just rip them off, and do use IBA quick-dip solution on the cuttings. Because of the bundles that we are dealing with — bundles of 25 cuttings — we can't get a rooting powder to get good coverage, so we do liquid dips. We stick them in, and then hand water them. We don't put any shade on the house — this is in January. When we get to about the last week in February we start getting some higher temperatures; if the temperature is above 32°F at 8 o'clock in the morning, we will air one end of the greenhouse; if above 40°F by 10 o'clock we will air the other end of the greenhouse. We don't have any of these expensive fans and louvers to get all broken down — we just open the doors. Then the last week in February we put about 65% shade cloth over the top of the house because heat seems to be our biggest problem. Then we are on mist — and we watch it closely right on through; when we get around the first full moon in April, we take the plastic cover off and leave just the Saran cloth on. Some of these cuttings are slow to root. I wish I could figure out how to do like my friend from England does in rooting Leyland cypress, but we can't root this worth a darn. We have a lot of problems but we are learning a lot all the time. Basically we use Greenleaf Nursery's methods.

IAN TOLLEY: What temperatures can you maintain in your houses with your heaters, bearing in mind the outside temperature. How much wind do you get on that structure? I am thinking of the 60 mph winds we had that flattened one that was almost identical.

CHARLES PARKERSON: The wind — 112 mph wind will take one down, because we have experienced that. But the heaters; we used to heat everything. Above all, heat them, we thought. We tried to put lights in there too. It just didn't work for us. Look, we were thinking just like Dr. Furuta, down the line. We said we must learn how to operate with the minimum amount of heat. This year the heaters went on only twice. We

had set the thermostats to come on at 35-36°F. We rotated around, my secretary and everybody else — we take a night. Tonight is your frost watch night. We don't trust those thermostats, because it is so critical so each of us spends a night down there. We are only talking about keeping above freezing and, basically, the critical time comes from about 4 o'clock in the morning until 8:30. It is that little period that we are concerned with. A very minimal amount of heat is needed if at all. If necessary, we do use some water. We believe in water for frost protection.

LES CLAY: What kind of media are you using?

CHARLES PARKERSON: We are very fortunate in our area. We have aged pine bark from a mill, already aged. There was a talk (IPPS Proceedings, Vol. 28, p. 370) given last year at the Southern meeting on the use of pine bark as a growing medium that you should look up. The trouble with fresh pine bark in our areas is of ever getting it wet. Once it dries out you are in real trouble. We do anything that we can to make sure we get 25% air space in the medium. We don't like a whole lot more than that because we are wasting water, but we don't want any less than that. That is the range that we want. There was a talk given in Chicago several years ago; I can't remember the chap's name but he was from Wooster, Ohio. He gave a test for determining air-filled porosity, and there are several easy techniques to determine that.

VOICE: On your burlap for winter protection, is this suspended above the plants or laid directly on the plant?

CHARLES PARKERSON: When we were experiencing a real freeze, I went home and we listened to our public broadcasting channel. It was about zero degrees outside, and I was all torn up inside; every plant that I owned was dead or dying and the banker was calling, etc. Do you know what was on that TV program? How to make an igloo. Maybe I can learn something from the Eskimo. So we put this burlap over the top of the plants and down the sides using junipers which have no frost problems in our area. The plants are all winterized by jamming them as close together as we can, and then this water is added. The water is frozen; we try to put somewhere around ⅛ of an inch of ice on top of this burlap at night before we go home. It can be accomplished very quickly. When we come back in the morning the ice is all gone. That ice layer is totally gone. It has been sublimated right out into the atmosphere. So the cold isn't taking moisture from our leaf surfaces, it is taking it from the burlap. So it seems to be working. I am not sure of all of the physics that goes with it, but it is a system that has worked very well for us in the last couple of years. Yes, we lay the bur-

lap right on the plants.

ARDA BERRYHILL: Three questions. One, does the burlap stay on day after day, or do you take it off every day. Another one, how many unrooted juniper cuttings do you place in your 3 gallon pot, and the third one, is there bottom heat under those 3 gallon juniper pots?

CHARLES PARKERSON: The burlap goes on just before Christmas, and it stays on until the first part of March. We process a fair number of roses; we handle them in the latter part of February so, as needed, we take the burlap off of some plants. They stay on one gallon plants the longest. They would be the very last thing they would come off of.

In regard to spacing of the juniper cuttings, read Mr. Austin Kenyon's article again; he gives bed spacing on his junipers. I have a template made up that is the same size as the pot with a bunch of nails in it. So we say we are going to use the blue board today. So they use the blue board to make indentations giving the spacing we need. Let's say that the space for Bar Harbour juniper is one thing, San Jose juniper, of course, would have to have a wider spacing. We color code everything. We use the yellow one, we use the green one, we use the blue one, the black one, or whatever; then people can't make a mistake.

For your third question — no, there is no bottom heat in these houses.

ALBERT NEWCOMB: Tom Wood, what pre-treatments do you give your seedbeds before seeding?

TOM WOOD: What I should have explained is that we grow this crop on a three year rotation, which means that we produce a one year seedling, then we produce an undercut 2 year plant, which may be transplanted or may be thinned out. At the end of two years we clear the crop; it is in that third year — which is actually more important than growing the crop — that we do our soil preparation. To start with, if necessary, we use Round-up herbicide on any pernicious weeds. Then we do a dry fallow, which is cultivation followed by a heavy dressing of farmyard manure; we put on at least 60 tons to the acre. This is plowed in and we then sterilize with Basamid. We use a sterilant which kills mealworms, but more important it kills weed seeds. Having done all this in the autumn and sealing the ground over by rolling it, we leave the seedbeds stale, and by that I mean we just run over the ground with a tractor and mark out the spaces where the beds are to be. Then in the spring, as the seed comes out of stratification — and that is why there is an odd collection of plants — as the seed is ready we sort of rake down the beds, and work in a little bit of superphosphate

and sow direct. So there is a certain amount of hand preparation following that basic year of preparation.

VOICE: I am curious about your direct seedling method. The seeds must be stratified, yet you plant them in an active state of development. Do you have a set schedule for planting?

TOM WOOD: The short answer is no — we do not have a set schedule. What we have done is this: we have endeavored to split our seed bed area into two or more lots so that as the seeds come on they can go into a respective area. We can control seeds that are dry stored before they go into an imbibing situation. So if we have seeds that are virtually dormant, we can then, by knowing the number of weeks of imbibing or pretreatment that they need to bring them to germination, determine what our sowing date will be. We do this with some species, particularly where frost hardiness is a problem.

But, in the main, we are still in the stage where we go through the normal stratification, say of a species like *Prunus avium*, the sweet cherry; we have summer stratified it, then we have been giving it a cool period in the winter, until the pits start to crack and break. We may have to sow in February and this is why we have to put frost protection on top. At the moment the seed becomes active we can't hold it back. One of the advantages of having it active is that you reduce the field factor. If the seeds are nearly at the stage of germination and we sow them, often appearance of the seed above the surface of the soil takes only 5 to 7 days. As that period is a very short one, it means that predators or rodents and things that would eat it while it is at its most vulnerable stage have only those 7 days. If we sow it when the seed is dormant and it takes 2 months to germinate then they have a long time to find it and have a go at it. The advantage of getting the seed to a germinable stage is paramount when field factors are concerned and this is most important when you are considering the density of the seedlings. It is not just the seedlings that you lose if the birds eat them or if the mice eat them, it is the fact that the seedling density changes. Instead of getting a nice straight stem for somebody to stick a chip bud onto or to use in some way to line out, if the density is reduced you finish up with a plant that is feathered all the way up. Nobody wants that, so the low density is not just the loss of plants, it is the quality that is impaired by the low density as well.

RALPH SHUGERT: What, if any, herbicides are you using on your seed beds after the seedlings are up? Secondly, you didn't show a slide or I didn't catch it of *Tilia cordata*. If you are in *Tilia cordata* production, what is your formula?

TOM WOOD: Answering your last question: We have grown *Tilia cordata* but we still experience difficulty. We can break dormancy of *Tilia*, but invariably we do it by natural means; in other words, we give it warm treatment to break the seed coat down in the summer, then we give it cold treatment for embryo development in the winter. We find that the seed germinates in March, which is still in our frosts. Probably the way to do it would be under glass; it is an important species so we have tried it but we are not really successful with *Tilia* at the moment. So I really haven't a lot of experience on that. We can do *Tilia platyphyllos* quite well.

About the other question on herbicides: there are very few herbicides we can put over the bed after sowing. We do pre-emergent use of paraquat and if there are coarse seeds such as *Quercus* and *Aesculus* and *Castanea*, which we also grow, we make up a cocktail of paraquat and simazine, which we can apply because the seeds are at a sufficient depth that we can put simazine over the top; otherwise it is hand weeding.

RALPH SHUGERT: Tom, one other question, how do you handle *Taxus cuspidata* seed?

TOM WOOD: We don't grow *Taxus cuspidata*, but we do grow *Taxus baccata*; I don't know whether it is similar, but we have had no experience with *Taxus cuspidata*.

PHILIP McMILLAN-BROWSE: I was going to ask whether Phil Barker had considered the age factor in relation to sex reversal in plants because, as you have already heard, I am interested in the sexual interests of plants since I am interested in seed production. Certainly in Europe we have found that in Asiatic maples, for example, that the young plants tend to produce male flowers and the proportion of female to male flowers increases with age so that, very often, old plants tend to be predominantly female.

The comment I was going to make, Mr. Chairman, was simply to give you an example of "to seek and to share" in the Charlie Parkerson tradition. About two years ago Phil Baker gave a paper in your Region on the propagation of *Acer grandidentatum*. It is a plant that I never heard of so I wrote to him for some seed. He sent me two samples of seed and I would like to report to you now that I have got a nice little family of 200 seedlings of *Acer grandidentatum* in the U.K., which is probably the first time it has been introduced there from the wild since it came in way back in 1880.

PHIL BARKER: That is, indeed, good news to hear. I hope that your plants continue to survive and provide many people with lots of pleasure.

HUGH STEAVENSON: Phil, on some of the so-called seedless plants that do produce seed as you described, if you take the seed and plant them and produce seedlings — what will happen to those seedlings? Will they be normal as far as seed production is concerned or will they revert to the parent characteristics of being seedless?

PHIL BARKER: I will answer Hugh's question first because that is the easiest one for me, and then I will go back to Philip's. I have had no experience with germinating seeds produced from what are typically male plants. It would be my belief, however, that those seeds would probably germinate and develop into a satisfactory seedling if they have the hormone composition that seeds of that species generally have. This is a question that might be observed by somebody else, too.

Now back to the earlier question — had I considered the age factor and the sex reversal in plants? Yes, indeed. I am well aware that, in many species, the young plants have a predominance of male flowers and, with increasing age, these plants have proportionately more female flowers. The examples given in my Table 1 are age-referenced with that in mind. The maples (*Acer grandidentatum*) that we studied in Utah were in a mature phase of growth.

VOICE: Hugh, how do you get sugar maple seedlings up to a desirable size in one year?

HUGH STEAVENSON: Seed source is extremely important. For example, in our area (Missouri) we have gotten seed from the northern states — say Michigan. From these we just get small plants in one year. Sugar maple is also native in our area and if we can get local seed we will get 2 to 3 times the growth that we will from the northern seed. That is one factor, and then the various practices that I have suggested; obviously you want to secure germination as early as you can in the spring. The seedlings will take a certain amount of frost. You want the longest possible growing period, you want the right cycle so the plants are growing at their natural cycle, which means early spring germination and with these various factors of growth stimulant through good soil drainage, plenty of nutrition, and plenty of water. In the case of the maples, one deterent of growth in Missouri is the leaf hopper. We have got to control leaf hopper. We will get 2 to 3 times the growth of the maples — sugar maple, Norway maple, and certain other species, when we control leaf hoppers.

DON DILLON: How do you control leaf hopper?

HUGH STEAVENSON: Various systemics. Orthene and various other systemics. Here in California I understand you don't

have leaf hopper.

VOICE: What sort of bark do you use in your seed beds? Is it fresh bark?

HUGH STEAVENSON: It is generally fresh because we pick it up about as fast as we can. Yes, it is fresh. Really no problem. It is all hardwood. It will be a mixture of oaks, soft maple, sycamore, most anything. It doesn't make any difference.

VOICE: Do you broadcast sow all of your seed beds, or do you drill the seeds?

HUGH STEAVENSON: Because of the problem of changing seeders with a variety of species, we mostly hand seed. We have been looking at a lot of drills, I am sure we are going to come to some drill usage but there is such a tremendous variation in seed size. There are very tiny seeds; then up to acorns and walntus and so forth. No one seeder is going to handle all those different seed sizes. We do weigh out the seed, to cover what might be a 400 foot seed bed. We have girls that can do a reasonable job of spreading the seed broadcast. Then, some of the heavier seed, like acorn, Kentucky coffee tree, and so on — we do use drills to get them down in the ground a little bit. With conifer seeds there is no problem. Weyerhaeuser and the forestry people use drills for conifer seeds, but with broad-leaved deciduous seed there is such great variation in seed character and seed size that it is a real problem to use a mechanical drill.

PHIL BARKER: Gibberellic acid has been shown to enhance growth of *Acer grandidentatum* seedlings. Have you tried this with sugar maple seedlings?

HUGH STEAVENSON: No, Phil, maybe we are missing a bet. Thanks for your suggestion.

VOICE: It appears that you have a fairly good stand of *Tilia* seedlings. How do you overcome inhibiting factors in germination of *Tilia cordata* seed?

HUGH STEAVENSON: *Tilia* is a rough one, particularly *T. cordata*, as Tom Wood has suggested. Really every now and then we can get a darn good stand, but it is tough to come through with an economic stand of *Tilia cordata*. As you suggested, *Tilia platyphyllos* is somewhat easier and *Tilia tomentosa* may be still somewhat easier. *Tilia americana* is even worse, though. Basically, we like to get the seed when we can in the winter time; of course, it has got to have the seed coat softened — unless you are using artificial scarification of some sort. We sow the seed in June to get seed coat break-down in summer, and then we get the after-ripening of the embryo the following winter. One thing about *Tilia*, the seeds seem ready

to germinate at the first break of spring, always before the last killing frost, and it takes a lot of protection to get them through that frost period. There is a fungicidal treatment of *Tilia* seeds that gives much better stands. We are looking into it. But *Tilia cordata* is a real toughie.

ED JELENFY: Larry Carville, how about root pruning in the field. Do you do this?

LARRY CARVILLE: Essentially what is done is that we plant a rooted cutting in a nursery bed for two years. After two years the two-year liner is lifted, graded, trimmed and sized and planted in the field by another planting machine. Let us stay with just *Taxus* for a while. The four-year-old *Taxus* plant is then lifted from the field again, graded, trimmed, and then again transplanted. This transplanting of the four-year-old is done manually. We make furrows in the field, we mark the field, we plant with a nursery spade. When that same *Taxus* is 5 to 6 years old we have two options: it can be sold as a 5 year liner, 10 to 12 in., or 12 to 15 in., or it is then lifted and transplanted one more time. Each time we transplant and trim the roots, we are trimming the top, grading the plant. At Rhode Island Nursery, when *Taxus* is sold they are sold pretty much by size, and when a field is dug and, I am talking about 100,000 *Taxus* to a certain block, you generally size out all 18-24's, 24-30's. Because of the constant handling and grading, quality in the field is insured. The other process is obviously to do continuous shearing and trimming of the plant. It is expensive, it's high labor, but if you have a quality product, there is a quality market that wants your item.

VOICE: Two questions with regard to your transplanter. First, can you adjust the spacing between plants with the transplanter? Secondly, is it compatible with the "plug" production?

LARRY CARVILLE: Concerning the spacing on that particular planter, which is one from Europe and which was referred to earlier by Tom Wood, we have tremendous flexibility in determining the distance between the plants in the row. We can do very little about the distance between rows; that is set at 6. It is a 50 inch bed. But we could space within the row anywhere from 2¼ inches up to 10 inches. You do this with the gear changes; there are 12 different gear changes. You can set up any type of planting spaces. The point that you bring up is obvious — we were lessening our density of planting when we went to the machine planter. We made up for it in terms of the production schedule that we could take, the number of plants that could be planted. Fortunately, there was sufficient land available so that we could expand.

The second point that you brought up — could this particular planter take plugs? Yes, we can plant the plugs that come out of the Styroblocks. We had a very nice 5-inch column of cuttings on a peatlite mix; they went through the planter very well. It could not be used for planting grafted plants because we had that heavy root ball on it; they would just fall over as the heavy wheel went around. We had another planter that we used for grafted material which would insure that the understocks went well into the soil.

HUGH STEAVENSON: Larry, you were referring to Rhode Island Nursery. It is just a beautiful example of the old and tried ways. If you are traveling East and want to see an example of really the standard in *Taxus* and other production, you want to stop and see Rhode Island Nursery. East of the Rockies, to grow *Taxus* we refer to Rhode Island Nursery for the standard of excellence in that type of production. One of the things that they do is to plow manure under as heavy an application as they can plow under. Then they get a lush green finish on their *Taxus* when some of their neighbors, who don't use manure on their *Taxus*, are producing plants somewhat on the yellow side. It is something to see, and if you are out there, have Larry show you what Rhode Island Nursery is doing.

IRRIGATION REQUIREMENTS OF TRANSPLANTED CONTAINER-GROWN PLANTS

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Container-grown plants often fail to establish in the landscape because of desiccation. Transplanted container plants can suffer from lack of water since they usually have a large top (leaf surface) compared to the volume of the rootball in the container. In the nursery, they are irrigated frequently to keep up with evaporative demand. When transplanted, the rootball provides almost all the water for transpiration until roots have grown into the surrounding soil. Because of the limited amount of available water in the rootball, the plant requires frequent irrigation until it is established and can exploit the surrounding soil for water. Infrequent irrigation after transplanting can therefore result in moisture stress.

Moisture Relations in Transplanted Rootballs. After planting, water supply to the top is limited not only by a relatively