Reports on Christmas Tree Production Problems

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THE GROWTH AND DEVELOPMENT OF CHRISTMAS TREES

AS RELATED TO WEATHER AND NUTRITION

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Forest physiology is a relatively modern science which has attracted only a few workers--there is no question but that the effort expended in one day on the space sciences exceeds the total thus far in this field. Furthermore, the great majority of the physiological work thus far undertaken with the coniferous species of this area has been concerned with seedlings no more than two years old or with second growth timber. Therefore, this talk will be limited to examining the growth of Christmas trees from a more basic point of view than that perhaps commonly employed by growers.

The growth of the underground portion of trees is affected by a markedly different environment from that which controls the growth response of the aerial parts and, therefore, it may be best to examine separately the relationship of root growth and top growth to their respective environments.

The extending portion of a coniferous root is about the size of a pencil lead. The root cap is formed of a hard substance which enables the plant to force it through the soil. The sides of the extending portion of the root are covered with a slippery material to reduce the friction between the moving root and the soil particles. There are great differences between coniferous species in their ability to force their roots through obstacles. For instance, ponderosa pine is able to force its roots through soil layers which are too compacted for Douglas-fir roots to penetrate. Ponderosa pine is a relatively deep-rooted species, while Douglas-fir roots are largely confined to the surface foot or two of soil. Western hemlock is even more shallow-rooted than Douglas-fir, while the true firs are similar in their rooting habits to Douglas-fir.

Immediately behind the root tip is a short zone where vascular tissues are differentiated and where some further elongation occurs. Still further back from the root tip is a zone of root-hair formation. These root hairs are really extensions of the epidermal cells of the root. They are very important organs for the absorption of nutrients and moisture, and they also help to anchor the plant in the soil. These hairs may be as long as a quarter of an inch, but they are extremely small in cross section. Because of their delicate structure, they are very short lived and are continually being replaced as the root grows through the soil.

The absorption of nutrient salts by plant roots is a phenomenon which has been widely studied for a number of years but is still only poorly understood. It is clear that expenditure of energy is necessary to produce the much greater concentration of minerals which occurs inside the roots, as compared with that in the soil solution.

There is, however, wide disagreement among the scientists specializing in the problem of the mechanism of salt accumulation. We do know that, except for brief periods after heavy rains when the soil is saturated with moisture, salts and moisture do not move through the soil. Thus it is essential that plants continually extend their roots to supply their tops with required nutrients and moisture.

The growth of roots appears to be affected by three factors: soil moisture, soil temperature, and soil compaction. Extremes of soil moisture limit root growth by restricting aeration in very wet soils and by killing sensitive growing tips in very dry soils. Soil temperatures between 65° F. and 75° F. are most favorable for root growth, but actively growing roots are frequently found when soil temperatures are below 50° F. In fact, British workers found that the root growth of Douglas-fir was reduced only 50% by soil temperatures as low as 36° F. when the air temperature was above 60° F. Soil compaction and subsequent low aeration frequently limits the growth of coniferous roots. It has been noted that seedlings planted in fields previously used as pastures have demonstrated greatly reduced top and root growth in areas used as paths by stock.

Although some root growth occurs on coniferous seedlings all during the year, the bulk of root regeneration and extension occurs during the spring months. A second much smaller peak of root activity may occur in the fall after rains have thoroughly moistened the soil.

Most coniferous species have various fungal organisms associated with their roots in a symbiotic or mutually advantageous relationship. These structures, part root, part fungus, are known as mycorrhiza. Mycorrhizal roots have the appearance of being infected with fungus; but in this case the fungus apparently increases the ability of the root to absorb moisture and nutrients from the soil. In exchange the root provides the fungus partner with carbohydrates and other nutrients. Generally speaking, all seedlings obtained from nurseries in western Oregon and Washington are well supplied with mycorrhiza. However, seedlings raised from seed on land which has been agricultural for a number of years may be deficient in mycorrhizal-forming fungus. When this condition occurs, it may be readily corrected by mixing small quantities of forest soil with the soil of areas to be planted. Seedlings lacking mycorrhiza generally make poorer growth than plants which have these structures.

Root tips and absorbing areas of the root system so far discussed comprise a very small portion of the total root complex of a seedling. Approximately 90 to 95% of a root system is composed of roots generally thought to function as anchoring and food storage organs. These older roots are covered with a hard protective layer and are composed of a core of water and nutrient conducting tissue surrounded by a relatively thin layer of tissue for conducting foods produced in the aerial portion of the seedling. Interspersed throughout these tissues are numerous parenchyma cells which store carbohydrates and other foods so produced. Much of this food storage occurs during the winter months, when there is no visible growth of aerial portions of the plant, but when the seedlings are, nevertheless, able to conduct appreciable photosynthesis.

Aerial portions of trees are subjected to much greater fluctuations in temperature than are roots; and, in addition they are exposed to alternating periods of light and darkness, while the roots, of course, are in continual darkness. As a result, growth patterns of above-ground parts of trees are modified by the environment to a much greater degree than growth of the roots.

There are two major growth zones in a tree crown: the terminal meristems, which are located at the tip of the tree and the tip of all the branches and which produce the yearly height increment; and the lateral meristems located a very small distance inside the bark of the trunk and branches and which produce the yearly diameter increment.

In many of our coniferous species the yearly height increment is a result of the expansion of tissues laid down the previous year in the terminal bud. Consequently, the amount and duration of the height growth of a tree in any given year reflects the growing conditions of the previous year more closely than it does the growth conditions of the current year. In contrast, diameter growth is controlled by the weather of the current year.

Temperature, daylength (or photoperiod), and soil moisture are the three components of a tree's environment which have the greatest influence upon the growth of the tree crown. In western Oregon and Washington temperature is most important in determining when the trees will break their buds and begin their annual growth. But once growth has started, our normal spring and summer temperatures apparently have little effect on the duration of the growth period. The effect of photoperiod on the growth of our native coniferous species is poorly understood in most cases. Undoubtedly, however, photoperiodic regulation of growth is much more important to trees growing several thousand feet up in the mountains than it is for trees growing at or near sea level. This is because mountain temperature and moisture are frequently favorable for growth well into the fall. But, if trees continue their growth in the fall, sudden killing frosts will frequently damage them. Therefore, growth of these plants is controlled to a large degree by the length of the day, which is constant for any given month from year to year, and the trees are hardened off during the period of decreasing day length in late summer. At the lower elevations where soil moisture is very often exhausted by late summer, it is this moisture stress that is most important in terminating the yearly growth period.

Nutrition of animals and humans involves feeding many organic compounds together with several essential minerals, but the nutrition of plants, which produce all needed organic substances themselves, involves only the feeding of essential minerals. For many years it was felt that trees could grow very well with just a little soil to hold their roots and sufficient moisture to prevent them from drying out. However, recent studies have shown that, while trees do not have as high a nutrient requirement as many agricultural crops, they do require appreciable quantities of several minerals. Only the elements mentioned below are required in such amounts that they are ever likely to limit Christmas tree growth on most soils in the Pacific Northwest.

<u>Nitrogen</u> is perhaps the most important element which plants absorb from the soil, and certainly the element most likely to limit Christmas tree growth.

This element is an essential component of all protoplasm and is also found in chlorophyll, the pigment the plant employs to convert solar energy to chemical energy. Deficiencies of nitrogen are manifested by greatly decreased growth and definitely chlorotic or yellowish foliage. Very probably, many areas now in Christmas tree production have soils with a nitrogen supply currently adequate for tree growth. Repeated harvests of trees, however, will greatly reduce the amount of readily available nitrogen in the soil and result in successively poorer crops if fertilizer is not applied.

Most commercial nitrogenous fertilizers have been developed for agricultural use and are not too applicable to forest plants because heavy rains leach them from agricultural soils and thus necessitate relatively frequent applications. Recently, however, the Grace Chemical Company has developed a series of metal ammonium phosphate fertilizers which are characterized by a very slow release of nitrogen. These materials have been shown to be very effective fertilizers for forest trees although they have the disadvantage of a low nitrogen (8%) content. Archer-Daniels-Midland Company has developed a coated nitrogenous fertilizer with a slow release rate which may prove to be of great value in the fertilization of forest plants. Still another fertilizer which has shown some promise in some areas is a urea-formaldehyde formulation distributed by the Mora Chemical Company in Seattle.

It should be noted that the application of nitrogenous fertilizers will probably result in considerably increased growth for two or three years. If the growth rate is adequate for Christmas tree production but the foliage color poor, this can be remedied the year of the projected harvest by the application of 8 to 10 ounces of a nitrogen fertilizer per tree in June. (It should be recognized that this is a very general recommendation, and that individual sites will undoubtedly require different quantities of fertilizer and different dates of application for optimum results.)

Phosphorus is the second major element necessary for good tree growth. This mineral is found largely in the energy-containing compounds of the plant and is essential in all growth activities. Phosphate deficiencies are expressed primarily as greatly reduced growth, although the older foliage may become reddish or purplish. While forest soils in the northwest generally have adequate phosphate to support good tree growth, it has been necessary to add phosphate fertilizers to forest nurseries where continual cropping has reduced the phosphate level. Therefore, it is probable that areas repeatedly cropped for Christmas trees will require phosphate fertilization.

Potassium is essential to plant growth, but there are no experimental data which define its function or functions. Currently it is believed to be a component of enzyme systems. Potassium deficiencies are manifested by leaf scorch, poorly developed roots, and generally sparse foliage. There have been no reports to date of potassium deficiencies limiting forest tree growth in western Oregon and Washington.

Calcium is essential to the growth of the meristematic tissues of the plant and in the formation of cell walls. Deficiencies of calcium result in very short internodes, and, in the case of extreme deficiencies, possible dying of branch tips and roots. Again, there are no known cases of calcium deficiency in the forests of the northwest.

Magnesium is essential to the synthesis of chlorophyll and deficiencies of this element result in golden tipped, unhealthy foliage. Fortunately, again no known deficiencies of this element occur in the soils of the Pacific Northwest. However, the low productivity of the serpentine soils of southern Oregon and northern California is largely due to an over supply of available magnesium.

Sulfur, the last "major" nutrient element, is essential to several enzyme systems. Little is known of the sulfur requirements of forest trees, although recent work has demonstrated some sulfur response by ponderosa pine grown on soils in eastern Oregon.

There are a number of other elements such as iron, copper, manganese, etc. which are essential to tree growth. With the exception of boron, which has been shown to improve the yield of nut trees in the Willamette Valley, trees have extremely low requirements for all of these elements, and there is currently no reason to suspect that deficiencies of any of these nutrients will exist in Christmas tree plantations.

Questions from the Audience

Q. Have you any evidence that you can decrease the mortality of plantings by the use of fertilizers?

A. In work that has been done on various sites from Nova Scotia to Oregon the effect of the addition of fertilizers on the mortality of the plantations has varied. In some locations mortality has been reduced, on others, increased. There has not been sufficient work as yet to determine the basic causes of the effects of fertilizer on the survival of seedlings. Work in the Midwest has shown, however, that poorly fertilized and heavily fertilized seedlings have a poorer survival potential than plants which have received a moderate supply of fertilizer in the nursery.

Q. Does this apply to one formulation of fertilizer?

A. Most of the fertilization of tree seedlings in plantations has been done with a urea-formaldehyde formulation which was designed to have a slow release rate of its nutrients. Very little use has been made thus far of the metal ammonium phosphates mentioned earlier. However, this fertilizer looks very promising. Unfortunately, it has a very low nitrogen content, only 8%, which makes it rather inefficient in remedying nitrogen deficiencies.

Q. What effect does frost have on needle retention?

A. It depends on the physiological condition of the plant at the time of exposure to freezing temperatures. If the tree is well hardened off, freezing temperatures should have no effect unless a severe freeze and a drying east wind occur at the same time. In this case, the ground may be so deeply frozen that the tree can obtain no moisture and the needles may be killed by dessication. If the tree is not hardened off, exposure to frost could kill the foliage. Most frost damage in the forest results from sudden frosts in the late spring.

Q. In other words, frost does not have too much effect?

A. That is not true. If your plant is not cold resistant, frost can have a great effect. Most of our native plants have developed their growth patterns so that they will be cold resistant during the season of the year when frosts commonly occur. However, plants brought into western Oregon from other environments might have growth responses which would result in great damage from frost. An example of the effect of moving a plant from its native environment to a sharply different one (although in this case, frost is not the damaging agent) is the case of noble fir in the Willamette Valley. This species grows very well at elevations above 3,000 feet in the Cascades, but when it is brought down to the much warmer valley, seedlings have a high rate of mortality and generally make very poor growth.

Q. Have you been able to correlate the survival of field planting with the fertilizing that has been done at the nursery? Is there a carry-over of the nursery fertilization program to survival in the field?

A. Not very much work has been done in the northwest on this problem. The only comment we can make is that we have a tree nursery in Washington which is characterized by a rather lush, large planting stock. Many foresters feel that these seedlings are not nearly so well adapted to difficult sites as the smaller stock produced in the Oregon State Forest Nursery at Corvallis or the Washington State Nursery at Bordeau. However, in areas where competing brush vegetation may be a problem, foresters are currently planting much larger seedlings than previously. In general, we are unable to state whether the fertilizer schedule in particular or the basic physiology of the planting stock in general resulted in high or low plantation survival. One example which shows how little we know about factors influencing the survival of forest plantations is the relationship of the physiological condition of the planting stock at the time it is lifted from the nursery with subsequent survival in the field. Current work has shown that although seedlings appear to be fully dormant in late September or early October they have a much lower survival potential if lifted from the nursery at this time than they do if they are lifted after the middle of November.

Q. How much risk would you say is involved in planting high-elevation true firs in the low-elevation areas of the valley?

A. My impression is that the mortality of noble fir in particular is high in valley plantations.

Q. Does that operate in reverse?

A. If you take valley species up, yes. Because, as previously noted, valley species do not use photoperiodic control as a method of stopping their growth; they employ the drying of the soil. If they are planted at higher elevations where the soil remains moist all summer, they will probably suffer frost damage in the fall. The same condition may result if southern species are planted in northern locations, although here photoperiodic control may be important.

BRUSH AND WEED CONTROL IN CHRISTMAS TREES

ON NATURAL AND PLANTATION AREAS

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In the life of any tree, the first few years--principally the first year--are the most critical. Its capacity to survive during these first few years is very limited when you consider what it is up against. Trees can succumb to any one of a number of agencies. Browsing and grazing animals eat them, mice eat the seeds, and rabbits take a substantial toll of seedlings. Insects may attack the seedlings; drought may kill them; litter-fall can weigh them down; fungi, particularly damping-off, may cause mortality; and so forth. In the absence of proper shelter, heat from direct sunshine can girdle them at almost any stage of their lives up to four years of age, maybe later.

This discussion will be devoted principally to the reduction of mortality and the improvement of seedling growth and vigor by evaluation and subsequently by manipulation of vegetation for the improvement of the habitat of seedlings.

Christmas tree plantations are really in a class by themselves. Most of our work has been done with forest plantations for purposes of establishing a stand of trees and allowing them to grow to maturity. In commercial forestry, we are primarily interested in getting the maximum growth of trees in a minimum time; we may have to wait 80 to 100 years for a return on investment. This is a very different situation than growing Christmas trees in a rotation of perhaps four to eight years.

For forestry purposes, we have not been as interested in planting trees where we cannot expect them to grow very fast, such as in the lowland portions of the Willamette Valley and in the foothills where soils are shallow and grassy vegetation prevails. However, as Christmas tree growers, this is probably the type of site in which we are primarily interested. These sites are the easiest from the standpoint of access; they are the easiest from the standpoint of associated vegetation control; easiest to go through to inspect; and easiest of access for prospective buyers. We will therefore discuss mainly the control of grass and associated drier country species of these areas. Brief mention will also be made of the more humid area forest-brush types of the Coast Range.

Grassy sites have posed survival problems ever since we have been planting trees. Just getting them to survive has been our biggest problem, and practically everything in the book has been tried just to increase survival. We have tried planting different species, mulching, cultivating, and a number of cultural practices. These cultural practices are directed toward controlling the rate of moisture loss. Drought has been commonly thought to be the principal factor involved in killing our seedlings, and it may very well be. A wild stand of grass that one might expect to find on an abandoned pasture or valley bottom land may support anywhere from 2,000 to 5,000 pounds of vegetation per acre. A stand of grass of this type will remove from the ground all the water that would be available to planted coniferous seedlings, in a period of about three or four weeks in the spring. After the middle of June, or possibly the first of July, the trees are getting along with virtually no available water. Some seedlings are very drought resistant. Douglas-fir is much more drought resistant than is commonly believed, but if drought conditions prevail into September, a seedling may have to survive for 90 days or more without appreciable water.

Grass cover can take this water only if the grass is in a healthy condition. After the grass dries out, or part of it has been killed, then transpirational loss can be expected to be reduced accordingly. In some recent experiments, it has been demonstrated that there is a distinct reduction in water loss with grass reduction to stands of a thousand pounds per acre or less. Thus, if we want to conserve moisture by reducing weed cover, we must reduce the weed cover to this point before we really begin to conserve water.

Control of Competing Vegetation

Fortunately, many of our annual weeds are very susceptible to a variety of herbicides at low rates. Simazine and amitrole, both separately and as a mixture, have been very effective on local weed projects. Many annual grasses are well controlled with rates of 2 to 4 pounds per acre or less of 80% Simazine applied in the fall. If the annual weed problem is the one that prevails, probably 5-6 pounds per acre of 80% Simazine applied pre-emergence will keep the stand in the range of 0 to 300 pounds per acre, which should provide adequate moisture conservation. If perennial weeds are common in addition to annuals, 1 to 2 pounds of active ingredient of amitrole per acre will be needed in addition to the 80% Simazine, and application should be made in early spring.

While the above treatments and reasoning apply in general, some modifications are in order when considering the direction of exposure. Temperatures and soil conditions are not as severe on north as on south slopes, and it may not be necessary to kill as much of the vegetation to provide for the same soil-moisture conditions.

Methods of Chemical Application

The method of application is not important in grass control treatments, except that uniformity of treatment is desirable. For rough terrain, aerial application appears to have considerable merit for broadcast application, although it precludes strip spraying. Knapsack-type mist blowers are useful in similar situations where the acreage is inadequate to justify an aerial contractor. For level ground, any farm sprayer is suitable if the pumps can handle wettable powder materials with adequate agitation. In any case, the equipment depends on the terrain, acreage, type of chemical, and the herbicide distribution pattern desired.

The distribution of chemical depends on a number of factors. If the treatments are being applied to save some conifers which are already present, an effort should be made to treat carefully in spots around the trees. Several chemicals are nontoxic to conifer foliage, and they may be applied without particular attention to avoiding foliage injury. Simazine and Atrazine may be used in this way; some of the substituted ureas and uracils also look promising in this respect. For treatments of this type, hand equipment is most suitable, and the applications should be made during the winter months. If the ground is being prepared for planting, and it is anticipated that plantation will be 6 x 6 feet or closer, it is recommended that the area be broadcast sprayed. If the treatment does not include amitrole, the chemical should be applied during the winter, either before or after planting. If amitrole is to be used, it is generally advisable to avoid spraying conifers. In this case, since amitrole is most effective on perennial plants via foliage activity, it may be most desirable to spray in March and plant immediately thereafter.

Protection From Heat

The susceptibility of Douglas-fir and true firs to heat damage has been recognized for many years. When we expose the soil surface to the direct rays of the sun, we are causing the solar energy to be converted into sensible heat at the ground surface. Since soil is a poor heat conductor, heat accumulates at the surface, which on exposed south slopes frequently reaches temperatures of 140°F. or more for several hours at a time. This may cause stem girdle on seedlings, which has frequently been shown to be the cause of substantial mortality. It is, therefore, recommended that seedlings exposed to heat of this magnitude be protected from the soil at the ground line, or that the soil in the immediate vicinity of the seedling be shaded during the heat of the day. One method that appears promising in laboratory tests is the placement of asbestos paper around the seedling stems before planting (Figure 1). This may be done in the barn or shed before taking seedlings to the field, and it saves the labor of visiting each planted tree in the field.

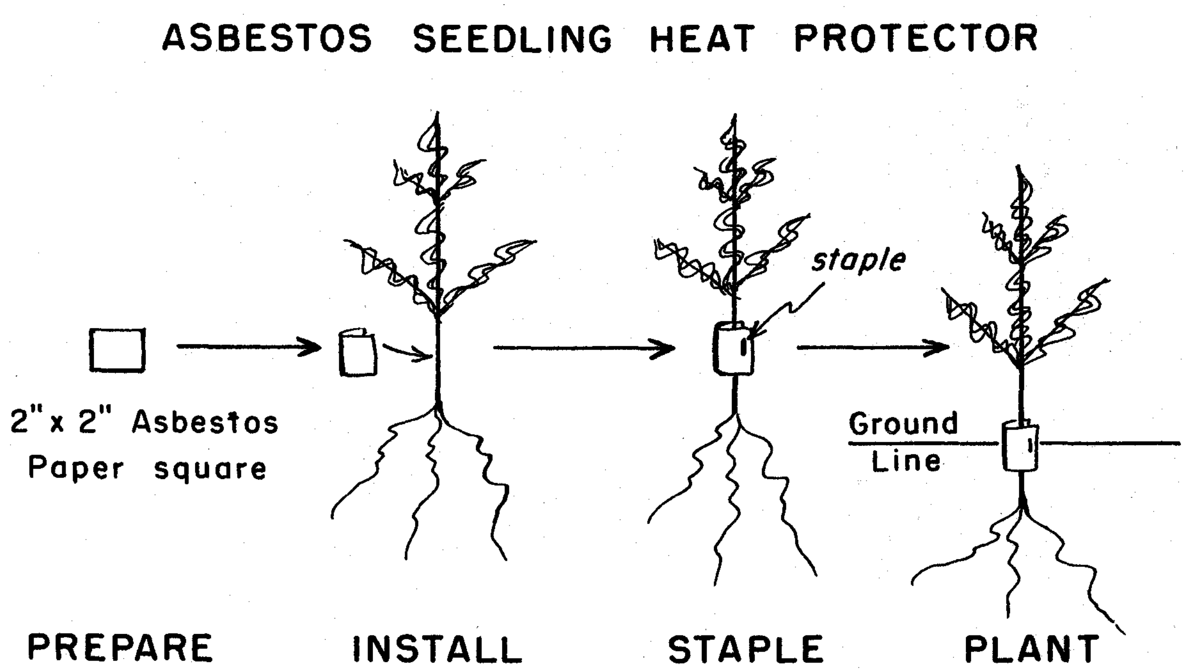

Figure 1. Asbestos heat-girdle protector for coniferous seedlings.

If this device is to be used with a planting machine, it would be advisable to use paper which will extend for 3 inches along the stem. In this way variations in planting depth inherent in the use of a planting machine will cause fewer problems. The cost of attachment of these protectors approximates four to five dollars per thousand, depending upon the size of the asbestos and the type of stapler used. An automatic stapler is well worth while if banding of ten thousand or more seedlings is contemplated. Other types of protection have been used with variable success, such as shingles for ground shade or various types of mulching materials which may serve the same function.

The incidence of difficulty with heat damage may be reduced by attempting to select sheltered or north-facing planting sites to favor heat-susceptible species and using the pines or other hardy seedlings on more severe sites. The use of larger seedlings of susceptible species may not prove to be very successful, as even 4-year-olds have been shown to be readily girdled. Ponderosa pine appears to be well adapted to hot situations without protection if 2-0 seedlings or larger are used; lodgepole pine is also rather resistant to heat damage.

Brush Control on Christmas Tree Plantations

The largest areas of Christmas tree plantations are on sites which have been occupied by abandoned pastures or agricultural lands. In these areas, in general, brush does not constitute a major problem with conifer establishment. The presence of some brush can, in fact, be temporarily beneficial in the sense that it may provide some protection from the direct sun. Christmas tree farmers who are managing naturally-seeded conifers on forest land may be faced with a different situation. Wild lands are generally occupied by mixtures of species after logging, including some brush species which are undesirable from the standpoint of Christmas tree management. These species may effect conifers by whipping leaders, shading out lateral branches, crushing seedlings with litter fall, and outright suppression.

Brush control under these conditions will involve killing a maximum amount of brush with a minimum amount of damage to the conifers. Early spring dormant spraying has given very promising results in situations of this type where the species of brush do not include large and thick-barked hardwoods. The dormant treatment involves the application of 2 pounds per acre of 2,4,5-T ester in 10 gallons of diesel oil before the conifer buds burst. Severe damage can result, however, if pines are directly exposed to the spray. Application is generally made with a helicopter.

Possibly a more common type of problem is that in which young conifers have seeded-in beneath a hardwood stand, particularly under oak trees. Single-stem treatment is more suitable for large hardwoods, as they are difficult to kill with broadcast treatments. Either basal spraying or frilling* plus herbicide can be used inexpensively and effectively; these treatments have no effect whatever on the associated conifers. With this type of hardwood cover, one may find that there are, in fact, too many conifers. If this

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* Frilling is a series of axe cuts at convenient cutting heights in which the herbicide may be applied.

condition prevails, it may be prudent to thin out the least desirable specimens while doing the chemical work, so that one operation will result in a good stand of thrifty Christmas trees.

A common type of brush problem on Christmas tree plantation sites is that of poison oak and blackberries. Midsummer foliage sprays of amitrole or 2,4,5-T ester in water in mixtures of 1:100 generally give satisfactory performance for spot treatment. Foliage should be thoroughly wetted for consistent results. Amitrole is the preferred chemical for poison oak. It is important that the brush should not be cut before treatment, or within two weeks thereafter. These brush species have enormous root systems, and the introduction of enough chemical to injure the roots depends on a large leaf area and full-thickness stems.

Questions From the Audience

Q. You were telling us that there was a concentration of heat right at the ground level from sunshine, now could you give me any figures as to height or depth of heating? Supposing the heat at the ground level is 150 degrees, what would it reach 4 or 5 inches above ground?

A. Well, I think maybe I can be a little more specific than that. If it's 150° F. at the ground line, it is probably not more than 120° an inch off the ground, and there is a very steep gradient both above the surface and below. If it is 150° F. at the surface, it probably is not more than 100° F. an inch below the surface, or 120° to 125° an inch above.

Q. Is that why these little asbestos coats are so effective?

A. Yes. These asbestos strips should be planted so that they reach one inch or more above and below the surface. We made these out of two-inch squares of asbestos furnace-pipe wrapper, which is about the lightest weight asbestos you can get; then took a regular stapler and stapled them around the seedling at the root collar. Then they were placed in the ground with the asbestos half way into the soil.

Q. Would tinfoil have the same effect?

A. Tinfoil, I think, would give you problems. The difference between tinfoil or aluminum foil and asbestos is that asbestos is a very poor conductor of heat and aluminum is one of the very best. If the aluminum came in contact with the tree, you might expect a lesion at the point of contact.

Q. How do we attack our weed problems if the seedlings begin to break dormancy in March?

A. If they are breaking dormancy in March, this represents a somewhat ticklish problem. Seedlings should be planted, of course, before they break dormancy. If you have a weed problem, you will have to treat the weeds before you put the trees in the ground, particularly if perennials are important. In this case, you would have to put the amitrole on a little sooner. We are working with some other herbicides now that may give us a little better control on perennials, and we may have better recommendations for this situation soon.

Q. When you have perennial grasses coming in on established plantations, say true firs, is there a place for Atrazine?

A. Is there a place for Atrazine where perennial grasses are present in an established stand? Well, I would say yes, but we do not have good information yet concerning the amount and depth of the soil activity of Atrazine. We do know that Atrazine has some foliar activity on conifers, and under some circumstances it may be possible to get some burn.

Q. If you prepare your soil for planting previous to March, like this winter, and you plan on planting your seedlings in March, will amitrole act as a pre-emergent spray with perennial grasses?

A. Amitrole probably would act as a pre-emergent spray. I think you would be a lot safer to use just Simazine, because I think Simazine will act as a pre-emergent for perennials if you have tilled the soil beforehand. If the soil is tilled beforehand, a couple of pounds per acre of Simazine will do the job for you, whereas in untilled sites you may have to go to 4 or 5 pounds to accomplish the same thing. In general, however, we tend to think of tillage as undesirable because of the extra operation and the extra soil washing involved.

Q. At what rate of Simazine would you expect to see discoloration of the needles of young trees?

A. To give you some idea of the safety factor involved on clay soil, we set up some initial toxicity plots in which we went to 32 pounds per acre of active ingredients of a mixture of Simazine and amitrole, and 24 pounds per acre of straight Simazine. The 3- to 4-year height growth on the trees that we planted immediately thereafter was between 4 and 8 feet. We saw no evidence of burning except where we had made a heavy treatment and subsequently driven some of the herbicides down into the planting slit. This was the only case where we had any obvious evidence of injury. If the tree is in the ground beforehand, I am sure you are not going to have any trouble, and with rates of 4 to 6 pounds per acre, it is inconceivable to me that you are going to get anything you could see. Does this agree with your observations?

Fairly well. However, I am surprised at the information on the high rate of Simazine, since Simazine is a soil sterilant. How many years after this chemical was applied did you make your observation?

Four. We have four years of information on this series of tests. The grass has almost fully recovered now, and the trees appear to be quite healthy. Where the grass was not controlled, only 3 out of 144 trees are still alive. The average height is just a little over a foot after four years. In our treated plots the average height of our trees, of which about half are still alive (the other half having succumbed to heat damage, among other things), is about four feet. So there is quite a bit to be said for the improvement of habitat, even when the seedlings are subjected to the very highest rates. We also got good survival at lower rates, but of course we were not looking for the same damage in these cases.

Q. Do you recommend chemical weed control over cultivating?

A. I think it is less expensive, and I think it does just as good a job.

Q. What about the trouble I have then with soil cracking?

A. You can have soil cracking anyway, can't you?

Q. Even if you cultivate regularly?

A. If you have complete control of weeds, you are not going to have as much soil cracking as without any treatment, but maybe more than with cultivation. We had negligible cracking where we applied adequate herbicide for complete weed control on heavy montmorillonite clay soil. You could stick your shovel into this soil any time during August and September and, within 6 inches of the surface, turn up moist, fresh soil. There had been negligibly effective rainfall for over 90 days. Last summer, if you remember, we had quite a few showers. From these the water was evaporated within a few days of the rain. It does cool things off for awhile, but it can not be considered an effective contribution to soil moisture. Despite this, even though we had soil only about 10 inches deep, we still had available moisture in September in plots where weed control was virtually complete, and cracking was relatively unimportant.

Q. Have you noticed any correlation between the amount of Simazine and the length of the control period?

A. I am sure that there is a correlation. On rates of application over 8 pounds per acre we would probably get fairly good control for two years. On 2 to 4 pounds, we could probably expect control for no more than one year. Now, the question is, how large a degree of control do we need after the seedlings are once up in the air? During that first year, if we control most of the weeds with 2 to 4 pounds, and the seedlings get a good start, they will make much more rapid growth the first year; they will second-flush and grow very rapidly, which is most unusual on a new plantation. If they do this, the seedlings will be in much better shape to grow the second year than they would be otherwise. You would probably see very good survival and growth the second year, even without much weed control. But if you want to put on a couple of pounds per acre of Simazine to hold the weeds down after your first year for aesthetic reasons, this is fine. I do not know if this is justifiable in terms of increased survival and growth.

Q. For what areas in western Oregon do your comments about heat damage apply?

A. I suspect that here in western Oregon, particularly in southwestern Oregon, you will find heat damage on any level ground or southerly oriented slopes. Southeast, southwest, due west, are all bad ones. We have even observed some heat damage on a north slope. So, I think it is a fairly widely occurring phenomenon. I hesitate to say at this point just how widely, but we see it under quite a wide variety of conditions. It is probably infrequent on the west slope of the Coast Range. We have seen it mostly on the east slope of the Coast Range, the Cascade foothills, and valley plantations.

Q. Would a mulch of sawdust, maybe 3 inches deep around each seedling, be as effective, or nearly as effective, as the asbestos protector?

A. I assume so. If you want to go to the trouble of taking a truck load of sawdust to the field and pouring and applying a mulch to each tree, the results might be very good. I expect the cost per tree would be around 15¢ or 20¢, whereas the cost per established tree with asbestos protectors is something less than a nickel.

Q. I have several thousand units of sawdust already stacked out there from an old sawmill. Could I use this economically?

A. Maybe so, but the physical problem of just getting it on the site is where your cost comes up.

Q. Do you have any experiments with dry and wet Simazine to compare them?

A. No, we do not have any specifically--we have not used the dry application. These materials are such fine powders that if you dusted them on, you would probably be controlling weeds in the next county. At this point, I would very seriously doubt that we would get as good results with powder applications as with sprays. A granular form might have some advantages but we have not yet tested these materials.

Q. What does elevation have to do with the heat problem?

A. Elevation probably has some effect insofar as you get lower atmospheric temperature at higher elevations, hence you would probably expect to get lower ground temperature. On the other hand, in high elevations (of 3,000 and higher) you may get sufficiently higher incoming sunshine energy on south slopes to pose an equally serious problem. Dr. Silen of the U.S. Forest Service found basal temperatures in higher elevations similar to those at the lower elevations. However, it may be that this occurs only on the more directly exposed sites on the higher slopes.

MOISTURE CONSERVATION IN CHRISTMAS TREE PLANTATIONS

WITH PARTICULAR REFERENCE TO CHEMICAL WEED CONTROL

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My purpose is to report on certain experiences we have had in growing plantation trees in Benton County, Oregon. We have been experimenting with chemicals as a means of weed control for five years and have progressed to the point where we have selected certain ones that have given consistently good results and have applied them successfully on a commercial field basis this past year.

The main reason for our interest in chemicals has been to find an economical and "sure-fire" selective method for controlling unwanted grass and weed competition. Heavy stands of weeds -- grass especially -- deplete soil moisture to a low level in summer months and can cause drastic reduction in tree survival rates. We observed this phenomenon six years ago in our first field planting. Where moisture was conserved by destroying grass and weeds with two cultivations, tree survival was 95% as contrasted to less than 25% on adjacent noncultivated areas. Subsequent observations have led us to conclude that moisture conservation during the growing season is the key to tree survival and more important than any other single factor.

In 1961 we decided to study and evaluate some of the newer chemicals more intensively. A triplicated series of chemical and mulch plots were established in cooperation with the Oregon State University Extension Service personnel on new plantings of Douglas-fir, grand fir, and noble fir. Chemicals tested were Casaron (G), Diuron (G and S), Atrazine (S), Simazine (S), and Amizine (S). All materials were applied directly over the trees at a 4-pound rate per acre either as a spray (S) or granular (G) form. Simazine and Atrazine plots were re-treated a year later at the same initial rate. In addition a new set of single-row duplicate plots was set up on a Douglas-fir plantation which had established grass and weed cover, the main grass being bentgrass, Agrostis tenuis var. Chemicals used were Simazine and Atrazine at 4- and 8-pound rates, and Hyvar, a new chemical, at rates of 1 and 2 pounds per acre.

Results from these trials showed that Atrazine and Simazine gave consistently good results without injury to trees. Of the two chemicals, Atrazine gave slightly better control, especially on the established bentgrass. Diuron results were inferior to both Atrazine and Simazine. Casaron apparently was too toxic in nature and resulted in nearly 100% loss of trees. Amizine gave good broadleaf control and fair grass control but resulted in some foliage injury to the trees the year applied. Hyvar with only one year's results gave excellent weed control at rates as low as 1 pound per acre. Further testing will be necessary in order to determine Hyvar's potential in field application.

We have some colored slides which will further illustrate the results of these experiments. Please feel free to interrupt if you have questions.

Slide 1. This picture shows three different moisture-conserving practices on a two-year-old plantation of Douglas-fir. Keep in mind that the soil type is a Willekenzie silt loam--a well-drained, reddish-brown hill-land soil. The plot on the far right illustrates the use of black plastic which was placed over the tree seedlings shortly after planting. Note the excellent growth and vigor of these trees. This picture was taken in late July and the trees were in an active growing condition. Note also the dark green color. Contrast this to the sawdust plot in the middle which is yellow and anemic looking. Fresh sawdust was used to a 4-inch depth right after planting. The paper square technique used on the trees at the left gave good weed control, but at the end of two years shows considerable disintegration which has allowed grass to become established adjacent to the trees.

Question: How was the plastic applied and what thickness was used?

Answer: The plastic strips were laid over the tree rows with slits cut to let the trees protrude from the plastic. I understand that there are special machines available now that will lay plastic sheets mechanically for transplanted crops. It should be possible to adapt the principle involved to a tree-planting machine. The thickness of plastic used was 2 mm. and 4 mm. Both thicknesses stood up quite well under field conditions, although the 4 mm. is somewhat superior.

Question: Do you think the plastic and sawdust mulch will show up better on our heavy clay-type soils than on sandy soils?

Answer: Yes, especially on those heavy soils which are low in organic matter and have a tendency to crack upon drying out. We have run into this cracking problem when using chemicals only. Any type of mulch--whether it is plastic, sawdust, or dust mulch by cultivation--will hold the moisture in the soil and thereby increase tree survival.

Slide 2. This slide shows the effect of different chemicals on noble fir. Note the relatively weed-free plot in the foreground which was treated with Simazine. Survival of the noble fir here was good and the improved vigor of the tree is a result of eliminating competition the first year. Note the plot on the right which was treated with Casaron. This chemical was apparently "too hot" for the trees as it destroyed all of them.

Slide 3. This is a plot showing the use of Atrazine. Survival was nearly 100%, and you will note that the re-treated area on the back side of the plot shows excellent control for 1962. Atrazine has shown up consistently well in all replications on all species of trees. The chemical is somewhat more soluble than Simazine, which may account for its better performance on older, established grass plants.

Slide 4. This is a plantation of Scotch pine--the French strain. Cultivation was used here as the main method of weed control. The Miller Trac-Till split rototiller was the implement used, an excellent tool for tree cultivation.

Slide 5. Here is a plantation of grand fir in which weeds and grasses have been controlled nearly 100% by cross cultivation. The planting stock for this field was unusually good and this, combined with good tillage practices, helped contribute to a survival rate of 98%.

Slide 6. This is a general view of the chemical plots established last April on a 2-year-old planting of Douglas-fir. Our objective has been to find a chemical that will control grass without harming the trees. This should enable us to shorten our rotation by improving the growth rate of trees. Further, chemicals may give us the tool we need to satisfactorily grow noble fir on this type of land. Heretofore, our noble fir plantings have "stood still" as a result of the terrific competition. We have experienced losses up to 50% of 3-year-old trees when we failed to carry cultivation into the third growing season.

Slide 7. There are new chemicals coming on the market each year. One of the newer ones that has great potential is Hyvar. Note the excellent control of grass and broad-leaf species at both the 1- and 2-pound rates. Both rates show evidence of injury as noted by the off-color foliage, however. Further testing may show a rate of less than 1 pound per acre that would be safe to use and at a very low cost per acre.

Question: What is the cost of Hyvar and did it show damage to trees immediately after application?

Answer: Cost is approximately $5 per pound--actual material. No damage was noted immediately after application. The off-color is undoubtedly due to the uptake of the chemical by the root system. Note, however, that color loss with the 1-pound rate is hardly perceptible. We are thinking of using it on a field application basis this spring.

Slide 8. This is Atrazine used at the 4-pound rate on established bentgrass. Note the good control of vegetation and the dark green color of the trees. Atrazine as well as Simazine imparts a nice color to trees similar to a response that you might expect from the application of nitrogen fertilizer. Scientists have noted a similar color response in certain agricultural crops but have been unable to explain why.

Question: When were these 1962 chemicals applied?

Answer: On April 13th. Temperatures were high and we were worried about foliage damage to the trees because they had just started new growth. No injury was noticed in our Douglas-fir plots.

Slide 9. This plot was treated with Atrazine at the 8-pound rate. Note the remarkable job of grass control. Simazine at 8 pounds was not nearly as effective.

Slide 10. This is our first field application using a combination of 5 pounds Simazine and 6 pounds Atrazine on a 3-year-old mixed planting of Douglas-fir, grand fir, and noble fir. The chemicals were applied broadcast with a field sprayer last April. A 20-foot boom was used. Again, trees were in the early spring growth stage and no discernible damage was noted. The combination of chemicals held competing vegetation to a minimum and released the trees from the terrific competition.

Slide 11. This is a comparison of concolor fir on a sprayed and nonsprayed area. Notice that the new leader growth on the sprayed area was 6 to 8 inches as compared to only 2 to 3 inches for the grassy, nonsprayed areas.

Question: What was the purpose of combining Simazine with Atrazine? Why not just one chemical?

Answer: Simazine is less soluble than Atrazine. We reasoned that a combination would give us longer residual effect than Atrazine alone. Comparisons of plots this spring, however, cast some doubt on this assumption. Atrazine, alone, may be as good as the combination for our particular conditions.

Slide 12. This slide shows a concolor fir plantation interplanted with Douglas-fir, spring 1962. The field had grown up to a combination of tough perennial grasses--Alta fescue, bentgrass, orchard grass, and velvet grass. It was sprayed with a combination of 5 pounds Simazine and 6 pounds Atrazine. We obtained 85% survival on the newly planted Douglas-fir. This suggests an interesting possibility for the use of chemicals under conditions that are too rough for tillage. It appears feasible to hand plant sodded areas without extensive land preparation if chemicals can be used to control competitive plants the first year after planting.

Question: Do you plan to re-treat this area this spring?

Answer: Only if regrowth indicates a justification for re-treatment. You will notice that Alta fescue is alive and still growing. Had the area been properly summer fallowed and prepared prior to planting, we could have eliminated this problem in the beginning. We normally summer fallow any land that is in sod and which will be put into trees.

Question: Will repeated applications of Simazine and Atrazine build up a toxic action in the soil and kill the trees?

Answer: We are fully aware of this possibility and plan to conduct plot experiments where we apply repeat applications each year. So far, two continuous years of application have shown no harmful effect. There is evidence that Willamette Valley trees can withstand quite heavy rates without injury. We would expect a greater hazard from the use of some of these chemicals on the sandy type soils which characterize the Shelton area of northwestern Washington.

Question: Is Atrazine giving good control of broad-leaf plants?

Answer: Yes. It has controlled a high percentage of them. It has not been effective in killing bracken fern, blackberries, and poison oak, however.

Question: Would one dare to put a little 2,4-D in the spray mixture where there is a broad-leaf problem?

Answer: I would not recommend it. Low rates can be harmful to trees, especially during their early spring growth spurt. I definitely would not recommend the combination of 2,4-D and 2,45-T.

Question: Do you have any cost figures on Simazine and Atrazine materials?

Answer: List price this year is $2.85 per pound. If you use the 4-pound rate your cost would be $11.40 per acre for the chemicals. Chemicals and application should not run over $15 to $16 per acre.

Question: When is the best time to apply Atrazine after planting the trees?

Answer: We like to apply the day after we plant or as soon thereafter as possible. These chemicals are dependent on soil moisture to carry them into the rooting zone. They can be applied in a light rain without danger of reducing effectiveness.

Question: How early can these materials be applied?

Answer: The earliest we have ever made field application is in early April. I would think that March applications would give equally good results. The principle to keep in mind in using these chemicals is to time the application so that there is enough rainfall to take them into the surface layer of the root zone but not enough to cause excessive leaching into the lower soil depths. I am certain that the timing with respect to rainfall would be more critical in sandy areas than on soils with a higher clay content.

In summary we can conclude that chemicals have a definite place in Christmas tree plantation management. They will become more useful as we obtain more information on the new chemicals, respective rates, and methods of application. Keep in mind, however, that there is probably no single recomendation that is best for all conditions. This will vary according to soil type, season, and type of vegetation to be controlled.

SOME OBSERVATIONS ON THE DISEASE PROBLEM IN CHRISTMAS TREE CULTURE

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From our brief discussion here, I conclude that you feel disease to be a very minor problem in Christmas tree production. This impression pretty accurately represents the facts as we find them here on the north Pacific coast, especially if our concept of disease is limited to infectious diseases. This healthy condition is almost unique to this region, and we should work to keep things as they are. Under existing conditions abnormalities which will catch your attention most often will be of physiologic rather than pathologic cause. Correction of physiologic deficiencies can usually be made by altering cultural practices and by changing tree species, although this may sometimes prove costly.

I would like now to turn to the pathogenic diseases. Let me pass around a number of examples in order that you may form a mental picture of the nature of these troubles.

The first specimen is leaf rust, in this case on Shasta fir. Most Christmas tree species are attacked by these rusts, and they are especially destructive to spruce and true firs. The most severe development I have seen in our immediate region is on grand fir where, on most shady sites, a lot of discoloration and defoliation may occur. Note that growth of the last four years of the Shasta fir specimen is terribly stunted and tree shape is ruined. The structures under the needles resembling insect eggs are spore sacs. There are two leaf rusts of Douglas-fir, but these do not occur at present in our region.

The next specimen is Douglas-fir needle blight, the most common foliage disease of Douglas-fir. While this disease is very destructive in the northern Rocky Mountains and in some parts of Europe makes culture of Douglas-fir impossible, the disease occurs with us only on widely scattered weak trees which, for other reasons, probably would not be merchantable. Again we are very fortunate. Trees are generally affected more or less all over and assume a rusty appearance. The fungus on the underside of the needles forms pustules resembling minute, tan sofa cushions when examined with a lens.

Those of you who have harvested true firs east of the Cascades are acquainted with the next disease. This is needle cast and the fungus is again evident on the underside of the needles, but here it has a long black line. This specimen was collected in early summer. By tree harvest time these branches would be nearly bare and the trees, no doubt, passed by as unmarketable.

The next specimen is gall rust of shore pine which recently was sent to the plant clinic by a Christmas tree grower in Curry County. This disease kills branches irregularly over the tree. Note the large galls. After the rust produces its mass of orange spores on these galls, the distal or outer portion of the branch dies and the trees may become very irregular. This rust differs from most tree rusts in that it can reinfect pine without passing through an alternate host species.

This is a specimen of Armillaria mellea or mushroom root rot of ponderosa pine. This is the most common root rot of forest evergreens of this area and is abundant in the foothills where Christmas tree culture is increasing. Undoubtedly occasional trees are infected by this fungus. However, the Christmas tree rotation probably is short enough that harvest will occur before damage becomes serious. All species of Christmas trees are attacked by this fungus. On the specimen, note particularly the lightweight, the white "web" of fungus between the bark and wood, and the black, root-like strings attached to the bark. These are rhizomorphs; they are distinctive and are the basis of the common name, shoestring root rot, sometimes applied to the disease.

These are specimens of a canker disease of pines. They are from young trees planted in McDonald Forest near Corvallis. They cause little noticeable rupture of the bark, but they are apparent on the surface by excessive flow of pitch and by the minute, black, cap-shaped fruiting bodies. When trunk or branch are cut across, a conspicuous black stain is seen to penetrate the wood. The plantation from which these cankers were taken was destroyed by the fungus.

My last specimen is of Douglas-fir canker. The string of hip-like, open cankers along this branch is exceptional, but I wonder if there is a grown fir in western Oregon without at least one of these cankers. Apparently, young trees are not infected and little damage results by the time of harvest for Christmas trees.

Pathogenic diseases as represented by these specimens are destructive and relatively easily diagnosed. Unfortunately they represent only a fraction of the disorders that occur on evergreens and are of concern to the grower. These other troubles usually are not distinctive and are very difficult to diagnose. Hundreds of specimens come to me from many sources; I am able to positively determine the cause of damage in only a few of them. These disturbances usually are physiological in origin and often cause and effect are so widely separated in time that we fail as growers or specialists to make their association. Some types of frost damage, for example, may not appear as recognizable symptoms until the second spring following the frost.

It is important, therefore, that the grower have a long memory and that he develop a consciousness of unfavorable environment which may appear as extremes of heat or cold, drought or drowning, summer or winter dryness, or radiation parching and scalding; as improper fertilization or as the presence of such dangerous chemicals as herbicides, dust settling chemicals, and atmospheric pollutants. These are things that the alert grower can be conscious of and can evaluate at the site where the trees are growing, whereas the specialist is rarely in a position to know of them. The grower should always provide the information he has on these things when submitting specimens for diagnosis. The specimen should also be representative and adequate and should depict a condition occurring in two or more individuals.

Diagnosis is also difficult simply because of our lack of knowledge of Christmas tree diseases. We have not in the past had a Christmas tree industry of sufficient strength to develop disease research. Christmas trees also are of an age class which, until only rather recently, has been of indirect interest to the forest industry and consequently they have not been well studied by forest pathologists. Our knowledge of diseases of Christmas trees has been generalized downward from studies on older forest trees and upward from research in the forest and ornamental nurseries. The gap between is not yet adequately filled.

I should like to point out also that today we are "seeing" more than formerly and we are more critical of what we see. Formerly we selected the one family Christmas tree from hundreds of wildings. Deficiencies in those we passed by failed to register on our consciousness. Today, as growers, we expect every tree to be marketable, and the defects we formerly overlooked are now very apparent and are of concern. We expect these trees to enter an increasingly competitive market where quality standards are constantly rising.

Let me repeat that the troubles we most often encounter are of physiologic origin. They periodically occur on native trees on natural sites as a consequence of abnormal climatic extremes, or they result from excessive exposure, either intentional or accidental, to agricultural and industrial chemicals or to air pollutants. These factors cause direct damage and are sometimes followed by infections. Douglas-fir, for example, regularly becomes infected with Dasyscypha canker following freezing damage to the leader. It must be emphasized that these effects usually are exaggerated when the trees involved are exotics or are natives growing under unnatural conditions or on poor sites.

As Christmas tree growers, you are exceedingly fortunate in having your business located in the Pacific Northwest. This is a phenomenal tree-growing region and, in addition, our trees are less subjected both to physiological disturbances and infectious diseases. Leaf rusts are a good example. These rusts are destructive in western Canada and extend in an almost uninterrupted belt across Canada and our northern tier of states. They are widespread in New England and the lake states and cause damage in the Rocky Mountains and in California. We have only one and it is of minor consequence, on grand fir.

What, then, are the infectious diseases that concern us? The list is not long. It includes the types of things we observed in the specimens. Root diseases may become our greatest concern over the long haul. If they succeed in invading the soil initially, they may become persistent and be quite impossible to control. With some, abandonment of the site may be necessary. The most important native root rots, mushroom root rot, yellow laminated root rot, and fomes root rot tend to attack trees a bit older than most Christmas trees and I believe will not become a serious problem in Christmas tree culture. Introduced root rot such as the species of Phytophthera, contrarily, may cause a different and serious problem. One of these has essentially eliminated production of ornamental Port Orford cedar and is now destroying the native forest trees. Another, more recently introduced, attacks most kinds of evergreens and is very destructive in irrigated nurseries. While it probably will not seriously damage trees in the absence of irrigation, its introduction into the land on contaminated seedlings is dangerous business. Because of the danger of introducing root pathogens, we must be very cautious in buying seedlings. Seedlings should always come from a nursery that can provide a solid guarantee that they are free from infection. When you order, you should insist that the nursery soil have a record of freedom from disease. Soil can bear a problem that can cause you great damage without ever reflecting its presence on the foliage of the tree itself. So you should ask for this guarantee in order to protect yourself and, in addition, to protect the economy of our state. Our state economy is so dependent on forestry that the importation or spread through planting stock of diseases with the potential of spreading from your plantations into the forest is a great responsibility.

The occurrence of canker diseases usually reflects poor growing conditions. Consequently, these diseases are uncommon in our native species in their natural habitats. Phomopsis, which produces flattened eliptical cankers about an inch long on the trunk and main branches of Douglas-fir, is perhaps our commonest representative of this group of diseases. Fungus fruiting structures appear as minute black dots near the center of the slightly sunken cankers. The infected individual usually bears many cankers but few individuals are affected. While cankers are of limited importance in natural stands, they are possibly the most destructive diseases of coniferous plantations. Almost invariably this damage is self-inflicted by the grower as a consequence of planting trees outside their natural range. Recall the specimen of ponderosa pine with Atropellis canker from the McDonald forest plantation. This plantation contained trees from sources distributed throughout the west. Only two races, the native Willamette and the Eldorado, withstood the disease. These races were scarcely infected, whereas all the others were destroyed. You should always remember that when you grow a foreign tree you are making a contract with trouble. Whether or not the contract will be met is uncertain, but it is something for which you should be prepared. If trouble arises, I believe in most cases you will be farther ahead to "destroy the contract" than to attempt artificial control.

Unlike the root rots and cankers, most foliage diseases are not perennial. They are dependent on favorable environment for infection and consequently tend to be of sporadic occurrence. The fungi involved usually attack either foliage of the current season or older foliage but not both. Damage as a result is to the tree's appearance rather than to survival. Trees rendered unsightly and unmarketable one year may subsequently recover completely. Direct control by spraying is sometimes helpful with these diseases. Foliage diseases, like canker diseases, are worse on trees grown out of range and on improper sites. This situation is well illustrated by Rhabdocline needle blight of Douglas-fir which attacks only widely scattered trees here in the Douglas-fir region, but in Europe this disease is a limiting factor to tree growth.

When we introduce exotic trees, we increase their liability to damage from native diseases. Or in the new environment undetected diseases accompanying the introduced trees may become aggravated. Finally, there is the danger of introducing foreign diseases which will not limit their destruction to the trees on which they were brought in, but will spread to the surrounding forests to cause inestimable losses. White pine blister rust and Phytophthora root rot are monuments to this short-sighted practice.

PREVENTION AND CONTROL OF INSECT DAMAGE TO CHRISTMAS TREES

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In the northwest there is more and more interest in the growing of Christmas trees for market, and plantations of various conifers for Christmas trees have increased. A number of destructive insects are becoming a problem, particularly on large plantations. These plantations require more intensive protection than, for instance, natural forest stands. There are several causes for the increased susceptibility of such plantations. Often the site conditions are not the most favorable for the tree species planted and the trees become susceptible to insect damage. Most important, however, is the fact that Christmas tree plantations are usually of one species and of the same age. This lack of diversification by tree species and age classes results in a very simplified insect community, with very few predatory and parasitic insects. The result is that the destructive insect is not kept in check by biological controlling agents, as usually is the case in a complex forest community. Therefore, some kind of applied insect control is often necessary.

The damage inflicted by some of the more important insect groups will be briefly described and, where known, control measures will be given. Insecticide formulations for control of insect species occurring both in the northwest and the central states are taken from Christmas Tree Insect Control, Extension Bulletin 353, Michigan State University, Cooperative Extension Service, East Lansing, Michigan. It is available in many of our county Extension offices.

SOIL INSECTS

1. White grubs or June beetles (Scarabaeidae). Grubs of several species of this family feed on various coniferous trees. The white, C-shaped larvae, with well-developed legs, are about 1/2 to 1 1/2 inches long; they live in the soil from 1 to 5 years before emerging as adults. The grubs damage the young trees by devouring the rootlets and eating the bark of larger roots, thus preventing normal uptake of water. Affected trees look weakened and droughty. In nurseries and plantations, the damage can be extensive at times, and many trees may be killed outright and turn red.

Control: Grub-infested soil should be treated with insecticides before planting. Chlordane (40% wettable, 25 pounds per acre; or 72% emulsion, 1 1/4 gallons per acre; or 5% dust, 200 pounds per acre), aldrin or heptachlor (25% wettable, 20 pounds; or 23% emulsion, 2 1/4 gallons; or 5% granules, 100 pounds per acre) can be used. Rototill the soil surface 4 inches deep following the insecticide application. When already established plantation has to be treated, apply only one-third of the chemical in a band 2 feet wide between the rows of trees, where rows are 6 feet apart.

2. Root weevils (Curculionidae). Damage to rootlets and bark of larger roots on conifers similar to that done by white grubs can be caused by strawberry root weevil. Other species of this family may also injure the

root collar, the stem at ground level. In the latter case, blackened pitch can be found around the root collar. The white curved, legless grubs measure 1/5 inch when full grown and can be found around the roots until midsummer.

Control: Measures are similar to those used for white grubs. For the control of pine root collar weevil, apply enough spray to thoroughly wet the tree's root collar and to soak the soil.

BARK BEETLES (family: Scolytidae)

1. Bark beetles (Pseudohylesinus nebulosus, Scolytus unispinosus). These small 1/8 inch dark brown bark beetles often invade and kill young Douglas-fir trees that have been seriously weakened by some other causes like diseases, drought, mechanical injury, high water table, compact soil, etc. The beetles enter the stem through a small hole and mine the cambium and girdle the tree. Fine, reddish-brown boring dust can be seen near the entry holes. Trees successfully invaded soon dry, and the tree crown turns red during summer or early fall. Once the beetles enter the bark, there is no way to save the trees.

Prevention: To prevent tree killing, the causes responsible for weakening the condition of the tree have to be known and removed. Temporary protection of weakened trees from these beetles can be achieved by spraying residual insecticides on the tree stem before the beetle's flight, i.e. late March or during April, depending on temperature. Lindane in 0.5% solution or 2% water emulsion of DDT can be used, and the stems should be sprayed to run-off condition. Spraying of needles should be avoided.

2. Twig beetles and weevils. Various genera of very small scolytid beetles (Pityophthorus, Carphoborus, Pityogenes, Orthotomicus, etc.) and weevils (Cylindrocopturus) frequently cause the death of twigs, limbs, and terminals of various conifers. They work under the bark or in the pith. Reddish boring dust at the tiny entry hole is evidence of their attack. Later in the season the branches turn red.

Control: When serious twig killing in a plantation is evident, pruning the infested twigs and burning while the brood is still in the twigs or spraying with DDT (2% emulsion) will be of benefit.

APHIDS AND SCALE INSECTS

1. Aphids are small soft bodied insects. Usually, there are several generations per year; some are winged, others are wingless. Aphids suck the sap from bark on branches and needles of Christmas trees. Any coniferous species may be affected. The feeding causes drooping or discoloration of needles, galls on twigs, or swelling. Honey dew is usually present on aphid-infested trees.

Control: Apply spray as soon as aphids are seen, usually in April or May. Use malathion (50% emulsion, 1 1/2 pints per 100 gallons of water; or 25% wettable powder, 3 pounds per 100 gallons of water), or nicotine sulfate and oil (one pint of nicotine sulfate 40% liquid and 1/2 gallon of summer oil per 100 gallons of water). Repeat treatment as needed (usually at 10-day intervals).

2. Wooly aphids belonging to the genus Pineus attack various species of pines, whereas those belonging to genus Adelges infest spruces, true firs, and Douglas-firs. The species on Douglas-fir, the so-called Cooley spruce gall aphid, needs two hosts to complete the life cycle: spruce on which it produces cone-like galls at the tip of new twigs, and the Douglas-fir on which it feeds on needles and causes dropping and discoloration of the needles. The woolly aphids on true firs cause "gouts" or swellings of reproductive buds which prevent formation of new shoots and needles. They also devitalize or kill true firs by feeding on the bark of stems and twigs. Woolly material like whitewash on the stem is evidence of their presence. Woolly aphids on pines (Genus Pineus) produce similar woolly material but no "gouts" or swelling on terminals.

Control: Spray trees in April or early May (at lower elevations in March) with malathion or with nicotine sulfate and oil as mentioned in the control for aphids. If practical, remove and destroy the galls on spruces before they open in June or July. If protection of Douglas-firs is sought, avoid planting of common blue, Colorado blue, Sitka, or Engelmann spruce in the vicinity of the Douglas-fir plantation.

3. Scale insects may infest white, red, Austrian, Scotch, and mugho pines; spruce is also affected when numerous, and the small (about 1/9 inch long), elongated, white scales whiten the needles. The scale sucks needle juices. Infested needles may discolor and eventually drop from the tree thus reducing the full foliage considerably.

Control: Spray when the crawlers are present in May and again in July. Use DDT (25% emulsion, 3 quarts per 100 gallons of water; or 50% wettable powder, 3 pounds per 100 gallons of water in knapsack sprayers), or malathion in formulations as mentioned for control of aphids. At least two treatments 10 days apart are needed for each brood.

DEFOLIATORS AND SHOOT INSECTS

1. Defoliators. (Spruce and pine budworms, sawflies, white pine butterfly, halisidota, etc.) Larvae of various species of moths and sawflies feed on the needles of conifers. When numerous, they strip the needles, often killing individual branches or entire trees. Some, like sawfly larvae, feed gregariously or in groups, whereas others, particularly moth larvae when full grown, feed singly. Certain species construct unsightly tents from webbing on branches, as for instance, silver-spotted halisidota.

Control: When control is necessary, spray while the caterpillars are still small. Delay of spraying can result in severely defoliated trees. DDT (50% wettable, 3 pounds per 100 gallons of water; or 25% emulsion, 3 quarts per 100 gallons of water) can be used against all of the defoliating caterpillars.

2. Shoot moths. (European pine shoot moth and other pine moths.) The caterpillars of shoot moths feed on various species of pine and damage needles, buds, and shoots. Deformation of the tree by stunting the twigs is the result of their work. Shoots tunneled in spring turn yellow in summer and die.

Control: As the young larvae enter the needles of the young bud and only leave it for a brief period in order to enter other uninjured shoots, the timing of insecticide application is of great importance. Consult your county agent about the timing. DDT (25% emulsion, 1 gallon per 100 gallons of water) should be used.

MITES

Mites damage conifers by piercing the needles and sucking the plant juices and thus reducing tree vigor. The effect of their feeding on Christmas trees is more pronounced during a prolonged drought, particularly on sandy soil. Close examination of mite-infested needles shows small whitish or brownish spots. The trees damaged by mites turn yellow in color.

Control: Spray when the first sign of mite damage appears on the tree, usually during summer. Use Aramite (15% wettable powder, 2 pounds per 100 gallons of water), or malathion (50% emulsion, 1 1/2 pints per 100 gallons of water; or 25% wettable, 3 pounds per 100 gallons of water).

If a smaller amount than 100 gallons of spray is required, reduce the proportion of insecticide accordingly.