HAZARDS TO SEEDLINGS IN NURSERIES

by

Wm. M. Riggs

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Successful nursery practice demands fully stocked seed beds and transplant beds. Some losses due to the elimination of weak individuals should be expected in the seed beds after germination. When fresh seed of high quality is sown, such losses are ordinarily low. Losses should also be expected in the transplant beds. These minor losses due to various causes are of little moment and can be provided for in seeding. However, special treatment is sometimes desirable as a precaution against occasional epidemics that cause heavy losses. Excessive losses are liable to occur in any nursery where provision is not made for eliminating the cause or for checking the damage as soon as the damage begins.

In this paper I have set forth some of the main hazards to seedlings in nurseries in some of the major regions of the United States. The regions here discussed include the Southern pine region, the Idaho and Montana region, the Northwest region, and the Northeast and Lake states region.

It should be noted that no attempt has been made to present all the dangers that arise in each of the regions, or all in any one of them. On the other hand, they have been more closely dealt with in one, the Southern pine region, with the idea of drawing somewhat of a comparison of the regions, indicating in some cases the difference in the treatments, or perhaps in others to set forth an entirely different danger to be met.
THE SOUTHERN PINE REGION

Destruction by Birds

Before any seed is sown, especially in small nurseries, some provision must be for protection from birds; a flock of blackbirds, larks, ricebirds, or doves, or even a few domestic pigeons can do tremendous damage the first time they discover the beds. In small nurseries it is nearly always necessary to protect the seed beds from birds and mice by fences of half inch or smaller wire mesh with covers of the same wire on top. The wire should run at least 6 inches into the ground and extend 12 inches above on a framework of sticks and light wood rails. The top covers should be in the form of removable screens small enough for one man to handle easily; 4 by 6 feet is a good size.

Birds are among the greatest destructive agencies, particularly to longleaf pine and on areas near the gathering points of migrating flocks. A large flock can practically ruin a small nursery in the early morning hours of a single day. According to reports from a dozen nurseries, the most injurious species are, in order, doves, meadow larks, bobolinks, domestic pigeons, and cardinals. Other species may exceed these in destructiveness is some areas. Bird screens made of small chicken wire on light frames are effective, but are expensive to build and handle and do not last long. The use of screens is not generally recommended. If bird damage is known to be only moderate in quantity, the seed bed covers used during germination can frequently be depended upon for protection. Burlap cover is better than pine straw in this respect. If
the birds are very numerous, the most satisfactory protective measure is to employ reliable laborers to patrol the beds with sling shots, air rifles, or shotguns, from just before dawn until just after dark. Damage from birds ceases just after the cotyledons are free from the seed-coats; therefore two months is the longest period during which a patrol is likely to be necessary. Care must be taken to avoid coming into conflict with the Federal Migratory Bird Treaty Act and with State laws, which protect many bird species that commonly injure seedlings. In a few instances it has proved effective to feed the birds oats or cracked grain at one side of the nursery. Coating pine seed with red lead or other repellents seems to have no effect in the South, and scarecrows and similar devices have proved useless. In some instances doves have been poisoned where it is not against the law to do so.

The following formula was used:

20 pounds of wheat  
1 qt. of water  
3⁄4 cup of gloss or laundry starch  
1 oz. of strychnia sulphate (pulverized)  
1 scant teaspoonful of saccharine

In mixing this preparation the strychnia and saccharine are dissolved in the water boiling after which the starch, previously softened in cold water, is stirred in the boiling, continuing until after the solution thickens. This solution is mixed with grain until the grains are coated.
PARASITIC DISEASES

Various diseases due to parasitic fungi may cause more or less serious damage in forest nurseries. The most serious of these are damping-off, stem and twig diseases, leaf diseases, and root rots.

Damping-off

Damping-off is caused by species of Pythium, Rhizoctonia, Fusarium, and Corticium. This disease is neither so general in occurrence nor so persistent in the South as in the North and West. This may result from the greater acidity of the southern nursery soils, as most of the fungi causing the disease prefer neutral or even slightly alkaline soils, or it may be from the greater resistance and more rapid initial growth of southern pine seedlings.

In its most typical form the damping-off occurs in seedlings in the cotyledon stage and causes the roots to die and turn watery brown and the stems to topple over and become so limp that they drop into any depressions in the soil surface. Freshly germinated longleaf pine seedlings, having stems too short to topple over easily, when attacked by the damping-off fungi, often flatten out on the ground like little rimless wheels. In its more obscure form, damping-off occurs in germinating seed before the seedlings appear above the surface of the soil and often remains a good deal of a mystery to the nurseryman. This phase of the disease may account for the lack of success in beds and of germinating tests in which the seed are covered with soil more than 1/4 inch deep. An
infrequent form called "top damping-off" occurs in the tops of seedlings as late as May of June.

Factors contributing to damping-off are overcrowding, poor drainage, too much rainfall or artificial watering, the addition of too much organic matter or of lime or wood ashes to the soil, and too much shade. The infrequent top damping-off can be controlled by providing ventilation; thinning may be needed in extremely dense stands. The so-called "late damping-off", really a root rot caused by damping-off fungi after the stems are too stiff to fall over, has not been observed in the South. To protect sprouting seed and very young seedlings from the usual type of damping-off, acid treatment, either with sulphuric acid or the more convenient aluminum sulphate, is the most generally successful. At nurseries where damping-off is feared, and where soil acidity is considerably less than that represented by pH 5, such treatment should be tested on a small scale. Either material may be applied to the beds just after they have been sown and covered; the amount to use per square foot varies from one-eighth to three-eights fluid ounces for sulphuric acid, and one forth to 1 ounce for aluminum sulphate, the largest amounts being used or tolerated only on heavy or alkaline soils. For such surface treatment the materials should be dissolved in water at the rate of one or two pints per square foot (the smaller amount only if the soil is already moist), and the beds should be properly sprinkled.

Modifications of the acid type of treatment are now being made, and the most recent information can be secured from the
Division of Forest Pathology, Bureau of Plant Industry, at Washington. Because different types of soil differ in their requirements and tolerance for acid treatment, they should not be used on large scale until after small scale local tests.

Where it is very essential to insure against first year seedling production on an untried nursery area, the formaldehyde treatment may be used without previous trial. The treatment is applied at the rate of two-thirds fluid ounce to the strongest (37%) liquid formaldehyde per square foot per bed, dissolved in approximately 2 pints of water per square foot. The beds must be exposed to evaporation for a week, or if the weather is cold, for two weeks before the seed is sown. The soil should not be turned over deeply after treatment; no soil cover other than treated soil, or clean river or subsoil sand, should be used on the treated beds. The treatment is more expensive, and usually less effective than against disease or weeds, than a proper strength acid treatment, but can be counted on to be of some value on almost any soil type.

In New York, the following method has been used with success; when the seed are down, dig a deep hole to the side of the bed and use the sub-soil from it to cover the seedlings. This is probably the most practicable method.

Another still more expensive method, but usually safe one, is that of steaming. The Maryland State Department of Forestry has successfully controlled damping-off fungus and greatly reduced weeds in the beds of loblolly pine and other
species by a modification of this method in which a 4 by 12 inverted pan supplied with a small portable steam boiler is left in place thirty minutes, with steam at 40 to 50 pounds per square inch, heating the soil at a depth of 4 inches to a temperature of from 160 to 180 degrees F. Loblolly pine has grown better in beds steam- ed by this method than in adjacent unsteamed beds. Scheffer has found it effective to use very low pressure steam for the same purpose, and describes the procedure in some detail.

PARASITIC DISEASES OF OLDER STOCK

Fungi

The only serious disease of nursery stock so far encountered on southern pines is the brown spot needle blight, caused by Septoria acicola. This is primarily a disease of longleaf pine seedlings. It occurs also on slash pine, particularly in nurseries that lie outside of the natural range of the species or that are subjected to extreme drought. The first symptom is the forming of small spots on the foliage. These spots soon develop into narrow brown bands, with definite margins, encircling the needles. The first signs of the disease are likely to appear in July or August, but infection may take place even in mid-winter. Nurseries far removed from any infected stands of longleaf pine seldom or never suffer seriously from brown spot. Infection is often heavy in nurseries in the immediate vicinity of infected young longleaf, and may take place very
suddenly when weather conditions become favorable. A
detailed study by Verrall of spore production and dissemination
during a period of nearly six months has indicated that
slight infection takes place at considerable distances
through the medium of wind blown spores but that serious
infection in traceable in spores producing in fruiting
bodies during prolonged warm rains and carried only as
far as they can be pattered by the rain.

Control of brown spot is simple, certain, and in-
expensive. The infection is checked immediately by spray-
ing bordeaux mixture, lime-sulphur, or zinc-sulphate-lime
mixture with casein or fish oil as a spreader. Reinfection
necessitates fresh sprayings, but there is no excuse for
letting brown spot make any serious inroads in the nursery.

F. H. Claridge reports that in the state nursery
near Raleigh, N. C., 2 year seedlings are heavily infected
with brown spot, but that 1 year seedlings, the class of
stock most commonly produced, are very lightly infected.

NON-PARASITIC DISEASES AND INJURIES

Drought Injury

Drought injury, or sun-scorch, as it is sometimes
called, is due to a lack of balance between water absorption by the roots and transpiration from the foliage during the growing season. It is most likely to occur in dense stands of 2-year seedlings in midsummer when the ground is the driest and the loss of moisture through transpiration is the greatest. In serious summer cases of sun-scorch the trees are killed outright, usually in large patches through the middle of the beds. In less serious cases, only the terminal bud and the leaves are affected. The leaves rapidly lose their green color, become straw-colored and finally a deep brown. Drought injury is sometimes very harmful in transplant beds of conifers after they have begun their growth. Extreme damage from drought takes the form of heavy mortality through the seed beds. Under milder drought conditions, conspicuous mortality is confined to soils less retentive of moisture. Even moderate drought may cause considerable losses by gradually killing a few trees here and there.

Failure of the seedlings to make sufficient growth during the summer is another serious after effect of drought. This may make the stock partly or wholly unsuited for planting, and thus not only result in waste of much of the money and effort spent on a nursery during the summer but delay seriously an entire planting program.

Visible drying of the surface soil to depths exceeding one inch, particularly in the centers of the beds, is a sign of serious danger. When seedlings are very young they sometimes show signs of needing water by temporary wilting.
At a later stage they do not wilt visibly even when about to die from the drought.

Aside from direct watering and the use of shade, means of forestalling drought killing are reducing beds to the level of the paths, terracing to prevent run-off of rain water, increasing the organic content of the soil, adding loam of clay if the soil is very sandy, and growing the seeds at relatively low density.

An after effect of drought that often gives the nurseryman warning to change his practice, the following year, is 'troughing' of the seed beds, or markedly inferior development of the seedlings in the center of the bed as compared with those along the sides. The inequality in growth results usually from the fact that the border seedlings can draw on otherwise unused water in the soil included in the paths, in which case the nurseryman should provide more water for the beds and should decrease the seedling density unless it is already very low. Troughing may be caused also by impoverishing of the soil.

**Winter-Killing**

Winter-killing is generally understood to mean the death of the seedlings as a result of drying when the soil and roots are so frozen that the amount of water given off from the leaves cannot be replaced to a sufficient extent by absorption from the soil. In this way, its cause is fundamentally the same as that of sun-scorch, the difference being that it occurs while the soil is frozen.
Alternate freezing and thawing is considered important in bringing about the damage. This may be due to the increasing loss of water from the needles during warm periods that do not last long enough to thaw out the soil materially. In the West, the warm winds known as "chinooks" produce such sudden very warm periods in the midst of the coldest weather that not only small plants but even the largest forest trees are killed. The formation of ice crystals in the tissues of the younger plants at the close of the thaws may also be concerned with the cause of the injury. Trees affected by winter-killing in the nursery look much like trees killed or affected with sun-scorch. Winter-killing may be distinguished from other types of blight by paying attention to attendant circumstances. The most damage may be looked for during the hardest winters or winters with little snow. It is likely to be the worst where the beds are the least protected by windbreaks or by mulch and in the least resistant species.

Winter-killing and sun-scorch work differently in that winter-killing is worse in the open stands, while the case of sun-scorch is reversed. This may be explained not only on the ground that the closely grown trees protect each other from drying winds, but also, as pointed out by Forest Supervisor Elers Koch, act as mulch, protecting the soil from deep freezing.

The ordinary measures for preventing winter-killing are to protect the beds as thoroughly as possible by windbreaks and to mulch the beds with straw. Mulching must be
done cautiously. It is likely, especially if heavy or close, to result in mulch injury, and do more harm than good. Mulch injury is entirely different from winter-killing.

Heaving is also distinct from winter-killing. The roots of nursery stock in heavy soils are sometimes lifted partly or entirely out of the ground by the action of alternate freezing and thawing. Both plants and surface soil are raised by the expansion of the soil in freezing. In thawing the soil settles back gradually around the roots, which are left higher than they were previously. The process is entirely mechanical. Like winter-killing, heaving can be prevented by mulch.

**Frost Injury**

Frost injury differs from winter-killing in that it is due to the formation of ice crystals on unripened tissues, while winter-killing is due probable to drying out, as above described. In addition to injury in unripened tissue above ground from early frosts, it is possible that early freezing of the soil injures by killing roots which have not yet stopped growing. According to Hartig, trees with injured roots are likely to start growth the following spring before showing effects and then turn brown rather suddenly. Very late spring seed sowing and encouraging the growth of stock toward the end of the season should be avoided, in order to get the tissues to properly ripen up and able to endure freezing. Covering the beds with a mulch before the first heavy freeze should prevent injury, though very much mulch-
ing should be avoided.

Death from late frosts in the spring are rather frequent. Jack pine, because of its tendency to start growth very early in the spring, frequently loses its terminal buds and shoots as a result of severe frosts after growth has begun, although these young, tender shoots are capable of standing temperature considerably below freezing without injury.

Insect Injury

Insects injurious to young southern pines may be grouped into three main classes. The first includes chewing and biting insects that feed on the external surface of the plants. Many insects of this class, such as the sawfly larvae and the adults of certain beetles, succumb readily to stomach poisons, such as arsenate of lead applied to the plant. The second class includes sucking insects, such as aphids and scales, living on exposed surfaces of the plants but getting their food by thrusting slender mouth parts through the epidermis of the plant and sucking the inner juice. Insects feeding in this way are unaffected by stomach poisons on the outside of the plant and can be controlled only by applying contact insecticides, such as nicotine sulphate and oil emulsions to the insects themselves. The third class includes insects of several types that work under ground or burrow into the tissues of the plant, out of reach of the ordinary sprays. Examples are the adults and larvae of the bark beetles, the larvae of the pine tip moths, leaf miners of all kinds, and white
grubs (May beetle larvae) working under ground. In many
instances the control of many insects of this third class
can be affected only indirectly, as by various cultural meth-
ods or is entirely undeveloped.

Among the most persistent and most destructive nursery
pests, and likewise among the most difficult to control, are
the larvae of June bugs or May beetles (Phyllophaga spp.),
commonly referred to by nurserymen as grubworms or white
grubs. The exact life histories of the southern varieties
of these pests are not known in every instance. In some
regions it appears that the eggs are laid in the spring and
the larvae which hatch from them feed on dead vegetable
matter in the soil until the following winter. In such
cases the larvae are small the first year of their exist-
ence, and comparatively or entirely harmless to pine seed-
lings. Recent studies in the Bureau of Entomology and
Plant Quarantine, indicate that in the South the larvae do
not feed on vegetable matter the entire season, but become
a menace to the younger pine seedlings. They feed through-
out the summer and late into the fall, usually doing the
most conspicuous damage during the hot summer months.
Working singly or in groups or working back and forth is
small tunnels, they cut off the seedling roots from one to
ten inches below the ground. The seedlings die in small
patches, which increase in size and irregularity as the
grub works outward from its starting point. Typical white
grub injury is easily recognized by the color of the dying
foliage, which changes from a faded green to brown, and
often by the patchy occurrence of the damage. The injured seedlings are easy to pull up, and show a characteristic pruning of the roots. If the roots are cut off 6 to 8 inches below the surface of the ground, they often heal over, and in that case the seedlings may recover and develop into satisfactory planting stock. Roots cut off 2 to 3 inches below the ground may begin to heal, but with the first water shortage the small quantity of moisture supplied by the reduced root system is exhausted and the seedlings die. Digging in the patches of injured or dead seedlings usually reveals one or more of the grubs. In general they are white in color, with hard brown heads and almost transparent abdomens, and bend double when disturbed. In addition to the white grubs there may be present other forms which resemble these very closely, but which are not injurious. This is apt to be the case where compost has been applied to the soil. Information on methods of distinguishing these forms is obtainable from the Bureau of Entomology and Plant Quarantine.

It is rare for a nursery to be entirely free from white grubs. Even a light infestation may result in a steady drain on the nursery throughout the season, and a loss of 10 to 25% of the plants. When a heavy flight of adults has been followed by two seasons of weather favorable to the development of grubs, the grubs have destroyed as much as 60% of all the stock in the nursery.

No thoroughly satisfactory control for grubs has been demonstrated in the southern pine region. Control by direct or cultural methods should be applied whenever practical. These methods include locating the nursery as far as possible from pecan groves and hardwood stands and even from
longleaf pines, on which the adults feed; keeping paths, beds, and fallow areas as free as possible from vegetation during the flight of the adults during the spring, and to make the ground less attractive for egg laying; practicing a rotation of crops; turning hogs or chickens into the nursery after the old stock has been lifted and before the new stock has been sown, especially during plowing; and killing all white grubs found in any stage of cultivation, weeding and lifting. More direct methods of control include the application of poison, both when the beds are made up and when damage becomes conspicuous. In the North and East and Australia the application of 80 pounds of white arsenic (arsenic trioxide) per acre, in mixture with enough sand to make spreading easy, gave good control. Use of white arsenic in this manner in midsummer, following by thoroughly wetting to wash the poison well into the soil, gave partial control in a nursery in Texas even after damage has become severe. A systematic trial of this method by the Southern Forest Experiment Station at Bagalusa, La. failed entirely. The Bureau of Entomology and Plant Quarantine reports it ineffective in Nebraska and South Carolina, and, on the basis of recent investigations, warns against its use in certain light, sandy, coastal plain soils until more is known about them lest serious damage to seedlings result and the site be rendered unproductive for a number of years.

Ordinarily less serious than white grubs, but occasionally more dangerous to an individual nursery or a block of stock, are cutworms. The different species appear and attack suddenly at various times of the year. The worst attacks
on record have occurred in midsummer. In one longleaf pine nursery more than a million seedlings were killed in approximately one week.

If discovered when they first begin working, cutworms are easy to control. A recommended method of control, as stated earlier, is to prepare a bran bait according to the formulae given, and scatter it about the nursery about sundown. The poison should be kept on hand at all times for emergency.

The formula:

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Amount</th>
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</thead>
<tbody>
<tr>
<td>Wheat bran</td>
<td>50 lbs</td>
</tr>
<tr>
<td>Paris green and crude arsenic</td>
<td>2 lbs</td>
</tr>
<tr>
<td>Black strap molasses</td>
<td>2 qts</td>
</tr>
<tr>
<td>Water</td>
<td>1 or more gal</td>
</tr>
</tbody>
</table>

Mix the dry ingredients very thoroughly. Mix the water and syrup (if syrup is used), and add slowly to the dry ingredients until the bait is just moist enough to fall, when scattered in lumps about the size of wheat grains. The bait seems to work better if allowed to stand a few hours before being scattered. It is well to scatter the bait late in the evening so that it will remain moist until the worms, which usually feed late at night, have had a chance to eat it. Use 10 to 15 pounds of bait per acre of nursery.

Scale insects of the genus Toumeyella are another group of dangerous nursery pests. These are plump, grayish brown scales, the diameter of which varies from that of small pencil lead to that of BB shot or a little larger. Frequently their presence is noted by a sooty coat on the needles and stems of infested seedlings. This coating is a harmless mold that grows on the honey dew exuded from the insects. The seasonal life history of the insects is not well known, but the rate of seedling development tends to confine their attacks to the middle or latter part of the summer. Scale insects of the genus Toumeyella have been reported most common-
ly on slash and loblolly pines. So far as is known, they do not attack longleaf pine seedlings in the nursery, although they have been found on the needles of naturally produced longleaf pine 3 or 4 feet high.

Prompt application of miscible oil is effective in controlling scale.

A pest somewhat less serious than scale insects is the mite Tetranychus telarius L., the common red spider. Particularly during the hot summer, this pest attacks pine seedlings and causes them to stop growing and turn yellow. The mites can hardly be seen without the use of a magnifying glass. As adults, they migrate by crawling rapidly. They spend the winter on the leaves of the common violet and evergreen plants.

In locations where red spiders are abundant on agricultural crops, special care should be taken to keep the surroundings of the nursery as free as possible from plants with heavy foliage that remain green all the year round. Red spiders are easily controlled by the use of Bordeaux mixture, nicotine sulphate, one of the oil emulsions recommended in the foregoing for controlling scale, or dry sulphur. Either spraying or dusting should be repeated after an interval of ten days or two weeks. The spray should be very fine and penetrating.

A conspicuous nursery pest, potentially serious, but very easy to cope with, is the larva of LeConte's sawfly (Neodiprion lecontei Fitch). Other sawfly larvae attack southern pine seedlings, but less frequently. Sawflies
resemble very closely the caterpillars of butterflies and moths, but differ from them in having 8 instead of 10 pairs of false legs (stubby, fleshy, unjointed appendages on the rear two-thirds of the body). They have a striking habit of rearing back when startled, from the leaves on which they are feeding. Usually they feed in groups. Their bodies are green or yellowish, usually with rows of black dots along the sides, and their heads mahogany colored, brownish or blackish. Like many other leaf chewing insects, they are easily killed by means of lead arsenate or other arsenical sprays.

Other Nursery Pests

Seedlings on very sandy soil, particularly on soil previously used for agricultural crops, sometimes become infested with nematodes. These cause knots on the roots and check growth almost entirely, soon causing an unhealthy appearance and causing heavy mortality. It is a bad practice to plant trees known to be the hosts of root knots or other nematodes on land infested with these pests. Species or varieties known to be immune to these pests should be planted exclusively, or the land should be first cleaned of the pests.

Salamanders, pocket gophers of the genus Goemys, tunnel and burrow through nurseries on sandy soils, throwing little mounds of earth up and destroying many seedlings by eating the roots. They are readily controlled by trapping with any of the several kinds of burrow traps on the market, or by placing poison bait in the burrows.
Destruction by Birds

All birds migrate more or less and are therefore liable to change habits from season to season and from year to year, depending on the available food supply. The past few years flocks of mourning doves have visited the Pocatello and Uinta nurseries early in the spring and have threatened to do considerable damage to the yellow pine beds by picking off the tops of the newly germinated trees, by scratching and dusting in the loose soil, and by stepping on the brittle plants and breaking them off. At the Pocatello nursery several hundred doves were poisoned in one spring through the use of the following formula:

20 pounds of wheat
1 quart of water
1/2 cup of gloss or laundry starch
1 ounce of strychnia sulphate (pulverized)
1 scant teaspoonful of saccharine

Bluejays and flocks of smaller birds of various kinds have visited the seed beds at the Wasach nursery early in the spring and have done considerable damage by picking off the tops of small trees and by scratching in the drills while germination is in progress. Although shooting has given good results, it is believed that poisoning here would give the best results.

Most of the species of birds that feed on the seed of the newly sown beds are protected by law. Measures must be taken to protect the beds in this case rather than get rid of the pilferers. Screen frames are efficient and
practical in small nurseries, but for larger nurseries, the
depreciation on the amount invested in screen frames may be
far greater than the cost of hiring boys to scare away the
birds. Shooting blank cartridges and pounding on tin cans
will frighten away the birds—only momentarily, however;
so the noise making must be repeated at frequent intervals.

PARASITIC DISEASES

Damping-off

The stock at Savenac nursery has been infected with
damping-off fungus at times over a period of over 15 years,
but its occurrence has been so infrequent that the cost of
disinfecting the seed beds after each sowing is not warranted.
The treatment has been used at Savenac nursery on only a few
occasions, and undoubtedly has been beneficial, but the
degree of benefit was uncertain because, unfortunately, no
controls were installed. The disinfectant used at Savenac
nursery, which is the one commonly used in coniferous nur-
series, is a solution of three-sixteenths of a fluid ounce
of commercial sulphuric acid and three-sixteenths of a gallon
of water, applied to a square foot of seed bed within 24
hours of sowing. Within 2 days after the application, the
seed beds are thoroughly sprinkled, to wash the disinfect-
ant well into the soil.

The same solution has proved injurious to seedlings at
Savenac nursery when applied after germination. A weaker
solution had no noticeable effect in checking the disease
when applied after the seeds have started to germinate.
PARASITIC DISEASES OF OLDER NURSERY STOCK

White Pine Blister Rust

White pine blister rust has been found in the Northwest. Work is under way to eradicate all species of the alternate hosts of the genus Ribes, within a mile of the nursery. If this mile wide safety zone can be kept free of the alternate hosts, it appears from the studies carried on by the office of blister rust control of the Bureau of Plant Industry that the distance is too great for the spores of other Ribes to be carried to the white pines in the nurseries.

Yellow Pine Blister Rust

A yellow pine blister rust by the name of Peridermium filamentosum has been identified at the Savanac nursery, but it has never occurred in enough quantity to cause appreciable damage, despite the fact that complete eradication of the alternate host, Indian paint brush, was never carried out.

NON-PARASITIC DISEASES AND INJURIES

Sun Scorch

Sun scorch is in reality a drought injury. The damage is often patchy, but more often affects individuals scattered through the beds. The plants so affected are the weaklings of the stand, having poor root absorptive powers in proportion to the transpiring tops. The spindly, suppressed seedlings in dense patches fall victim to the first drying out of the soil. Gravel pockets in the seed beds dry out
more quickly than the surrounding denser soils, and on these the seedlings often succumb when the soil is only slightly dry.

The needles of the affected seedlings first bleach to a pale, lifeless green, and then dry out and turn straw color. The bleaching of the needles is the first sign of the wilting in conifers, but even at this early warning, the plant is beyond recovery.

Sun scorch is less common in transplants. The trees that are transplanted have been more or less selected by surviving drought conditions in the seed beds and by being passed in the culling at the transplanting. The loss occurring the first few months after transplanting, called transplant loss, is sometimes attributed entirely to sun scorch, but ordinarily is due to mechanical injuries as well.

Unlike the seed bed stock, the transplant stock may recover after the needles begin to bleach. The cause of their bleaching is slightly different from drought. When the transplants are placed in a dry trench the soil absorbs the moisture quickly from the plants until an equilibrium is reached. This is called plasmolysis. As soon as more moisture is added to the soil by watering, the plant retrieves its lost moisture and revives.

Shading is often applied to reduce the loss from sun scorch. This practice is not recommended because in order to save the weaklings that would better be dropped at the start, the stronger seedlings are subjected to conditions that tend to weaken them. Frequently light watering and having plants of a predetermined satisfactory density
spaced uniformly are the best means of reducing loss from sun scorch.

**Winter-Killing**

Transpiration during warm days in midwinter when the tops of the trees are exposed and the root systems are in the frozen ground, and therefore unable to supply soil moisture to the transpiring tops, may cause death. The needles of the trees so affected turn a copper color. This color has led to the term "red belt", which is synonymous to winter-killing. Needles under the snow cannot transpire; consequently larger stock may suffer in some years when young trees, under a protective covering of snow, are not injured at all. Conifers may lose all their needles from winter-killing and provided their buds are not injured, may entirely recover. Non-indigenous trees of the region, if from warmer climates, are subject to winter-killing more than native trees.

Mulch may be placed on the stock to prevent it from winter-killing. However, if deep snow is anticipated, it is advisable to depend on only the snow for protection from winter-killing, with native stock in the nursery. More sensitive plants should be mulched.

**Frost Nipping**

Frost nipping occurs in the fall or early spring when the stock has either continued growth up until the time of heavy frost or commenced spring growth and then encountered a heavy frost. In such instances of fast growing,
succulent parts of the plant are frozen, causing the water in the plants to crystalize and explode the cells. Precautioning to prevent this damage in the fall is called "hardening off". Ordinarily the measure consists of reducing artificial watering several weeks or a month before heavy frosts can be expected. The danger of light frost nipping, especially in the spring, may be overcome by placing shade frames over the stock. The frames slightly retard spring growth.

Frost nipping kills back new growth and results in deforming tops, but rarely kills the plants.

**Insect Injury**

Frequently cutworms migrate to the nursery beds from the weedy patches and grasslands and meadows adjoining the nursery, and for this reason the nursery should be located, if possible, some distance from such places. At Savenac nursery a ditch plowed under the seed bed compartments has been effective in stopping such migrations. Where water can be kept in such a ditch, worms do not cross.

Once the cutworms get into the beds they feed on the tender shoots of the newly germinated seedlings, cutting them off at, or just below the surface. Unless the beds are closely watched the damage may continue for a long time without being noticed. The cutworms do most of their feeding at night and burrow into the soil an inch or two during the day. If the small area where they are located is known, they may be dug up during the day by raking the top inch or
two of the soil off with the fingers. For the species that come above the ground to feed, a very effective control has been developed in the form of the following poison bait. Wheat bran, 25 pounds; Prairie green or crude arsenic, 1 pound; black strap molasses, 2 quarts; water, 15 to 20 quarts. Thoroughly mix the poison with the bran; this is important. Mix the syrup with the water, and add this solution, a small quantity at a time, to the mixture of bran and poison, stirring all the time. This bait, when scattered thinly over the infested area at the rate of about ten pounds of wet bait per acre, often secures complete control in one night. Sometimes it may require two or three applications at two day intervals to rid the nursery entirely of the pest.

**White Grubs**

White grubs are not important in this region; they may be controlled by plowing the ground for two years before using it for seed beds or transplants.

**Rodents**

Pocket gophers may damage the beds slightly by excavating the loose soil. They can be controlled by the use of the regular gopher traps or through the use of poison. Jumping mice, white-footed mice and white-bellied chip-munks are by far the most destructive of all the animals found in the neighborhood of the nurseries as they are especially fond of each kind of seed used, showing a preference for the larger seeded species. These animals have usually appeared in the nurseries immediately after sowing
and continued until after the seed was up. In case of complete germination there is, therefore, a period of from three to four weeks when the seeds must be closely guarded and measures adopted to prevent serious damage. In case of complete germination the damage may continue for the greater part of the summer and the trees already sprouted may be destroyed in an effort to get the vital seed remaining. Mice are strictly nocturnal in their habits, but the work can be detected in the morning by the fresh digging of the beds and by the seed hulls left. Chipmonks only work in the daytime. Their work is very similar to that of mice except that a portion of the seed is usually carried off.

At the Pocatello nursery rodents have been excluded from the lath houses by inclosing them with closely woven wire screens about two feet wide and partially embedded in the soil. Screening may be advisable in the small nurseries, but in large nurseries it is less satisfactory than other methods, like the destruction of animals. As a first measure, the nurseries and their surroundings should be kept in a neat and orderly condition. Brushy areas, stump and rock piles and other rubbish should not be found in the immediate neighborhood as such places harbor these animals. In destroying mice, drowning, trapping and poisoning have been tried. In drowning, small lard buckets and even tin cans have been used. They are buried even with the soil, filled one half to three-fourths full of water and a small quantity of seed is scattered into and
close to the vessels. They are placed along the paths at intervals along the seed beds. When the mice are plentiful, half a dozen have been caught in a bucket in a single night. Guillotine traps, baited with cheese and set here and there along the beds, also give excellent results. By a combination of these two methods 600 white-footed mice were destroyed at Wasatch nursery the first two seasons. Since then they have made very little trouble. It is estimated that chipmonsks destroyed from 15 to 20% of the seed sown in the Uinta nursery in the spring of one year alone. The above methods of trapping have not proved satisfactory with chipmonsks; approximately 300 were shot, but shooting is tedious and expensive and is liable to injure the beds. Both mice and chipmonsks and other rodents can be successfully poisoned with the following formula:

\[
\frac{1}{3} \text{ bushel of wheat} \\
1 \text{ pint of beef or mutton tallow} \\
1 \text{ oz. strychnine or strychnia sulphate} \\
1 \text{ teaspoonful of saccharine.}
\]

In preparing this mixture, the wheat is heated as much as possible without burning. The melted tallow is then poured upon the wheat and thoroughly mixed; the pulverized strychnine and saccharine are then added and the whole is again thoroughly mixed; both the wheat and tallow should be warm upon mixing and the poison and saccharine are stirred in from the top until each grain has become coated.

After rodents have once considerably reduced through one or several of the above methods, a family of house cats will prove valuable in keeping the nursery ridded.
THE NORTH WEST REGION

Destruction by Birds

As in other regions, there are many birds in this part of the country that are seed eaters. The species that do damage to the conifer seed beds are protected by law. Since this is true, other means than poisoning and shooting must be used to control bird damage. Covering the beds with screened frames is effective.

The three species of birds that do damage to the conifer beds are the junko or snow bird, toohee, and the song sparrow. All birds are encouraged to stay in or near the nursery, especially the insectivorous ones. The erection of bird houses in suitable places will help to achieve this result.

The most effective method of protecting the seed beds from birds is by covering them with wire netting. Watching the seed beds and driving off the birds as they appear can be economically practiced in larger nurseries and is often preferred to other methods. Screen frames are efficient and practicable for small nurseries, but for larger ones the cost of screen maintenance is far greater than the cost of hiring boys to scare away the birds.

PARASITIC DISEASES

Damping-off

Fungus diseases are usually the nurseryman's greatest enemies, especially to the coniferous seedlings. The best control method seems to be the chemical treatment. Many
Chemicals have been used experimentally. Some have controlled damping-off, while others have damaged the seedlings. Sulphuric acid has proved to be the most dependable chemical for this use. At most nurseries, if the minimum amount of acid is used to prevent damping-off, no fear need be given for seedling injury.

Slightly acid soil seems to be partly exempt from damping-off fungus. If this is true, the seed bed soils should not be treated with lime to counteract the acids in the soil. The large Forest Service nurseries, as Wind River and Savanac, use sulphuric acid to control damping-off. The Pennsylvania State Nurseries combat damping-off successfully by spraying the infected beds with Bordeaux mixture.

Damping-off has given very little trouble at Oregon Forest Nursery. All conifer seed, except the cedars, are treated with Bayer dip dust before planting. A teaspoonful of this fungicide is added to every quart of seed. If damping-off damage is discovered, the shade frames are removed at once and the beds are not watered until the top surface is dried just enough not to cause sun scorch. Drill sown beds are cultivated. Cultivation and sunshine are the deadly enemies of the damping-off fungus.

Top Fungus

A most peculiar enemy attacked a small percentage of western yellow pine and maritime pine seedlings in the fall of 1927. Due to it, the tops of the infected seedlings bent over and some died. The roots, however, were healthy
and a large lateral bud tended to take the place of the terminal one destroyed. Indications pointed to insect injury but research work by the Oregon State College Entomologists found no signs of insect punctures. The Botany department of the College could not detect any pathogene work.

New specimens were sent to the Bureau of Plant Industry at Washington, D. C. Mr. Carl Hartley, pathologist, concluded that it was the top fungus, Botrytis sclerotia, which did the damage. Causes of the fungus are due to warm humid weather in the late summer. Control measures were considered necessary if weather conditions favorable to the fungus continued. The shade frames were removed and the sprinkling discontinued. The infested seedlings were sprayed with a Bordeaux mixture(5-5-50) with plenty of spreader. The infected trees were destroyed when the disease occurred in definite patches.

**White Pine Blister Rust**

The blister rust pathogens have not been found in or near the nursery. Blister rust spores have been found on red flowering current in the Mary’s Peak region about thirty miles south-west of the Oregon Forest Nursery.

**NON-PARASITIC DISEASES AND INJURIES**

**Sun Scorch**

Very few cases have been observed in the Oregon Forest Nursery. However, when it does occur, it can be taken care of easily by watering the beds thoroughly during dry periods. If sun scorch is likely, the beds, soon after the damping-off period, should not be too dense, and it may be necessary
to shade the beds.

Winter-Killing

In some localities, young nursery trees are killed because on a warm winter day, transpiration in the tops is rapid, when the roots underground are frozen. The inactive roots are unable to supply moisture to the transpiring tops. This condition results in the death of thousands of small trees and sometimes even larger ones are killed. Many exotic species at the State Nursery have not lived through severe winters as during the year of 1929-30. The Eucalyptus species were all killed outright by sudden changes in weather. Part protection may be secured by mulching the trees with a covering of light straw, leaves or burlap. In regions where the snowfall is likely to be heavy, it will not be necessary to apply the mulch, as the heavy blanket of snow acts as a protection against drying winds.

Frost Heaving

Frost heaving has been noticed in this area quite a bit. Heaving takes place during freezing nights. During the following day, the sun melts the frozen ground, causing it to settle back in place. This process may happen several times causing the little seedlings to be lifted out of the ground. A light covering of straw, leaves, burlap, or excelsior prevents frost heaving.

Frost Nipping

Frost injury occurs when the stock continues growth during the early fall or when there is early spring growth. In some instances the fast growing, watery parts of the
plant are frozen, causing the water within the plant to crystalize and explode the plant cells. This damage may be prevented by not watering the young trees for several weeks to a month before frosts are expected. Early spring frost injury may be prevented by covering the young trees with shade frames. This shading helps to retard early growth.

Frost nipping seldom occurs in the nurseries at lower altitudes. The genera Eucalyptii, Sequoia, and many warm climate trees have been frozen back by frost injury. The injury generally kills back the new growth which results in deforming the trees but seldom kills them.

**Insect Damage**

Insect injury in this region, especially at the State Nursery, has been of very little importance. As conditions change, insect damages may be severe due to the growing of both hardwoods and conifers, where that is the case.

Evidences of cutworm work have been found at the Oregon Forest Nursery but the damage is not enough to warrant control. The cutworms of the larvae of the common "miller" have been known to do some damage. The larvae are a dirty, gray color. They are voracious feeders, usually feeding at night. A satisfactory control measure for the cutworm is the use of poison mash. The area should be treated just before it is planted and just before dark. The poisoning formula follows:

<table>
<thead>
<tr>
<th>Coarse bran</th>
<th>16 pounds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium fluoride</td>
<td>1 pound</td>
</tr>
<tr>
<td>Molasses</td>
<td>2 quarts</td>
</tr>
<tr>
<td>Water</td>
<td>2 gallons</td>
</tr>
</tbody>
</table>
Dissolve the fluoride in water, stir with molasses, and add the bran. Mix the crumbly mash and scatter.

White grubs have troubled the nurseries of the Northwest region to a certain extent. Control measures have been tried at different nurseries as follows: 1. Practice crop rotation at least two years before the area is planted back in trees. 2. Treat the land with carbon disulphide. 3. Apply three and one-half pounds of lead arsenate to one hundred square feet of ground, working the arsenate into the soil before planting the tree crop.

The elm leaf beetle (Galerucella luteola) second brood of adults was found infesting the (2-0) Chinese elm stock at the State Nursery. These insects are small (1/8 to 1/4 inch long), reddish brown to greenish color, with a dark stripe down each elytron and several dark spots on the thorax. It is very easily controlled. The method is to spray or dust with arsenate of lead about ten days after the leaves are developed. Repeat the control plan for the second brood. In the spray, use four or five pounds of lead arsenate to fifty gallons of water.

The cucumber beetle (Diabrotica soror) is a leaf feeder, attacking most any kind of vegetation. It is injurious to farm crops and even attacks nursery trees. The adults are voracious feeders. The beetles are 1/4 inch long, of a yellowish, green color, with twelve black spots on the wing cover. D. soror is a very difficult pest to control. The insects are restless and migrate about every ten days. The trap crop has proved successful in control measures.
Spraying with lead arsenate is repelling but a contact spray applied directly to the pests kills the beetles and larvae attacking the hardwood trees. The spray should be applied in the early morning before the beetles are very active.

All three species of strawberry root weevils have been found in Oregon attacking strawberries, raspberries, and other crops. These three species are the small weevil (Brachyrinus ovatus), the medium weevil (B. rugifrons), and the large species (B. sulcatus). The three species are very destructive at the Crown-Willamette Forest Nursery, located near Willamette, Oregon. The adult weevils are dark brown in color and vary from 3/16 of an inch to nearly 5/8 inch long. The severest injury to forest nursery stock is done to the roots of the seedlings by the larvae. Some grubs may feed on the foliage of the smaller trees. The adults feed about the ground but seldom do serious damage. The poison bait method has proved to be the best control measure for these pests.

White ants comprise another danger. The most important ones are: Leucotermes, L. virginiicus, and L. lucifugus. These resemble the tree ants in their colony life. The white ant feeds on foundation timbers, dead wood, poles, clothing, shoes, paper, and forest nursery stock. The damage to nursery stock at certain times is considerable, especially if the nursery has been in new ground recently cleared of timber. The ants feed on the young roots and trees. To control termite damage, all sticks
and roots should be cleared from the nursery area and then clean cultivation and crop rotation practiced.
THE NORTHEAST AND LAKE STATES

Damage by Birds

As in other nurseries, care must be taken to prevent damage by birds in the nurseries of this region; the real danger lies in the time after germination before the seedlings have lost their seed coats. Various methods may be resorted to to handle the situation, including screens, scarecrows, or boys hired to scare off the birds when they are troublesome. No information is available, however, as to the method that gives the best results.

PARASITIC DISEASES

Damping-off

Damping-off is a serious menace in all nurseries, and this region is of course not an exception. As detailed discussion has been given in the preceding sections of this paper concerning other regions, it is not deemed necessary to repeat them here. This damage is combatted by the use of a number of different sprays, the most successful of which has been a slightly acid Bordeaux mixture.

There are other types of fungi that cause damage to the seedlings, the symptoms of which are brown spots on the needles, and a general appearance similar to that of drought injury. Bordeaux mixture is used against this fungus also.

White Pine Blister Rust

Blister rust indigenous to the United States have been found on pitch pine, yellow pine, and jack pine in the New
England states. The great danger, however, from excessive losses in the United States from blister rust is due to white pine blister rust (Cronartium ribicola) introduced from Europe. This is a disease of eastern white pine and a number of allied species. It has long been known in Europe as one of the most serious nursery pests. Although first recognized in this country in 1906, it is now widely distributed. The Cronartium stage which occurs on various species of Ribes has been reported from such widely separated localities as Kansas and Maine. The blister rust ordinarily enters the white pine tree through the leaves, begins its attack at the leaves or the bases of them, and then spreads through the bark to the branches and trunk. Ordinarily one or more years intervene after the infection before evidence of the disease shows on the surface of the bark. During this period the infected stock is often shipped from the nurseries without the shipper or its recipient really knowing of its existence. This makes the disease very difficult to eliminate when shipments are permitted from infected nurseries. The presence of the disease first becomes apparent by a perceptible swelling of the stem due to the thickness of the infected bark. The swelling proceeds rapidly and the following spring the fruiting bodies break through the bark, setting free a multitude of yellow, dustlike spores. If badly diseased stock is shipped at this time clouds of spores arise from the stock as it is unpacked. The disease is nearly fatal to the young seedlings as the infection on the stem gradually spreads until the
tree is completely girdled. Its possibilities for causing enormous losses are so great that close watch should be kept in all nurseries that grow white pine and allied species in order to prevent it from gaining foot hold. Wild and cultivated species of Ribes in the vicinity of the nursery which harbor the Cronartium form of the fungus should be destroyed. If the species appears in the seedbeds or transplant beds, all the stock should be pulled up and destroyed. There is no known method of treating which will save a young tree after it has been infected.
REFERENCES


Longdell, R. S. Reforestation in Massachusetts, 1913.


