

Crop Profile for Christmas Trees in Pennsylvania

Revised: January, 2004

General Production Information

Christmas trees are grown in every county in Pennsylvania except Philadelphia. Although the census data do not support it, the three counties with the greatest production are Columbia, Indiana, and Schuylkill. They are listed as having 875, 672, and 458 acres in Christmas tree production, respectively; however, there are individual growers in each of these counties that alone have that much acreage in production.

This section provides information on the 1997 Agricultural Census results on Christmas trees in Pennsylvania, as well as a short history of tree species grown in Pennsylvania and how to successfully produce trees in Pennsylvania. It is anticipated that the publication of data from the 2002 Agricultural Census and information collected in the coming months by the National Agricultural Statistics Service/Pennsylvania Agricultural Statistics Service (NASS/PASS) will provide more accurate information.

Weed Control

This section provides information on weed control and various herbicides, and general field recommendations.

Insect and Mite Control

This section provides information about key pests of Christmas trees and the presence of these pests based on scouting reports in Pennsylvania.

Disease Control

This section provides information on disease management issues in Pennsylvania Christmas tree plantations, major disease problems, fungicides labeled for control, and future threats to the Christmas tree industry in Pennsylvania.

Figures from the 1997 U.S. Census of Agriculture

The National Agricultural Statistical Service (NASS) conducted the U.S. Census of Agriculture in 1997. The ag census is conducted every 5 years. The surveys related to Christmas trees were to be returned by

February 1, 1998, which was the first year Christmas trees were included in the census. The 1997 ag census included approximately 75,000 "new farms" being counted for the first time. These farms were not counted in the past because they produced only Christmas trees and no other agricultural products.

The ag census reports that 17,234 farms harvested Christmas trees in 1997. The top six states in numbers of Christmas tree farms and sales of Christmas trees are shown in Table 1. Christmas tree production by Pennsylvania county is shown in Table 2.

Table 1. Top-ranking states in Christmas number of tree farms and sales (data from 1997 ag census).

State	No. of Farms	State	Sales (\$)
Oregon	1,626	Oregon	111,999,000
Pennsylvania	1,458	North Carolina	49,422,000
North Carolina	1,257	Pennsylvania	35,439,000
Michigan	1,204	Michigan	33,350,000
New Jersey	1,099	Washington	25,597,000
New York	1,060	Wisconsin	25,209,000

Table 2. Christmas tree production by Pennsylvania county (data from 1997 ag census).

County	No. of Farms	Acres in Production	Sales (\$1,000)
Adams	27	253	843
Allegheny	17	61	106
Armstrong	25	105	663
Beaver	19	139	495
Bedford	31	138	316
Berks	86	450	1,728
Blair	13	533	375
Bradford	29	252	664
Bucks	43	220	663
Butler	27	212	679
Cambria	21	133	642
Carbon	32	182	1,140

Centre	20	131	596
Chester	52	532	1451
Clarion	7	27	(D)
Clearfield	13	54	278
Clinton	12	68	268
Columbia	64	875	3,175
Crawford	11	348	321
Cumberland	19	80	142
Dauphin	34	264	657
Delaware	5	20	53
Elk	6	14	(D)
Fayette	21	112	825
Franklin	15	138	165
Fulton	12	75	767
Greene	5	116	38
Huntington	13	79	476
Indiana	61	672	4,580
Jefferson	14	91	133
Juniata	15	120	132
Lackawanna	10	46	120
Lancaster	38	183	739
Lawrence	8	62	49
Lebanon	18	64	230
Lehigh	23	307	541
Luzerne	32	213	192
Lycoming	44	330	1,228
McKean	11	106	(D)
Mercer	13	71	177
Mifflin	7	26	(D)
Monroe	25	81	246
Montgomery	18	143	388
Montour	12	56	139

Northhampton	28	186	650
Northumberland	26	128	333
Perry	27	170	337
Pike	5	19	29
Potter	13	273	342
Schuylkill	58	458	1,834
Snyder	20	69	175
Somerset	11	53	164
Sullivan	2	(D)	(D)
Susquehanna	26	232	598
Tioga	19	98	591
Union	10	(D)	119
Venango	9	23	9
Warren	13	37	83
Washington	26	116	296
Wayne	18	86	254
Westmoreland	15	66	551
Wyoming	16	119	174
York	51	356	1,569
Totals	1,458	10,927	35,439

Discrepancies in Census Data

The author of this report is a Professor of Ornamental Horticulture at Penn State University and a Christmas tree grower in Centre County. His estimates on Christmas tree production in Pennsylvania are as follows: total number of farms, 2,000; acres in production, 45,000; and sales (\$1,000), 55,000.

The estimate of number of farms is based on attendance at extension educational programs, the mailing list for the annual Penn State Christmas Tree short course, and the list of growers generated for the proposed Christmas tree marketing and research referendum. The data on acres in production generated by the Census of Agriculture is grossly low. There was probably confusion among those filling out the surveys between acres in production and acres harvested. The 10,927 acres in production figure would be closer to the total number of acres harvested than the total acres in production.

Example: Centre County has 20 farms listed, with 131 acres in production. The author of this report is

aware of four Christmas tree farms in Centre County within 15 miles of each other that have a total of approximately 200 acres in production.

For comparison, the 1997 Census of Agriculture shows that Oregon had 18,628 acres in production, whereas the Pacific Northwest Christmas Tree Association estimated there were 57,000 acres in Christmas tree production.

None of these figures include the nursery seedling/liner production segment of the Christmas tree industry that would add another \$20 to 25 million (conservatively) in annual sales.

History of Major Christmas Tree Species Grown in Pennsylvania

In the 1950s and 1960s, Scotch pine was the predominant Christmas tree species grown in Pennsylvania. Many Colorado and Norway spruce and white pines also were produced. During this time, Douglas fir was introduced into Pennsylvania. In the 1970s, the popularity of Scotch pine decreased, whereas the popularity of Douglas fir soared. Scotch pine developed many insect and disease problems, making it more expensive to produce, and consumers were beginning to avoid it because of its stiff needles and tendencies to have fat, crooked trunks. Douglas fir was adapted to grow well in all parts of Pennsylvania, was easy to shear to an attractive shape, had few insect or disease problems, soft needles, and held its needles very well in homes.

Although improved types of Scotch pine have been introduced to the industry through breeding and selection programs, it has developed the reputation as the "cheap" Christmas tree. It is hard for wholesalers or retailers to get a decent price for even the best of Scotch pines. It is the opinion of the author of this report that the number of Scotch pine planted in Pennsylvania will continue to decline.

During the 1970s and 1980s the number of acres planted to Douglas fir increased dramatically. It is currently the most planted Christmas tree in Pennsylvania and can be profitably grown statewide.

During this time, the market for Norway spruce and white pine declined sharply. The needle retention for Norway spruce is its limiting factor, and the soft needles and branches of white pine do not support ornaments well. Although some of both are still sold as Christmas trees, they are not major parts of any grower's product mix anymore. There is one exception: Christmas tree growers that sell some of their trees as balled in burlap nursery stock have found both Norway spruce and white pine to be very marketable.

Colorado spruce has the sharpest, most disagreeable needles of any Christmas tree species, but it has retained a fair share of the Christmas tree market. There is a certain customer base that seems to want the blue color and strong, stiff branches regardless of the blood-letting associated with handling this tree. Although it is not a high percentage of any growers' mix, most growers still are planting Colorado spruce. It is very desirable as a dug tree for the landscape.

White fir is an excellent tree that would be grown more if its growth was more predictable. There is too much variation in it for growers to be comfortable growing many of them. They are also the most susceptible to frost of any Christmas tree species grown in Pennsylvania.

The tree that has taken the state, and country, by storm in the past 15 years is Fraser fir. It seems to be the tree in the highest demand throughout Pennsylvania. Unfortunately, it is the most site-demanding tree and is not suitable for growth on some of the land currently being used for the production of Christmas trees in Pennsylvania. It does not grow on soils that are too wet or too dry, and it does not perform well at lower elevations. It is an excellent tree for those that can grow it because they can get a reasonable price, and they are relatively easy to sell. Consumers love the dark green color, soft texture, relatively stiff branches for supporting ornaments, straight trunk, and excellent needle retention. Currently, it is the ultimate Christmas tree for many consumers. It is the best tree to be growing at this time.

Major Christmas tree species currently grown in Pennsylvania and price ranges are listed in Table 3.

Table 3. Major Christmas tree species grown in Pennsylvania and their price range (price range for a good quality tree seven [6–7] feet tall) as cut trees in 1999.

Species	Wholesale	Retail*
Fraser fir	\$20–24	\$25–60
White fir	18–22	25–50
Douglas fir	16–22	25–40
Balsam (or canaan) fir	10–18	18–35
Colorado (blue) spruce	16–22	25–40
Norway spruce	10–16	18–35
Scotch pine	8–12	15–25
Eastern white pine	10–14	15–25

*Includes choose-and-cut operations.

Producing Christmas Trees in Pennsylvania

Site Selection

In the past, it was common to use marginal land, i.e., land that was not suitable for the production of agronomic crops, for the production of Christmas trees. Scotch pine tolerated a wide range of soil

conditions, and the price for trees was low, so it was hard to justify growing them on high-priced, high-quality land. Currently, the best trees, Douglas fir and Fraser fir, are much more site-demanding than Scotch pine and require better quality sites. The value of Christmas tree per acre is also so much higher than any agronomic crop that it only makes sense to plant the trees on the highest quality land. It also is recognized that trees growing on good sites have fewer insect and disease problems than trees growing on poor sites. Some growers have been slow to make the change, but more and more growers are selecting class I and II soils for producing their trees. This soil selection is especially important if some of the trees will be harvested balled in burlap for the landscape market.

Species Selection

There are no good data available on the species mix currently being planted in Pennsylvania. The following species mix represents the opinion of the author:

- Douglas fir 40%
- Fraser fir 35%
- Colorado spruce 8%
- Scotch pine 8%
- Balsam (canaan) fir 3%
- Eastern white pine 3%
- Others 3%

One of the more important changes in the Christmas tree industry in the past 15 years is the availability and use of genetically improved types of Christmas tree species. Some Pennsylvania seedling producers have seed orchards for Douglas fir, Fraser fir, Colorado spruce, and Scotch pine. Using these seed orchards as the source of seed results in a higher percentage of saleable trees, in a shorter amount of time, with less work.

Age of Planting Stock

In the past, the most common age for planting stock was 2-0 or 3-0 seedlings. In the 1980s, growers started planting more 2-1, 2-2, and 3-2 transplants, depending on the species. Pines, Colorado spruce, and Douglas fir are now commonly planted as 2-1 or 2-2 transplants. Fraser fir is commonly planted as 2-2, 2-3, or 3-2 transplants. The relatively new introduction to the industry is plugs. Genetically improved seed is sent to the West Coast and grown in greenhouses by Weyerheuser Corporation. The plugs can be planted directly into the field, but most growers prefer plug + 1, plug + 2, or plug + 1 + 1 transplants. The plugs are grown in transplant beds by Weyerheuser or by Pennsylvania nursery staff who buy the plugs from the producers of the seed.

Planting

Most planting is done between late March and mid-May. Trees establish and survive better if planted by

mid-April, especially in years with hot summers and below average rainfall. Pennsylvania has a lot of small Christmas tree farms, and trees on these farms are generally planted by hand. Many small farms, especially those with choose-and-cut operations practice stump planting. When a tree is cut in December, a new tree is planted close to the stump the following year. This practice is efficient in terms of use of land, but it is a poor practice culturally. Diseases and insects established on older trees can move freely onto the newly planted stock. Herbicide application rates that are safe for the older trees may injure the younger trees. There is not an opportunity to correct compaction problems that develop with time. Larger growers generally clear-cut a field, pull or grind stumps, chisel plow, disc, and replant entire fields with mechanical planters. From an integrated pest management perspective, this system is much preferred over stump planting.

Fertilization

There is nothing that can be considered a standard fertilization practice in the Christmas tree industry in Pennsylvania. Most large growers test their soil and amend the pH, calcium, magnesium, potassium, and phosphorous levels before planting. Many growers do not do this. Some growers fertilize their trees the year of planting, but most do not. After the year of establishment, the amount of fertilization that is done depends on the tree species that are grown. Pines and Douglas fir are known to grow excessively if fertilized heavily. These trees are either not fertilized or are lightly fertilized to enhance their color. Fraser fir requires the most fertilizer. Trees that are underfertilized stay thin and open and have poor color. Well fertilized trees get denser and have much better color. A serious problem in the industry is that there is no solid research data on which to base fertilizer recommendations for Christmas trees grown in Pennsylvania. Current recommendations are based on research on agronomic crops.

Shearing

Christmas trees are shaped with hand pruners, shearing knives, gas powered rotary knives, or sickle bar cutters. There is concern among some people in the industry (the author included) that the powered shears make it too easy to trim a tree too hard, making it look more artificial than many artificial trees. However, the economics of shearing with powered equipment is causing an increase in their use each year. Many more trees can be managed by an individual grower at a lower cost by using power equipment.

The second year in the field it is common to remove strong double leaders. The third year in the field, the leaders of some trees may have to be held back, and some side trimming may be done. Each subsequent year, until harvest, the trees will have to be sheared. Pines are sheared in June and July. Other species are sheared from July through the winter.

Basal Pruning

To produce a tree of the highest quality, growers remove the limbs from the lower 6 to 12 inches of the trunk of the tree. This process makes harvest easier, but more importantly; it gives the consumer a more

manageable product. Basal pruned trees have thinner trunks that fit into tree stands much easier than the trunks of trees that are not basal pruned. It is also true that some trees have strong branches growing upward from the base of the tree that must be removed to make the tree fit into a stand. The removal of the limb may result in a serious loss of density on one side of the tree.

Disease, Insect, and Weed Control

Each of these topics is covered individually in sections that follow.

Worker Activities

The majority of pesticide applications for Christmas tree farms are made in spring and fall, starting with dormant applications as early as March. Insecticides, fungicides, and herbicides are applied, as needed, from late March through June, with the heaviest period of activity from mid-April through May. Occasionally pesticides must be applied in midsummer to combat insect pests with multiple generations (in particular, scale insects). Insecticide and herbicide applications resume in September but are limited. All materials should be applied before mid-October.

Planting is done in early spring, but generally pesticides are not a factor at these sites. The most intense worker activities occur from June through July when trees are sheared. Mowing activities continue through the growing season. Precautions should be taken at these times by workers reading and following the label directions for appropriated personal protective equipment and re-entry times. Harvest begins in early November for wholesale operations and continues through December for retail sales and choose and cut, where customers do the harvesting. Exposure is not a concern for workers or customers who harvest trees as pesticide materials have not been applied mid-October

Marketing Christmas Trees in Pennsylvania

Trees in Pennsylvania are sold wholesale, retail, or choose-and-cut. Because of ready access to large urban markets, many trees are sold in each category. However, the fastest growing segment of the market in the 1990s was the choose-and-cut market. Visits to the farm with the family, to select and cut "their own" guaranteed fresh tree have become more and more popular among families. This trend does not show any signs of reversing.

Weed Control/Vegetation Management

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Weed Control/Vegetation Management

Why control weeds?

There are many reasons to control weeds in Christmas tree plantings. By competing with the trees for nutrients, water, and light, weeds reduce the survival rate and growth of the trees. They reduce tree quality by adversely affecting needle color, causing the loss of lower limbs, and creating dirt problems by lodging in the lower limbs of cut trees. Weeds reduce air drainage and movement in plantations, which makes the plants more susceptible to frost damage and foliar diseases.

Dense weeds provide cover and food for rodents, which can cause severe injury to trees by girdling them in the winter when other foods are scarce. Weeds also can be a fire hazard after they die and dry out. A carelessly discarded cigarette or match can result in the loss of an entire field of trees.

Weeds interfere with standard Christmas tree maintenance practices. It is hard to shear trees when weeds are growing around or throughout them. Weeds also can intercept insecticide or fungicide sprays directed at trees. They can hide small trees and make mowing extremely time-consuming, as the mower operator tries mowing close to trees without hitting them. Still, many young trees are lost to mowers because of heavy weed cover.

Finally, more and more growers are opening their fields to choose-and-cut sales. A plantation in which weeds are well controlled is much more attractive to customers than one in which briars tug at their legs and poison ivy threatens their comfort.

Levels of Weed Control

Some growers ignore weeds, whereas others mow, apply herbicides, plant cover crops, or use a combination of these methods. Many growers that ignore weeds plant their trees on rocky, weeds grow well on these sites. Surprisingly, most Christmas tree species grow in rocky, infertile soils in their native range, which means they can survive and grow on these sites, but they do not produce optimum growth. Growers that rely on low-fertility soils to provide their weed control are not producing uniform, high-quality trees in a reasonable length of time.

Other growers rely entirely on mowing for weed control. For best control with mowing, the planting should be mowed both with and across the rows, i.e., the plantation must be very carefully planted so that all rows are straight in both directions (check-rowed). Although relying only on mowing eliminates the risk of herbicide injury, there is the constant risk of hitting trees with the mower. Mowing is time-consuming and therefore expensive. Also, no matter how well it is done, mowing alone does not provide all the benefits of a weed control program that includes herbicides.

Combining the careful use of herbicides and mowing provides several advantages over mowing alone. The herbicides can be used in the rows to provide a weed-free band 24–36 inches in width. Weeds

growing between the rows can then be mowed quickly with little risk of hitting the trees with the mower. Maintaining the weed-free area around the trees limits the competition between weeds and trees and keeps the weeds from interfering with maintenance of the trees.

There are several problems associated with letting naturally occurring vegetation grow between the rows. One is varying growth rates of weeds. One part of a field may have quackgrass, which starts growing early in the spring, whereas another part may be dominated by foxtails, which start growing in early summer. To maintain uniform control in the field, it must be frequently mowed. Another problem is the lateral spread into the clean rows of the rhizomes (underground stems) of perennial weeds and the foliage of large or creeping weeds.

The optimum level of control would include maintaining a weed-free band in the rows and a controlled cover crop between the rows. A properly selected cover crop would crowd out fast-growing, aggressive weeds and require little mowing. The current recommendation for a cover crop between the rows of Christmas trees is hard fescue. It is a low, slow-growing, bunch-type grass that does not encroach on bare rows very quickly.

Herbicides

The development of safe and effective herbicides for use in Christmas tree plantings has revolutionized Christmas tree production. Growers used to avoid high-fertility sites and the application of fertilizers because of the weed growth associated with them. It was not unusual to take 10–15 years to complete one production cycle. With the aid of herbicides, growers can now grow trees on higher fertility sites and provide supplemental fertilizer applications annually without fear of excessive competition from weeds. On carefully managed sites superior trees can be produced in 5–8 years.

Still, people avoid using herbicides. Some fear the risk herbicides may pose to their trees. Others are concerned about how the chemicals may affect their health or the environment. Still others simply believe they do not need them. The following herbicides have been approved for use by the Environmental Protection Agency. They have been extensively tested by the companies producing them and research personnel at universities across the country. Used according to directions, they are safe for the trees, the applicator, and the environment.

Postemergence Herbicides

(used to control existing weeds)

MAJOR CHANGE, EFFECTIVE SPRING, 1996: ROUNDUP AS WE HAVE KNOWN AND USED IT FOR ALMOST 20 YEARS HAS CHANGED. READ THE FOLLOWING CAREFULLY.

The chemical **glyphosate** is the active ingredient in Roundup, Roundup Pro, Roundup Ultra, Accord, and Glyfos. All contain four pounds of glyphosate per gallon. The difference between all of these products is the type and amount of surfactant they contain. The surfactant improves the activity of the glyphosate by helping it cover, stick to, and penetrate the leaves of the weeds. A description of each of the products is presented below, with emphasis on their significance to Christmas tree growers.

All of the products containing glyphosate have several major advantages over many other herbicides. They are absorbed by actively growing foliage and translocated to above- and belowground growing points. Translocation is in association with carbohydrates (the foods produced in the leaves through photosynthesis). During the early stages of growth of established perennial weeds, net carbohydrate movement is up, so glyphosate applied at this time kills the tops but not the roots. Glyphosate is inactivated when it contacts the soil, so there is little risk of root uptake by the trees in the treated area. It is safe to plant in soil that was recently treated with glyphosate. Because of its low toxicity rating and its high solubility in water, glyphosate is easily mixed and easily cleaned out of sprayers.

Roundup

Roundup contains a surfactant, but it has several weaknesses. Regarding weed control, the label recommended the addition of another surfactant or ammonium sulfate to increase its effectiveness against weeds. It was not especially rainfast. Rainfall less than 6 hours after application reduced its effectiveness. The speed of kill was slow. Weeds might not show symptoms of injury for 7 to 14 days after application. The surfactant had relatively poor toxicity ratings and caused Roundup to carry a WARNING statement on its label. It could not be used near water because of the toxicity of its surfactant to aquatic animals. However, because the surfactant was not the best, it could be used around Christmas trees pretty loosely after their buds were well set and their new growth was hardened off. Growers have been hitting the lower one-half to two-thirds of their trees in September with no harm for many years. The thick, waxy cuticle that develops on conifer needles was apparently protecting the trees from low rates of Roundup. However, when growers got sloppy with Roundup around their trees, applying at too high a rate or at the wrong time of year, slight to severe injury occurred. So we know our trees are not resistant to glyphosate and that must mean that it just was not getting into the trees if we followed the proper precautions. This formulation of glyphosate is no longer being produced.

Roundup Pro and Roundup Ultra

Roundup Pro and Roundup Ultra are the same products. They have different names because they are produced for different markets, although both are labeled for use in Christmas trees. They contain the same amount of glyphosate that Roundup contained, but they have a much improved surfactant. It is less toxic, so these products only carry a CAUTION label. No additional surfactant is needed when using these products around crops. Ammonium sulfate may still be added to enhance the performance of applications made for site preparation. The improved surfactant results in these products giving better weed control, greater rainfastness, and faster burndown of weeds. As little as 1 hour is needed between application and rainfall, and weeds show injury symptoms 4 to 10 days after application. Symptom

development may be delayed by adverse weather.

A negative aspect of the improved surfactant is the increased risk of injury to the trees if they are contacted as in the past. A series of studies have been conducted to determine the potential of Roundup Pro and Roundup Ultra to injure Christmas trees when used in the same way the old formulation was used. Results of these studies show that the new formulations do pose a greater risk to the trees, but if the following precautions are followed, they can be safely used on Christmas trees:

1. Do not use more than 1 qt/acre on sensitive species such as white pine and balsam fir.
2. Do not use more than 1.5 qt/acre on other species.
3. Newly planted trees are more sensitive than established trees. Use low rates for the first 2 years in the field.
4. Do not apply over the top of Christmas trees. Always apply as a directed spray to the lower one-third or one-half of the trees.
5. Make sure the foliage is thoroughly hardened-off before application. In Pennsylvania, it is best to wait until September to apply.
6. Do not apply within 2 weeks of trimming trees if there is a chance that the spray will contact cut tips that are still moist.

Glyfos

Glyfos is a generic form of glyphosate that contains a surfactant. It has been used by Christmas tree growers for a few years in the same way as Roundup. Based on the results of the recent studies, it should be used with the same cautions listed for Roundup Pro and Ultra.

Accord

Accord contains glyphosate, but no surfactant. It could be safely used around trees the same way Roundup was for so many years. If used alone, the weed control is not be as good as it was with Roundup, so a surfactant should be included. Unfortunately, no research has been done to determine which surfactants should be used with glyphosate around Christmas trees. Use a standard nonionic surfactant at the low end of its recommended range.

Fusilade II, Vantage, and Envoy

Fusilade II, Vantage, and Envoy kill annual and most perennial grasses. They have little or no effect on broadleaved weeds, and they are safe for use around Christmas trees at all stages of growth. Fusilade II provides better control of quackgrass than Vantage. They are rapidly absorbed by the leaves of grass and translocated to above- and belowground growing points, where they cause all growth to stop. The first symptoms of injury are termination of growth followed by death and decay of the inner whorl of the grass plant. Under good growing conditions, the initial symptoms occur in 5–7 days. It may take 2–3 weeks for the grass to wilt and die, so be patient after application. Fusilade II, Vantage, and Envoy have

very limited soil activity at recommended rates. Vantage contains a surfactant and no additional surfactant is needed. When using Fusilade II include a nonionic surfactant at 0.25% (v/v) (0.3 fl oz/gal or 1 pt/50 gal). When using Envoy, include a crop oil concentrate at 1.0% (v/v) (1.25 oz/gal or 2 qt/50 gal).

Garlon

Garlon is a postemergence, translocated herbicide that kills only broadleaved weeds and brush; it has no effect on grass. Garlon is available in 3A (3 lb/gal amine) and 4E (4 lb/gal emulsifiable concentrate) formulations. Christmas trees are not specifically listed on the Garlon labels, but they may be covered under the term "conifer release," which is on the labels. Garlon 3A is the safer of the formulations to use around Christmas trees. As with Roundup, conifers are susceptible to injury during periods of active growth, but resistant in the late summer and early fall after buds have set and all new growth is hardened. Garlon 3A should be applied to herbaceous broadleaved weeds at the rate of 1 lb of active ingredient per acre (AIA) (42 oz/acre) and woody weeds at 2 lb AIA (84 oz/acre). Use it as a spot treatment to control exceptionally tough weeds or woody plants such as poison ivy, Virginia creeper, or briars, or apply it between rows of trees to control creeping broadleaf weeds without killing the grass strip. The same precautions presented for the use of Roundup should be followed when using Garlon in plantations. In addition, Garlon should only be used in Christmas trees planted for 3 years before application. Garlon can be safely used to kill larger brush in areas surrounding plantations.

Stinger

Stinger is a postemergence, translocated herbicide that kills only some broadleaved weeds. It is especially effective on weeds in the legume family (e.g., clover, alfalfa, crownvetch, trefoil) and composite family (e.g., thistles, asters, daisies). It can be applied over-the-top of most Christmas tree species grown in Pennsylvania even during active growth. Stinger is available only in the 3A (3 lb/gal amine) formulation. To control annual weeds apply 1.5–3.0 oz AIA (4–8 fl oz/acre). Repeat applications can be made but do not exceed 4 oz AIA (10 fl oz/acre) per year. On Colorado spruce, do not exceed 3 oz AIA (8 fl oz/acre) per year. Do not add surfactant or crop oil to spray solutions containing Stinger. Do not apply to plants during their first growing season in the field.

Basagran T/O

Basagran T/O is a postemergence herbicide that provides excellent control of nutsedge and good control of many broadleaved weeds. It is labeled for use as a directed spray and is not recommended for over-the-top applications. It is likely to burn needles of firs and spruce that it contacts.

2,4-D and Shotgun

2,4-D is also a postemergence, translocated herbicide that can be used to selectively remove broadleaved weeds from grass growing between rows of trees. It should be applied in September, after the new

growth on the conifers is hardened, to minimize the risk of injury from drift. Avoid directly contacting the trees with 2,4-D. Shotgun is a premixed combination of 2,4-D and atrazine that is labeled for use in Christmas trees.

Preemergence Herbicides

Preemergence herbicides control weeds at the seed germination stage—they do not control existing weeds, or perennial weeds regrowing from underground parts. For best control, preemergence herbicides should be applied to weed-free soil.

Some preemergence herbicides control broadleaved weeds better than grasses. Herbicides in this category include atrazine (Aatrex), simazine (Princep, Simtrol, Simazine), Goal and Ronstat, Regal O-O, and Gallery. Others control grasses better than broadleaved weeds. These herbicides include Devrinol, Factor, Pendulum, Surflan, Pennant, and Kerb. For best results, a herbicide that works best on broadleaved weeds is combined with one that works best on grasses.

Atrazine (Aatrex) and Simazine (Princep, Simtrol, Simazine)

These herbicides provide outstanding control of broadleaved weeds and fair control of grasses. Combining a grass herbicide with atrazine or simazine produces excellent broad-spectrum weed control. Both products are available under a variety of trade names. There are two major differences between Princep and Aatrex. Aatrex has a higher solubility in water, so its residual activity is shorter than that of Princep; and it can be absorbed by leaves, whereas Princep generally is not. Aatrex cannot be absorbed by hardened needles of conifers, but it can be absorbed by, and injure, new growth. The higher water solubility of Aatrex also makes it more likely to injure trees if accidentally applied at an excessive rate, because product more leaches down to the roots of the trees. When using Aatrex or Princep, be aware that their activity is strongly dependent on soil conditions. Soil pH, texture, and organic matter content affect how much herbicide is needed to control weeds and how likely the herbicides are to injure the trees.

Atrazine and simazine are most active in the pH range 6.5–7.5. As the pH drops below 6.5, more and more of the herbicide is inactivated and held in the soil, which means higher rates are needed to obtain satisfactory weed control. A serious problem can occur when high rates of atrazine or simazine have been applied to a field with a low pH for a number of years and then the pH of that field is raised. The herbicide that was bound in the soil in an inactive form can be released and severely injure plants growing in the field. To determine the pH of your soil, purchase a soil test kit from your county cooperative extension office.

Atrazine and simazine also are partially bound by clay particles and organic matter in the soil. Soils high in clay or organic matter require higher rates for good control, but they also slowly release some of the herbicide over time, so that one application at a high rate provides safe, long-term control. Sandy, coarse

soils do not bind much of the herbicide and require more frequent applications at lower rates for adequate control.

Atrazine and simazine are closely related chemicals in the group called triazines. They kill or injure plants by destroying their chlorophyll and inhibiting photosynthesis. Atrazine or simazine that is absorbed by the roots of trees moves through the plant with water and accumulates where the most water passes out of the plant—at the tips of the needles. Injury symptoms from these herbicides are very distinct. It begins as a yellowing of the new growth needle tips and progresses to further yellowing of the new growth tips and also spreads to the older growth needle tips. Although entire trees may be killed by gross overapplication, most trees fully recover from slight-to-moderate injury. Nutrient deficiency symptoms and injury caused by poor drainage are often confused with triazine herbicide injury, but experienced personnel can distinguish them.

To avoid injuring trees with atrazine or simazine, monitor the pH and characteristics of your soils and keep good records of the rates of herbicides applied to them. Then, if some trees are injured or weed control is poor, the rate of application can be adjusted accordingly.

Goal and Ronstar

Both Goal and Ronstar provide very good control of broadleaved weeds and fair control of grasses. They have very low solubilities in water and remain on the soil surface for a long periods. They are weak contact herbicides that form a chemical barrier on the soil surface that burns weeds as they grow through it. Small annual weeds are killed, but perennial weeds with established root systems have enough energy reserves to grow past the chemical barrier. They are burned a bit at ground level, but can grow past the initial injury. The growing points in grasses are protected by a sheath as they emerge through the soil. Shortly after application, there is enough chemical present to burn through the sheath and kill the growing point, effectively killing the grass seedling. But after some of the chemical breaks down, the sheath protects the growing point enough to let the grass keep growing. That is why Goal and Ronstar should be combined with preemergence grass herbicides.

The sprayable formulation of Goal is recommended for use at 0.25–1 lb AIA (1 pt–2 qt/acre). It is extremely safe because it stays on the soil surface and is broken down before it gets down to the roots. Because it is a weak contact herbicide, Goal should be applied before bud break, or 4 weeks after. Application within 4 weeks after bud break may burn the new growth of some species, with Colorado spruce being the most sensitive. Goal can be used in place of Aatrex (atrazine) or Princep (simazine) to reduce the risk of buildup of triazine herbicide residues and to control triazine-resistant weeds.

Because Goal has some postemergence activity, it is a good product to add to preemergence herbicide applications that are being made a bit late. The Goal burns down small weed seedlings and provides immediate preemergence activity. Most preemergence herbicides are not effective until they have been moved into the soil by rainfall. For best postemergence activity, add a nonionic surfactant to the spray solution.

Goal is the best material for use in seedbeds and liner beds. In seedbeds, it should be applied before emergence of the seedlings. Applying Goal during the first 4 weeks after emergence can result in severe injury or death of the seedlings. The primary growing point of the seedlings is the most sensitive part of the plant. After the primary growing point develops true needles, the plant is much more resistant to injury.

Granular formulations of Goal + Surflan (Rout) and Goal + Pendulum (Scott's OH-2) are available, but they are too expensive to use in field plantings, and should not be used in seed- or liner beds because of the risk of injury to the trees from the Surflan and Pendulum.

Ronstar is available in granular and sprayable formulations. Because of cost, the granular form should only be used in seedbeds or liner beds. The sprayable formulation (50WP) can be applied to field plantings or seedbeds at 2–4 lb AIA (4–8 lb/acre) before bud break or at least 4 weeks after bud break.

Regal O-O

Regal O-O is a granular product that contains the active ingredients in both Goal and Ronstar. It could be used in seedbeds or liner beds.

Gallery

Gallery is labeled for use on fir, pine, and spruce at 0.5–1 lb AIA (0.66–1.33 lb/acre). It provides very good control of broadleaved weeds but is weak on grasses. It should be combined with one of the materials that provides good grass control. It has very little foliar activity, so it can be applied over the top of the trees. Gallery can be used in place of atrazine or simazine to reduce the risk of buildup of triazine herbicide residues and to control triazine-resistant weeds. It has essentially no postemergence activity.

Devrinol, Factor, Pendulum, and Surflan

These herbicides provide excellent long-term, preemergence control of grasses. They do not provide satisfactory control of broadleaved weeds or any control of perennial grasses growing from underground parts.

When used on conifers at the recommended rates of 4–6 lb AIA (8–12 lb/acre), Devrinol is extremely safe, but it must be applied in the cool seasons or irrigated in. If it is applied when the temperature is above 45°F, it must be watered into the soil immediately. It decomposes in sunlight and at temperatures above 45°F. It is best to apply Devrinol to field stock in late fall or very early spring. It can be applied in seedbeds or liner beds any time if irrigation is available.

Factor is available as a 65% wettable powder. It is stable on the soil surface and can be applied at any

time of the year, even to newly transplanted stock. Apply it at 0.65–1.5 lb AIA (1–2.3 lb/acre).

Pendulum is available in 60% water dispersible granule (WDG) and 3.3 EC formulations. It is stable on the soil surface and can be applied at any time of the year. Apply it at 2–4 lb AIA (3.3–6.6 lb 60 WDG or 4.5–9 pt 3.3 EC/acre) to stock that is at least 2 years old from seed.

Surflan is stable on the soil surface and can be applied at any time of the year. At 2–4 lb AIA (2–4 qt/acre), it provides outstanding control of grasses growing from seed. It is safe for use on field planted trees more than 2 years old, but has injured 1-0 and 2-0 stock. It caused a girdling effect at the ground line that resulted in an abnormal swelling of the stems just above the ground and inhibited root growth. Some seedlings were killed, others are stunted. The stunted plants recovered. Do not apply Surflan to Douglas fir, or any seed- or liner beds.

Devrinol, Factor, Pendulum, and Surflan move slowly in the soil; Devrinol binds to soil particles, Factor and Surflan have very low solubilities in water, and Pendulum for both of these reasons. Thus, they should be applied several weeks before the time weed seeds germinate so that they have time to move into the soil before their germination.

Pennant

Pennant provides good preemergence control of grasses, but it does not provide as long of a control as Devrinol, Factor, Pendulum, or Surflan. Its most important characteristic is its ability to provide excellent preemergence control of nutsedge. To control nutsedge, it should be applied in early spring at or before the nutsedge is emerging. Pennant should be applied before bud break. Pennant has reduced the growth of plants in seedbeds and injured some plants when sprayed over the top during active growth. White pine is especially sensitive at the time the new growth is expanding.

Kerb

Kerb provides very good control of grasses and a few broadleaved weeds. It is the only preemergence herbicide that provides good control of perennial grasses. It has two disadvantages: it must be applied in the late fall, after the temperature is below 45°F, but before the soil freezes; and it does not provide control very long into the spring. It is of little use to Christmas tree growers except for eliminating perennial grasses in certain situations. It provides excellent control of fine fescues used as cover crops that invade the tree rows.

Weed Control Program

Too many growers look at weed control as fire fighting—when weeds become a problem, they try to control them. This approach is difficult and dangerous. It is much easier to prevent weed growth than to kill existing weeds because preventive measures are safer and longer lasting. Christmas tree growers

must think in terms of a weed control program and plan how to control weeds before ever planting the crop. The program has three parts:

1. Eliminate all weeds before planting. It is especially important to kill all perennial weeds because they are not controlled by preemergence herbicides, which are the safest to use in existing plantings. Postemergence herbicides that can be applied freely before planting must be used with extreme caution after planting.
2. Prevent weed growth. Preemergence herbicides are the only practical way to prevent weed growth in rows of trees. They should be applied in the spring and fall. Weed growth can be controlled between the rows by mowing or by growing a cover crop that competes with, and limits the growth of weeds.
3. Eliminate problem weeds. Some weeds may escape the preventive measures. Light stands of annual weeds can be ignored; they die at the end of the growing season. Dense stands of annual weeds or tough-to-control perennial weeds such as quackgrass, goldenrod, or Canada thistle should be killed before they get too well established and spread.

Some growers believe it is too time-consuming and expensive to walk through a field and spot treat weeds. This management decision needs to be made: which is going to cost the most in the long run, the weeds or the spot treatments?

Recommendations for Field for Weed Control

Site Preparation

Growing a crop such as corn, and following the recommended weed control program for it, suppresses or kills most perennial weeds. But many can survive and develop into problems if not controlled after the trees are planted.

For general, broad-spectrum weed control, Roundup Pro or Ultra are the best herbicides available for site preparation. It is best to apply them at 1.5–4 qt/acre in August or September the season before planting. Use the low rate for fields with light weed cover and the high rate for fields with a lot of deep rooted, hard-to-control weeds. July, August, or September are the best months to apply Roundup Pro or Ultra because that is when it most effectively controls perennial weeds. Spring applications are not practical because not many weeds begin growth before optimum planting time. Also, spring applications of Roundup Pro or Ultra to perennial weeds generally kill only the sprayed parts. Very little chemical is translocated down to the roots at this time of year.

Garlon can be used as a spot treatment to control especially tough herbaceous or woody broadleaved plants. If the field is infested with woody weeds and vines or hard-to-control perennial weeds such as milkweed or Canada thistle, use 1.5–2 qt of Roundup Pro or Roundup Ultra plus 2 qt of Garlon 3A per acre. After applying the herbicides, the field may be left undisturbed until later in the fall when it is plowed and/or disced in preparation for planting. This approach should kill weeds that germinate after

the herbicide application. Be sure to test the soil and adjust the pH at this time, so that future applications of triazine herbicides are effective at recommended rates.

Alternatively, the field could be plowed and disced 7–10 days after application and a cover crop could be planted. The cover could then become established before planting in the spring. Then, the cover should either be planted in rows, leaving open areas for the trees, or the cover should be band-sprayed with Princep before the seeds emerge or with Roundup Pro or Ultra in the fall or spring (before planting).

If there are Christmas trees in the field the year before replanting, broadcast apply Roundup Pro or Ultra between the rows in September. Contacting the lower parts of trees that will be harvested that year with recommended rates will have little effect on them.

Preventing Weed Growth

The application of preemergence herbicides is the only practical way to prevent weed growth in the rows of trees. However, with few exceptions, these herbicides do not control existing weeds or perennial weeds regrowing from underground parts. They must be applied to weed-free soil or in combination with a postemergence herbicide that kills the weeds already there. Fall applications of preemergence herbicides are often needed to prevent the growth of winter annual weeds. These weeds germinate in the fall and begin active growth in late winter. Spring-applied herbicides do not provide good control of winter annuals.

Newly planted trees are more likely to be injured by herbicides than established trees, so herbicide application rates must be adjusted accordingly. Herbicide combination 1 (Table 4) should be applied after planting but before bud break. If nutsedge is a problem, use Pennant in the combination.

There is little risk of injury from this combination because the three parts are made up of herbicides with different methods of action. Aatrex and Princep are root-absorbed photosynthetic inhibitors, but little of either should make it to the roots when applied at this low rate. Goal remains on the soil surface where it is harmless to the trees. Devrinol, Factor, Pendulum, and Surflan are root inhibitors, but they should not reach the roots of the trees because of their low rate of leaching. Pennant is a general growth inhibitor that does not injure dormant trees when applied at recommended rates.

If the herbicide application cannot be made before bud break, use combination 2. Aatrex, Goal, or Pennant applied during the period immediately after bud break can injure the new growth. Devrinol applied late in spring may be broken down in warm sunny weather if rainfall does not occur shortly after application.

To maintain good preemergence weed control during the first season, apply Princep at 1.5 qt per acre 10 weeks after the initial application. The alternative is to let weeds grow in the rows as the herbicides gradually lose their effectiveness. The encroaching weeds may be killed with a directed spray of Accord at 0.75 to 1.5 qt/acre in September, or they can be ignored until frost kills them. Frost kills annual

weeds, but the belowground parts of perennial weeds survive. Accord kills the belowground parts of perennial weeds but may injure small tree seedlings if the spray is misapplied and hits their leaders.

If the midseason application of Princep is not made, herbicide combination 3 may be used in place of Accord alone. This combination kills existing weeds and winter annuals that germinate in the fall. If woody weeds or perennial broadleaved weeds are especially prevalent in the area, use 1.5 pt of Accord + 1qt of Garlon 3A in place of the Accord in combination 3.

In late March or early April the year after planting, herbicide combination 4 should be applied, using the lower rates of Aatrex, Princep, or Gallery. This combination provides control through most of the season. Then, in September or early October, apply combination 3 if the rows become infested with weeds late in the season. Again, include Garlon 3A if woody or broadleaved weeds are especially troublesome.

After the trees have been in the ground for 2 years and are well established, the higher rates of Aatrex, Princep, or Gallery in herbicide combination 4 can be safely used. The higher rates recommended will not hurt the trees after they are well established.

Table 4. Herbicide combinations for use in Christmas tree plantings.

Combination No.	Herbicide	lb AIA	Amount of Product/Acre
1	Atrazine or	1.5	1.5 qt
	Simazine or	1.5	1.5 qt
	Gallery	0.5	11 oz
	+ Goal	0.5	1 qt
	+ Factor or	1.5	2.3 lb
	Surflan or	2.0	2 qt
	Pendulum 3.3 E	3.0	3.6 qt
	60WDG or		5 lb
	Pennant or	3.0	3 pt

	Devrinol	3.0	6 lb
2	Simazine or	2.0	2 qt
	Gallery	0.75	1 lb
	+ Factor or	1.5	2.3 lb
	Pendulum 3.3 E	3.0	3.6 qt
	60WDG or		5 lb
	Surflan	2.0	2 qt
3	Glyphosate or	0.75–1.5	1.5–3 pt
	Glyphosate + or	0.75	1.5 pt
	Garlon 3A	0.75	1 qt
	+ Princep or	1.0	1 qt
	Gallery	0.5	11 oz
4	Atrazine or	2.5–3.0	2.5–3 qt
	Simazine or	2.5–3	2.5–3.0 qt
	Goal or	1	2 qt
	Gallery	0.75–1	1–1.3 lb
	+ Factor or	1.5	2.3 lb
	Surflan or	2.0	2 qt
	Pendulum 3.3 E	3.0	3.6 qt

	60WDG or		5 lb
	Pennant or	3.0	3 pt
	Devrinol	3.0	6 lb

The recommended rates of application are presented in pounds of active ingredient per acre (AIA) and amount of product to use per acre; presented in pounds, fluid ounces, pints or quarts. The amounts of atrazine and simazine recommended are for a loam soil at pH 6.5. The exact amounts required for safe, adequate weed control will vary with the soil characteristics of the field being treated.

Eliminating Weeds from Existing Plantings

To eliminate weeds from existing plantings, use herbicide combination 3. Direct spray glyphosate at 1.5–3 pt/acre towards the base of the plants several weeks after bud set. Do not apply before September. Use off-center nozzles mounted in single-swivel nozzle bodies to keep the spray in the rows and off the cover growing between the rows. Do not spray over the top of the trees, but contacting hardened foliage at the base of the trees does not harm them. Garlon 3A at 1 qt can be combined with the glyphosate at 1.5 pt/acre in a directed spray application to kill especially tough broadleaved weeds and woody plants.

Examples of weeds that are difficult to control with this method are goldenrod, milkweed, and hemp dogbane. The lower leaves of these plants die and their stems harden by September. To control these weeds, mow them off in late July to mid-August so that their regrowth is green and actively growing when the glyphosate is applied in September.

Stinger can be used as an over-the-top band application at 4–6 oz/acre during the growing season to control susceptible weeds such as thistles and vetch. Combining it with Goal at 1 qt/acre results in quicker burndown, and some additional preemergence control.

To control grasses only, Fusilade II, Envoy, or Vantage can be sprayed right over the trees or as a directed spray in June, July, or August. Kerb can be used to kill dormant perennial grasses by applying it in late fall, preferably in combination with Princep.

Basagran T/O can be used as a directed spray to control nutsedge. Do not apply Basagran T/O over the top of any trees. Foliage of spruces and firs contacted by Basagran T/O may be burned.

Patches of tough-to-control perennial weeds should be killed before they spread. Glyphosate, Garlon 3A, Stinger, Fusilade II, Envoy, or Vantage can be used, depending on the weeds to be controlled. A carefully directed spray or a wick applicator can be used to apply Roundup Pro or Roundup Ultra during the growing season.

Mowing is used to reduce the height and competitive effects of weeds growing between the rows. Growers who are uncomfortable using herbicides also can use mowers or weed eaters to control the growth of weeds in the rows.

Table 5. Estimated herbicide use in Pennsylvania (1999).

Herbicide		Est. Acres Treated in PA	Average Rate (lb AI/acre)	Est. Amount Used per Year (lb AI/acre)
Common Name	Trade Name			
Glyphosate	Roundup Pro, others	30,000	1.5	45,000
Simazine	Princep, others	20,000	2.5	50,000
Atrazine	Aatrex, others	14,000	2.5	35,000
Pendimethalin	Pendulum	10,000	3.0	30,000
Oryzalin	Surflan	10,000	2.0	20,000
Oxyfluorfen	Goal	10,000	0.75	7,500
Metolachlor	Pennant	8,000	3.0	24,000
Clopyralid	Stinger	8,000	0.15	1,200
Fluazifop	FusiladeII	7,000	0.4	2,800
Sethoxidym	Vantage	4,000	0.5	2,000
Triclopyr	Garlon	2,500	1.5	3,750
Isoxaben	Gallery	1,000	0.75	750
Clethodim	Envoy	500	0.15	75
Pronamide	Kerb	500	1.5	750
Sulfosate	Touchdown	500	1.5	750
Bentazon	Basagran T/O	500	1.0	500
Oxadiazon	Ronstar	0	0	0
Napropamide	Devrinol	0	0	0

Insect and Mite Control

This section provides information about key pests of Christmas trees and the presence of these pests based on scouting reports in Pennsylvania.

Admes Spider Mite

In 2002 a population of the Admes spider mite, a relatively uncommon pest of spruce in Pennsylvania, was found on Colorado spruce in Northumberland County. This is only the third report of this species in the state, following its initial discovery about 5 years ago. Admes spider mite can cause significant browning of needles of all spruces. The adults are much larger than spruce spider mite and tend to settle out on the needles in a "stretched-out" position. The mites are reddish with long legs and sort dorsal hairs.

Balsam Twig Aphid

Growers are starting to notice damage from balsam twig aphids feeding in the new growth of true firs. This damage appears as curling and stunting of new needles. The most efficient time to spray for this pest is before bud break. Once the new growth begins to appear the aphids are already there and feeding on the tender needles. Sprays applied now may reduce next year's pest population, but the aphids have already done the damage. Many different predators feed on balsam twig aphids and will provide some degree of free pest control at this time. Lady beetles may be found on damaged trees and if you look close you may even observe the larvae of the flower, or syrphid, flies. These pale green to yellow maggots look like slugs and each one can consume as many as 400 aphids during its development. Follow all label directions prior to applying a registered insecticide.

Eastern Pine Shoot Borer

In 2003 this moth began to emerge in late April and peak counts were found in early May. After May, few adults could be found in pheromone traps. Eastern white pine and Scotch pine are favored hosts of this native pest. However all pine, Douglas fir and white spruce are known hosts. The caterpillar of this small moth usually attacks new lateral side shoots and sometimes the terminal leader. Female moths begin laying eggs on the new shoots soon after emerging and young larvae bore into and feed in the center of elongating shoots. Once larvae are mature they chew an exit hole at the base of the shoot and drop to the ground to pupate and over winter. Look for yellowing and stunted shoots. On thinner shoots, wilting will be noticed. Damage is generally not severe unless trees are repeatedly attacked, in which case stunted, forked leaders and general loss of shape can occur. Some control is generally achieved by normal shearing of Christmas trees. Late shearing, however, may enhance population build-up by allowing larvae to complete their feeding and exit before the shoots are pruned. This pest does not cause widespread damage, and sprays are not generally recommended. Damage may mimic shoot feeding activity of adult introduced pine shoot beetles. However, the beetles feed later in the year and their galleries are not packed with frass and wood shavings. Galleries of eastern pine shoot borer are often packed with frass. In addition, the insect creates perfectly round entrance and exit holes, while the exit hole of the moth larva is oval and irregular.

European Pine Sawfly

European pine sawfly larvae are 0.75 inch in size in Lebanon County and consuming entire needles on Scotch pine. These larvae always feed in groups and are quite capable of stripping a tree of most of last year's needles. The fact that they only have a single generation each year and feed exclusively on the previous years growth reduces their importance as a pest. Hand removal is the most effective method when larvae reach this size. Once larvae complete their development they will drop to the ground to pupate.

Pine Needle Scale

Pine needle scale eggs beginning to hatch under the scale cover. Crawlers move out onto the needles. For best results are achieved when a first generation spray program begins when crawlers are out on the needles. Follow all label directions prior to applying a registered insecticide. Likewise follow all label directions regarding reapplication intervals.

Spruce Spider Mite

The spruce spider mite is not just a pest of spruce or true firs but all Christmas tree species. Infestations on pines and Douglas fir may not be common but do occur.

Disease Control in Pennsylvania Christmas Trees

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Most Pennsylvania Christmas tree growers use some variation of mist blower to apply fungicides. The majority use drawbar-mounted blowers; a few growers use backpack mist blowers, high-pressure hoses, aerial applications, or other methods. The recommended rates are applied in 100 gal/acre volumes of water, but some aerial applications and small "between the row" mist blowers apply in smaller volumes. One primary problem is getting fungicides distributed evenly on target foliage. As trees grow through a 6–10-year rotation, the volume of foliage increases dramatically, and growers must compensate by increasing pesticide volume for complete coverage. Hence, the rate per acre must increase through the course of the rotation as trees grow. The increasing size of the trees also causes them to physically block spray from reaching the backside of trees or the next tree row behind them. This "shadowing effect" causes lapses of coverage and allows pockets of infection to go untreated. The problem is particularly difficult in harvest-sized trees where bottom branch whorls are very dense. The 100-gal volume of water application rate helps to alleviate this problem.

Most fungicide applications are applied from April through August, with frequency dependent upon the target diseases, fungicide used, and the weather. Many serious foliar diseases require two or three fungicide applications at 7–10-day intervals, and in wet years, sometimes a fourth spray is

recommended. Trees slated for fall harvest would not usually need applications after August, because any symptoms of infection would not be visible until the following spring, thus allowing a generous spray-free preharvest interval for tree tagging and cutting to safely occur without exposure to fungicides.

There are relatively few fungicides for disease management, and they are all solely preventative. This limitation is serious because the most severe foliar and twig diseases infect during tissue elongation in the spring. At that time, any of these fungicides must be applied on a weekly or biweekly basis to maintain coverage on the rapidly expanding tissue, even under the best weather conditions. If continuous rainfall occurs during this period of tissue elongation, it becomes impossible to prevent infection.

If growers are careful in selecting and preparing good planting sites and establishing healthy transplants regular fungicide treatments are not usually necessary. Few fungicide treatments are generally needed in a growers' first rotation, or in the first 3–5 years of subsequent rotations. Growers who scout diligently can identify early outbreaks and treat "hot spots" before the entire plantation is infected. Most serious disease outbreaks occur late in the rotation when canopies of trees are dense and begin to overlap, "trapping" moisture and cool temperatures, which favor fungal development. Currently, the industry relies heavily on fungicides, but the majority of them are applied in the last 2 to 3 years of a rotation.

Block planting and harvesting are recommended to best manage the various tree species and their respective pests. The long rotation of this crop, 6–10 years, allows pest problems to build up and potentially destroy long-term investments. Small choose-and-cut growers often cannot follow block-cut recommendations due to their limited acreage. This limitation compounds their pest problems because some diseases and insects can cross species, and if they apply pesticides by air-blast sprayer, they must spray nontarget hosts as well as infected ones, thus applying more pesticide than necessary. Further pests are "perpetuated" from one rotation to the next on infected hosts. Species or crop rotation is recommended where possible to reduce the number of pests. Many serious foliar pathogens can be reduced or eliminated by growing an alternate or cover crop for a year between rotations or by changing species.

Weed control is recommended to increase airflow, encourage foliar drying, and decrease competition for water and soil nutrients. Most fungal diseases begin in the lower crown because bottom branches are shaded, closer to the ground, and thereby cooler. Cooler temperatures allow moisture to remain on the foliage for longer periods, thus enabling fungal spores greater opportunity to germinate and infect their host. Weed control provides increased airflow around the trees and hastens moisture evaporation.

Few disease-resistant host stocks have been identified or developed and consistent sources or large quantities are not readily available. On the advantageous side, open-pollinated trees are not uniformly susceptible when disease organisms are present. As yet, we have not had fungicide resistance problems among the Christmas tree pathogens, but with such a limited selection of fungicides to use, resistance is a potential threat to the industry. The wide genetic diversity of our hosts, the broad variety of tree species grown, and the knowledge that many of our most serious pathogens infect only once each year have all been factors in delaying this problem. As yet, Pennsylvania has not had severe or consistent

problems with the blight type of diseases that often have repeating infection periods each year and can adapt and rapidly overcome host resistance. However, with more and different tree species being imported into Pennsylvania, the threat of introducing such pathogens increases.

Summary of Major Disease Problems in Pennsylvania Christmas Trees by Host Species

Douglas fir

Pseudotsuga menziesii

Rhabdocline (needlecast)

Sphaeropsis (tip blight)

Cytospora and other canker fungi

Phytophthora (root rot)

Swiss (needlecast)

Armillaria (root rot)

Threats: Increasing *Phytophthora* root rot

Potential loss of chlorothalonil for needlecast control

Scots

Pinus sylvestris

Lophodermium (needlecast)

Sphaeropsis (tip blight) and bleeding stem canker

Endocronartium pine gall rust

Armillaria (root rot)

Atropellis, *Cennangium*, and other canker fungi

Sclerophoma (needle blight)

Threats: Potential loss of chlorothalonil for needlecast control

Lack of adequate control for *Sphaeropsis*

Brown spot (needle blight)

Firs

Abies balsameae, *concolor*, *fraseri*, *grandis*, *alba*, *procera*, *amabilis*

Phytophthora (root rot)

Cytospora and other cankers

Threats: Potential loss of Mancozeb for needlecast control

Increasing *Phytophthora* root

Rhizosphaera (needle blight)

Rusts and broom rust

Needlecasts—various potential introductions

Delphinella (tip blight) potential introduction

Needle blights—various potential introductions

Spruces

Picea pungens, engelmannii, abies, glauca, omorika, mariana

Rhizosphaera (needle blight)

Chrysomyxa (foliar rust)

Cytospora (canker) and other various canker fungi

Armillaria (root rot)

Threats: Potential loss of chlorothalonil for needlecast and needle rust control

Lirula (needlecast) potential introduction

Eastern white pine

Pinus strobus

Procera (root rot)

Threats: White pine blister rust

Other pines

Pinus nigra, banksiana, thunbergiana, densiflora, ponderosa, resinosa

Sphaeropsis (tip blight) and bleeding stem canker

Ploioderma lethale (needlecast)

Dothistroma or red band (needle blight)

Brown spot (needle blight)

Lack of adequate control for *Sphaeropsis*

Major Disease Problems in Pennsylvania Christmas Trees by Type of Disease

Foliar Disease Problems—Needlecasts, Needle Blights, and Foliar Rusts

Of the Christmas trees diseases in Pennsylvania, needlecasts have been the most consistently damaging due to their explosive damage potential when environmental conditions are conducive to infection. Typically, each host species has at least one or two serious foliar diseases. There are often significant life cycle differences between the various types of diseases, which can impact the disease cycle, and should be taken into account in management strategies. The single denominator for all diseases is water during infection periods. In drought years, less disease is usually seen, whereas in rainy seasons epidemic incidence and severity may occur. Once foliar diseases are established in plantations, cultural methods are not generally effective if weather is wet during infection periods. Chemical prevention is usually necessary to avoid damage and is crucial in plantations within 2–3 years of harvest that are infected with needlecasts.

The **needlecast** diseases are generally host specific and often can infect only a new complement of foliage. For example, *Rhabdocline* needlecast can only infect Douglas fir and does not harm other Christmas tree species, and it only infects the complement of newly developing needles each year. Needlecasts typically infect during one interval each year, mostly in the spring after bud break, but timing varies. *Lophodermium seditiosum*, for example, infects in mid-to-late summer. The needlecasts vary in saprophytic ability. Many are obligate parasites; others can develop and survive on dead foliage. Knowing the characteristics of specific needlecasts is imperative to successful management. The sexual stage of the fungus is usually the inoculum source for needlecasts. The ascospores are forcibly discharged and wind disseminated. In Pennsylvania, the major needlecast diseases have been *Rhabdocline*, *Lophodermium*, *Phaeocryptopus* (Swiss), *Ploioderma*, and *Cyclaneusma*.

Needle blight diseases are not usually as host specific; for example, both *Rhizosphaera pini* and *Dothistroma pini* can infect several species of conifers. Many needle blights can infect any age foliage and may have several infection periods per growing season, the number and duration depending on environmental conditions. Due to the multiple infection periods and the ability to infect all foliage complements, the potential for severe outbreaks is generally very high with needle blights if there is a rainy season. Both sexual and asexual stages of the fungus may provide inoculum for needle blights, which are rain-splash and wind-disseminated. Typically, needle blights are somewhat saprophytic, and infected debris must be removed from plantations during dry weather to avoid further inoculum production. As yet, Pennsylvania does not have many needle blights, but introductions are a potential serious threat. The blights causing the most damage in Pennsylvania are *Rhizosphaera kalkoffii* and *Dothistroma*, and to a minor degree, *Phyllosticta*, *Sclerophoma*, *Phoma*, and *Botrytis*.

There are only two known **foliar rusts** in Pennsylvania: *Chrysomyxa* on *Picea* and *Coleosporium* rust on *Pinus*. Foliar rusts are obligate parasites and most have herbaceous alternate hosts. For example, *Coleosporium* must alternate to members of the aster family to survive. *Chrysomyxa*, however, is an autecious rust, and thus can rapidly build high levels of infection.

Foliar Disease Management Strategies: Needlecasts, Needle Blights, and Foliar Rusts

Selecting planting sites with good air drainage and maintaining weed control and spacing helps to dry tree crowns and reduce infection periods.

Plant disease-free stocks and monitor and scout plantations regularly.

Always work in healthy plantations first, before moving to infected ones to avoid accidentally spreading infected plant materials or spores.

Remove severely infected trees well before the infection period and always during dry weather. Dragging infected materials through a plantation during the fungal infection period may further distribute the spores and increase disease incidence.

Carefully calibrate spray equipment and check that spray distribution patterns cover the lower tree crowns where the foliar fungi proliferate. Fungicides must be applied thoroughly during infection period (s) to prevent infection.

Follow block management and rotate host species where possible, to reduce foliar disease problems; or, for diseases with broad host ranges, grow an alternate or fallow crop for a year between rotations. (This approach is very effective only if other infected plantations are not adjacent).

Needlecast Diseases

Rhabdocline Needlecast (*Pseudotsugae menziesii*)—HIGH Outbreak and Damage Potential

Pseudotsugae is the most widely planted Christmas tree species in Pennsylvania, and *Rhabdocline* needlecast is the most serious disease. Infection occurs only during the spring, just after bud break, and only on the newly expanding foliage. However, there is tremendous outbreak potential depending on environmental conditions during infection. Continuous rainfall during shoot elongation prohibits the application of the fungicide and massive levels of infection may occur within a single month. Infected new foliage discolors in late fall, and symptom intensity increases throughout the winter. Severely infected trees are not salable. Repeated severe infection can cause lower crown mortality and eventually tree death.

Growers with severely infected plantations spray weekly after bud break, particularly in the final 2–3 years before harvest, and use the highest rate recommended. This approach is appropriate considering the rapid tissue expansion, frequent spring rainfall, and high potential for damage.

Rhabdocline is an obligate parasite and does not continue to develop or sporulate when the tree is dead. *Rhabdocline* fruiting structures are typically raised and swollen when wet, and bright orange to brick-colored when sporulating. Growers know to stop spraying when the fruiting bodies no longer swell when wet, are dark brown to black, or when the discolored, desiccated foliage drops from the trees.

The Lincoln provenance of *Pseudotsugae* is the most widely planted seed source in Pennsylvania, along with smaller acreage of Coconino, and others. These commonly planted sources are very susceptible to *Rhabdocline*. Although some seed sources are known to have higher proportions of trees resistant to *Rhabdocline*, these specific sources are not as well adapted to Pennsylvania growing conditions and are not readily available or identifiable for the growers in the quantities required.

Chlorothalonil is the primary fungicide used and is effective if growers can apply it at the proper time, rate, and distribution. Sterol inhibiting fungicides were tested but found ineffective in preventing infection. Continuous rainfall after bud break often leads to high levels of infection.

Merrill, W., Wenner, N.G., and Gerhold, H. 1987. The southwestern Douglas-fir - a seed source resistant to *Rhabdocline* needlecast. *Am. Christmas Tree J.* 31:41–42.

Merrill, W., Wenner, N.G., and Gerhold, H. 1990. *Rhabdocline* needlecast resistance in Douglas-fir seed sources from the southwestern United States, pp. 93-95. In Merrill, W., and Ostry, M.E. (eds.), Recent Research on Foliage Diseases. USDA For. Serv. Gen. Tech. Rept. WO-56.

Wenner, N.G., and Merrill, W. 1993. Banner and Rubigan fungicides ineffective in controlling *Rhabdocline* needlecast (Abstr.). Phytopathology 83:

Merrill, W., and Wenner, N.G. 1988. Pest Note No. 21 - *Rhabdocline* needlecast. Pa. Christmas Tree Growers' Assoc. Bull. 181.

Wenner, N.G., and Merrill, W. 1987. Bud break in Douglas-fir in relation to control of *Rhabdocline* needlecast. (Abstr.) Phytopathology 77:123.

Swiss or *Phaeocryptopus* Needlecast of *Pseudotsugae menziesii*—LOW Outbreak Potential

Although Swiss needlecast occurs in Pennsylvania, it has not been nearly so prevalent or damaging as *Rhabdocline*. This disease is thought to be due to the warmer temperatures in Pennsylvania during the period of shoot elongation, which are not optimal for *Phaeocryptopus* infection. Swiss needlecast is far more severe in the states farther north through New York, Vermont, New Hampshire, and Maine where the infection period temperatures are cooler.

Infection occurs during shoot elongation on new needles. Infected foliage may begin to form fruiting initials on green needles in the fall of the first year. The cup-like apothecia do not fully mature until the following spring, when foliage discolors to a brown tipped yellow or brownish hue. Discolored, infected foliage can often be seen hanging in chlorotic infected trees.

Swiss and *Rhabdocline* often infect the same tree and can be found fruiting on the same needle. Fortunately, the two infection periods overlap, with *Rhabdocline* beginning sooner, and Swiss extending longer, so that simply extending the pesticide spray coverage for 2 weeks beyond *Rhabdocline* also controls *Phaeocryptopus* infection. Chlorothalonil is the primary fungicide used and is effective if the growers can apply it at the proper time, rate, and distribution. Two applications applied 2–3 weeks apart are usually effective.

Merrill, W., and Wenner, N.G. 1988. Pest Note No. 22 - Swiss Needlecast. Pa. Christmas Tree Growers' Assoc. Bull. 181.

Lophodermium Needlecast of *P. sylvestris*—HIGH Outbreak and Damage Potential

Lophodermium is the most common foliar disease of *P. sylvestris*. It can be very destructive if infection is severe each year, leading to lower crown mortality and eventually tree death. It is atypical of needlecasts, because it does not infect until mid-to-late summer, depending on temperature and rainfall.

During most years, the black football-shaped apothecia mature and infection occurs during from mid-July through August. Infected foliage shows few symptoms until the following late winter when chlorotic and brown spots occur, expanding and coalescing through the late spring until the infected needles die and brown completely.

Controlling midsummer infection is a real advantage for the growers because the foliage is already full-sized, and they do not have to be concerned about the tissue "outgrowing" the fungicide coverage as they do during the spring shoot-elongation period. Furthermore, studies conducted with chlorothalonil showed that flowable provided 4–6 weeks of consistent protection for mature foliage. Growers can apply two protective applications of fungicide, in early-to-mid-July and again in August and control most infection if rate and distribution are appropriate. The only exception with *Lophodermium* occurs during drought years. If there is not sufficient rainfall during July or August to permit sporulation and infection to occur, the fungus can remain quiescent until rain develops even in October or until infection is cut off by low temperatures. Therefore, in drought years, an additional spray application in September or even early October could be needed. The potential loss of chlorothalonil would substantially increase the number of alternate fungicide spray applications needed and significantly increase production costs.

Merrill, W., and Wenner, N.G. 1987. Pest Note No. 1 - Lophodermium Needlecast. Pa. Christmas Tree Growers' Bull. 176.

Merrill, W., and Wenner, N.G. 1990. Christmas tree pest note: Lophodermium needlecast. NH-VT Christmas Tree Assoc. Tree Line 79:12–13.

Ploioderma lethale Needlecast of Hard Pine (*Pinus*)—LOW-to-MODERATE Outbreak Potential

Hard pines such as *P. resinosa* (red pine), *ponderosa* (ponderosa pine), or *nigra* (Austrian pine), are grown in the Pennsylvania, but more for landscape and nursery purposes than for Christmas tree production. The fungus infects elongating needles in late spring and early summer. *Ploioderma* symptoms occur as first spotted and chlorotic needle tips, and later as reddish brown dead needle tips that eventually fade to tan during the winter. The elongate black stripe-like apothecial structures develop in late spring and early summer. *Ploioderma* has an unusual and easy to identify symptom characteristic—the infected needles virtually always have a green needle base between 25 and 60% of the total needle length. The unfortunate outcome of this is that damaged needles remain hanging on trees until they are naturally shed. The disease is controlled with three applications of chlorothalonil during foliage elongation. Growers often complain that the disease comes out of "nowhere" because naturalized hard pines in windbreaks and roadside plantings are often infected and harbor the fungus within wind dissemination distance of plantations.

Longenecker, J., and Towers, B. 1990. Epidemiology and control of *Ploioderma lethale* on *Pinus nigra*., pp. 43–44. In IUFRO proceedings 1990 Recent Research on Foliage Diseases. USDA For. Serv. Gen. Tech. Rep. WO-56, pp. 93-95.

Merrill, W., and Wenner, N.G. 1987. Pest Note. No. 7 - *Lethale* (=Hypoderma) Needlecast. Pa. Christmas Tree Growers' Assoc. Bull. 177.

Cyclaneusma Needlecast of *P. sylvestris*—LOW Outbreak and Damage Potential

P. sylvestris, or Scots pine, was once the most popular and widely planted Christmas tree species planted in Pennsylvania. Many seed sources were grown and some were apparently very susceptible to infection by *Cyclaneusma minus*. On highly susceptible trees, *Cyclaneusma* can infect and prematurely discolor all but the current-year foliage, leaving the crop unsalable. Today's plantations contain much less *P. sylvestris* and seed sources used now do not seem to be as susceptible to *Cyclaneusma*. The fungus is ubiquitous, and some growers with susceptible trees do spray to control it. Currently, *Lophodermium* needlecast is the more serious of the two needlecasts on *P. sylvestris* and has an overlapping period of infection. The primary fungicide used, chlorothalonil, controls both diseases and is often combined with various insecticides in an integrated spray approach because *Cyclaneusma* can infect from April to October. The majority of the infection occurs in the spring, from April to May, in most years.

Hill, H., Wenner, N.G., and Merrill, W. 1992. Chlorothalonil efficacy reduced by simultaneous application of Safer® insecticide concentrate (Abstr.). *Phytopathology* 82:244.

Merrill, W., and Wenner, N.G. 1994. Genetically controlled needle retention of Scots pine in relation to *Cyclaneusma* needlecast (Abstr.). *Phytopathology* 84:549.

Merrill, W., and Wenner, N.G. 1996. *Cyclaneusma* needlecast and needle retention in Scots pine. *Plant Dis.* 80:294–298.

Wenner, N.G. 1987. The effect of chlorothalonil on the infection of Scots pine by *Cyclaneusma minus*. MS thesis, The Pennsylvania State University, State College.

Wenner, N., and Merrill, W. 1986. *Cyclaneusma* needlecast of Scots pine in Pennsylvania: a review, pp. 35–40. In Peterson, G. (ed.), *Recent Research on Conifer Needle Diseases*. USDA For. Serv. Gen. Tech. Rep. WO-50.

Wenner, N.G., and Merrill, W. 1990. Control of *Cyclaneusma* needlecast on Scots pine in Pennsylvania. pp. 27-33. In Merrill, W., and Ostry, M.E. (eds.). *USDA For. Serv. Gen. Tech. Rep. WO-56*.

Wenner, N.G., and Merrill, W. 1993. Comparative efficacy of Bravo 825 and Bravo 720 in controlling *Cyclaneusma* needlecast (Abstr.). *Phytopathology* 83:248.

Other needlecasts occur in the state, but they have not been economically important. For example, although *Bifusella linearis* is common on *P. strobus* in damp, shaded natural stands, it has not caused economic losses in any known *P. strobus* Christmas tree plantation. Thus far, Pennsylvania has not had any *Abies* needlecasts introduced. It is certainly a potential threat to the industry if this should happen,

although we have no idea whether these fungi would survive or proliferate under Pennsylvania growing and climatic conditions. If the *Abies* needlecasts such as *Isthmiella* or *Lirula* were introduced and able to proliferate in Pennsylvania, they would pose a very difficult management problem. These organisms have 2-year disease cycles, and discolored, infected foliage remains hanging in the trees for many years, marring its aesthetic uses for cut trees, or boughs for roping or wreaths. Furthermore, little work has been done on these diseases, and chlorothalonil is not recommended for use on *Abies* due to potential phytotoxic effects.

Albers, M., Albers, J., Cummings-Carlson, J., Haugen, L., and Wenner, N.G. 1996. How to identify and manage needlecast diseases on balsam fir. United States Department of Agriculture, Forest Service. Northeastern Area. NA-FR-02-96.

Needle Blight Diseases

Although several needle blights have been reported in Pennsylvania, only blights caused by *Rhizosphaera* and *Dothistroma* have been significant and repeated problems to warrant control. Other foliar blight fungi such as *Sclerophoma*, *Phyllosticta*, *Phomopsis*, *Phoma*, and others occur occasionally but primarily on trees stressed by other factors, most often drought.

Rhizosphaera needle blights. There are two species, *R. kalkoffii* and *R. pini*, that cause needle blights on various host conifers and can be differentiated only through microscopic spore examination. Thus far, only *R. kalkoffii* has been found on Pennsylvania growing stock.

R. kalkoffii on *P. pungens*—MODERATE Outbreak and Damage Potential

R. kalkoffii is a primary pathogen on *P. pungens* and can be very destructive when there is significant rainfall during the period of infection, and it seems to sporulate more profusely when trees are stressed. Although *Pinus*, *Pseudotsugae*, and some *Tsugae* and *Abies* species are susceptible, *P. pungens* has been the only host in Pennsylvania with notable damage. The fungus has been found to have multiple infection periods in Pennsylvania and can infect any age foliage. Needles discolor and drop from the tree, leaving "twiggy holes" in the crown. At least three spring applications are recommended applied at 7–14-day intervals after bud break. One or two late-summer applications may be needed if current-year foliage begins to discolor. Chlorothalonil is the primary fungicide used and is effective if the growers can apply it at the proper rate and distribution. Chlorothalonil can, however, remove the glaucous color from "blue" *P. pungens*.

R. pini infects various *Abies*, *Pinus*, and *Picea* host species, but it has not thus far been reported or caused problems in Pennsylvania growing stock. *R. pini* is a significant potential threat for Pennsylvania, though, due to its wide host range and history of causing significant problems on native and plantation *Abies* both to the north, throughout the New England states and Canada, and to the south of Pennsylvania in *A. fraseri* plantation trees. We do not know how the fungus would acclimate to Pennsylvania growing conditions, but severe damage on plantation *A. balsameae* and *fraseri* in New

Hampshire is reason for concern. Infected foliage rapidly discolors and destroys the appearance of the tree.

Albers, M., Albers, J., Cummings-Carlson, J., Haugen, L., and Wenner, N. 1996. Pest alert: *Rhizosphaera* needle disease of fir. United States Department of Agriculture, Forest Service. Northeastern Area. NA-PR-06-96.

Dothistroma septospora on hard pines—LOW-to-MODERATE Outbreak and Damage Potential

D. septospora, sometimes called red band needle blight (*Mycosphaerella pini*) infects any age foliage on hard pines. Although other hosts species such as *Pseudotsugae*, *Larix*, and *Picea* are susceptible, in Pennsylvania the damage primarily occurs on *P. nigra*, *ponderosa*, or *resinosa*. Infection occurs during late spring and early summer and can be very destructive in seasons with frequent intervals of wet weather. Infected foliage develops reddish bands with dark-centered fruiting structures, and eventually discolors and kills infected needle tips. Bases of infected foliage often remain green and may remain on the tree until naturally shed. Two fungicide applications at 3-week intervals during needle elongation are usually effective. Monthly applications may be needed during the summer in very wet seasons. Chlorothalonil is the primary fungicide used and is effective if the growers can apply it at the proper rate and distribution.

Towers, B., Forer, L., Wagner, V., Merrill, W., and Wenner, N. 1984. Needle blight caused by *Dothistroma pini* in Austrian and red pines in Pennsylvania. *Plant Dis.* 68:450.

Wenner, N.G., and Merrill, W. 1997. *Phyllosticta multicorniculata* on *Abies* spp. in the northeastern U. S. *Plant Dis.* 81:230.

Foliar Rusts

In Pennsylvania, the only foliar rust of economic importance is *Chrysomyxa* on *P. pungens*. Although *Coleosporium* spp. rust is common on *P. resinosa*, it does not cause significant economic damage. Weed control of the alternate aster host is usually the only action taken.

Chrysomyxa weirii on *P. pungens*—HIGH Outbreak and Damage Potential

Spruce rust caused by *C weirii* on *P. pungens* is a recent introduction to Pennsylvania. First discovered in the 1980s, this autecious rust has spread to many areas of the state and caused significant economic damage. Although many *Picea* species are susceptible, *P. pungens* is the only reported host in Pennsylvania. The fungus infects new foliage just after bud break and symptoms later develop as chlorosis and reddening of foliage during the following winter and spring.

Three fungicide sprays after bud break applied at weekly to biweekly intervals usually provides good control. Chlorothalonil and chlorothalonil with fenarimol (Twosome) are effective if the growers can

apply them at the proper time, rate, and distribution, but may remove the glaucous color from "blue" *P. pungens*. Continuous rainfall after bud break may lead to high levels of infection.

Merrill, W., and Wenner, N. G. 1992. *Chrysomyxa weirii* on *Picea pungens* in Pennsylvania (Abstr.). *Phytopathology* 82:246.

Wenner, N. G., and W. Merrill. 1994. Chemical control of *Chrysomyxa weirii* on *Picea pungens* (Abstr.). *Phytopathology* 84:545.

Wenner, N.G., and Merrill, W. 1994. Evaluation of Bravo 720 and ASC 66792 fungicides for control of *Chrysomyxa weirii* on Colorado blue spruce. *Am. Phytopathol. Soc. Fungicide Nematicide Tests* 48:393.

Broom Rusts

Melampsorella Broom Rust

Thus far, we do not have a problem with any broom rusts in Pennsylvania Christmas trees. Although *Melampsorella caryophyllacearum* and its alternate host chickweed were found once in a Pennsylvania *Abies fraseri* plantation, the tree broom did not sporulate or spread. It is possible that the environmental conditions at that site were not suitable for the pathogen.

Merrill, W., and Wenner, N.G. 1992. *Melampsorella caryophyllacearum* on *Abies fraseri* in Pennsylvania (Abstr.). *Phytopathology* 82:246.

Gall and Stem Rusts

Endocronarium Gall Rust of *P. sylvestris*—LOW-to-MODERATE Outbreak Potential

The only significant gall rust in Pennsylvania is caused by *Endocronartium harknessii* on *P. sylvestris* (and other hard pines). This fungus is autecious and infects during shoot elongation and can cause significant damage. Only about 10% of most *P. sylvestris* seed sources are susceptible, but once infected, the galls on the trees can be difficult to spot until they have grown large enough to begin girdling branches. Infected trees should be rouged and remaining trees carefully inspected and sprayed two to three times during shoot elongation to prevent further infection.

Chemical controls such as Bayleton and mancozeb are effective if growers can apply them at the proper time, rate, and distribution, and if they are vigilant in scouting and removing infected trees.

Merrill, W., and Wenner, N.G. 1987. Pest Note No. 2 - Pine-Pine Gall Rust. Pa. Christmas Tree Growers' Bull 176.

Wenner, N.G., and Merrill W. 1988. Evaluation of Benefit to control pine-pine gall rust on Scots pine Christmas trees, 1986–87. *Am. Phytopathol. Soc. Fungicide Nematicide Tests* 43:311.

Merrill, W., Wenner, N., and Towers, B. 1983. Introduction of *Endocronartium harknessii* into central Pennsylvania (Abstr.). *Phytopathology* 73:371.

Wenner, N., Merrill, W., and Towers, B. 1983. Susceptibility of ponderosa pine to *Endocronartium harknessii* in Pennsylvania (Abstr.). *Phytopathology* 73:377.

Cronartium ribicola on *P. strobes*—LOW Outbreak and Damage Potential

White Pine Blister Rust caused by *Cronartium ribicola* on *P. strobus* occurs in Pennsylvania, mostly in the northern tier of the state, but it has not yet caused significant economic damage in Christmas tree plantations. Historically, Pennsylvania had a control program active for many decades to eradicate the alternate *Ribes* hosts. That program no longer exists, and it is unknown how much *Ribes* has reestablished or what potential threat it poses. Furthermore, many gardeners and small farms have begun to grow various *Ribes* species in fruit production. The impact of these factors on the incidence of *C. ribicola* on *P. strobus* is as yet unknown.

Tip and Shoot Blights

Sphaeropsis Tip and Shoot Blight and Stem Canker—HIGH Outbreak and Damage Potential

Many tip and shoot blight fungi occur in Pennsylvania, but *Sphaeropsis* is the most common and difficult to manage. It causes severe damage on a consistent basis and is problematic due to its tremendous host range (virtually any conifer), and ubiquitous distribution. Even conscientiously rouging infected materials does not eliminate the threat from plantations because the fungus is so widespread that it can survive in landscape and highway windbreaks and plantings and be brought in on the bird feathers, animal fur, or equipment. The fungicides labeled are helpful, but they do not usually provide complete control.

Sphaeropsis is not only a pathogen but also can survive as a saprophyte for years, making it impossible to eliminate from infected trees. Pycnidia form and sporulate on needles for 3–5 years, and on woody material for 5–7 years. Large pine trees with infected cones are a particular threat because spores are rain splash-disseminated, and inoculum literally "drips" down to infect new host branches with each rain. Although all conifers can become infected, *Pinus* spp. are the most common and severely affected hosts. When a large inoculum source is nearby, *Picea* spp. and *Pseudotsugae* can incur heavy damage as well. Large pines infected with *Sphaeropsis* are a threat to any nearby conifer plantation.

Adding to the problems, *Sphaeropsis* is known to develop more rapidly in trees under stress from drought or other environmental problems. Although the majority of infection occurs during spring shoot elongation, the fungus also can enter wounds or even spittlebug damage later in the growing season and

cause perennial bleeding stem cankers.

Managing this disease problem and all other shoot blight and canker diseases requires stringent sanitation to remove all infected materials during dry weather, and to either burn or bury debris. Any work done in the infected plantations should be done during dry weather to avoid accidentally carrying the spores to new hosts. Infected materials left in the plantation continue as a source of inoculum.

The chemicals labeled for use aid in controlling this fungus, but must be coupled with strict sanitation. Thiophanate methyl or Mancozeb can be applied at 7–10-day intervals after bud break to help prevent infection. During very rainy seasons, high incidence and severity may be incurred despite fungicide applications. This disease is by far the most difficult to manage and control.

Gerhold, H.D. Rhodes, H.L.H., and Wenner, N.G. 1994. Screening *Pinus sylvestris* for resistance to *Sphaeropsis sapinea*. *Silvae Genetica* 43:333–338.

Merrill, W., and Wenner, N.G. 1987. Pest Note No. 3 - Diplodia tip blight. Pa. Christmas Tree Growers' Bull. 176.

Stanosz, G.R., and Smith, D.R. 1996. Evaluation of fungicides for control of *Sphaeropsis* shoot blight of red pine nursery seedlings. *Can. J. For. Res.* 26:492–497.

Stanosz, G.R., Prey, A.M. and Cummings Carlson, J. 1994. Biology and control of *Sphaeropsis sapinea* in nurseries and plantations of Wisconsin, USA, pp. 13–26. *In Proceedings, Diseases and Insects in Forest Nurseries, Dijon (France), October 3–10, 1993.*

Other shoot blights such as *Discosia*, *Phomopsis*, *Sirococcus*, and *Sclerophoma* and many others occur in Pennsylvania but have not caused serious or consistent problems. They are primarily problems on poor sites, stressed trees, or when weather is conducive to infection for long periods.

Merrill, W., Wenner, N.G., and Kelley, R. 1997. *Delphinella balsameae* tip blight of *Abies lasiocarpa* in Vermont. *Plant Dis.* 81:229.

Wenner, N.G., and Merrill, W. 1993. *Discosia pini* on *Pseudotsuga menziesii* in Pennsylvania (Abstr.). *Phytopathology* 83:248.

Management Strategies for Tip and Shoot Blight/Dieback and Cankers

Work and rogue in infected plantations only when they are dry to avoid spreading spores.

Maximize tree vigor by selecting good planting sites, providing proper pH and nutrients.

Avoid J-rooting seedlings during planting.

Maintain weed control to avoid competition and promote airflow between trees.

When pruning out diseased material, cut well below any visible wood discoloration or distortion.

Disinfect pruning and shearing implements before moving to healthy plantations.

Rogue all diseased materials from the plantation and either burn or bury them.

Shearing—timing varies according to species but generally avoid dormant pruning. Open wounds allow an easy entry point for canker forming fungi.

Cankers

Many of canker-causing fungi occur in Pennsylvania, and many have caused significant economic losses. They are, however, usually pathogens that attack weakened trees grown on poor sites or those environmentally stressed in other ways. *Cytospora* is the most common canker pathogen encountered across species, but *Atropellis* is often found on *Pinus* spp. The only control for cankers is through plantation management to provide vigorous growing conditions and to quickly remove infected trees. Infected debris must be removed from the plantation in dry weather and burned or buried to avoid continued sporulation. Table 6 shows the most common canker-causing fungi and the commonly reported host genera.

Table 6. Common canker-causing fungi and reported host genera in Pennsylvania.

Fungus	PA Host	Frequency	Threat
<i>Cytospora/Leucostoma</i>	<i>Abies, Picea, Pseudotsugae</i>	Common	High
<i>Dermea</i>	<i>Pseudotsugae</i>	Uncommon	Low
<i>Sclerophoma</i>	<i>Pinus, Pseudotsugae</i>	Common	Low to Moderate
<i>Thyronectria</i>	<i>Abies</i>	Uncommon	Low to Moderate
<i>Atropellis</i>	<i>Pinus</i>	Common	Low to Moderate
<i>Cenangium</i>	<i>Pinus</i>	Uncommon	Low
<i>Phomopsis</i>	<i>Pinus, Pseudotsugae</i>	Common	Low to Moderate
<i>Sphaeropsis</i>	<i>Pinus, Pseudotsugae</i>	Common	Low to Moderate

Note: *Sphaeropsis* shoot blight is much more common and damaging than the stem canker.

Wenner, N., and Merrill, W. 1985. A new twig canker of Fraser fir (Abstr.) *Phytopathology* 75: 630.

Wenner, N. G., and Merrill, W. 1992. *Dermea pseudotsugae* stem canker of Douglas-fir in eastern North America (Abstr.) *Phytopathology* 82:248.

Wenner, N. G., and Merrill, W. 1992. *Leucostoma kunzei* canker of Douglas-fir and Fraser fir Christmas trees (Abstr.). *Phytopathology* 82:248.

Wenner, N.G., and Merrill, W. 1995. *Sclerophoma semenospora* canker on *Abies fraseri* Christmas trees in Pennsylvania (Abstr.) *Phytopathology* 86:1561.

Root Rots

There are three primary root rots of plantation Christmas trees in Pennsylvania.

Root rot fungi can generally survive indefinitely in soils. Fungicides for root rots have not proven cost effective for plantations, so avoiding poor sites and maximizing tree vigor are the only practical management strategies.

Root Rot Management Strategies

Careful site selection for well drained soils.

Inspect new transplant roots carefully upon arrival and reject any with discolored roots.

Proper planting either by hand or machine to avoid J-rooting. J-Rooting stunts tree growth and predisposes them to serious environmental and pest problems.

Regular scouting and removing heavily infected or disease-prone individuals is recommended.

Do not stump-plant or plant on land recently cleared of hard wood trees.

Renovate old plantations before replanting by pulling old stumps and preparing soils with pH and nutrients to provide conditions for vigorous tree growth. Some wet sites can be drained with tile or by corrective grading.

Armillaria root rot has been the most prevalent in the state and can be found on any Christmas tree species. It is more common on drier sites, but it can occur anywhere trees are stressed and is usually more common in years following droughts. In Pennsylvania, approximately 85% of the *Armillaria* found in Christmas tree plantations is on J-rooted stock and is therefore very common on shallow or strip-mined soils. *Armillaria* is ubiquitous in the state and is also found in new plantations, recently cleared of

hardwoods, or in plantations bordering hardwood stands. The fungus survives on large woody tissue, so pulling old stumps before replanting and avoiding stump-planting are good recommendations.

Phytophthora root rot has become a more widespread and serious problem in the past 20 years. The increasing prevalence correlates to the increasing proportions of *Abies* being grown in Pennsylvania. *Abies* species are the most susceptible to *Phytophthora* infection and this, coupled with our heavy soils, has become an increasing disease problem. *Phytophthora* is a common fungus on wet or heavy soils, and it has a motile spore that can swim in soil water. Although *Abies* species are particularly susceptible to *Phytophthora* infection, virtually any Christmas tree species can be infected if sites are too wet. More studies are needed to expand our understanding of *Phytophthora*'s activity its control in Pennsylvania soils as we start to grow new and very susceptible *Abies* species.

Procera root rot, caused the fungus *Verticicladiella procera*, is a problem primarily on *Pinus strobus* and is also generally found on heavy or wet soils. This fungus is disseminated in soil water and infected soil and plant parts. Typically, infected plantations have low spots in the field, seasonal springs, or have very heavy, wet soils that do not drain.

Fusarium and *Pythium* are primarily a seedling and transplant bed problems. Infected transplants usually do not survive outplanting.

Merrill, W., and Wenner, N. 1985. *Fusarium* root rot and poor seedling survival. Pa. Christmas Tree Growers' Assoc. Bull. 168:6.
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Fungicides Labeled for Control of Christmas Tree Fungi in Pennsylvania

The most commonly used control(s) are shown in bold type in Table 7.

Table 7. Fungicides used on Christmas trees in Pennsylvania.

Foliar Disease Labeled Needlecasts	Fungicide Labeled	Rate of Active Ingredient/100 gal water

Rhabdocline	Chlorothalonil	1.1–2 lb. AI/100 gal
	Mancozeb	1.2 lb AI/100 gal
	Chlorothalonil with fenarimol	1.1–2.2 lb. AI/100 gal
	Copper hydroxide	1.5 lb AI/100 gal
Swiss	Chlorothalonil	1.1–4.1 lb AI/100 gal
	Mancozeb	1.2–3.2 lb AI/100 gal
	Chlorothalonil with fenarimol	1.1–4.4 lb. AI/100 gal
Lophodermium	Chlorothalonil	2–4 lb AI/100 gal
	Mancozeb	1.2–3.2 lb. AI/100 gal
	Chlorothalonil with fenarimol	2.2–4.4 lb AI/100 gal
	Bayleton	4 oz AI/100 gal
Cyclaneusma	Chlorothalonil	2–4 lb AI/100 gal
	Mancozeb	1.2 lb AI/100 gal
	Chlorothalonil with fenarimol	2.2–4.4 lb AI/100 gal
Ploioderma	Chlorothalonil	2–4 lb AI/100 gal
<i>Needle Blights</i>		
Rhizosphaera On spruce	Chlorothalonil	4 lb AI/100 gal
	Mancozeb	1.2 lb AI/100 gal
	Chlorothalonil with fenarimol	4.4 lb AI/100 gal
Dothistroma	Chlorothalonil	2–4 lb AI/100 gal
	Copper salts of rosin and fatty acids	1.7 pt AI/100 gal
Scirrhia	Chlorothalonil	4 lb AI/100 gal
	Mancozeb	1.2–3.2 lb AI/100 gal
	Chlorothalonil with fenarimol	4.4 lb AI/100 gal
Phyllosticta	Mancozeb	1.2 lb AI/100 gal
<i>Rust Diseases</i>		
Spruce Needle Rust	Chlorothalonil	4 lb AI/100 gal
	Chlorothalonil with fenarimol	1.1–4.4 lb AI/100 gal
Endocronartium	Bayleton	4 oz AI/100 gal
	Mancozeb	1.2–3.2 lb AI/100 gal

Shoot Blights		
Sphaeropsis	Thiophanate methyl	0.35–0.7 lb AI/100 gal
	Mancozeb	1.2 lb AI/100 gal
	Copper salts of rosin and fatty acids	1.7 pt AI/100 gal
Sirococcus	Chlorothalonil	1.5–2.6 lb AI/100 gal
	Chlorothalonil with fenarimol	1.7–2.8 lb AI/100 gal
	Bayleton	4 oz AI/100 gal

Future Threats to Christmas Tree Industry in Pennsylvania

Imported Diseases

In the past 20 years, there has been a shift in the Pennsylvania Christmas tree industry away from pines and toward *Pseudotsugae* and particularly *Abies* spp. Some Pennsylvania Christmas tree growers are still in the "honeymoon" period for many of the true fir species, which have become very popular and are now being planted, in ever-increasing numbers. Some plantations are still in early rotations of these species and pests either may not have been introduced or built up enough to cause significant problems, as eventually happens with subsequent crops. The potential threat of importing needlecasts, needle blights, rusts, shoot blights, canker fungi, and root rots are considerable, and for some pests has already occurred. The potential of these organisms to survive and proliferate under Pennsylvania growing conditions, however, is not yet known.

Merrill, W., Wenner, N.G., and Peplinski, J.D. 1993. New host and distribution records from Pennsylvania conifers. *Plant. Dis.* 77:430–432.

Limited Fungicide Options

The limited number of fungicides labeled for use on Christmas trees is another threat to the industry. Chlorothalonil is by far the most effective and widely used fungicide in Pennsylvania Christmas trees. This compound is currently under review, and its potential loss to the industry would be devastating. Mancozeb, the second choice in pathogen control is also currently under review and is of crucial importance as one of the few labeled and effective materials available for use on true firs, because chlorothalonil has been reported phytotoxic on *Abies* species.

Furthermore, all fungicides currently available are solely preventative and have no systemic or "kick-back" potential. Therefore, if inclement weather prohibits fungicide application, the grower is helpless to protect the crop. A continuing threat is that some diseases, such as canker, root rot, or even shoot blight fungi have no adequate controls. The materials labeled are either only marginally effective or there is

nothing labeled.

New fungicidal compounds such as Azoxystrobin are currently being used on other crops and may have potential for use in Christmas tree plantations. Azoxystrobin and other similar natural fungicide compounds have no known human toxicity problems, demonstrate some systemic or kick-back activity on other crops, and have a broad spectrum of fungicidal activity. However, as yet, the material has been found highly phytotoxic to some apple varieties, it permanently contaminates spray equipment, and has potentially serious drift problems. Christmas tree plantations, trying to capitalize on cut-your-own markets, are often situated in highly diverse and populated areas where apple orchards, or at least backyard apple varieties or ornamentals could be at risk for damage. Compounds such as Azoxystrobin may hold promise for the Christmas tree industry nationwide if these difficulties could be overcome, and the material were found to be effective. Apparently, the compound has been tested in Europe on conifers with some success.

As yet, we have not encountered problems with fungicide resistance in controlling Christmas tree diseases in Pennsylvania. Obtaining other fungicide options such as Azoxystrobin or other effective compounds for use would permit growers to rotate fungicide use and help to avoid potential resistance problems.

Provenance and Stock Sources

One of the unique and difficult problems in working with Christmas trees is that the commercial plantations are still composed of individual trees from open-pollinated seed collections. Each tree becomes a "unique" individual in responding to all environmental interactions from pests, to soils, to temperature and moisture, and other climatic variations. It is very different from working with most other agricultural "crops." which rely heavily on clonal, grafted, or genetically bred and improved stock. It is virtually impossible to consistently rate and research some problems because one cannot distinguish host variation from treatment differences or environmental fluctuations. The future holds great promise for the industry, because some growers have been establishing seed orchards of superior trees, some have been doing controlled crossing studies, and some scientists have been testing and producing limited numbers of genetically improved clonal materials by various means. The challenge will be to provide more consistent tree sources without too severely limiting the gene pool diversity.

More Biological Field Research Needed

Very little research has been done on some Christmas tree pests, and there are many damage symptoms for which we do not know the cause. Even many of the known causal organisms have not been studied to know infection periods, survival, and other crucial disease cycle components. Many "minor pests" have never been surveyed or studied to determine thresholds for damage, pesticide sensitivity, timing, or other life cycle investigations. Introduced pests must be surveyed and monitored carefully to determine emerging threats and thresholds for damage and management.

Grower Production Information

One of the other unusual characteristics of the Pennsylvania Christmas tree industry is that the majority of the growers are part-time producers. Many growers hold small acreage and work only on weekends and holidays. Many of them do not belong to grower organizations and consider themselves more as hobbyists than commercial growers. Thus, historically it has been difficult to get concrete production data for the most basic of questions, such as the number of acres and proportions of species in production or the number of trees produced each year. Without this information, it is very difficult to justify the type of research efforts or improvements that are needed in the Pennsylvania Christmas tree industry.

Contacts and References

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