Crop Profile for Christmas Trees in North Carolina (Mountains)

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General Production Information

North Carolina is first in the nation in Fraser fir (*Abies fraseri*) production and second in Christmas tree production behind the Pacific Northwest. In 2006, an estimated 50 million trees were grown on 25,000 acres. Annual cash receipts for Christmas trees are estimated at $100 million or more with an addition of $12 million from value-added products such as wreaths, roping and greenery. North Carolina reportedly produces 19 percent of the U.S. production of Christmas trees. Fraser fir is native to the highest elevation mountains in western North Carolina, southwestern Virginia and eastern Tennessee.

Production Regions

Christmas trees are grown in two regions of the state. Western North Carolina produces Fraser fir Christmas trees at elevations usually greater than 3,000 feet. More than 99 percent of Christmas tree production is in western North Carolina. These trees are produced primarily for the wholesale market, though some growers retail their own trees either choose and cut on their own farms, or have tree lots at other locations. Major counties, from most to least production, are Ashe, Avery, Alleghany, Watauga, and Jackson (these five counties produce 88 percent of all trees), plus Mitchell, Yancey, Madison, Transylvania, Buncombe and Macon. All the other North Carolina counties have fewer than 100 acres in production. Trees grown in the Piedmont and Coastal Plain of North Carolina include Virginia pine (*Pinus virginiana*), eastern white pine (*Pinus stobus*), eastern red cedar (*Juniperus virginiana*), and Leyland cypress (*X Cuppressocyparis leylandii*). These producers sell trees "choose and cut." The state’s two Christmas tree growing regions are very different (producing different species in such different climates).

This crop profile focuses on Fraser fir production in western North Carolina. Information provided in this crop profile is based on data collected in a pest management survey of Christmas tree growers in western North Carolina conducted in 2007 to determine pest control practices used by these growers during 2006. Survey questionnaires were completed by 352 Christmas tree growers, which produced 22,249.8 acres of Christmas trees.

Western North Carolina Production

The climate of western North Carolina is usually cool, often wet, and mild. Rainfall varies greatly through the region and can be from 48 to more than 100 inches of rain per year. Droughts occur periodically as well as periods with excessive rainfall. These may be caused by hurricanes either from the Gulf of Mexico or the Atlantic Ocean. Snows may be non-existent some years and heavy others.

Mountains soils are often shallow and low in pH, phosphorus and calcium. Rock outcroppings may be common in some fields, as are springs. Creeks are common in the region and may affect production practices. Farm roads are often not well laid out and may be prone to eroding. Roads to the farm are often narrow and winding, making it difficult for tractor-trailers to gain access. Trees may be handled two or three times from the time they are cut until they are loaded on the truck to their final destination. Though some Christmas tree farms appear isolated, with good advertising "choose and cut" customers often travel many miles to purchase a tree.

Land prices continue to increase, especially as people from other parts of North Carolina or the U.S. buy land and build homes for vacations and retirement. Most of these people have never farmed and may object to common farming practices such as insecticide applications.

Labor for producing Christmas trees are primarily Hispanic. Some workers work on a farm 10 to 11 months out of the year, returning to the same farm year after year. Other labor, particularly shearing and harvesting, is more seasonal and requires help of migrant labor. Increased political problems with foreign labor have created many worries for Christmas tree growers, particularly with concerns at harvest.

As labor and land costs continue to rise, many Christmas tree growers have only made modest increases in the wholesale value of their trees. Growers are also concerned with government regulation of migrant labor, pesticide use, and measures to protect water quality.

Production Practices

Christmas trees have been produced in the area since the late 1950’s and some fields are producing their fourth or fifth generation of Christmas trees. Fields are typically replanted with Christmas trees as soon as the trees are harvested. Only when a field has been infested with *Phytophthora* root rot will trees no longer be planted with Christmas

trees. Farms are family farms with several generations working different aspects of production.

According to the results of the 2007 North Carolina Christmas Tree Pest Management Survey, the average Christmas tree grower in western North Carolina produces 63.4 acres of Christmas trees, though 47.4 percent of the growers produce less than 10 acres. Average operational costs to produce Fraser fir Christmas trees are $2,500 per acre per year. This does not include the cost of either renting land or paying a mortgage on land, nor does it include harvest costs.

Site selection is very important to Fraser fir production, particularly for *Phytophthora* root rot control. This fungal disease is worse in areas that remain wet, or where surface water flows through the field during heavy rains. Fraser fir grows best in rich, loamy, well-drained soils. Elevation is important in western North Carolina in Fraser fir production, with most production occurring between 3,000 and 4,000 feet.

Typically transplants are set in the spring though sometimes in the fall, usually at a 5 foot x 5 foot spacing. A transplant is usually a 3-2, which is a seedling that has grown three years in a seedbed and two years in a lineout bed. Some growers are also buying transplants grown as plugs in the greenhouse that have been lined outside for a year or two. Transplants are set directly in the sod. Sometimes the weeds are killed in a strip where the trees will be set and sometimes they are not. Growers are encouraged to soil sample fields before setting and incorporate needed elements, particularly phosphorus if possible. It is also encouraged that growers scout for white grubs the fall before setting and treat if them if there are many present.

Trees are fertilized once or twice a year. Though some growers fertilize by airplane, the majority of growers fertilize by hand. Mountain soils are typically low in phosphorus and calcium. Soil pH is often below the optimum range of 5.5 to 5.8. Growers are encouraged to take soil samples in increments such as 0 to 4 inches, 4 to 8 inches and even 8 to 12 inches to determine where nutrients are present. As soil samples are processed free in North Carolina, many avail themselves of this service.

Trees are sheared yearly by hand after they have been in the field three years. Fraser fir has a single flush of growth annually. Shearing involves trimming the terminal to create a fuller, denser tree and maintaining the side-shoot growth in the shape of a cone. Fields must be clear of tall and noxious weeds to allow workers access to each tree at shearing time.

Christmas tree growers not only manage one crop in their fields; they manage two. Growers maintain ground covers that do not compete with the trees, which also prevent the growth of difficult-to-control weeds. Ground cover management is achieved with the use of both pre- and post-emergent herbicides. Herbicides are primarily applied with backpack sprayers, though some growers make applications with ground equipment or air blast mistblowers. Often, lower-than-labeled rates of post-emergent herbicides such as Roundup are applied to stunt rather than kill weeds. This is called "chemical mowing." In

addition to chemical mowing, growers will mechanically mow or use weed-eaters to cut down tall weeds.

Insect control is usually more important as the trees get larger and closer to marketing. Most trees are treated with an insecticide the last two years before they are harvested to control the balsam twig aphid and spruce spider mite. In addition, most Fraser firs in western North Carolina are treated for the balsam woolly adelgid once or twice in the rotation. Some areas of the mountains have problems with the rosette bud mite, which require an additional pesticide application.

Trees are harvested by size based on foot increments. Most trees sold are 6 to 7 feet in size (60 percent of sales) or 7 to 8 feet. Trees this size have typically been grown in the field from 5 to 10 years and are from 10 to 15 years of age. Some growers produce tabletop trees (3 to 4 feet in size). Most growers will also sell trees larger than 8 feet in size. It usually takes two to three years to completely harvest a field of trees. Cull trees are often used for greenery. Tree quality affects wholesale value. Defects that reduce quality include a top that is not straight, uneven or light density of foliage, visible insect or disease damage, and holes in the canopy.

Worker Activities

Notes on timing, importance, and worker exposure to pesticide residue while workers conduct the following activities.

Fertilizing: When fertilizers are applied by hand, workers typically use backpack applicators that feed a handheld container with fertilizer, which can then be picked up by hand and thrown on the ground. Because of contact with fertilizers, workers usually wear gloves, long-sleeved shirts and long pants. Fields may have been recently treated with herbicides when applications are made but there will be little worker contact with pesticide residues.

Shearing: Christmas trees are typically sheared from July through August, although shearing may continue through the winter. The sides of trees are sheared with a knife, and individual shoots or limbs may also be removed with pruners. Some growers will not shorten terminals until fall so that they will grow straighter. In this case, each tree is visited twice, usually in the summer and the fall. During shearing, exposure to pesticides depends on what has been recently applied. Typically only low rates of Roundup are applied in June and July, resulting in little exposure to herbicides. Trees may have been sprayed in June with dimethoate to control rosette bud mites, or with any one of a number of materials any time from July on to control balsam woolly adelgids. Usually these materials have been applied a month or more before shearing occurs, resulting in little exposure.

Tagging: Workers typically tag trees for market before shearing, as the style of shearing is different if the tree will not be harvested that year. Workers will start tagging in late June and will continue into early August. Workers will need to lean into the tree to attach

the colored ribbon to identify the grade and size class of the tree. If trees have been recently treated for the rosette bud mite or balsam woolly adelgid, pesticide exposure may occur. Long REI on dimethoate to control rosette bud mites would make early tagging difficult. Tagging and shearing both could occur later in July or in August. Typically, trees to be harvested are not treated for rosette bud mites.

Harvesting: Growers harvest Christmas trees any time from late October into December. Foliage to make wreaths may be harvested in mid-October. During this time period, some growers may treat for Cinara aphids, or other post-harvest pests (see below). Trees may be treated preventatively, even if aphids are not found. According to the results of the 2007 North Carolina Christmas Tree Pest Management Survey, 12.5% of growers treated at least some trees to be harvested for post-harvest pests. Depending on when trees are treated, workers may be exposed to insecticide residues.

Mowing: Growers typically use herbicides to "chemical mow." However, mowing with push mowers or weeding eating may be necessary in the summer months, especially prior to shearing to allow easy movement in the field. This would result in little contact with treated Christmas tree foliage, but does result in contact with vegetation surrounding the trees that may also have pesticide residues.

Insect and Mite Pests

Most insect and mite pests cause only cosmetic damage to the tree. Only the balsam woolly adelgid and white grubs can kill trees. However, heavy insect damage can either drop trees in grade and therefore their market value, or make the trees unmarketable during the current season. Fraser fir Christmas trees should go to market with five years of good foliage and at least two years of completely undamaged foliage.

Not all growers own the spray equipment necessary to treat for pests. Only 56.7 percent of growers reported they owned a high-pressure sprayer in the 2007 North Carolina Christmas Tree Pest Management Survey, and only 25.6 percent of growers own an air blast mistblower. Large acreage growers are more likely to own their own spray equipment than small acreage growers. Growers that do not own their own equipment must hire a professional pesticide applicator to treat their trees.

Balsam Twig Aphid (*Mindarus abietinus*)

The balsam twig aphid (BTA) is a serious springtime pest of fir species that causes needle curl and associated with sooty mold. The BTA can be found in virtually every Fraser fir Christmas tree field. In 2006, 27.1 percent of growers reported damage due to the BTA. Currently, BTA is classified as *Mindarus abietinus*. However, there is evidence that there are several distinct species of *Mindarus* in different regions of North America.

The BTA in southern Appalachians is probably distinct from that in the Northeast, the Midwest, or the Pacific Northwest.

Damage is caused when the aphids feed on the newly broken buds. Damage is worse in a dry, warm spring that favors the rapid maturation of the stem mothers and survival of their offspring. However, tree needles will often straighten as they mature during springs with adequate rainfall.

Life cycle.

Twig aphid eggs begin hatching in western North Carolina in mid to late March. In one research study, degree-day analysis did not consistently predict spring egg. The form that hatches from the egg is the fundatrix or stem mother, which can produce as many as 70 live young. These are either apterous viviparae (similar to the stem mothers though they do not produce as many young), or winged sexuparae. The later form produces the sexulaes that mate and lay eggs. Eggs for the following year are first seen in early June, and the life cycle is complete by the end of June.

Scouting.

Damage from the BTA is difficult to predict because aphid numbers can increase quickly as the stem mother begins to reproduce. Because this pest is so prevalent, damage so costly and the treatment window so narrow, it is currently recommended that growers treat automatically to protect trees to be marketed that year without scouting. In addition, growers may have to treat in the spring for other pests including the balsam woolly adelgid, hemlock rust mite, and spruce spider mite.

Twig aphids are easily scouted by beating tree foliage over a collection tray and counting the aphids (and predators) that fall into the tray. Sampling 10 to 15 trees in a block provides a good indication of the aphids present. Trees may be sampled immediately before and immediately after bud break to determine if aphid numbers are increasing. If more than 2 aphids are found before bud break or 5 aphids after bud break, treatment is probably necessary. Trees may also be sampled a few days after a pesticide application in this manner to determine the extent of control and the need for reapplication. In 2007, 55.6 percent of growers scouted for BTA but of those that did, only 10.3% found so few aphids that they felt comfortable leaving trees untreated.

Cultural practices.

The BTA will feed on immature cones that break several weeks before vegetative shoot growth. Growers are encouraged to remove and destroy these cones to improve chemical control of the BTA. In 2006, 25.1% of growers reported removing cones.

Biological control.

Natural predators, including the hover fly and ladybeetle larvae, readily control the BTA. However, natural controls typically do not prevent damage to trees as the natural predators do not build to sufficient numbers to control the twig aphids before the trees break bud. There are no known parasitoids of twig aphids.

Chemical control.

Trees are usually treated for BTA only in the later years of the rotation, since the pest causes primarily cosmetic damage. Therefore, in a 6 or 7-year rotation, trees are only treated the last two or three years.

Pesticide timing is important. The treatment window for the BTA is narrow. Pesticides are ineffective against the twig aphid egg. And once the trees have broken bud and the aphids enter the new growth, they are protected from the pesticide spray. Balsam twig aphid hatch is complete by April 15 in western North Carolina, perhaps earlier in warm springs. Bud break occurs anywhere from the last week in April through May 15. During this 2 to 3 week window, the weather is often not suitable to apply a pesticide.

Since the treatment window is so narrow, many growers use Di-Syston 15 G to control the BTA in western North Carolina. Some growers apply materials with an air blast mistblower to apply a liquid insecticide instead. On limited acreage that also needs to be treated for the balsam twig aphid, grower may apply insecticides before bud break with a high-pressure sprayer as early as the end of February. However, when such early applications are made, it is important to scout for BTA control close to bud break to make sure the twig aphids were controlled.

In 2007, 44.2 percent of growers controlled BTA with Di-Syston, 24.5 percent used a high-pressure sprayer, 16.2 percent used an air blast mistblower, 4.3 percent used a backpack sprayer, 2.3 percent used a backpack mistblower, and 2.0 percent used a vehicle-mounted sprayer. This represents a 19 percent decrease in the use of Di-Syston and an increase in about 9percent increase in the use of mistblowers in the past six years.

Di-Syston 15 G (disulfoton)

Di-Syston was used on 31.9% of Christmas tree acreage in 2006 which is down from 49.6 percent in 2000 and 64.6 percent in 1994. Di-Syston is used on average 1.03 times on each acre where it was applied; reapplication is rare. Often, season long control of the spruce spider mite is attained with the pre-bud break use of Di-Syston. Di-Syston 15 G was relabeled in 2006 to allow the use in Christmas trees with a closed-system applicator. Di-Syston may be applied in Christmas trees at up to 30 pounds per acre. The average use rate in 2006 was 25.9 pounds per acre. If granular Di-Syston were not available, more growers would have to depend on air blast mistblower applications. Few growers producing less

than 20 acres of Christmas trees own a mistblower or have a large enough horsepower tractor to pull it on steep slopes.

Lindane 20 EC (lindane)

Lindane use is down considerably as growers use up old supplies. It is no longer being manufactured for sale. Lindane was used on 1.9 percent of Christmas tree acreage down from 23.8 percent in 2000. There were no reports in the 2007 North Carolina Christmas Tree Pest Management Survey of growers reapplying Lindane on any acreage. Labeled at 2 to 3 quarts per 100 gallons, the average use rate was calculated at 71.4 ounces per 100 gallons. The primary target for Lindane is the balsam woolly adelgid but it may be applied in the spring to give both twig aphid and woolly adelgid control.

Dimethoate (dimethoate)

Dimethoate was used on 34.8 percent of the Christmas tree acreage in 2006. Dimethoate use continues to increase as Di-Syston use declines. It was applied to 21.2 percent of acreage in 2000 and only 2.3 percent in 1994. Dimethoate is used primarily for rosette bud mite and hemlock rust mite control, but will also control the BTA and the spruce spider mite nymphs and adults. Dimethoate is labeled at 1 to 1 1/2 pints per acre or 1 1/3 pints per 100 gallons for rosette bud mite control. The average use rate in 2006 was 27.5 ounces per 100 gallons. Dimethoate was reapplied an average of 1.2 times in 2006. Dimethoate may be applied twice to control different pests at different times of the year, or reapplied a second time to control spider mites hatching from eggs.

Asana XL (esfenvalerate)

Asana is used on 13.3 percent of the Christmas tree acreage in 2006. Use of this material has been rather consistent the past 12 years with it being applied on 16.6 percent of acreage in 2006 and 11.8 percent in 1994. Asana, like Lindane, is primarily used for balsam woolly adelgid control, but also controls the BTA when applied in the spring. Asana is labeled at 4.8 to 9.6 ounces per 100 gallons and the average use rate in 2000 was estimated at 12.2 ounces per 100 gallons. Reapplication is rare with an average of only 1.02 applications per year in 2006.

Thionex (endosulfan)

Thionex use has increase in the past six years. It is primarily used for balsam woolly adelgid control, but may also be applied in the spring to include twig aphid control like Lindane or Asana. Thionex was applied on 11.9% of Christmas tree acreage in 2006. Labeled at 2/3 quart per 100

gallons, the average use rate in 2006 was estimated at 38.8 ounces per 100 gallons. Thionex was reapplied in 2006 an average of 1.13 times. Reapplication may be to control different pests such as Cinara aphids in the fall.

Talstar (bifenthrin)

Talstar, like Thionex, Asana and Lindane is often used for balsam woolly adelgid control but may be used for twig aphid control as well. Talstar was applied on 6.3% of Christmas tree acreage in 2006. It is labeled at up to 40 ounces per acre. The average use rate in 2006 was estimated at 14.2 ounces per 100 gallons. There were no reports of reapplication of Talstar in 2006. Talstar also has activity against spruce spider mites.

Lorsban 4E (chlorpyrifos)

Lorsban was used on only 4.6% of the Christmas tree acreage in 2006 similar to the 8.4 percent use in 2000 and 5.8 percent use in 1994. Lorsban may be used to control the balsam woolly adelgid, balsam twig aphid or white grubs with a soil application. It is labeled at 1 quart per acre. In 2006 the average use rate was 34.8 ounces per 100 gallons. There were no reports of Lorsban being reapplied in 2006.

Other Insecticides

Other insecticides used on Christmas trees that provide control of the BTA include Diazinon (diazinon), Cinnamite (cinnamaldehyde), horticultural oil (petroleum and vegetable based), Provado (imidachloprid), Metasystox-R (oxydemeton-methyl), Sevin (carbaryl), Triact (Neem oil extract), Orthene (acephate) and Malathion (malathion).

Balsam Woolly Adelgid (*Adelges piceae*)

The balsam woolly adelgid (BWA) is native to central Europe and was introduced to North America in the early 1900's. Since then, it has spread throughout most of the natural range of *Abies* species. Fraser fir is one of the most susceptible species of fir to BWA and has experienced widespread mortality due to the BWA. The adelgid was first observed in the natural stands of Fraser fir in the 1950's. All natural stands of Fraser fir have since been impacted.

The BWA feeds in the bark of the tree, and can be found on the trunk, branches and buds of Fraser fir. Damage is done to Fraser fir because it overreacts to this injury. Infested trees produce reaction wood, sometimes called *rotholz*, which is harder than normal wood and restricts water and nutrient movement.

Life cycle.

The BWA overwinters as an immature nymph. Molting begins in April, and the adult female lays eggs soon after. There are no males produced in North America as the insect requires a spruce species that is only present in Europe to complete its life cycle. Therefore, all reproduction is parthenogenic, the females laying eggs that are clones of herself. The eggs hatch within 4 weeks to produce a crawler. This is the only stage of the insect that is motile. The crawler has no mouthparts, and must settle in a spot to feed and molt within a few days or die. Crawlers may be blown to other trees, or travel on the feet of birds. Once the crawler molts to the nymph and inserts its feeding tube, it does not move again. There are 2 to 3 generations of the BWA in western North Carolina depending on the elevation and weather through the growing season.

Scouting.

Growers are encouraged to scout for the BWA yearly and 62.4 percent of growers scouted for the BWA in 2006. The first and most easily recognized symptom of a BWA infestation is the loss of apical dominance in the affected tree. The tree will not produce a straight top, rather a crooked one. When trees with crooked tops are found in the field, the trunk can be examined for the presence of the insect. In the 2007 North Carolina Christmas Tree Pest Management Survey, 69.2 percent of growers thought they could recognize a BWA adult, but only 34.5 percent thought they could recognize the nymph.

Growers may also find BWA infestations when they harvest trees. Trees infested with BWA produce hard reaction wood, which is red in color. These trees are harder to cut down. The red rings can also be seen on the tree stump. In the 2007 North Carolina Christmas Tree Pest Management Survey, 10.8 percent of growers discovered the BWA this way.

The treatment threshold is a single infested tree, although in some instances if the field will soon be harvested within a year, culling symptomatic trees may slow the spread.

Cultural control.

Large trees that cannot be adequately treated should be cut down. This includes Fraser fir trees grown in yards and not managed as Christmas trees and abandoned Christmas trees. Trees that have not had a straight top for 2 or more years should be culled. Culled trees should not be removed from the field when crawlers are present, as dragging the tree out of the field may spread the insect. Culled trees may be burned. Growers are encouraged not to plant young trees among older trees in partially harvested fields. In this way, the insect is not spread as quickly to younger trees.

Biological control.

Several general predators feed on BWA, including the *Harmonia* ladybeetle, but will not eliminate an infestation. Fraser fir is extremely sensitive to this pest, and even a few of

the pests will impact tree quality. Many biological control organisms were imported and released on Mount Mitchell in North Carolina and in the northeast and Canada to try to stop BWA invasions of natural stands of Fraser and balsam fir in the 1950's and 1960's. With the advent of the hemlock woolly adelgid in the eastern U.S., there is increased interest in predators and diseases of adelgids, which may result in greater natural controls of the BWA.

Chemical control.

The BWA is found throughout western North Carolina wherever there are fir trees. Therefore only a few isolated fields will not have to be treated for this pest. The natural stands, untreated trees growing in yards and abandoned Christmas trees all harbor the insect. Most growers only treat for BWA once in a rotation unless they are adjacent to such sites with heavy infestations.

Insecticides must be applied with a high-pressure sprayer using 300 to 800 gallons per acre depending on tree size and density. Pressures at the pump will be anywhere from 200 to 400 pounds per square inch to completely wet the tree bark. Trees are treated from two directions with the applicator pulling 200 to 300 feet of hose up and down rows. Only 2 or at most 3 rows can be treated at a time. About half of the Christmas tree growers (56.7 percent in 2006) own this type of equipment. Otherwise growers must hire someone to treat their trees at a cost of $300 to $500 per acre.

Treatments may be made virtually any time of year. Treatments made from late February through bud break will also control the BTA. Most growers treat from July through winter. Because eggs are present from April through October, insecticides must remain on the trees at least a month to be effective. Reapplication within a month to control the individuals hatching from eggs is not economically feasible. When trees are treated in the winter, pesticides that do not have a long residual can be used. Winter applications have the least impact on natural predators. In 2006, 57.5 percent of growers used an insecticide to treat for the BWA.

Lindane 20 EC (lindane)

Once the primary material for BWA control in western NC, the use of lindane continues to decrease as supplies are used up.

Asana XL (esfenvalerate)

Asana was the primary replacement for Lindane. However, growers did not feel like they were receiving as long lasting control with Asana as they had with Lindane. Also, growers reported having more problems with the hemlock rust mite the year following Asana applications. Asana is used on 13.3 percent of the Christmas tree acreage in 2006. Use of this material has been rather consistent the past 12 years with it being applied on 16.6 percent of acreage in 2006 and 11.8 percent in 1994.

Thiodan 3EC (endosulfan)

A 24(c) Special Local Needs label for FMC Thiodan 3EC was obtained in 2000 in North Carolina for the control of the BWA. This material had been used to a limited extent by a handful of growers for years for the control of BWA. With the concerns association with Asana, a 24(c) Special Local Need label was granted for two years. Thiodan cannot be used within 300 feet of surface water because of concerns with fish kills and the effects on other aquatic life. Thionex was applied on 11.9% of Christmas tree acreage in 2006.

Horticultural oil

Horticultural oil is currently used on only 1.3 percent of the acreage. Treatments with oil to control the BWA are only effective during the winter when no eggs are present. Oils can burn foliage of Fraser fir depending on the rate and the time of year used.

Other Insecticides

Provado 1.6F, Metasystox-R and Lorsban 4E are labeled for adelgid control, but are not frequently used. Control has not been long lasting with these materials. Growers are currently interested in two other synthetic pyrethroids, Astro (permethrin) and Talstar (bifenthrin). Astro, especially, has provided up to 18 months control in pest control trials.

Spruce Spider Mite (*Oligonychus ununguis*)

The spruce spider mite (SSM) has a wide range of coniferous host species. It is considered a cool-season mite, but in western North Carolina temperatures are not high enough to slow mite activity in the summer. The SSM can damage trees from March through October, though damage typically occurs in July and August. It causes yellow spotting on needles, which discolors the foliage and often results in premature needle shed.

Spider mites are not a problem every year, although they can be found in any Christmas tree field. Certain factors favor spider mite activity including farms at lower elevations, farms on windy and exposed ridges, trees on rows adjacent to gravel roads (which create dust), warm and dry weather, and the use of broad spectrum insecticides. These factors affect spider mites because they also affect the mite’s natural predators.

Spider mites can also be a problem on harvested trees. In warm, dry falls, the mites remain active. Once the tree is harvested and set up in the home, the mites will continue to feed and reproduce. Mite numbers may build so high that they form webbing on the

foliage, and even move off of the tree onto furnishings. Spider mite control is therefore especially important in the fall in "go-to-market" trees.

Life cycle.

The SSM overwinters as an egg. Egg hatch occurs once the weather warms in the spring. It can take as little as two weeks for a newly hatched mite to grow to an adult. Males and females are both produced. There are multiple generations of spider mites produced each season.

Scouting.

Spider mite numbers can increase quickly in response to environmental conditions that favor the mites and not their predators. Scouting is required to determine the need for mite control. Trees to be marketed that year should be scouted more frequently and have a lower treatment threshold than smaller trees. Trees should be scouted for the SSM at least four times through the growing season, although occasionally scouting every two weeks is required. In 2006, 19.1 percent of growers scouted for the SSM with a hand lens.

Cultural control.

As pesticide use has such a profound effect on subsequent spider mite activity, growers are encouraged to use pesticides only when required. This is especially true of BWA treatments as most of the materials used are broad spectrum and long lasting and kill the spider mite predators. Spider mites are often worse along dusty roads, on western or southern exposures, on windy ridges, at lower elevations, or during dry weather. A managed ground cover where weeds are allowed to flower should harbor more predatory mites and other predators.

Biological control.

Many predators will feed on spider mites. However, predatory mites appear to be the most important predators. The effects of cultural practices and weather on spider mites are often truly effects on the predatory mites rather than the spider mites themselves. Research is currently underway to determine the effect of various ground covers on predatory mites. In fact, spider mite problems have been declining in western North Carolina as more and more growers have adopted the use of low rates of Roundup to management living ground covers around their trees.

Chemical control.

Most growers depend on spring-applied Di-Syston for the control of the BTA to give full season control of the SSM as well. However, a second treatment to control spider mites may be necessary as determined by scouting later on in the growing season. Other miticides are more difficult to apply, as thorough coverage is needed with most materials

to receive adequate control. Really good coverage is usually not obtained with an air blast mistblower, and spraying trees individually with a hand-held gun is too labor intensive for most growers. Growers favor miticides that are ovicides since eggs are present throughout the year. However, most of these materials are currently too expensive for most growers to use. In 2006, 42.5 percent of growers treated for the SSM.

Di-Syston 15 G (disulfoton)

Di-Syston is the most efficacious pesticide for control of the SSM. It is used on 34.8 percent of Christmas tree acreage in 2006, down from 64.6 percent in 1994. Di-Syston was used on average 1.03 times on each acre where it was applied in 2006; reapplication was rare. Often, season long control of the spruce spider mite is attained with the pre-bud break use of Di-Syston.

Dimethoate (dimethoate)

Dimethoate was used on 34.8 percent of Christmas tree acreage in 2006, up considerably from 1994 when it was only used on 2.3 percent of the acreage. Dimethoate is used primarily for rosette bud mite and hemlock rust mite control, but will also control SSM (not the eggs). Dimethoate is labeled at 1 to 1 1/2 pints per acre or 1 1/3 pints per 100 gallons for rosette bud mite control. Many growers are mixing Dimethoate with Savey (hexythiazox), which does control the eggs.

Lorsban 4E (chlorpyrifos)

Lorsban was used on 4.6 percent of the acreage in 2006. Lorsban does not kill the spider mite egg and needs to be reapplied in 10 to 14 days to kill the mites that hatch out before they can in turn lay eggs. However, there were no reapplications of Lorsban reported by growers in the 2007 North Carolina Christmas Tree Pest Management Survey. It was not known what percentage of Lorsban use was targeted towards spider mite control, but it is probably inconsequential.

Savey 50 WP (hexythiazox)

Savey was used on 3.0 percent of the acreage in 2006. Savey does not kill the adult mites and must either be applied early in the season or be mixed with an adult miticide. Many growers are combining Savey with Dimethoate.

Sanmite (Pyridaben)

Sanmite was used on 1.0 percent of the acreage in 2006. Sanmite is an excellent miticide that controls both rust mites and spider mites, but its cost makes it prohibitive to growers.

Hemlock Rust Mite (*Nalepella tsugifoliae*)

The hemlock rust mite (HRM) causes bronzing of the foliage and premature needle drop on Fraser firs. It is primarily a springtime pest, though damage can also occur in the fall. Widespread rust mite problems were first observed in 1995 in western North Carolina. Since then, rust mites have been a frequent problem.

Life cycle.

It is not known how the HRM overwinters. It may be found as adults or as eggs. Mites start to reproduce in the late winter. Mite populations increase with mild temperatures. Heavy rainfall may keep numbers low.

Scouting.

Fields should be scouted in March or April for rust mites. Fields should be scouted similarly to the spruce spider mite. The treatment threshold is 80 percent incidence with at least 8 mites per needle on some needles sampled.

Cultural control.

No known cultural practices affect rust mites.

Biological control.

Several predators have been found feeding or rust mites including syrphid fly larvae. However, since these mites are so small, feeding is not generally observed. Trees harboring high numbers of HRM do not seem to attract predators. However, treating trees for the BWA, especially with Asana XL, seems to create HRM problems the following year. The implication is that the effect of past pesticide use is on the natural predators.

Chemical control.

In 200, 25.4 percent of growers used insecticides and/or miticides for the HRM. If rust mites are found in trees before bud break, growers should switch from using Di-Syston 15 G to another material, as this is not effective against the rust mites. Materials can be sprayed onto trees using either a high-pressure sprayer or air blast mistblower. This is one pest that is controlled effectively with mistblower applications.

Dimethoate (dimethoate)

Dimethoate was used on 34.8 percent of Christmas tree acreage in 2006, up considerably from 1994 when it was only used on 2.3 percent of the acreage. Using dimethoate will control both the BTA and HRM before bud break, even when applied with a mistblower.

Horticultural Oil

In test plots, horticultural oil was found more effective than dimethoate at controlling the HRM. However, most Christmas tree growers do not use this product because of problems with foliage burn.

Sanmite (Pyridaben)

Sanmite was used on 1.0 percent of the acreage in 2006. Sanmite is an excellent miticide that controls both rust mites and spider mites, but its cost makes it prohibitive to growers.

Rosette Bud Mite (*Trisetacus fraseri*)

The rosette bud mite (RBM) is an eriophyid mite that causes galls to form inside vegetative buds of Fraser fir. The damaged buds do not break in the spring. This loss of bud tissue results in uneven density and holes in the tree canopy, weak bottoms and light density, all of which reduce the grade and therefore the value of the Christmas tree. Good quality trees may be produced in fields infested with the RBM, but it may take a year or two longer to produce, increasing production costs. The earlier in the rotation that there are rosette buds on the tree, the more quality will be affected. Rosette buds are primarily a problem in Avery County and Grayson County, Virginia, as well as certain plantations at more than 4,000 feet in elevation. However, the range of the RBM continues to increase in western North Carolina.

Life cycle.

The RBM emerges from the previous year's gall in the spring the same time normal vegetative buds are breaking. They are either windblown or drop onto a healthy shoot. The mites feed at the top of the developing shoot, and their feeding causes the growing bud to distort. A gall forms instead of a healthy bud for the next year, and as many as 3,000 mites can be found inside a single rosette bud by the winter.

Scouting.

Fields of trees two years from harvest or younger should be scouted yearly for the RBM in areas where the pest is present. An estimate of the percentage of trees having rosette

buds is made in the fall. If 10 percent or more of the trees are infested, that block of trees should be treated in June the next year.

Cultural control.

One method of reducing the likelihood of the RBM getting into smaller trees is not to interplant young trees with old trees. It is better to clear cut a block of trees before replanting. In addition, practices that increase bud set, such as good fertility and shearing early and lightly, help offset the effects of the RBM on tree quality. Selectively harvesting heavily infested trees early also reduces problems with the RBM the following year.

Biological control.

No natural predators of the RBM have been discovered, probably because the mite spends most of the year in the protective gall.

Chemical control.

Controlling the RBM will not have an effect on tree quality until the following year. Therefore, it is not necessary to control the RBM on trees nearing harvest. The only effective single application treatments are with dimethoate and Mavrik. Sevin and Metasystox-R are effective if two applications are made two weeks apart, but growers cannot afford this treatment. Trees are seldom treated for the RBM more than twice during a rotation. In 2006, 12.0 percent of growers used an insecticide or miticide for control of the RBM.

Dimethoate (dimethoate)

Dimethoate was used on 34.8 percent of Christmas tree acreage in 2000, up considerably from 1994 when it was only used on 2.3 percent of the acreage. Dimethoate is used at 1 1/3 pints per 100 gallons for rosette bud mite control. Dimethoate is applied with a high-pressure sprayer in June spraying between 200 and 600 gallons per acre. Often, when trees are treated with dimethoate in June to control RBM, the balsam twig aphid is controlled for the following spring. This is because the twig aphids are laying their eggs at that time of year.

White Grubs

White grubs are the larvae of scarab beetles. Several species have been observed feeding on Fraser fir roots in both plant beds and in the field including May/June beetles (*Phyllophaga anxia, Phyllophaga fusce, Polyphylla comes*), the Asiatic garden beetle grub (*Maldera castanea*), and the masked chafer grub (*Cyclocephala* sp.). Grubs are most

often a problem when trees are planted into old pastures. They are not a problem every year.

Life cycle.

The adult beetles emerge from the pupae found in the soil in the spring and summer depending on the species. The adults mate and the female lays eggs, preferring short grass. The egg hatches and the larva move into the soil where they start to feed. The larvae molts several times. In the winter, the larvae move deeper into the soil to avoid freezing. The larvae of the May/June beetle grubs will remain in the soil for two years. The life cycle of the Asiatic garden beetle is a one-year life cycle.

Scouting.

Growers are encouraged to scout fields before planting by digging three holes per block that are one-foot square and sifting through the soil to look for grubs. If more than one grub per hole is found on average, it is recommended to treat with a pesticide. Grubs are best scouted in late August or early September.

Cultural control.

Growers are encouraged not to kill all of the ground covers when growing Christmas trees. This leaves some grass roots for the grubs to feed on. If ground covers are controlled through chemical mowing instead of conventional mowing, the grub populations tend to decline over a year or more.

Biological control.

Grubs may be controlled by a parasitic wasp, *Tiphia vernalis*. These wasps are present in western North Carolina associated with yellow poplar trees. Use of any pesticides may reduce the number of these wasps. In addition, control of grubs with parasitic nematodes has been observed, but the controls are usually not consistent.

Chemical control.

There are few good insecticides to control white grubs currently on the market. Triumph 4E was frequently used for grub control. In 1994, Triumph was used on 45 percent of the acreage as a preplant treatment for grubs. Triumph is no longer being manufactured. Only 5.7 percent of growers treated for white grubs in 2006.

Lorsban 4E (chlorpyrifos)

Lorsban is used on 4.6 percent of acreage in 2006. Lorsban may be used to control grubs and is labeled at 1 quart per acre. Growers will apply Lorsban when they are planting trees in the row. However, the

effectiveness of Lorsban is questionable, as it does not readily move into the soil.

Other Insecticides

Other materials that are labeled for grub control include Marathon (imidacloprid) and Mach 2 (halofenozide). Neither of these insecticides were reported by growers responding to the 2007 North Carolina Christmas Tree Pest Management Survey.

Diseases

Fraser fir Christmas trees have very few diseases. Only *Phytophthora* root rot is a major problem for growers in western North Carolina. Several minor diseases such as fern-fir rust, Annosus root rot, Botrytis shoot blight and needle rust occur, but are never treated with fungicides.

Phytophthora Root Rot (*Phytophthora cinnamomi*)

The most significant disease limitation to Fraser fir production in NC is Phytophthora root rot (PRR). PRR, caused by several *Phytophthora* spp., has been associated with significant damage to Fraser fir since the 1960s. Although there are other species of *Phytophthora* found in western North Carolina, *Phytophthora cinnamomi* is the most common species found infecting Fraser fir roots. The host range of *Phtophthora cinnamomi* includes more than 1,000 plant species. Fraser fir is one of the most sensitive plants to this disease. In the 2006 North Carolina Christmas Tree Pest Management Survey, 72.4 percent of growers reported tree death in the field due to PRR, while 13.1 percent of growers reported seedling loss to PRR in their seed beds/transplant beds in 2006.

Life cycle.

The fungus survives in the soil on infected root pieces as chalmydospores. During the growing season when soils are warm and wet, mycelia or chlamydospores germinate and produce sporangia. These lemon-shaped spores cause new infections, either by germinating and growing on roots, or by releasing 10 to 15 zoospores that will swim towards roots and cause root infection.

Scouting.

If any transplants or trees are dead or dying, the cause should be determined. Roots should be examined and sample trees may be sent to a diagnostic lab to confirm the presence of the fungus.

Cultural practices.

Disease development can be avoided in the field through the use of disease-free transplants and careful site selection and preparation. Sites for Fraser fir production should be carefully evaluated for the risk of PRR. The surface soil and subsoil should be examined for clay content and the drainage through the fields should be observed for areas where water might collect. Unsuitable sites for production should be avoided. Site preparation should result in minimal soil disturbance, especially in shallow soils. Maintaining a managed ground cover will help reduce the potential for spread of PRR by limiting soil movement.

Chemical control.

Disease development can be prevented in seedbeds and transplant beds through soil fumigation and fungicide use. It is currently recommended to treat plant beds with methyl bromide before planting, and treat twice a year with Subdue to prevent disease development. Disease free seedlings are crucial to PRR control.

Few fungicides are used in the field because of the cost to growers. Occasionally a field application of a fungicide made in the year or two prior to sale of the trees may keep as many trees as possible alive until harvest.

Subdue Maxx (metalaxyl)

Subdue Maxx was used on 0.1 percent of the field acreage in 2006.

Aliette (fosetyl-aluminum)

Aliette was used on 0.01 percent of the field acreage in 2006.

Aliette did slow disease spread in at least one field site in recent demonstration plots.

Weeds

Weed control is very important to producing high-quality Christmas trees. Fraser fir competes in its native habitat by being able to grow under harsh, cold growing conditions

where other plants cannot survive. By bring the tree down to lower elevations, this slow-growing plant must be helped to compete with the growth of other plants. Competition from grasses and other vegetation can kill young trees and reduce growth of older trees by blocking sunlight and competing for soil moisture and nutrients. Weed growth can also affect tree quality, as vegetation growing up through the tree will restrict lower branch growth. Vines growing up into trees will bend and distort the tree's top. Noxious weeds such as briars, thistles, or poison ivy will restrict field workers' ability to care for trees.

Managed ground covers, however, enhance Fraser fir growth. Ground covers are preferable to bare soil because there is less soil erosion and the soil temperature is kept cooler, allowing the tree roots to grow nearer the surface of the soil. Ground covers may also provide habitat for the natural enemies of Christmas tree pests.

Ground cover management will be different from young trees to old trees that will shade much of their weed competition. In addition, ground covers may be managed differently in the tree row where a weed-free strip may be maintained especially in young trees to the row middles. Row middles are maintained through mechanical mowing or chemical mowing.

Chemical mowing involves the use of lower-than-labeled rates of post-emergent herbicides. Generally, two to four herbicide treatments are required. The first treatment is usually before the trees break bud, with the second about six weeks later. Sometimes a third treatment is necessary in wet years where there is a lot of weed growth. In the fall, a killing rate of post-emergent herbicides may be used to eliminate certain problem weeds such as briars and hardwood tree sprouts. Mowing or weed-eating can be used any time through the growing season when weeds grow too large, especially in the fall. Growers may also use knives to cut large weeds out of fields prior to shearing. Proper use of chemical mowing requires accurate weed identification and scouting to determine proper timing.

Scouting.

Growers must scout for weeds in their trees. Scouting includes identifying problem weeds and observing weed height and regrowth to determine the need for herbicide application. In 2006, the 10 most problematic weeds reported by growers included poke, ragweed, pigweed, lambsquarters, morning glory, poison ivy, briars, poison oak, thistle, and foxtail. However, the percentage of growers reporting these and other problem weeds is much lower in 2007 than in 2001. In 2006, 70.1% of growers reported scouting weeds. Only 26.2% of growers reported using herbicides based on the calendar without benefit of scouting.

Chemical control.

Herbicides are primarily applied with backpack sprayers with most people applying four 3-gallon backpacks per acre. However, some herbicides are being applied by air blast

mistblowers (accounting for 12.3 percent of growers in 2006) while others are using nozzles on booms attached to a tractor, 4-wheeler, or some other type of vehicle (accounting for 6.6 percent of growers in 2006).

Roundup (glyphosate)

Roundup was used on 89.6 percent of the Christmas tree acreage in 2006. Roundup is a post-emergent herbicide, which if used at certain times of the year and/or at certain rates, will not damage Fraser fir when applied in a *semi-directed* manner. That means that the herbicide spray is directed to the ground covers away from the trees, but some may touch the lower branches of the tree. For this use, Christmas tree growers rely on the old Roundup formulation, and not some of the newer formulations on the market that have a different surfactant. Other conifer species grown for Christmas trees such as white pines are much more sensitive to Roundup and cannot be treated in this manner. Roundup is often used at the labeled rate in the fall after the trees are hardened off (usually after Labor Day), and at lower than labeled rates from April through August to suppress weeds. Current research has demonstrated that Roundup can be used successfully to stunt weeds at as low as 4 ounces of formulation per acre. Roundup can be mixed with Garlon in the fall to better control hard-to-kill weeds. The average rate for Roundup use was calculated at 0.38 pounds of active ingredient per acre, which is less than the range of killing rates.

Simazine (simazine)

Simazine was used on 16.8 percent of the Christmas tree acreage in 2006, down dramatically its use in 1994 (72.2 percent of the acreage). Simazine is a broad spectrum, pre-emergent herbicide. The average rate for Simazine was 1.63 pounds active ingredient per acre in 2000. Typically, only an 18-inch band is treated on rows spaced 5 feet apart. Simazine is seldom applied more than once a year. As growers have moved from complete kill of ground covers and bare ground management to leaving ground covers around their trees, the use of Simazine has declined. In some counties, the presence of triazine-resistant weeds (including ragweed, pigweed and lambsquarters) has contributed to grower's shift to other weed management strategies.

Goal (oxyfluorfen)

The use of Goal has also declined, from 43.8 percent of the acreage treated in 1994 to 10.7 percent in 2006. The mixture of Stinger-Vantage-Goal was used previously at lower-than-labeled rates to chemical mow. This expensive mixture of herbicides has been replaced by the relatively inexpensive Roundup. Goal can be used at suppressive rates, at killing rates for post-emergent control, and at killing rates for pre-emergent

control. The average use rate for Goal was 0.26 pounds of active ingredient per acre.

Stinger (clopyralid)

Stinger was used on 6.1 percent of the Christmas tree acreage in western North Carolina in 2006, down from use on 22.8 percent of the acreage in 1994. The calculated rate for Stinger was 0.13 pounds of active ingredient per acre, which is in the range of killing rates. Stinger is primarily a post-emergent herbicide effective against asters, thistles and field bindweed.

Vantage (sethoxydim)

The use of Vantage has declined from 23.9 percent of the acreage in 1994 to 5.8 percent in 2006. Vantage is a grass killer. The average calculated rate for Vantage was 0.41 pounds of active ingredient per acre, which is in the range of killing rates.

Garlon (triclopyr)

Garlon was used on only 6.3 percent of the Christmas tree acreage in 2006. Garlon is a brush killer. The average calculated rate for Garlon was 0.41 pounds of active ingredient per acre.

Other Herbicides

Other herbicide used on Christmas trees in 2006 include Crossbow (2,4-D plus triclopyr) on 5.0 percent of the acreage, Atrazine on 2.9 percent of the acreage, Pendulum (pendimethalin) on 0.8 percent of the acreage, Fusilade (fluazifop-butyl) on 0.2 percent of the acreage, Surflan (oryzalin) on 0.1 percent of the acreage, Gallery (isoxaben) on 0.04 percent of the acreage and Pennant (S-metolachlor) on 0.02 percent of the acreage.

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