PEST MANAGEMENT STRATEGIC PLAN FOR CHRISTMAS TREE PRODUCTION IN NORTH CAROLINA, TENNESSEE, AND VIRGINIA

Summary of a Workshop held on June 17, 2003
at the Watauga County Agricultural Conference Center
in Boone, North Carolina

Workshop sponsored by:

North Carolina Pest Management Information Program
(North Carolina State University)
Tennessee Pest Management Information Network
(University of Tennessee)
Virginia Pest Management Information Program
(Virginia Polytechnic Institute and State University)

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May 17, 2004

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REGULATORY BACKGROUND

The organophosphates, carbamates, and B/2 carcinogens (EPA's Phase 1 list for tolerance reassessment under the Food Quality Protection Act) include many of the important pesticides used in Christmas tree production. These chemistries control many of the key pests that appear every year as well as some of the pests that appear occasionally in Christmas tree fields. These tools are at risk of being lost to Christmas tree growers.

The EPA is in the process of re-registering pesticides under the requirements of the Food Quality Protection Act (FQPA) and the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA). The Agency is examining dietary (including drinking water), ecological, residential, and occupational risks posed by the "high risk" pesticides (organophosphates, carbamates, and B/2 carcinogens) especially when used on foods consumed by infants and children. The priority list of pesticides that will undergo reassessment first includes several that have important uses in Christmas tree production.

EPA's regulatory focus on theses chemistries has created uncertainty as to their future availability. At some point the EPA may propose to modify or cancel some or all uses of these pesticides. The regulatory studies that EPA requires registrants to complete may result in some companies voluntarily canceling registrations. In addition, environmental groups are raising public awareness through campaigns addressing pesticide use and residues. Public awareness can lead to consumer pressure on growers to grow and sell products that are free of pesticides. At this point no one can predict which of the pesticides will be available for growers in the future.

The risks and concerns regarding the use of these "high risk" pesticides are not going to go away in the near future. Agriculture needs to respond in a proactive manner by developing pest management strategic plans that reflect the needs of growers and show the EPA and the USDA what is required to reduce and/or eliminate the risks and residues associated with pesticide use. The USDA, the EPA, the land-grant universities and the Christmas tree industry need to proactively identify regulatory, research, and educational needs for replacing the pesticides of concern with cost-effective alternatives as FQPA is implemented. The development of the specific pest by pest "To Do" list reflects these needs and is a primary goal of this document.

Several key principles were considered during the workshop:

1. First and foremost was the welfare of the Christmas tree grower; any strategic plan developed had to allow for the continued profitability for growers by providing cost-effective alternative pest management tools.

2. Geographical regions had to be considered when developing pest management strategic plans due to differences in production practices, pest complex and pressure, environmental conditions, varieties, and marketing opportunities.

3. The "big picture" needs to be considered. The one chemical at a time process would not work. Discussing the issues in terms of chemical class, individual commodity, and specific pests is the most effective way to develop a pest management strategic plan.

4. The group would identify gaps and needs that would become the a "To Do" list. This "To Do" list identifies what is needed in terms of research, regulatory actions, and educational programs as Christmas tree growers attempt to move away from use of “high risk” pesticides.

WORKSHOP AGENDA

North Carolina / Tennessee / Virginia Christmas Tree Pest Management Strategic Plan
Watauga County Agricultural Conference Center, 252 Poplar Grove Road, Boone, NC
June 17, 2003

Workshop Agenda

8:00 a.m. - 8:15 a.m.	Coffee and Doughnuts
8:15 a.m. - 8:30 a.m.	Welcome and Introduction of Workshop Participants - *Steve Toth, North Carolina State University, Darrell Hensley, University of Tennessee, and Mike Weaver and Therese Schooley, Virginia Tech University (Facilitators)*
8:30 a.m. - 8:45 a.m.	Purpose of Workshop and Value of Pest Management Strategic Plans in FQPA Implementation by EPA and USDA - *Steve Toth*
8:45 a.m. - 9:00 a.m.	Instructions for Preparing the Christmas Tree Pest Management Strategic Plan - *Steve Toth*
9:00 a.m. - 10:00 a.m.	**Small Groups:** Develop Efficacy Tables for Insect, Disease, Weed and Vertebrate Pest Management in Christmas Trees
10:00 a.m. - 10:15 a.m.	Morning Break (refreshments provided)
10:15 a.m. - 12:00 noon	**Small Groups:** Complete Efficacy Tables and Begin Work on Pest-by-Pest Profiles for Insect, Disease, Weed and Vertebrate Pests in Christmas Trees (i.e., indicate pest status, list pest management practices, and identify research, education and regulatory needs)
12:00 noon - 1:00 p.m.	Lunch (box lunch provided)
1:00 p.m. - 3:30 p.m.	**Small Groups:** Complete Development of Pest-by-Pest Profiles for Insect, Disease, Weed and Vertebrate Pests in Christmas Trees
3:30 p.m. - 3:45 p.m.	Afternoon Break (refreshments provided)
3:45 p.m. - 4:45 p.m.	Develop Research, Extension and Regulatory Priorities for Christmas Tree Industry - *Steve Toth, Darrell Hensley, Mike Weaver and Therese Schooley (Facilitators)*
4:45 p.m. - 5:00 p.m.	Closing Comments and Establishment of Time Frame for Completion of Pest Management Strategic Plan Document

CRITICAL NEEDS AND PRIORITIES FOR PEST MANAGEMENT IN CHRISTMAS TREE PRODUCTION IN NORTH CAROLINA, TENNESSEE, AND VIRGINIA

The work group developed a prioritized list of critical research, regulatory, and educational needs for the Christmas tree industry in North Carolina, Tennessee, and Virginia. This document may be used to:

1. Identify the registration needs and priorities of the Christmas tree industry in North Carolina, Tennessee, and Virginia for the United States Environmental Protection Agency (EPA) and pesticide registrants;

2. Seek United States Department of Agriculture (USDA) funding for the research priorities that have been identified; and

3. Identify the research, regulatory and educational needs within the Christmas tree industry.

Research Priorities:

- Need research to determine host plant resistance to and chemical control of balsam woolly adelgids.

- Need to support research on Phytophthora root rot management (i.e., genetic selection of trees, resistant stock, and grafting root stock as an alternative).

- Need research into yellow nutsedge control in seedbeds and transplant beds.

- Need additional herbicides for weed control in seedbeds and transplant beds (alternatives to Goal).

- Need alternatives to methyl bromide for fumigation of seedbeds and transplant beds.

- Need controls for pales weevil in white pine to avoid transfer of Procerum root disease. Only registered pesticides presently are Lorsban (chloropyrifos) and Asana.

- Need alternative to dimethoate for control of rosette bud mite and for hemlock rust mite, balsam woolly adelgid, and spruce spider mite control.

- Determine effects of groundcover management systems (optimal) to promote the best habitat to keep predators in the fields.

- Develop methods to control spread and/or fungus of Phytophthora root rot.

- Develop methods to measure Phytophthora levels in soils (sampling methods that would allow growers to determine potential levels of infestation).

- Increase knowledge of the biology/life cycles of the elongated hemlock scale and root aphid.

- Need research to determine the most economical methods of deer management, including finding economical repellents, the most easily disseminated repellents, wider and more efficacious repellents, and other solutions. More research needed on fencing and related means to exclude deer.

- Need research to determine risks to growers from using enclosed cabs to avoid pesticide exposure and solutions to determining which enclosed cab systems are adequate to protect growers from exposure in enclosed cabs. This stems from the recent loss of the ASAE Standard for Enclosed Cabs and pesticide exposure.

- Need adaptation of equipment or design of new equipment to use more efficacious and environmentally sound chemical application. In Virginia, growers receive a tax credit to adapt or purchase application equipment and related engineering technology that reduce pollution from pesticides and fertilizers.

- Need research into application technology to promote low volume applications and mechanization beyond present technology of backpack sprayers.

- Considerable research is needed with fertilization and tree mortality. Site information versus pest management. Identify the cultural practices that will speed up the amount of time to raise a tree to market and reduce pest management requirements. Solution to answer the following questions: How to raise a good healthy tree? What are the optimal conditions and cultural methods? Comments: Need specific research for location and species. Much of the income for Christmas tree growers include operations popping up around urban areas (choose and cut). Reduced pesticide use appeals to consumers.

Extension/Education Priorities (Technology Transfer):

- Need grafting workshops to teach growers how to graft trees with Phytophthora-resistant root stock.

- Need outreach to growers. Need outreach personnel to work with growers in the states (perhaps multi-state or regional personnel). A major problem in the states is the loss of Extension agents and specialists to state budget cuts in recent years. Need the transfer of university research to growers. Need agents in field to deliver information to growers. A "proactive" pest management program is needed.

- Information is needed on the work conducted with fertilization and tree mortality. Site information versus pest management. Identify the cultural practices that will speed up the amount of time to raise a tree to market and reduce pest management requirements. Solution

to answer the following questions: How to raise a good healthy tree? What are the optimal conditions and cultural methods? Comments: Need specific research for location and species. Much of the income for Christmas tree growers include operations popping up around urban areas (choose and cut). Reduced pesticide use appeals to consumers.

- Increase adoption of scouting and other Integrated Pest Management (IPM) practices by growers.

- Train professional scouts (e.g., conduct scouting workshops).

- Provide timely pest management information (e.g., Pest Alerts) to warn growers of potential pest problems.

- Multi-lingual programs for Hispanic farm workers to teach them to scout for pests.

- Publish research (for growers via Extension publications) on nitrogen study and rotation of trees. Also, publish research for the study on rooting of cuttings.

Regulatory Priorities:

- Need to register lindane for balsam woolly adelgids as the pyrethroid insecticides contribute to mite problems and lindane has a longer residual. Is this a possible IR-4 project?

- Need IR-4 or other projects to expand labels. Example: Petition the IR-4 project to establish a label for lindane for Balsam wooly aphid control. Keep Di-Syston and dimethoate for Balsam wooly aphid (invasive species), and others. There is an issue with hemlock rust mite coming in behind and increasing pesticide applications. This would reduce applications of pyrethroid insecticides. Lindane has longer residual effect. The balsam woolly adelgid needs to be declared an invasive species.

- Regulatory need to clarify and develop a solution to the loss of the ASAE Standard for enclosed cabs and pesticide exposure. This is a critical issue to protecting applicators from exposure to pesticides. Loss of standard may force inspectors to cite growers -- growers not aware or have no options to past standard.

- State Lead Agency's need to clarify label enforcement resulting from interpretation of label language. Currently there are variations between states on labels and how the wording on sites is interpreted (i.e., Christmas trees versus general ornamentals).

- Need alternative to S-metolachlor (Pennant Magnum).

- The loss of methyl bromide for the control of all pests in nursery stock will be problematic. A regulatory solution needs to be sought.

- Efforts to inventory nurseries to determine if *Phytophthora ramorum* (Sudden Oak Decline) is already present and try to prevent it from being introduced to North Carolina, Tennessee and Virginia. This holds for all exotic pests and diseases. Gypsy moth will produce a major problem with quarantines. Other examples exist.

- Adjust hunting seasons and bag limits to control deer in areas to manage populations and reduce damage to crops.

- Regulatory needs to be more cautious when considering the reintroduction of species like the elk into North Carolina, Tennessee and Virginia. Growers are worried about adding larger "grazers" to their crops. Will this impact Christmas tree production?

PEST-BY-PEST PROFILES

INSECT PESTS

MAJOR PESTS

BALSAM WOOLY ADELGID

The balsam woolly adelgid (BWA) (*Adelges piceae*) is native to central Europe and was introduced to North America in the early 1900s. The adelgid was first observed in the natural stands of Fraser fir in the 1950s. All natural stands of Fraser fir have since been impacted. Fraser fir is one of the most susceptible species of fir to BWA and has experienced widespread mortality due to BWA. The BWA feeds in the bark of the tree, and can be found on the trunk, branches, and buds of Fraser fir. Complete spray coverage is required to control this pest. Systemic pesticides don't control BWA because feeding occurs in the bark and not the vascular tissue. In 2000, 48.5% of growers reported treating for BWA.

Growers generally control BWA by treating at least once during the rotation. 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 range from 200 to 400 pounds per square inch to completely wet the tree bark. About half of Christmas tree growers (53.5%) own this type of equipment. Otherwise a grower must hire someone to treat the trees at a cost between $300 and $500 per acre.

Most growers used Lindane until the material was no longer available. Since Lindane has been taken from the market, growers are reporting needing to treat more often, sometimes as often as every year. In addition, following treatments with the synthetic pyrethroids, the hemlock rust mite often causes damage. When Lindane was used almost exclusively for BWA, hemlock rust mites were virtually never found in Fraser fir Christmas trees in the southern Appalachians.

In addition to pesticide applications, growers reduce problems with BWA by removing Fraser fir trees that can't be treated such as those in yards, and by culling heavily damaged trees. With the current interest in biological control for a similar pest, the hemlock woolly adelgid, research is ongoing to determine how those predators may also control BWA.

Organophosphates

Chlorpyrifos (Lorsban): Lorsban is occasionally used to control BWA. Control is enhanced when applied during the winter months when eggs are not present. Lorsban use has caused phytotoxicity, causing needles to drop in a small percentage of trees. Damage is often worse when the trees are under drought stress or when there is past spider mite damage.

Carbamates

None.

Chlorinated hydrocarbons

Lindane: Lindane has traditionally been the primary material used to control BWA and has been used since the mid-1950s ever since Christmas trees have been commercially grown in the region. Lindane was used on 23.8% of Christmas tree acreage in 2000, representing over half of the BWA treatments made that year. However, as the supplies of Lindane 20 EC dwindle, the usage of Lindane continues to decline. As growers switched to synthetic pyrethroids such as Asana, they began having more problems with hemlock rust mites and scales. Instead of getting 2 to 3 years worth of control, they began to have to treat every 18 months to every year.

Endosulfan (*Thiodan)*: Control of BWA with Thiodan is excellent. Thiodan was not considered labeled for use in Christmas trees in North Carolina until a 24(c) Special Needs Label for FMC Thiodan 3EC was obtained in 2000. Thiodan cannot be used within 300 feet of surface water because of concerns with fish kills and the effects on other aquatic life. Hemlock rust mites have been found after the use of Thiodan.

Pyrethroids

Esfenvalerate (Asana): Asana has been used by growers for many years as an alternative to Lindane. The hemlock rust mite often causes damage as much as 18 months after Asana application. Control has not been as long lasting as with Lindane, although in test plots, control will be as good as with Lindane.

Permethrin (Astro): Experimental demonstrations using Astro at 32 ounces formulation per 100 gallons and 16 ounces formulation per 100 gallons were started the fall of 2001. The control of BWA has been excellent thus far. However, rust mites, although not as bad as with Asana, have still been found following the use of Astro.

Bifenthrin (Talstar): Experimental demonstrations using Talstar at 40 ounces formulation per acre were started the fall of 2001. The control of BWA has not been as complete as with Astro or Asana. However, Talstar provides some spruce spider mite control which will with also aid growers.

Other Chemicals

Imidachloprid (Provado): The imidachloprid products are systemic, and therefore would not control BWA which feeds on the bark and not the vascular system. However, Provado can be applied topically to the tree. Control of BWA with Provado has not been as good as with Lindane or Asana in field trials.

Horticultural oil: Horticultural oil will control BWA when applied in the winter months. At that time, the eggs of the insect are not present. Eggs will survive oil treatment to hatch later on. Also when trees are dormant, foliage burn is less likely. Few growers use horticultural oil because BWA

control is not as long lasting as with other pesticides, and foliage burn is always a concern. Growers producing Fraser fir Christmas trees organically have used horticultural oil. Growers have used vegetable based oil as well as petroleum based oils.

Insecticidal soap: Insecticidal soap is similar to horticultural oil, only providing control when eggs are not present. Foliage yellowing has been observed with the use of soaps. Soaps have been used to reduce the impact of BWA at Clingman's Dome in the Great Smokey Mountains Nation Park. In the 2000 Pest Management Survey, no grower reported using insecticidal soap.

Unregistered Chemicals

None.

Non-Chemical Alternatives

Sanitation: 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 two or more years in the field 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.

Interplanting: 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.

Scouting: All fields of Christmas trees should be scouted annually for BWA to learn when it first comes into a field. Almost three-fourths of all growers although they could recognize a BWA adult and 68.5% of growers reported scouting for BWA in 2000.

Research Needs

1. *Host resistance*. Fraser fir is the most susceptible of all fir species to BWA. There is resistance in other fir species which could be incorporated into Fraser fir. Tolerance to BWA is related to bark thickness. Even in Fraser fir there are individuals that exhibit resistance which may be due to bark thickness. There may be immunity in Veitch's fir, the mechanism of which is not understood and needs to be researched. To better identify resistance, a method of screening for resistance needs to be developed. If resistance is discovered there is currently no quick method of cloning Fraser fir to make use of such resistant trees.

2. *Juvabiome*. Juvabiome is a growth regulator that affects the ability of the BWA nymphs to mature and the adults to produce eggs. The role of juvabiome production in resistance in fir species to BWA needs further clarification. In addition, it may be possible to produce juvabiome as a bioration pesticide to control BWA.

3. *Screening other pesticides that aren't synthetic pyrethroids*. Materials must either have activity against BWA eggs or residues that last long enough on the tree to kill the crawler

that hatches from the egg to be an effective BWA control at any other time than the winter. Currently, the only alternatives to Lindane and Thiodan have been synthetic pyrethroids, which all have the same mode of action and detrimental effect on natural predators. Often BTA and SSM are controlled when BWA is controlled in the spring, and the screening of control for these pests must be conducted as well.

4. *Spray equipment*. Currently growers apply BWA materials using high pressure sprayers and trees are sprayed from two directions. Growers can treat no more than 2-3 rows at a time. The use of different types of application technology that are not as labor intensive such as electrostatic spraying and mistblowers needs to be investigated.

5. *Monitor the regeneration of Fraser fir in the natural stands*. There is considerable regeneration of Fraser fir in the natural stands. It is not known if these trees are more resistant to BWA, or if a natural predator is keeping BWA numbers in check.

6. *Natural enemies of BWA*. In the 1950-60s there was considerable research to try to introduce predators of BWA into the natural stands. This proved unsuccessful. However, these predators could be reared and released in Christmas tree fields which are at a considerably lower elevation and not as harsh a climate. There are many predators of hemlock woolly adelgid being investigated. Their ability to control BWA should continue to be researched. The effect of pesticides to control BWA on predators should be investigated. Is this the primary effect that is creating more problems with hemlock rust mites? If Lindane is only used once in rotation while synthetic pyrethroids are applied multiple times would the net impact on natural predators be less? How does the time of year BWA materials are applied affect the natural enemies of BWA and other pests?

7. *Preserve the genotype of the Fraser fir of resistant and surviving plant material*. This has been done in the Great Smokies National Forest but it needs to be done in the rest of the natural range. Preserving the remaining genetic materials may aid in developing BWA resistance as well as other scientific research.

8. *Fertility and BWA*. Fertilizing trees with nitrogen fertilizer has been demonstrated to increase the fecundity of BWA. Research into lowering the nitrogen requirements for Fraser fir could reduce problems with BWA in Christmas trees.

Education Needs:

1. *Scouting*. Education on scouting for BWA needs to continue. In addition to training that has occurred in the past, teaching Latino workers to recognize BWA when they are shearing or doing other activities would help growers find the first trees that are infested in the field.

2. *Spray coverage*. How much water and coverage is really needed to control BWA? Demonstrations on spray coverage will help growers know when they are getting adequate control.

3. *Education on PPE*. Many growers use the disposable Tyvek suits to apply Di-Syston 15 G. However, these suits are not waterproof and are not adequate for BWA applications. More education on the proper use of PPE will help growers apply pesticides safely when controlling BWA.

4. *Natural enemies*. Growers and scouts need more education to be able to recognize natural enemies of BWA.

Regulatory Needs:

1. *Lindane.* There is interest among growers to re-register Lindane. When most growers used Lindane, problems with hemlock rust mites were non-existent. As growers switched to synthetic pyrethroids, rust mites have become a yearly pest requiring pesticides to control. Most growers when using Lindane only treated once in a rotation. Switching to other materials to control BWA, an invasive species, have resulted in *a net increase in pesticide use and exposure of workers to pesticides*. Previous well sampling and stream sampling demonstrated little problems with Lindane contaminating water sources. Lindane could be applied closer to surface water than Thiodan. Would it be possible to get a critical use exemption for Lindane?

2. *Legislation to remove or destroy abandoned Christmas plantations*. Other states such as Michigan have legislation to require abandoned cherry orchards to be removed. Would it be possible to do the same for Christmas trees as these trees harbor BWA? It may also be possible for NRCS to cost share the removal of abandoned Christmas trees.

SPRINGTIME PESTS

Most growers apply a pesticide in the spring on trees nearing market size to control the balsam twig aphid (BTA) (*Mindarus abietinus*). In addition, at that time, the spruce spider mite (SSM) (*Oligonychus ununguis*) is often controlled. If the grower finds the hemlock rust mite (HRM) (*Nalepella tsugifoliae*), that will need to be controlled as well. If BWA is present, it can be controlled in the spring, and with the addition of a miticide, BTA, SSM and HRM can all four be controlled. Therefore the three springtime pests will be discussed together.

The BTA is a serious springtime pest of fir species that causes needle curl and is associated with sooty mold. 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 and trees grown with adequate fertility. Pesticide timing is important to the control of BTA. The treatment window is narrow. Pesticides are ineffective against the twig aphid egg. 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. Growers are encouraged to treat for BTA the year of sale and the year previous to sale. In 2000, 71.7% of growers reported treating for BTA.

The SSM has a wide range of coniferous host species. It is considered a cool-season mite, but in the southern Appalachians temperatures are not high enough even in the summer to slow mite activity. The SSM can damage trees from March through October, although damage typically occurs in July and August. Spider mites cause yellow spotting on needles, which discolors the foliage and often results in premature needle shed. Spider mites are not a problem every year. Certain factors favor spider mite activity, the most important being rainfall. Spider mites are a dry season problem. However, production practices can affect SSM activity including farm location at lower elevations or on windy, exposed ridges; trees on rows adjacent to gravel roads which create dust; and the use of broad spectrum insecticides. These factors affect spider mites because they also affect the mite's natural predators. In 2000, 54.5% of growers reported treating for SSM.

The HRM causes bronzing of the foliage and premature needle drop on Fraser firs. It is primarily a springtime pest, although 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. In 2000, 20.2% of growers reported treating for the HRM.

Organophosphates

Disulfoton (Di-Syston 15 G): Control of BTA and SSM is excellent with this product although control of HRM is only fair. Di-Syston 15 G, being a granular, is quickly applied in the narrow treatment window for BTA control. Di-Syston is used on 49.6% of Christmas tree acreage and accounts for approximately 58.5% of all the insecticides used on the basis of pounds active ingredient per acre. Labeled at a much higher rate, research has demonstrated that 30 pounds formulation per acre provides good control of BTA and SSM. It is not effective against HRM, and if rust mites are present at treatment thresholds in April, an alternative pesticide such as Dimethoate should be chosen. Currently there is a 24(c) Special Local Needs label for Di-Syston 15 G use in Christmas trees in North Carolina. Di-Syston will be relabeled probably in June 2004 to allow the use in Christmas trees with a closed-system applicator that is currently being developed and tested. A study of worker exposure with the new applicator was conducted in the spring of 2003.

***NOTE**: All other products for BTA control must be applied with either an airblast mistblower or high pressure sprayer. Mistblower applications usually do not result in adequate coverage to achieve SSM control.*

Dimethoate: Control of BTA is excellent with Dimethoate while control of the mites is good, as Dimethoate does not have any activity against mite eggs. In 2000, growers applied Dimethoate on 21.2% of their acreage. When the HRM is a problem in the spring, most growers switch from using Di-Syston to Dimethoate. By adding an ovicide such as Savey, growers will often achieve full season control of both HRM and SSM. This is the only material that controls all three pests applied only one time a year. In most instances, Dimethoate applications in the spring are made with an air blast mistblower. In 2000, 18.1% of growers used dimethoate in a mistblower to achieve control of springtime pests. Dimethoate applied with a high pressure sprayer is the only product that will achieve BTA after the trees have broken bud. In trees to be marketed that year where the first BTA

treatment failed, applying Dimethoate in this manner will save the crop. Dimethoate is the only product that controls rosette bud mites with a single application. To control bud mites, Dimethoate is applied in June, during the time when the BTA are mating and laying eggs. Often, the grower can skip a BTA treatment the following year when trees are treated for rosette bud mites with Dimethoate.

Chlorpyriphos (Lorsban): Lorsban was used on only 8.4% of the acreage in 2000. Effective against the BTA, control of the SSM is enhanced with the addition of an ovicide. Control of HRM is also not good. Damage is often worse when the trees are under drought stress or when there is past spider mite damage.

Others: Other organophophates that are used on less than 1% of the Christmas tree acreage in western North Carolina that control BTA and SSM include Diazinon, oxydemeton-methyl (Metasystox-R), acephate (Orthene) and Malathion. To get season long control of SSM, an ovicide such as Hexythiazox (Savey) must be added.

Carbamates

Carbaryl (Sevin): Sevin will control BTA but is used on less than 0.1% of the Christmas tree acreage.

Chlorinated hydrocarbons

Lindane: Lindane will control BTA. Adding a miticide can result in SSM and HRM control as well. Growers treating for the BWA as early as late February will usually get control of springtime pests, although scouting is still necessary to determine if that is so.

Endosulfan (Thiodan): Thiodan has activity against BTA and SSM. Adding an ovicide may get season long control of SSM as well.

Pyrethroids

Esfenvalerate (Asana): Asana is extremely effective against BTA. Some growers use this product at lower than labeled rates with a mistblower to achieve BTA control. Growers will use Asana from late February through April to achieve BWA and BTA control. Adding a miticide is necessary to achieve SSM and HRM control.

Permethrin (Astro): Astro controls BTA as well as BWA. Adding a miticide is necessary to achieve SSM and HRM control.

Bifenthrin (Talstar): Talstar is the only product that will control BWA, BTA, and SSM. Adding a miticide is necessary to achieve season long control of SSM.

Other Chemicals

Imidachloprid (Provado): Provado will control BTA but not SSM or HRM. Control of BTA is not as good as with Asana or Di-Syston 15 G. Provado use will often make spider mites worse.

Hexythiazox (Savey): Savey was used on 5.4% of the acreage. 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. Growers in some mountain counties have achieved season long control of SSM with this mixture, although in areas prone to spider mites because of lower rainfall, mites may come back by the end of the growing season. Savey does not control either BTA or HRM.

Pyridaben (Sanmite): In research plots, Sanmite has achieved season long control of SSM. Having ovicidal activity, Sanmite has also proven effective against HRM. It would have no effect on BTA. Sanmite is not used by Christmas tree growers because of the cost.

Cinnamite: Cinnamite has not proven effective at controlling any of the springtime pests.

Neem oil extract (Triact): Triact has proven effective against the BTA. Control is slow, but BTA damage is controlled. The control of SSM and HRM is not known.

Horticultural oil: Horticultural oil will give some control of BTA and SSM. Usually, at least two applications must be made to achieve adequate control. Control of HRM is excellent with horticultural oil. Most hemlock growers in the region use this product for rust mite control, but almost no Christmas tree growers do because they must also control BTA and SSM.

Insecticidal soap: Insecticidal soap should give some control of BTA, SSM and HRM, although this has not been tested. Two applications would be necessary to achieve SSM control, as it has no reported activity against spider mite eggs.

Elemental sulphur: Growers have achieved control of HRM with sulphur. Only slight control of BTA and SSM has been observed with sulphur use.

Etoxazole (TetraSan): TetraSan is a new miticide that has not yet been tested for SSM or HRM control. It is not expected to control aphids.

Pymetrozine (Endeavor): Endeavor is labeled for aphid control. In other states, Endeavor has worked well to control the balsam twig aphid, but in North Carolina, BTA control was not very good. Endeavor has no activity against mites.

Unregistered Chemicals

Triazamaste (Aphistar): Aphistar is a carbamate and is an excellent systemic. Applied to the foliage, it will control root aphids in the root system. Excellent BTA control has also been observed. It will not control mites.

Fenpyroximate (Akari): Akari has provided excellent control of HRM in hemlocks. Control was longer lasting than with Dimethoate. Spider mite control has been reported to also be excellent in the greenhouse, but has not been tested in the field.

Thiamethoxam (Flagship): Flagship is reported to work well against aphids. Control against the BTA has not been tested. It will not control mites.

Oxythioquinox (Morestan): Morestan is no longer being manufactured; however, growers did achieve full season control of SSM with it. It has ovicidal properties.

Dicofol (Kelthane): Kelthane is not considered labeled for Christmas tree use in North Carolina. Used in Tennessee and Virginia, SSM control is reported as excellent, although it does not control SSM eggs. A second application must be made in 10-14 days, or another miticide such as Savey added to achieve full season control.

Non-Chemical Alternatives

Scouting: Scouting for SSM and HRM are key to control. Growers should especially assess their rust mite numbers prior to BTA control in the spring so they can switch to another material besides Di-Syston if necessary. Scouting is not used as often with BTA to determine if treatment is necessary, but it is very important in assessing if BTA controls have worked. This can be important when controls are applied with airblast mistblowers, or when determining if previous BWA or rosette bud mite controls have also controlled the BTA.

Ground cover management: Christmas growers produce not one, but two crops. Just as important to tree production are the ground covers that surround the trees. If these ground covers are allowed to flower, they will attract many natural predators that depend on nectar and pollen to reproduce. These can include syrphid flies, lacewings, ladybeetles and predatory mites. Managing ground covers to promote native, flowering vegetation may help reduce problems with twig aphids and spider mites.

Site selection: The spruce spider mite is more active in sites that are warm and dry. Factors that favor spider mite activity include farms at lower elevations (lower than 3,000 feet in the southern Appalachians); on windy, exposed ridges; on southern or southwestern exposures; and trees on rows adjacent to gravel roads which create dust. These factors affect spider mites because they also affect the mite's natural predators. To reduce problems with spider mites, and especially for organically grown Christmas trees, sites for Christmas tree production should be chosen that avoid these problems.

Research Needs

1. *Identifying important mite predators*. There are many predatory mites observed when scouting for pests. Many of these have not been properly identified, nor their role in spider mite control studied.

2. *The effect of synthetic pyrethroids on hemlock rust mites*. When synthetic pyrethroids such as Asana are used to control the BWA, hemlock rust mites develop to damaging levels even as long as 18-months later. It is not known if this is due to an effect on rust mite predators or to the mite itself.

3. *How do groundcovers affect predators*? It is not known which ground covers make the best habitat to support natural predators in Christmas trees.

4. *Pesticide application technology*. There are many pesticides that work well to control the BTA and SSM if the spray coverage is adequate. More work is needed to improve mist blower coverage and reduce drift, and to look at other experimental methods of applying pesticides.

5. *Scouting for BTA*. Currently few growers scout for the BTA. However, twig aphid numbers are often not great enough to warrant control. More work needs to be done to determine treatment thresholds for BTA.

6. *Effective use of predators for BTA control*. Syrphid fly larvae and ladybeetle larvae often effectively eliminate twig aphids from a field. Unfortunately, this usually occurs after trees have suffered irreparable damage. If these predators could be released into Christmas trees earlier or attracted to the trees sooner, they could control the aphids before damage occurred.

7. *Environmental effects of Di*-Syston. The effects of Di-Syston on small rodents and other creatures is not well understood. It is assumed that Di-Syston may cause a problem, yet rodents are abundant in Christmas tree fields. Learning more about the rodents in Christmas tree fields will help determine if Di-Syston use is causing a problem.

8. *Resistance to SSM and BTA*. There are individual Fraser fir trees that appear to be resistant to the SSM. Understanding the mechanism of resistance and incorporating it into Fraser fir would greatly aid growers in mite control. Also, late breaking individual trees often avoid problems with the BTA. Developing Fraser fir lines that break later than normal would aid in twig aphid control as well as frost damage.

Education Needs

1. *Scouting*. As scouting techniques for twig aphids are developed, growers will need to learn how to scout well enough to decide whether or not to treat. There also needs to be greater use of scouting for SSM and HRM.

2. *Predators*. Growers have little experience identifying predators. As important predators are identified, growers will need to be taught to recognize them.

3. *Ground covers*. As important ground covers are identified, growers will need to know how to identify them, and to use herbicides so that these ground covers are not killed.

Regulatory Needs:

1. *Keeping Dimethoate and Di-Syston.* There are still concerns that Dimethoate and Di-Syston will be taken from the market because they are organophosphates. Di-Syston and Dimethoate are key to integrated pest management in Fraser fir Christmas trees, controlling pests with the least impact on natural predators and worker exposure.

2. *Scouting*. The North Carolina Natural Resources Conservation Service will pay for professional scouting in Christmas trees as part of their Environmental Quality Incentives Program. However, currently only growers who are applying for cost share of other practices such as road construction or pesticide handling facilities are likely to be funded. Changing this rule would allow more growers to take advantage of the cost share for scouting.

WHITE GRUBS

White grubs are the larvae of scarab beetles. It is primarily the May and June beetle grubs that feed on tree roots. Grubs are most often a problem when trees are planted into old pastures as grubs are already present in high numbers, feeding of the short grass. Grub feeding kills seedlings, requiring the grower to reset fields. Grubs are also often a problem in seed beds. Once seedlings have been damaged with grubs, they seldom grow well, even if they aren't killed. Only 3% of growers reported having damage from grubs in 2000, but individual losses can be serious. In 2001, one grower lost 70,000 3-1 transplants to Asiatic beetle grubs valued at $17,500.

Organophosphates

Chlorpyriphos (Lorsban): Lorsban is effective in controlling grubs if it can be incorporated into the soil. This can be done before planting in the field or in seed beds, but can't be done once the trees are planted in the field. In fields of established Christmas trees, control is often poor.

Diazinon: Diazinon has also been used to control grubs, but control is often not effective.

Carbamates

Carbaryl (Sevin): Sevin has been used to control grubs, but control is often poor.

Chlorinated hydrocarbons

None.

Pyrethroids

None.

Other Chemicals

Halofenozide (Mach 2): Mach 2 has not proven effective against grubs in western North Carolina.

Imidachloprid (Marathon): Marathon has not proven effective against grubs in western North Carolina. However, this may be due to problems in the timing and method of application.

Unregistered Chemicals

Thiamethoxam (Flagship): Flagship has proven effective in white grub control in other states. It is currently not labeled in Christmas trees.

Isazophos (Triumph): Triumph resulted in the best field control in Christmas trees. However, it is no longer available in U. S.

Non-Chemical Alternatives

Ground cover management. Research has demonstrated that using suppressive rates of herbicides to "chemically mow" ground covers will reduce grub numbers over time. That is because the adult beetles prefer laying eggs in short grass rather than taller, uneven ground covers. The May and June beetle grubs spend 2 to 3 years in the soil before molting and emerging as an adult. Therefore, it will often take a couple of years before this strategy will reduce grub numbers. By then, damage has already occurred.

Scouting. Growers should scout before setting trees to determine if grubs are present. If they are, applying Lorsban and working it into the soil can reduce problems with grubs in newly set trees.

Research Needs

1. *Which grubs are important*: Research was conducted in the 1980s that identified several species of May and June beetles as being important including *Phyllophaga anxia, Phyllophaga fusce,* and *Polyphylla comes*. However, growers have also been experiencing problems with other grubs such as the Asiatic garden beetle grub (*Maldera castanea*), and the masked chafer grub (*Cyclocephala* sp.). In addition, black vine weevil larvae (*Otiorhnchus sulcatus*) have been damaging seedlings in seed beds. Also, the Oriental beetle grub (*Exomala orientalis*) has become a problem in certain counties in western North Carolina on hemlocks. It is not known if it damages Christmas trees.

2. *Research on grub control pesticides:* Research needs to continue in materials that will effectively control grubs.

3. *Timing of imidachloprid products*: Imidachloprid has been reported as controlling grubs well; however, tests in western North Carolina have not proven successful. Timing of application needs to be worked out for better control.

4. *Site preparation in pastures*: Often grubs are worse in old pastures as they are already present feeding in the grass. Recommendations need to be researched to help growers know how to apply pesticides at planting or during site preparation to effectively control grubs. Also, if ground covers were killed in a band where trees were to be set in the spring previous to planting, would the grubs move out of the planting row?

5. *Predacious nematodes*: The predacious nematodes *Steinernema* spp. and *Heterorhabditis* spp. have proven effective at controlling grubs in other agricultural systems. Research needs to be conducted in Christmas trees in the southern Appalachians to determine if these predators could be used effectively.

6. *Parasitic wasps*: The parasitic wasp, *Tiphia vernalis*, is found in the southern Appalachians and has been used successfully to control grubs in golf courses in the area. It is not known if this wasp could be used in Christmas tree fields or seed beds to control grubs or not.

Education Needs

1. *Scouting*: Controlling grubs early before they cause damage is far better for the grower than trying to treat after damage has occurred. Growers need to scout for grubs in seedling beds and fields to be set in Christmas trees. Education in scouting for grubs is on-going.

2. *Grub identification*: There are many species of scarab beetles. Not all feed on tree roots. Grubs are often identified by examining the raster pattern. Growers need to be educated to do this.

Regulatory Needs

1. *Triumph reregistration*: Triumph 4E (Isazophos) was one of the most effective pesticides to control grubs in field grown Christmas trees. However, it was voluntarily withdrawn from the market. Bringing Triumph back would greatly aid growers in the control of grubs in the field.

2. *Flagship registration*: Research conducted in other states has determined that Flagship is effective in controlling grubs. Getting a label in Christmas trees for Flagship would aid growers in grub control.

3. *Labeling of Dylox*: Currently Dylox (Dimethyl phosphonate) is labeled for landscape use, but it does not have the worker protection standard necessary for use in commercial production. Field trials with Dylox have demonstrated that it controls grubs better than Marathon or Flagship. Having a label for Dylox would help growers control grubs in the field and seed beds.

ROSETTE BUD MITE

The rosette bud mite (RBM) (*Trisetacus fraseri*) 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 RBM, but it may take a year or two longer to produce, increasing production costs and a delay in revenues. The earlier in the rotation that RBM infests a tree, the more tree quality will be affected. Rosette buds are primarily a problem in Avery County, North Carolina, and Grayson County, Virginia, as well as certain plantations at more than 4,000 ft elevation. However, the range of RBM continues to increase. In 2000, 11.9% of growers reported treating for RBM.

Organophosphates

Dimethoate: Dimethoate controls RBM with a single application made in early to mid-June. The rosette bud mites are killed in the buds. Coverage is crucial to control, and dimethoate must be applied with a hydraulic sprayer. Dimethoate is the only material known to control RBM with a single application.

Carbamates

Carbaryl (Sevin): Sevin will control the RBM, but it must be applied twice (at budbreak and two weeks afterward) to achieve control. Growers cannot afford to make two applications with a high pressure sprayer.

Chlorinated hydrocarbons

None.

Pyrethroids

None.

Other Chemicals

None.

Unregistered Chemicals

Fenpyroximate (Akari): Akari has proven effective in controlling hemlock rust mites. It is not known if it would control rosette bud mites.

Pyridaben (Sanmite): Sanmite has proven effective in controlling hemlock rust mites. It is not known if it would control rosette bud mites.

Non-Chemical Alternatives

No interplanting. One method of reducing the likelihood of RBM getting into smaller trees is to not interplant young trees with old trees. It usually takes 2 to 3 years to cut all the trees in a block. Some

growers will plant small trees next to the larger trees that are left. However, then the young trees with get RBM at a young age. It is better to clear-cut a block of trees before replanting.

Fertility. Maintaining good fertility is important to control. With adequate fertility, good bud set will offset the effects of RBM as more buds are produced to replace those that don't break.

Good shearing practices. Shearing early and lightly will help offset the effects of RBM on tree quality because it encourages good bud set.

Early harvesting. Selectively harvesting heavily infested trees early also reduces problems with RBM the following year. Each infested bud can have as many as 3,000 mites in it. By harvesting the worst trees, some growers have been able to avoid pesticide applications altogether.

Research Needs

1. *Screening other pesticides.* Several pesticides such as Sanmite and Akari have proven effective against the hemlock rust mites which is also an eriophyid mite. These and other new miticides should be screened to find another material besides Dimethoate that will control RBM with a single application.

2. *Natural enemies.* The RBM is found in natural stands but seldom affects many buds on a tree. Research needs to be conducted to determine if there are natural enemies of RBM in the natural stands that are not found in Christmas tree plantations.

Education Needs

1. *Educating growers to identify RBM.* Growers in regions of the southern Appalachians that currently do not have RBM must continue to be educated to identify the pest in case it comes into their area or is found on their seedlings they purchase from areas where the pest is present.

Regulatory Needs

1. *Keeping dimethoate*. There is no other material that will control RBM with a single application. As dimethoate moves through the FQPA process, it's importance for the control of this pest must be kept in mind.

ROOT APHIDS

Root aphids (*Prociphilus americanus*) are woolly aphids that feed on conifer roots during the winter months and move to ash trees to feed on the leaves during the spring. Some portion of the root aphid population appear to stay on conifers year round. It is not known what effect root aphids have on

their conifer host. It appears that when numbers are high (greater than 200 aphids per plant), tree growth is reduced. Root aphids may also exacerbate the effects of other problems such as poor fertility, dry sites, and prior grub damage. There is currently no labeled control for root aphids available for Christmas tree growers in the southern Appalachians. Only 1.8% of growers reported having damage due to RBM in 2000.

Organophosphates

Disulfoton (Di-Syston): Some growers have attempted to control root aphids using rates of Di-Syston 15 G at 100 pounds formulation per acre or more. Research results as to the effectiveness of granular Di-Syston have been inconclusive.

Carbamates

None.

Chlorinated hydrocarbons

None.

Pyrethroids

None.

Other Chemicals

None.

Unregistered Chemicals

Triazamaste (Aphistar): Aphistar applied to the foliage will translocate down to the roots and kill root aphids effectively. Control is greatly enhanced with the addition of an adjuvant such as LI-700. Aphistar has a Section 18 Emergency Label in the Pacific Northwest for the control of root aphids on Christmas trees. It is not labeled in the southern Appalachians.

Thiamethoxam (Flagship): Flagship is reported to translocate down effectively to the roots. This material may also control root aphids.

Non-Chemical Alternatives

None identified.

Research Needs

1. *Are root aphids causing damage?* Research needs to be conducted to determine if root aphids are really causing a problem in Christmas trees. Paired clones of Fraser fir could be grown in the lathhouse with and without root aphids to determine the effect on growth.

2. *Understanding of life cycle.* The life cycle and seasonal movement of root aphids onto its alternative host away from the conifer host is not well understood.

3. *Control with Flagship.* Flagship is an excellent systemic with activity against aphids. Research is needed to determine if root aphids could be controlled in the field with Flagship.

4. *Recommendations for transplanting.* Growers sometimes find root aphids in their transplants when they lift them to plant them in the field. There are currently no recommendations for growers as to whether or not the root aphids need to be controlled, or how to do that before or shortly after planting.

Education Needs

None were identified.

Regulatory Needs

Aphistar labeling. Growers in the southern Appalachians could control root aphids if Aphistar were labeled. Currently, growers cannot control root aphids at all.

CINARA APHIDS

Cinara aphids (*Cinara* spp.) are large brown to black aphids that feed on conifers. They are relatively rare on firs and cause no damage. However, if a tree infested with root aphids is harvested and set up in the home, these aphids will become active and move out onto furnishing. Christmas tree growers have had to pay for the clean up of these pests from customers' homes.

Organophosphates

Acephate (Orthene): Control of aphids is excellent with Orthene, but it is seldom used in Christmas trees in the mountains.

Chlorpyriphos (Lorsban): Control is excellent with this material.

Diazinon: Diazinon gives fair control of Cinara aphids.

Dimethoate: Dimethoate is another material often used to control this pest with good results.

Disulfoton (Di-Syston 15 G): Di-Syston gives good control of Cinara aphids.

Malathion: Malathion controls aphids well.

Oxydemeton-methyl (Metasystox-R): Metasystox-R controls aphids well.

Carbamates

Carbaryl (Sevin): Sevin is another excellent material for Cinara aphids.

Chlorinated hydrocarbons

Endosulfan (Thiodan): Thiodan is used to control this pest with excellent results.

Lindane: Lindane gives good control of aphids, although there may be residues on harvested trees.

Pyrethroids

Bifenthrin (Talstar): Talstar gives excellent control of aphids.

Esfenvalerate (Asana): Asana is used to control this pest.

Permethrin (Astro): Astro also controls this pest with excellent results.

Other chemicals

Horticultural oil: Horticultural oil can be used to effectively control this pest.

Insecticidal soap: Soaps could give good control of Cinara aphids.

Imidacloprid (Marathon, Provado): Provado gives excellent control of this pest.

Pymetrozine (Endeavor): The control of Cinara aphids with Endeavor is excellent.

Unregistered Chemicals

None.

Non-Chemical Alternatives

None were identified.

Research Needs

1. *Scouting methods.* Cinara aphids are seldom found on Fraser fir Christmas trees. However, every year a few trees are harvested and sold with these aphids. Developing a method of detecting the aphids either in the field or after harvest would help prevent the subsequent problems with this pest.

2. *Control.* Currently, Virginia and white pine Christmas tree growers treat trees to be harvested that year in the fall for Cinara aphids. Fraser fir growers by and large do not do this. However, when treatments are necessary, it is not known which materials would work the best, and be less likely to have harmful residues on the Christmas trees.

Education Needs

Public education. Cinara aphids do not feed on houseplants, cannot bite people or pets, and do not carry diseases. Yet, some people will fumigate their homes with pesticides if these pests were found on their Christmas trees. They have been mistaken for ticks, and these reports have made their way into the local media, especially in Florida. Public education on Cinara aphids would help people realize they are only a nuisance and not a threat.

Regulatory Needs

None were identified.

ELONGATE HEMLOCK SCALE

The elongate hemlock scale (*Fiorinia externa*) is an introduced pest from Japan. First found in New York in 1908, it has spread slowly throughout the eastern U. S. The scale attacks primarily eastern hemlock, but will also attack firs. It has spread to several Christmas tree farms in Watauga and Ashe Counties in North Carolina. The scale causes yellow spots on the foliage and reduces tree growth. It is a very difficult scale to control as crawlers are produced throughout the growing season. Because it is an armored scale, systemic pesticides also do not control it, as it feeds in the epidermal cells of the needles and not in the vascular tissue.

Organophosphates

Dimethoate: According to growers in Pennsylvania, Dimethoate is one of the best materials for elongate hemlock scale control. It may take multiple applications with a high pressure sprayer to achieve control.

Carbamates

None.

Chlorinated hydrocarbons

Lindane: Lindane has also been used successfully to control the elongate hemlock scale.

Pyrethroids

None.

Other Chemicals

None.

Unregistered Chemicals

None.

Non-Chemical Alternatives

None have been identified.

Research Needs

1. Identifying times for peak crawler production. The most effective way to treat armored scales is to apply a pesticide when the crawlers emerge. In the northeast, May is reported to be the peak crawler emergence. Observations must be made in the southern Appalachians to confirm this.

2. *Pesticide control.* Pesticide controls need to be conducted to determine the best materials to use and the best timing of application.

3. *Natural predators.* In the northeast, a predator, the twice-stabbed ladybeetle (*Chilocorus kuwanae*) and a parasite (*Aspidiotiphagus citrinus*) have been identified as being key to keeping elongate scale numbers in check. It is not known if these natural enemies or others are present.

4. *The extent of the problem.* Only six Christmas tree farms in North Carolina have currently been identified as having this problem. However, elongate hemlock scale is also prevalent on hemlocks in Henderson and Buncombe Counties in North Carolina. The range of this pest in the southern Appalachians needs to be determined.

Education Needs

Grower education. Growers in the southern Appalachians are by and large unfamiliar with the elongate hemlock scale which is new to this area. Educational efforts are continuing to teach growers to recognize this pest.

Regulatory Needs

None were identified

MINOR PESTS

BAGWORMS

Bagworms (*Thyridopteryx ephemeraeformis*) have a wide host range but are usually associated with arborvitae or junipers. Bagworms have occasionally been a problem on Fraser fir Christmas trees. The caterpillars feed on the foliage from the protective bag they form which is anchored to the tree. Having only one lifecycle a year, timing is key to control. Materials that are less toxic can control the young bagworms soon after they start to form their bags in May. However, later on in the growing season, harsher materials must be used.

Bagworms are seldom a problem on Fraser fir. However, once the bagworms develop a taste for a new conifer species, the numbers can begin to increase. It is important to continue to take bagworm infestations seriously.

Organophosphates

Chlorpyrifos (Lorsban): Lorsban gives excellent control of bagworms.

Diazinon: Diazinon gives excellent control of bagworms.

Acephate (Orthene): Orthene gives good control of bagworms.

Dimethoate: Dimethoate gives good control of bagworms.

Malathion: Malathion gives excellent control of bagworms.

Oxydemeton-methyl (Metasystox-R): This product works well against bagworms.

Carbamates

Carbaryl (Sevin): Sevin gives excellent control of bagworms. However, it kills off natural predators and create subsequent problems with spider mites.

Chlorinated hydrocarbons

Lindane: Lindane gives good control of bagworms.

Endosulfan (Thiodan): Thiodan gives good control of bagworms.

Pyrethroids

Bifenthrin (Talstar): Talstar gives excellent control of bagworms.

Cyfluthrin (Decathlon): Decathlon gives excellent control of bagworms.

Esfenvalerate (Asana): Asana gives good control of bagworms.

Permethrin (Astro): Astro works well against bagworms.

Other Chemicals

Diflourorbenzamide (Dimilin): Dimilin gives fair control of bagworms. The product works much better on young caterpillars than when the bags are large.

Spinosad (Conserve SC): This product gives excellent control of bagworms.

Tebufenozide (Confirm): Confirm gives excellent control of bagworms.

Horticultural oil: Horticultural oil can work well against bagworms with early control.

Insecticidal soap: Like the oils, soap works well when applied early in the season for bagworm control.

Unregistered Chemicals

None.

Non-Chemical Alternatives

Bagworms can be removed by hand.

Research Needs

None were identified.

Education Needs

None were identified.

Regulatory Needs

None were identified.

EASTERN SPRUCE GALL ADELGID

The Eastern spruce gall adelgid (*Adelges abietis*) is a pest of white and Norway spruce which are occasionally sold for Christmas trees in the southern Appalachians. Feeding by nymphs causes galls to form at the base of the new growing shoot. Galls turn brown in the summer, reducing tree appearance and value. This pest is relatively easy to control with proper timing.

Organophosphates

Chlorpyriphos (Lorsban): Control is excellent with this material.

Dimethoate: Dimethoate is another material often used to control this pest with excellent results.

Malathion: Malathion is used by some growers to control eastern spruce gall adelgid with excellent results.

Carbamates

Carbaryl (Sevin): Sevin is another excellent material for eastern spruce gall adelgid control, although spider mites may become a subsequent problem.

Chlorinated hydrocarbons

Endosulfan (Thiodan): Thiodan is used to control this pest with excellent results.

Lindane: Lindane was used in the past to control the eastern spruce gall adelgid.

Pyrethroids

Bifenthrin (Talstar): Many growers use Talstar to control the eastern spruce gall adelgid with excellent results.

Esfenvalerate (Asana): Asana is used to control this pest, as with the other adelgids.

Permethrin (Astro): Astro also controls this pest with excellent results.

Other Chemicals

Horticultural oil: Horticultural oil can be used to effectively control this pest.

Imidacloprid (Marathon, Provado): Provado gives only good control of this pest.

Unregistered Chemicals

None.

Non-Chemical Alternatives

Galls can be removed by hand if not many are present.

Research Needs

None were identified.

Education Needs

None were identified.

Regulatory Needs

None were identified.

PINE BARK ADELGID

The pine bark adelgid (*Pineus strobi*) is a native pest of eastern white pine. It feeds on the bark much like the balsam woolly adelgid, but white pines are seldom affected by it in the forest setting. However, on young white pines in the nursery, the pine bark adelgid can reduce growth, and it is usually controlled chemically if numbers are high. It is not a difficult pest to control.

Organophosphates

Chlorpyrifos (Lorsban): Lorsban gives excellent control of the pine bark adelgid and is often used.

Oxydemeton-methyl (Metasystox-R): Metasystox-R gives excellent control of this pest as well.

Malathion: Malathion gives excellent control of this pest.

Acephate (Orthene): Orthene gives fair control of the pine bark adelgid.

Diazinon: Diazinon gives good control of the adelgid.

Dimethoate: Dimethoate also gives good control of the pine bark adelgid.

Carbamates

Carbaryl (Sevin): Sevin gives good control of the pine bark adelgid.

Chlorinated hydrocarbons

Lindane: As with BWA control, growers have often used Lindane to control the pine bark adelgid with great success.

Endosulfan (Thiodan): Thiodan has been used successfully to control this pest.

Pyrethroids

Esfenvalerate (Asana): Asana is often used and gives excellent control.

Permethrin (Astro): Astro gives excellent control of the pine bark adelgid.

Bifenthrin (Talstar): Talstar gives excellent control as well.

Other Chemicals

Horticultural oil: Horticultural oil can control the pine bark adelgid with good results.

Imidacloprid (Marathon, Provado): Provado gives good control of this pest.

Insecticidal soap: Insecticidal soap gives good control of the pine bark adelgid.

Unregistered Chemicals

None.

Non-Chemical Alternatives

Scouting: Growers should scout for the pine bark adelgid in the spring when the new growth is lengthening. Only if the pest is present in high numbers should it be controlled.

Research Needs

None were identified.

Education Needs

None were identified.

Regulatory Needs

None were identified.

WEEVILS

There are several weevils that occasionally damage Christmas trees. These include the pine root collar weevil (*Hylobius radicis*), the white pine weevil (*Pissodes strobi*), and the Pales weevil (*Hylobius pales*). These damage several species of pine and spruce trees and occasionally Fraser fir.

Damage is different for the different weevils. The pine root collar weevil larvae girdles the root collar of young pine trees. The pales weevil feeds on stems, and is most often found when pines have been recently felled. The white pine weevil destroys or deforms the tree's leader.

Although many pesticides are reported as giving good control of weevils, timing is key. Usually the damage is already done before it is noticed, and the weevils are no longer present to be controlled.

Organophosphates

Chlorpyrifos (Lorsban): Lorsban is reported as excellent in controlling the Pales weevil. Control of other weevils is good.

Diazinon: Diazinon is reported as giving good control of weevils.

Dimethoate: Dimethoate gives good control of weevils.

Oxydemeton-methyl (Metasystox-R): Metasystox-R has been reported as giving good control of weevils.

Malathion: Malathion has been reported as giving good control of weevils.

Carbamates

Carbaryl (Sevin): Sevin gives good control of weevils.

Chlorinated hydrocarbons

Lindane: Lindane has been used in the past for Pales weevil control.

Endosulfan (Thiodan): Thiodan gives good control of weevils.

Pyrethroids

Esfenvalerate (Asana): Asana has been reported as giving excellent control of Pales weevil. Control of other weevils is good.

Bifenthrin (Talstar): Talstar gives good control of weevils.

Permethrin (Astro): Astro gives good control of weevils.

Other Chemicals

Diflourorbenzamide (Dimilin): Dimilin is reported as giving good to excellent control of weevils.

Imidacloprid (Marathon, Provado): These products give good control of weevils.

Horticultural oil: Horticultural oil gives good control of weevils.

Insecticidal soap: Soaps are reported as giving good control of weevils.

Unregistered Chemicals

None.

Non-Chemical Alternatives

Sanitation: Removing dead pines is often a way to control weevils.

Basal pruning: Trimming the bottom branches from trees creates conditions that are unsuitable for the pine root collar weevil, but this is time consuming and seldom done.

Research Needs

None were identified.

Education Needs

Grower education. Growers must continue to be educated so that they know the conditions of white pine harvest that may create problems with weevils.

Regulatory Needs

None were identified.

PINE SAWFLIES

There are several species of pine sawflies that can affect white pines in the southern Appalachians including the redheaded pine sawfly (*Neodiprion lecontei*), the blackheaded pine sawfly (*Neodiprion excitans*), and the introduced pine sawfly (*Diprion similis*). Damage is from loss of needles due to larval feeding. Natural controls, primarily parasites, keep the sawflies in check. Growers seldom have to treat for sawflies.

Organophosphates

Acephate (Orthene): Control with Orthene is excellent.

Chlorpyriphos (Lorsban): Control is excellent with this material.

Malathion: Malathion is used by some growers to control sawflies with excellent results.

Carbamates

Carbaryl (Sevin): Sevin is another excellent material for sawfly control, although spider mites may become a subsequent problem.

Chlorinated hydrocarbons

None.

Pyrethroids

Bifenthrin (Talstar): Many growers use Talstar to control sawflies with excellent results.

Cyfluthrin (Decathlon): Control with Decathlon is excellent.

Other Chemicals

None.

Unregistered Chemicals

None.

Non-Chemical Alternatives

None.

Research Needs

None were identified.

Education Needs

None were identified.

Regulatory Needs

None were identified.

GYPSY MOTH

The gypsy moth (*Lymantria dispar*) is currently only found sporadically in the southern Appalachians. It is monitored and treated as needed by the North Carolina Department of Agriculture and the North Carolina Forest Service. Gypsy moth feeds on many tree species but not on Christmas tree species. However, the egg masses could potentially be transported on Christmas trees. In states such as Michigan where gypsy moth is found, the Christmas trees must be inspected and treated in order to be shipped to areas where the pest is not currently located.

Currently, gypsy moth is not treated in Christmas trees in the southern Appalachians.

Research Needs

None were identified.

Education Needs

None were identified.

Regulatory Needs

Quarantines. As gypsy moth moves into the southern Appalachians, it may be necessary to quarantine certain items such as Christmas trees. This must be done to help slow the spread of gypsy moth, but in a way that is scientifically sound so that unnecessary pesticides are not used.

DISEASES

PHYTOPHTHORA ROOT ROT

Phytophthora root rot is the biggest disease problem for Christmas tree production (Fraser fir). Once sites are infested, growers lose fields to production for Fraser fir (also Canaan Fir). However, they can plant white pine in these sites in North Carolina (not the case out of the white pine range).

Field conditions: No economic control in field. Controls work somewhat well in nurseries. Lack of control in nurseries becomes a disease transmission problem to field if not careful without buffer in nursery beds.

Subdue: It is not used as much because it is too expensive (some growers using Ridomil instead, even though label doesn't include Christmas trees). Subdue used in nurseries more than in the field. Subdue may work for small acreage fields. It will double costs.

North Carolina State University Field Research

1. Subdue and Alliette: Subdue too expensive ($2 per tree times 3 applications, which is too expensive). It can work, but cost is too much (keeping trees alive).

2. Biophos and Agbios: Provides some control (poor).

3. SE-27: not effective.

4. Screening Fraser fir and other species for Phytophora root rot resistance.

5. Grafting resistant species to Fraser fir.

6. Resistance screening within families of Fraser fir

Site Preparation: Initial on new site. Moving soil around – probably not good to remove stumps. Good to excellent control.

Ground Cover: Needs to be done in combination of other pest management practices.

NEEDLE CAST

Sporatic disease.

Douglas Fir in Virginia (Bravo/Cleary).

Frasier fir and spruces (Blue/Norway) in North Carolina.

Once recognized, it is fairly easy to control if growers control it early. Site selection important (not as big a problem on seedlings). Growers don't look for the disease because it is not a big problem. People don't scout for the disease.

Treatment:

Remove bad problems, treat if near market (within two years).

Preventive spray at bud break. Growers do scout for it if they have had a problem.

BOTRYTIS

Excellent to good control of Botrytis with thiophanate methyl if the disease is caught early. Sometimes grower get poor control of the disease. Poor control of the disease may result from attempts to control after disease was caught too late. The disease can be confused with tip moth damage in Douglas fir and other species.

AMMOSUM ROOT ROT

Occurs primarily on yellow pine (Southern species) in the Piedmont. Not a problem in Virginia and most of North Carolina.

FERN FIR RUST

On Fraser fir, fern fir rust is seen in North Carolina. It affects the color of tree (cosmetic damage). Site selection an issue. Presence of ferns and species of ferns a factor. Shading and site preparation important. Dependent upon conditions.

NEEDLE RUST

Needle rust is a minor problem in Virginia and North Carolina.

DIPLODIA

Diplodia is a problem on Scotch pine (severe) and Douglas Fir (not as bad).

Daconil 2787 (not easy to mix) and Bravo (better) are options for managing the disease. Bordeaux mixture was recommended in Virginia, but not used as much.

Keep grasses down to get good airflow.

Better to choose slopes south or west (east and north slopes had disease problems).

Nova + Bravo works well on diplodia on Scotch pine.

PHOMOPSIS ON EASTERN RED CEDAR

Phomopsis can be a bad problem, but eastern red cedar is a species not widely used.

CEDAR APPLE RUST ON EASTERN RED CEDAR

Cedar apple rust on eastern red cedar is a curiosity. Species not widely used (eastern Virginia and North Carolina).

EASTERN GALL RUST

Bayleton can work to keep eastern gall rust in check. Most likely growers will have to remove trees. It is a problem on Scotch pine and Austrian pine. Remove alternative hosts (yellow pine, oak, etc.).

PINE OAK GALL RUST

Pine oak gall rust is bad problem on Scotch Pine. In Virginia, the disease is not a big problem. It can be a problem on Austrian pine (not an important species).

AIR POLLUTION

Fertilization after symptoms and selection of species for resistance (white pine).

WHITE PINE ROOT DECLINE
(Procerum Root Disease – *Leptographium procerum*)

Control weevil. A problem in Virginia.

RESEARCH, EDUCATION AND REGULATORY NEEDS FOR CHRISTMAS TREE DISEASES

Research Needs

- Need to support research on Phytophthora root rot management (i.e., genetic selection of trees, resistant stock, and grafting root stock as an alternative).
- Develop methods to control spread and/or fungus of Phytophthora root rot.
- Develop methods to measure Phytophthora levels in soils (sampling methods that would allow growers to determine potential levels of infestation).

Education Needs

- Need grating workshops to teach growers how to graft trees with Phytophthora-resistant root stock.

Regulatory Needs

- Efforts to inventory nurseries to determine if *Phytophthora ramorum* (Sudden Oak Decline) is already present and try to prevent it from being introduced to North Carolina, Tennessee and Virginia.

VERTEBRATE PESTS

Widespread Problems

Deer: browsing (bigger of two problems) and rubbing velvet (bucks)

Localized Problems

Birds: roosting and break treetops

Moles: problem with thick vegetation (ground cover management)

Rabbits: problem with thick vegetation (ground cover management)

Ground hogs: problem with thick vegetation (ground cover management); holes caused by ground hogs can be a liability in cut-your-own operations

Mice/Voles: occur in older plantations, thick thatch, and mostly in older trees; a problem in nurseries (seed and transplant beds); cover with straw or vegetation gives cover to allow girdling

Bears: local problem, can damage trees

Treatment

Most growers need a special permit to control vertebrate pests. Need special permit, bait or hunting license. Control restricted to non-protected species (5 rodents and 8 bird species exempted).

Research Needs

- Need research to determine the most economical methods of deer management, including finding economical repellents, the most easily disseminated repellents, wider and more efficacious repellents, and other solutions. More research needed on fencing and related means to exclude deer.

Regulatory Needs

- Adjust hunting seasons and bag limits to control deer in areas to manage populations and reduce damage to crops.

- Regulatory needs to be more cautious when considering the reintroduction of species like the elk into North Carolina, Tennessee and Virginia. Growers are worried about adding larger "grazers" to their crops. Will this impact Christmas tree production?

WEEDS

INTRODUCTION

As a group of pests, weeds compete with Christmas trees for water, nutrients, light, and space. Weeds have the potential to inflict serious quality defects on Christmas trees even to the point of making trees unmarketable. Thick weeds underneath trees can ruin their shape and kill lower branches. Vines can distort the tops of Christmas trees. Large weeds like pokeweed or hardwood sprouts can overtop and shade young Christmas trees. Competition from weeds can add years to the production cycle if not properly managed. Other weeds such as poison ivy or brambles can hurt those working in the trees. Dry weeds can provide fuel to flash fires in Christmas tree fields. Certain types of weed management can attract pests such as grubs or voles. Yet weeds also provide food and habitat for desirable wildlife from beneficial insects to song birds. For these reasons, weed management is critical to effective IPM in Christmas trees.

Hundreds of weed species may be present in different Christmas tree fields representing diverse groups of plants. For practical management, weeds can be categorized by the biological characteristics which determine herbicide selection. For preemergence herbicides, the season of seed germination is the key distinction along with the major class of weed. Weeds are grouped either as summer or winter germinating annuals and perennials, and as grasses, grasslike (sedges) or broadleaf weeds. For selective postemergence herbicides, control tends to follow the major classes of weeds and weed families. Some herbicides control grasses, others broadleaf weeds. Choice of herbicide and the rate may vary with the life cycle of a weed and whether it is an annual, biennial, or perennial. While these distinctions are oversimplified, they adequately match most weeds to the appropriate herbicide tool and serve as an organizing structure to our description of weed pests.

Not all weeds are simply problems to be controlled. Many low growing annual and perennial weeds can serve as beneficial ground covers. These plants minimize soil erosion and keep the root zone cool while providing minimal competition for water and nutrients. These desirable ground covers include white clover, dandelion, dwarf buttercup, wild strawberry, trailing cinquefoil, ground mint, and chickweed to name a few. Yarrow and false dandelion provide the added benefit of habitat for beneficial predatory mites. Some ground covers can be competitive or too tall unless they are suppressed by a low rate of postemergence herbicide. Good IPM growers lightly suppress the desirable ground covers while killing or suppressing the undesirable weeds. Over time with repeated suppression and spot treatment of problem weeds, plant populations shift to a greater percentage of desirable ground covers.

When the management of a natural ground cover becomes an IPM goal, the way that problem weeds are viewed changes as well. If a weed is not a desirable ground cover it is than considered either manageable or a problem species. The problem species are those weeds that escape the herbicide suppression program and affect tree growth or quality. These undesirable weeds may require additional treatments, higher herbicide rates, or possibly the sacrifice of desirable ground covers to achieve control. However, most can be eliminated through spot treatment with killing rates of postemergence herbicides in the fall. If an undesirable weed can be managed within the context of the ground cover suppression program it is not really a problem weed. As more North Carolina Fraser fir growers rely almost exclusively on low suppression rates of glyphosate herbicide, susceptibility or tolerance of a weed to that one material has become the primary weed management decision. See the following table for a list of desirable, manageable, and undesirable weeds:

Desirability of weeds in Fraser Fir Christmas Trees based upon weed height, competitiveness, and postemergence herbicide suppression.

Desirable	**Manageable**	**Undesirable**
Chickweed	Asters	Vines
Cinquifoil	Ragweed	Bindweeds*
Dandelion	Horseweed	Catchweed bedstraw
False dandelion	Yarrow	Trumpet creeper*
Creeping buttercup	Mustard	Virginia Creeper*
White clover	Pigweed	Greenbriar*
Nimblewill	Lambsquarters	Wild buckwheat
Wild strawberry	Wild carrot	Poison ivy*
Red sorrel	Horsenettle	Briars*
Plantain	Cool season grasses	Burdock & thistle*
Violet	Most annual grasses	Evening primrose*
	Seedling pokeweed	Goldenrod
		Hardwood sprouts*
		Dayflower*
		Established pokeweed*

* These weeds will likely need spot treatment with a postemergence herbicide at a killing rate.

In North Carolina, weed management in Fraser fir Christmas trees has evolved into an IPM system based on periodic monitoring of weed size, vigor, and species. Weed management has shifted from primary dependence on preemergence herbicides to postemergence herbicides. Pesticide decision-making now involves the consideration of soil conservation and the establishment of beneficial ground covers equally with the control of problem weeds. With the use of suppression rates of postemergence herbicides, native weed populations have become a soil management tool that many growers manipulate for a desired balance of surface cover, cooler soil temperatures in summer, nitrogen fixation, water percolation, and surface durability.

For many Christmas tree growers, the area of greatest concern is the management of weeds in their seedling and transplant nurseries. Fewer herbicides are labeled for Christmas tree nurseries; and young Fraser fir seedlings and transplants have less tolerance to those herbicides than established trees. Few growers still fumigate their beds for weed and disease control. Therefore, Goal is particularly important, both as a pre- and postemergence herbicide for broadleaf and grass weeds. Vantage is the primary strategy for grasses that escape Goal. Some growers use dormant season application of Roundup to address perennial weeds such as briars. Many resort to hand weeding for those that escape these limited strategies. Currently, no strategy provides optimal control of yellow nutsedge.

WEED GROUPS

Cool season perennial grasses

Cool season perennial grasses such as tall fescue, the fine fescues, Kentucky bluegrass, quackgrass and orchardgrass are highly competitive with Christmas trees for water and nutrients. Allowed to grow, these grasses can shade bottom branches and ruin the shape of Christmas trees. All cool season grasses can be eliminated either by labeled rates of preemergence or postemergence herbicides. Most can be eliminated over several seasons of suppression using repeat applications of low rates of postemergence herbicides. Where particularly aggressive patches are established of grasses such as quackgrass, fall spot treatment with killing rates of postemergence herbicide may be justified.

Cool season grasses provide ideal habitat for white grubs. In old pasture conditions, grasses should not be eliminated completely from between the trees to provide an alternative food source for the white grubs. Grubs are particularly attracted to grass that has been mown. By allowing a rough weed height profile to develop from the growth of broadleaf weeds, additional egg-laying by beetles may be discouraged.

Summer annual broadleaf weeds

Weeds such as ragweed, pigweed, horseweed, and lambsquarters begin to germinate as soon as the soil warms up in late spring. Germination can occur any time during the summer when the soil surface is exposed to sunlight. Improperly managed, dense stands of summer annuals can grow tall very rapidly. Management problems arise more from shading the trees and physically impeding work in the trees than from competition for water and nutrients. Thick stands get in

the way of any summertime activities, especially the shearing of Christmas trees. Often by the middle of winter, a field predominantly covered with dead and decayed summer annuals will lack adequate ground cover to avoid soil erosion.

On the positive side, coarse annual root systems of broadleaf weeds are less competitive than perennials or grasses for water and nutrients. Coarse roots of annual broadleaf weeds also create extensive pore spaces in the soil after they rot. In newly planted fields, a light stand of summer annuals provide shade to trees and can ease transplant shock.

The majority of summer annual weeds can be kept in check with suppression rates of postemergence herbicides. While the weeds may not die, height, density, and the amount of seed are reduced. Postemergence herbicide effectiveness can vary from season to season if growers do not pay attention to the timing of initial summer annual weed germination. By delaying weed suppression treatments until weeds like ragweed and pigweed have germinated, uniform suppression is much more likely. Baring the ground with killing rates of either preemergence or postemergence herbicides open the site to new waves of seed germination later in the summer and encourage establishment of undesirable perennial weeds. Fall treatment of summer annual broadleaf weeds with Roundup accomplishes little if seed has already matured and the weeds will soon die with the first killing frost.

Summer annual grasses

Weeds such as the foxtail, panicum, crabgrass, and barnyardgrass follow a very similar pattern of development and timing of treatment as summer annual broadleaf weeds. Germination is governed by soil temperature and the availability of open soil. Germination will continue until days shorten and soils cool in the fall. Some grasses can become extremely thick in just a few weeks. When a thick stand of annual grasses is killed or dies from frost in the fall, it can be a fire concern and may leave the soil bare and subject to erosion in the winter.

Weed growth must be monitored and treatment timings adjusted accordingly. Annual grasses can easily be killed or suppressed by several postemergence herbicides including products selective for grasses. While several preemergence herbicides will interupt the germination of summer annual grasses, the grasses are often the first weeds to come back in the bare ground of a preemergence band as it begins to fail in mid summer.

Winter annuals

Weeds including mustard, henbit, chickweed, pepper weed, and catchweed bedstraw germinate in late summer or fall and overwinter as small seedlings. Winter annuals undergo rapid growth in early spring and usually die in early summer. Most are easily suppressed or killed by postemergence herbicides. If preemergence herbicides are used without the addition of a postemergence herbicide, they should be applied in the fall before winter annual germination occurs. Some growers have managed winter ground covers of chickweed and henbit to protect soils through the winter.

Catchweed bedstraw is a winter annual vine that can be particularly difficult to control because it can germinate in midwinter and grow under the partial protection of a Christmas tree's lower limbs. Spring applications of postemergence herbicide often fail to kill all the seedlings. Fall treatments of a preemergence herbicide will inhibit germination. Establishment of a solid perennial ground cover will also minimize germination of this winter annual.

Biennial broadleaf weeds

Biennial weeds require two growing seasons to complete their life cuycles. Wild carrot, common mullien and a few thistles germinate and form a low growing rosette of leaves in the summer or fall of one year and grow a tall flower stalk in the second year. After producing seed the second year, they die. Biennials that appear to be inconsequential in their first year can become a major impediment to traffic and shearing operations in their second year.

Biennials can be controlled by a number of different preemergence and postemergence herbicides. Most growers rely on postemergence herbicides to kill or suppress the weeds before they produce flower stalks in their spring and early summer applications. Most are readily controlled by glyphosate. Clopyralid, a selective postemergence herbicide is particularly effective on thistles, but is not effective on Queen Anne's lace or mullein.

Perennial broadleaf weeds

Perennial weeds live two or more years. Many different broadleaf weeds fall into this category and have diverse means to reproduce and survive winter. Many herbaceous weeds die back to their roots, stolons, or storage roots. Woods violets have corms. Wild garlic has bulbs. Pokeweed has a large woody crown and thick root. Japanese knotweed, and peppermint are examples of weeds with rhizomes (underground stems). Yellow nutsedge spreads by rhizomes and overwinters as tubers. Woody plants generally survive winter with dormant stems in tact as well as roots. With the means of storing energy from year to year and an array of different characteristics, many perennials are difficult to control.

Management of perennial weeds has largely been addressed in the previous discussion of the IPM approach. Preemergence herbicides have a place in controlling the germination of perennial seedlings in bareground conditions. Where perennials are already established, postemergence herbicides are necessary. Many perennials are kept in check in the course of regular suppression herbicide applications. Several weeds generally need additional treatments at higher rates to eliminate them. These include woody vines, hardwood stump sprouts, established pokeweed, and brambles.

Where growers opt for less intensive site preparation, woody sprouts and vines can be a greater problem. Non-selective herbicides can be very effective during site preparation and in spot treatments in the fall after Christmas tree foliage has hardened off. Virtually all perennial weed problems can be addressed through the complement of non-selective herbicides although several seasons of treatment may be needed for some weeds.

HERBICIDES THAT ARE CURRENTLY REGISTERED

Preemergence herbicides

Atrazine (Atrazine 4L, Aatrex 4L)
- Preemergence control of many annual broadleaf weeds
- Not recommended by North Carolina State University for use in Christmas tree production
- Triazine-resistant pigweed, ragweed, lambsquarters
- Will control a broad spectrum of other weeds
- Need to use lower labeled rates
- Will not give season long control

Flumioxazin (Broadstar)
- Preemergence control of annual broadleaf and grass weeds
- Granular formulation
- Controls triazine-resistance weeds
- Not for use in nurseries
- Controls hoary alyssum, which is a weed not controlled by other preemergence herbicides

Flumioxazin (Sureguard)
- Preemergence control of annual broadleaf and grass weeds
- Can be applied over top of dormant trees
- Long residual
- Controls triazine-resistance weeds
- Could apply only two applications of herbicide annually with this product
- Controls hoary alyssum, which is a weed not controlled by other preemergence herbicides

Isoxaben (Gallery)
- Good preemergence control of broadleaf weeds
- Expensive, not widely used
- Possible replacement for simazine
- May be used in tank mix with other preemergence herbicides to improve grass control
- Fall application can control horseweed

S-Metolachlor (Pennant Magnum)
- Good preemergence control of annual grasses and yellow nutsedge
- Problems with weed control at non-damaging rates
- Needs water to activate the herbicide
- Reasonable cost

Oryzalin (Surflan)
- Good to excellent preemergence control of annual grasses
- Will control triazine resistant weeds
- Need 2 inches of rain within 21 days after application
- Expensive
- Not used on newly planted trees (such applications can girdle the stem at the soil line)

Oxyfluorfen (Goal)
- Good preemergence and early postemergence control on various broadleaf weeds and some annual grasses
- Most important herbicide in nurseries
- Expensive

Pendimethalin (Pendulum)
- Excellent preemergence control of annual grasses
- Same family as Surflan but less phytotoxic
- Needs rainfall to activate (2 inches to 1 inch)
- Less expensive than Surflan
- Stains equipment

Pronamide (Kerb)
- Not used much any more
- Good for cool season grasses, especially quack grass
- Good for high organic sites
- Must be applied when soil temperature is less than 55 degrees F
- Expensive, reason for limited use
- More water soluable than other soil-applied herbicides and can move down slope

Simazine (Princep)
- Preemergence control of annual broadleaf weeds
- Poor weed control on higher organic sites
- Triazine resistant weeds - ragweed, lambsquarter, pigweed, etc
- Tank mixed with a killing rate of Roundup to maintain bands
- Public concerns about groundwater contamination
- Most widely used preemergence herbicide in Christmas trees due to low cost
- Grower concern about potential loss
- Not a season long product, late season weeds are not controlled

Postemergence herbicides

Clethodim (Envoy)
- Good control of fine fescues and other perennial grasses
- Not used as widely as Vantage among grass-selective herbicides
- Expensive
- Safe applied over the top of trees

Clopyralid (Stinger)
- Very selective broadleaf herbicide
- Low rates (3 to 5 ounces per acre)
- Great on legumes and most composits, including clover, vetch, thistles and spotted knapweed
- Very expensive compared to Roundup
- Relatively cost effective due to very low rates
- Need to control weeds when young

Fluazifop-P-Butyl (Fusilade II)
- Excellent postemergence annual and perennial grass and quackgrass control
- Grass needs to be actively growing and not under stress
- Can be used in combination with other herbicides
- Timing critical, more effective on smaller grasses
- No residual
- Vantage used more commonly in North Carolina

Glyphosate (Roundup and others)
- Excellent control of a wide variety of weeds
- Non-selective
- Use low rates during season (4 to 8 ounces) for vegetation suppression
- Most widely used herbicide
- Very inexpensive, cost effective
- No residual

Oxyfluorfen (Goal)
- Good early postemergence control on many broadleaf weeds
- Contact burn of weed foliage
- Widely used in nursery production and not as much in field
- Most important herbicide in nurseries
- Expensive

Pronamide (Kerb)
- Postemergence control of cool season grasses
- Applied in the winter to control perennial grasses
- Very little used, expensive

Sethoxydim (Vantage)
- Good to excellent grass control, no residual
- Can be applied over the top of Christmas trees without injury
- More effective on younger, actively growing grasses (not under moisture stress)
- Can be used in combination with other herbicides, usually Goal for vegetation suppression
- Used extensively in nurseries
- Growers are using suppression rates of Roundup instead

OTHER PEST MANAGEMENT AIDS

Mowing
- Used in conjunction with preemergent bands under trees
- Primarily in southern mountains with gentler terrain
- Aggravates white grub problems
- Favors grasses that are competitive for water and nutrients
- More expensive than “chemical mowing”
- Less acreage being mowed than in past

- Will always be used on main roads

Fabric mulches
- Used in organic production
- Labor intensive to install
- Problems with weed eating or mowing
- Problems with rodents
- Will last 2 or 3 years without covering with a mulch

Organic mulches
- Poor weed barrier
- Labor intensive and expensive
- Only one known practitioner in North Carolina

Sown groundcovers
- Can work after recent tillage
- Better germination if rolled for good soil contact
- Some species will inhibit weed germination (rye, oats, fine fescue, plantain)
- Growing interest among growers

Weed suppression (chemical mowing)
- Very low rates of glyphosate, or clopyralid + sethoxydim + oxyfluorfen
- Glyphosate suppression is becoming dominant weed management practice
- Encourages low growing perennial ground cover, especially white clover

PIPELINE PEST MANAGEMENT TOOLS

Dimethenamid (Outlook)
- Preemergence control of annual grasses and yellow nutsedge
- Similar uses as S-metolachlor
- Limited data on Christmas tree safety
- Limited data on efficacy in conifer nurseries

Lactofen (Cobra)
- Good to excellent as preemergence and postemergence broadleaf weed control
- Problems with phytotoxicity as post application
- Could be used in seed beds and nursery plantations for some conifer species
- Has not been used much because of cost and lack of safety data

Hexazinone (Velpar)
- Good, Scotch pine (two needle pines), broad spectrum, grasses, broadleaves, some woody
- Contact and residual activity
- Widely used in Scotch pine production
- Cost effective
- Woody control early in season

- Safer to trees than Roundup applied over top
- Safety on other conifers not documented

RESEARCH, EDUCATION AND REGULATORY NEEDS FOR CHRISTMAS TREE WEEDS

Research Needs

- Yellow nutsedge control in conifer nurseries
- Evaluate various application techniques and equipment
- Evaluate alternative control methods such as biological controls, cover crops, etc.
- Dayflower (*Commelina* spp.) control in conifer nurseries
- Birdweed control options in established trees

Regulatory Needs

- Expand label definition of a Christmas tree to include herbicides registered for field-grown nursery crops

Education Needs

- Hold educational workshops and demonstration plots with growers and technical representatives as new products are developed
- Improve weed and ground cover management guidelines

EFFICACY TABLES FOR CHRISTMAS TREE PEST MANAGEMENT PRACTICES

Tables 1a - 1d: Efficacy ratings for various pest management tools against Christmas tree insect and mite pests.

Tables 2a - 2d: Efficacy ratings for various pest management tools against Christmas tree disease and nematode pests.

Tables 3a - 3d: Efficacy ratings for various pest management tools against Christmas tree broadleaf weeds and grasses.

Tables 4a - 4d: Efficacy ratings for various pest management tools against Christmas tree vertebrate pests.

Table 1a. Efficacy ratings for various pest management tools against Christmas tree insect and mite pests. Rating scale: E = excellent; G = good; F = fair; P = poor; ? = research needed; NU = not used; * = used, but not a stand alone tool.

Pest Management Tools	Christmas Tree Insect and Mite Pests																			
	Balsam woolly adelgids	Balsam twig aphids	Spruce spider mites	Hemlock rust mites	Rosette bud mites	Bagworms	White grubs	Root aphids	Eastern spruce gall adelgids	Cinara aphids	Pine bark adelgids	Weevils	Elongate hemlock scale	Pine sawflies						
Registered Insecticides and Miticides																				
abamectin (Avid)	NU	NU	F	?	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU						
acephate (Orthene)	NU	G[2]	NU	NU	NU	G	P	NU	NU	G	F	NU	NU	E						
Beauvaria bassiana (Naturalis-O)	P	P	?	?	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU						
bifenazate (Floramite)	NU	NU	F-P	P	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU						
bifenthrin (Talstar)	G	G[2]	G-F*	P	NU	E	NU	NU	E	E	E	G	NU	E						
carbaryl (Sevin)	NU	G[2]	P*	E	G-F	E	P	NU	E	E	G	G	NU	E						
oxythioquinox (Morestan)	NU	NU	E	E	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU						
chlorpyrifos (Lorsban)	G[1]	G[2]	G*	G	NU	E	G[3]	NU	E	E	E	E-G	NU	E						
cinnamaldehyde (Cinnamite)	P	G[2]	P	?	NU	F?	NU	NU	?	?	?	?	NU	NU						
clofentezine (Ovation)	NU	NU	E	?	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU						
cyfluthrin (Decathalon)	NU	?	NU	NU	NU	E	NU	NU	?	?	?	?	NU	E						
diazinon (Diazinon)	NU	G[2]	G*	?	NU	E	P	NU	?	F	G	G	NU	E						
dicofol (Kelthane)	NU	NU	E*	E	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU						

1 Only used in winter months when eggs are not present.
2 Product may work well, but short treatment window does not allow for the length of application.
3 Product works well when it can be incorporated into the soil.

Table 1a (continued). Efficacy ratings for various pest management tools against Christmas tree insect and mite pests. Rating scale: E = excellent; G = good; F = fair; P = poor; ? = research needed; NU = not used; * = used, but not a stand alone tool.

Pest Management Tools	Christmas Tree Insect and Mite Pests																			
	Balsam woolly adelgids	Balsam twig aphids	Spruce spider mites	Hemlock rust mites	Rosette bud mites	Bagworms	White grubs	Root aphids	Eastern spruce gall adelgids	Cinara aphids	Pine bark adelgids	Weevils	Elongate hemlock scale	Pine sawflies						
Registered Insecticides and Miticides																				
diflubenuron (Dimilin)	NU	NU	NU	P	NU	F	NU	NU	NU	NU	NU	E-G	NU	NU						
dimethoate (Clean Crop, Dimethoate)	NU	E[2]	G*	G	E	G	NU	NU	E	G	G	G	G	?						
disulfoton (Di-Syston)	NU	E	E	F	NU	NU	NU	?	NU	G	NU	NU	NU	?						
endosulfan (Thiodan)	G	G[2]	G*	F?	NU	E?	NU	NU	E	E	E	G	?	?						
esfenvalerate (Asana)	G	G[2]	F*	P	NU	E	NU	NU	E	E	E	G	NU	?						
etoxazole (TetraSan)	NU	NU	?	?	?	NU	NU	NU	NU	NU	NU	NU	NU	NU						
halofenozide (Mach 2)	NU	NU	NU	NU	NU	NU	F	NU	NU	NU	NU	NU	NU	NU						
hexythiazox (Savey)	NU	NU	E-G*	P	P	NU	NU	NU	NU	NU	NU	NU	NU	NU						
horticultural oil	F[1]	G[2]	F	E	NU	G	NU	NU	E	G	G	?	NU	NU						
imidacloprid (Marathon, Provado)	P	G[2]	NU	NU	NU	E	F	NU	G	E	G	G	NU	?						
insecticidal soap	G[1]	G[2]	F	F	NU	G	NU	NU	G	G	G	G	NU	NU						
lindane (Lindane)	E	NU	NU	G	NU	E	NU	NU	E	E	E	G	G	NU						
malathion (Malathion)	?		?	?	NU	E	NU	NU	E	E	E	NU	NU	E						

1 Only used in winter months when eggs are not present.
2 Product may work well, but short treatment window does not allow for the length of application.
3 Product works well when it can be incorporated into the soil.

Table 1a (continued). Efficacy ratings for various pest management tools against Christmas tree insect and mite pests. Rating scale: E = excellent; G = good; F = fair; P = poor; ? = research needed; NU = not used; * = used, but not a stand alone tool.

Pest Management Tools	Christmas Tree Insect and Mite Pests																			
	Balsam woolly adelgids	Balsam twig aphids	Spruce spider mites	Hemlock rust mites	Rosette bud mites	Bagworms	White grubs	Root aphids	Eastern spruce gall adelgids	Cinara aphids	Pine bark adelgids	Weevils	Elongate hemlock scale	Pine sawflies						
Registered Insecticides and Miticides																				
oxydemeton-methyl (Metasystox-R)	F	G[2]	G*	?	NU	E	NU	NU	?	E	E	G	?							
permethrin (Astro)	G	G[2]	G*	P	NU	E	NU	NU	E	E	E	G	NU	?						
propargite (Ornamite)	NU	NU	?	NU?	?	NU	NU	NU	NU	NU	NU	NU	NU	NU						
pymetrozine (Endeavor)	P	F[2]	NU	NU	NU	NU	NU	NU	?	E	?	NU	NU	NU						
pyridaben (Sanmite)	NU	NU	E-G	E	?	NU	NU	NU	NU	NU	NU	NU	NU	NU						
spinosad (Conserve SC)	NU	NU	NU	NU	NU	E	NU	NU	NU	NU	NU	NU	NU	NU						
sulfur	NU	P[2]	P	E	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU						
tebufenozide (Confirm)	NU	NU	NU	NU	NU	E	NU	NU	NU	NU	NU	NU	NU	NU						

1 Only used in winter months when eggs are not present.
2 Product may work well, but short treatment window does not allow for the length of application.
3 Product works well when it can be incorporated into the soil.

Table 1b. Efficacy ratings for various pest management tools against Christmas tree insect and mite pests. Rating scale: E = excellent; G = good; F = fair; P = poor; ? = research needed; NU = not used; * = used, but not a stand alone tool.

Pest Management Tools	Christmas Tree Insect and Mite Pests																			
	Balsam woolly adelgids	Balsam twig aphids	Spruce spider mites	Hemlock rust mites	Rosette bud mites	Bagworms	White grubs	Root aphids	Eastern spruce gall adelgids	Cinara aphids	Pine bark adelgids	Weevils	Elongate hemlock scale	Pine sawflies						
Unregistered/New Insecticides and Miticides																				
fenpyroximate (Akari)	NU	NU	?	E	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU						
isazophos (Triumph)[1]	NU	NU	NU	NU	NU	NU	E	NU	NU	NU	NU	NU	NU	NU						
Neem oil extract (Triact 70)	NU	G	?	?	?	NU	NU	NU	NU	?	NU	?	NU	NU						
thiamethoxam (Flagship)	NU	NU	NU	NU	NU	NU	F-G	?	NU	NU	NU	NU	NU	NU						
triazamate (Aphistar)	NU	E	NU	NU	NU	NU	NU	E	NU	NU	NU	NU	NU	NU						
trichlorfon (Dylox)	NU	NU	NU	NU	NU	NU	G	NU	NU	NU	NU	NU	NU	NU						

1 Product was taken off the market in the U.S.

Table 1c. Efficacy ratings for various pest management tools against Christmas tree insect and mite pests. Rating scale: E = excellent; G = good; F = fair; P = poor; ? = research needed; NU = not used; * = used, but not a stand alone tool.

Pest Management Tools	Christmas Tree Insect and Mite Pests																			
	Balsam woolly adelgids	Balsam twig aphids	Spruce spider mites	Hemlock rust mites	Rosette bud mites	Bagworms	White grubs	Root aphids	Eastern spruce gall adelgids	Cinara aphids	Pine bark adelgids	Weevils	Elongate hemlock scale	Pine sawflies						
Cultural/Nonchemical Pest Management Practices																				
Site selection to avoid warmer and dryer conditions that promote spruce spider mites	NU	NU	E	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU						
Site preparation	NU	NU	NU	NU	NU	NU	G?	NU	NU	NU	NU	NU	NU	NU						
Maintain good fertility	NU	NU	NU	NU	E	NU	NU	E	NU	NU	NU	NU	NU	NU						
Scouting to determine need for pesticide application	E	F	E	E	G	G	G	F	G	G	E	G	G	G						
Managed ground cover through chemical mowing instead of mowing to keep ground covers taller and uneven	NU	NU	NU	NU	NU	NU	G	NU	NU	NU	NU	NU	NU	NU						
Manage ground covers to harbor natural predators	NU	E	E	NU?	NU	NU	NU	NU	NU	?	NU	NU	NU	NU						
Remove yard trees or other trees that cannot be treated chemically	E	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU						
Cull/destroy trees	E	NU	NU	NU	E	NU	NU	NU	NU	NU	NU	NU	E	NU						
Early harvest of trees	NU	NU	NU	NU	E	NU	NU	NU	NU	NU	NU	NU	NU	NU						
Don’t interplant young trees with older trees	E	NU	NU	NU	E	NU	NU	NU	NU	NU	NU	NU	NU	NU						

Table 1c (continued). Efficacy ratings for various pest management tools against Christmas tree insect and mite pests. Rating scale: E = excellent; G = good; F = fair; P = poor; ? = research needed; NU = not used; * = used, but not a stand alone tool.

Pest Management Tools	Christmas Tree Insect and Mite Pests																			
	Balsam woolly adelgids	Balsam twig aphids	Spruce spider mites	Hemlock rust mites	Rosette bud mites	Bagworms	White grubs	Root aphids	Eastern spruce gall adelgids	Cinara aphids	Pine bark adelgids	Weevils	Elongate hemlock scale	Pine sawflies						
Cultural/Nonchemical Pest Management Practices																				
Remove and destroy immature cones	NU	E	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU						
Prune or remove pests by hand	NU	NU	NU	NU	NU	G	NU	NU	G	NU	NU	NU	NU	NU						
Host resistance	?	?	?	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU						
Augmenting natural predator population by releasing predators	?	?	?	NU	NU	NU	?	NU	NU	NU	NU	NU	NU	NU						

Table 1d. Efficacy ratings for various pest management tools against Christmas tree insect and mite pests. Rating scale: E = excellent; G = good; F = fair; P = poor; ? = research needed; NU = not used; * = used, but not a stand alone tool.

Pest Management Tools	Christmas Tree Insect and Mite Pests																			
	Balsam woolly adelgids	Balsam twig aphids	Spruce spider mites	Hemlock rust mites	Rosette bud mites	Bagworms	White grubs	Root aphids	Eastern spruce gall adelgids	Cinara aphids	Pine bark adelgids	Weevils	Elongate hemlock scale	Pine sawflies						
Biological Controls																				
Harmonia lady beetles and other native lady beetles	G	E	G	?	NU	NU	NU	NU	NU	G	NU	NU	NU	NU						
syrphid (hover) fly larvae	F	E	G	?	NU	NU	NU	NU	NU	G	NU	NU	NU	NU						
Tiphia vernalis (parasitic wasp)	NU	NU	NU	NU	NU	NU	?	NU	NU	NU	NU	NU	NU	NU						
predatory mites	NU	NU	E	?	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU						
twice stabbed lady beetles	?	?	?	?	NU	NU	NU	NU	NU	?	NU	NU	G	NU						
Aspidiotiphagus citrinus (aphelinid parasitoid)	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	G	NU						
Pseudoscrimnus tsugae	?	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU						
Laricobius sp.	?	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU						
orbadid mites	?	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU						
milky spore disease	NU	NU	NU	NU	NU	NU	?	NU	NU	NU	NU	NU	NU	NU						
predatory nematodes	NU	NU	NU	NU	NU	NU	?	NU	NU	NU	NU	NU	NU	NU						

Table 2a. Efficacy ratings for various pest management tools against Christmas tree disease and nematode pests. Rating scale: E = excellent; G = good; F = fair; P = poor; ? = research needed; NU = not used; * = used, but not a stand alone tool.

Pest Management Tools	Christmas Tree Disease and Nematode Pests																			
	Phytophthora root rot	Needle cast	Botrytis shoot blight	Annosum root rot	Damping-off (seedling disease)	Fern-fir rust	Needle rust	Sooty mold	Nematodes	Diplodia (Scotch pine)	Phomopsis (Eastern red cedar)	Cedar apple rust (Eastern red cedar)	Air pollution (ozone) (White pine)	Pine oak gall rust (Scotch/Virginia/Austrian pine)	Procerum root disease (White pine)					
Registered Fungicides and Nematicides																				
fosetyl-aluminum (Aliette)	E	NU	NU	NU	E	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU					
chlorothalanil (Bravo)	NU	E	G	F	F	G	G	G	NU	E	NU	NU	NU	NU	NU					
mefenoxam (Subdue Maxx)	E	NU	NU	NU	E	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU					
methyl bromide + chloropicrin	E	NU	NU	E	E	NU	NU	NU	E	NU	NU	NU	NU	NU	NU					
mycobutanil (Nova)	NU	NU	NU	NU	NU	NU	NU	NU	NU	E	NU	NU	NU	NU	NU					
thiofanate methyl (Cleary's 3336, Fungo Flo)	NU	G-E	P-E	F	E	E	E	NU	NU	G?	NU	NU	NU	NU	NU					
triadimefon (Bayleton)	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	F-G	NU					

Table 2b. Efficacy ratings for various pest management tools against Christmas tree disease and nematode pests. Rating scale: E = excellent; G = good; F = fair; P = poor; ? = research needed; NU = not used; * = used, but not a stand alone tool.

Pest Management Tools	Christmas Tree Disease and Nematode Pests																			
	Phytophthora root rot	Needle cast	Botrytis shoot blight	Annosum root rot	Damping-off (seedling disease)	Fern-fir rust	Needle rust	Sooty mold	Nematodes	Diplodia (Scotch pine)	Phomopsis (Eastern red cedar)	Cedar apple rust (Eastern red cedar)	Air pollution (ozone) (White pine)	Pine oak gall rust (Scotch/Virginia/Austrian pine)	Procerum root disease (White pine)					
Unregistered/New Fungicides and Nematicides																				
QST 713 (Serenade, Rhapsoda) *	NU	F	G	NU	P	P	P	P	NU	NU	NU	NU	NU	NU	NU					
Gliocladium catenulatum Strain J1446 (Prestop) *	F	NU	NU	NU	G	P	P	P	NU	NU	NU	NU	NU	NU	NU					
Harpin Protein (Messenger) *	F	F	P	NU	NU	P	P	P	NU	NU	NU	NU	NU	NU	NU					

* New chemistry being investigated by Interregional Research Project #4 for disease control on ornamentals (http://pestdata.ncsu.edu/ir-4/Bindex.cfm?doc=newchem.cfm)

Table 2c. Efficacy ratings for various pest management tools against Christmas tree disease and nematode pests. Rating scale: E = excellent; G = good; F = fair; P = poor; ? = research needed; NU = not used; * = used, but not a stand alone tool.

Pest Management Tools	Christmas Tree Disease and Nematode Pests																			
	Phytophthora root rot	Needle cast	Botrytis shoot blight	Annosum root rot	Damping-off (seedling disease)	Fern-fir rust	Needle rust	Sooty mold	Nematodes	Diplodia (Scotch pine)	Phomopsis (Eastern red cedar)	Cedar apple rust (Eastern red cedar)	Air pollution (ozone) (White pine)	Pine oak gall rust (Scotch/Virginia/Austrian pine)	Procerum root disease (White pine)					
Cultural/Nonchemical Pest Management Practices																				
Use of disease-free transplants	E *	NU	NU	NU	E	NU	NU	NU	E	NU				NU	NU					
Selection of site to reduce risk of disease (i.e., soil type, soil drainage)	E *	G	G	E	E	NU	NU	NU	E	G		*		NU	NU					
Scouting trees for presence of diseases	P-G *	E	E	G	G	E	E	NU	G	G				G	NU					
Removal of disease-infested trees from fields	F-G *	F	P	P	F	F	F	NU	G	*				G	NU					
Control of aphids	NU *	NU	NU	NU	NU	NU	NU	E	NU	NU				NU	NU					
Ground cover management *	F-G *	NU	NU		NU	NU	NU	NU	NU	*				NU	NU					
Site preparation (not removing stumps)	G-E	NU	NU	E	NU	*	NU	NU	NU	NU		*		NU	NU					
Control of weevils (Lorsban-Lindane)															G-E					

Table 2d. Efficacy ratings for various pest management tools against Christmas tree disease and nematode pests. Rating scale: E = excellent; G = good; F = fair; P = poor; ? = research needed; NU = not used; * = used, but not a stand alone tool.

Pest Management Tools	Christmas Tree Disease and Nematode Pests																			
	Phytophthora root rot	Needle cast	Botrytis shoot blight	Annosum root rot	Damping-off (seedling disease)	Fern-fir rust	Needle rust	Sooty mold	Nematodes	Diplodia (Scotch pine)	Phomopsis (Eastern red cedar)	Cedar apple rust (Eastern red cedar)	Air pollution (ozone) (White pine)	Pine oak gall rust (Scotch/Virginia/Austrian pine)	Procerum root disease (White pine)					
Biological Controls Practices																				

Table 3a. Efficacy ratings for various pest management tools against Christmas tree broadleaf weeds and grasses. Rating scale: E = excellent; G = good; F = fair; P = poor; ? = unknown / research needed; NU = not used; * = used, but not a stand alone tool.

Pest Management Tools	Christmas Tree Broadleaf Weeds and Grasses																			
	Aster	Brambles / Briars	Cocklebur	Eveningprimrose	Bindweed	Goldenrod	Horseweed	Lambsquarters	Morningglory	Pigweed	Poison ivy	Pokeweed	Ragweed	Smartweed	Thistles	Vetch	Fall panicum	Foxtail	Kentucky bluegrass	Orchardgrass
Registered Preemergence Herbicides and Fumigants																				
atrazine	E	P	G	G	P	P	E	P-E	E	P-E	P	E	P-E	E	G	G	F	F	F	F
isoxaben (Gallery)	E	P	F	F	P	P	G	E	P	G	P	G	E	G	G	F	P	P	P	P
S-metolachlor (Pennant Magnum)	F	P	P	P	P	P	F	P	P	F	P	P	F	F	P	P	E	E	P	F
napropamide (Devrinol)	F	P	P	P	P	P	P	G	P	G	P	P	F	G	P	F	G	F	P	F
oryzalin (Surflan)	E	P	?	G	P	P	F	E	F	E	P	G	G	F	F	F	E	G	P	G
oxadiazon (Ronstar)	G	P	NU	G	P	P	F	G	F	G	P	P	G	G	F	F	E	G	P	G
oxyfluorfen (Goal)	G	P	E	E	P	P	G	E	F	E	P	G	G	E	G	F	F	F	F	F
pendimethalin (Pendulum)	G	P	P	G	P	P	G	E	P	E	P	G	P	F	F	P	E	G	P	G
prodiamine (Barracade)	G	P	P	P	P	P	F	G	P	E	P	G	P	?	F	P	G	G	P	G
pronamide (Kerb)	P	P	P	P	P	P	P	P	P	F	P	P	F	P	P	P	F	F	E	E
simazine (Simazine)	E	P	F	G	P	P	E	E	E	P-E	P	G	P-E	E	G	G	P	P	P	P
trifluralin (Treflan)	P	P	P	P	P	P	P	G	P	F	P	P	P	P	P	P	G	G	P	P
flumioxazin (Sureguard, Broadstar)	G	P	G	G	P	P	E	E	E	E	P	G	E	G	E	G	F	F	P	P
MeBr, chloropicrin fumigants	E	E	G	E	G	E	E	E	E	E	P	G	E	E	E	E	E	E	E	E
Basamid fumigant	G	G	F	F	G	G	G	G	P	G	P	F	G	G	F	P	G	G	G	G
Metam sodium fumigant	G	G	F	F	G	G	G	G	G	G	P	F	G	G	F	P	G	F	G	G

Table 3a (continued). Efficacy ratings for various pest management tools against Christmas tree broadleaf weeds and grasses. Rating scale: E = excellent; G = good; F = fair; P = poor; ? = research needed; NU = not used; * = used, but not a stand alone tool.

Pest Management Tools	Christmas Tree Broadleaf Weeds and Grasses																		
	Quackgrass	Tall fescue	Catchweed Bedstraw	Yellow Nutsedge	Black Locust	Hardwood Sprouts	Buckwheat	Mugwort	Bittersweet	Woody Vines	Knapweed	Dayflower							
Registered Preemergence Herbicides and Fumigants																			
atrazine	F	F	G	P	P	P	G	P	P	P	?	P							
isoxaben (Gallery)	NU	P	E	P	P	P	G	P	P	P	?	P							
S-metolachlor (Pennant Magnum)	P	P	P	F	P	P	P	P	P	P	?	P							
napropamide (Devrinol)	P	P	F	P	P	P	?	P	P	P	?	P							
oryzalin (Surflan)	P	P	G	P	P	P	G	P	P	P	?	P							
oxadiazon (Ronstar)	P	P	F	P	P	P	?	P	P	P	?	P							
oxyfluorfen (Goal)	P	P	E	P	P	P	G	P	P	P	?	F							
pendimethalin (Pendulum)	P	P	G	P	P	P	G	P	P	P	?	P							
prodiamine (Barracade)	P	P	G	P	P	P	?	P	P	P	?	P							
pronamide (Kerb)	G	E	P	P	P	P	P	P	P	P	?	P							
simazine (Simazine)	P	P	E	P	P	P	E	P	P	P	?	F							
trifluralin (Treflan)	P	P	F	P	P	P	P	P	P	P	?	P							
flumioxazin (Sureguard, Broadstar)	P	P	G	P	P	P	?	P	P	P	?	F							
MeBr, chloropicrin fumigants	E	E	E	G	F	F	E	E	E	E	G	G							
Basamid fumigant	G	G	G	F	F	F	G	G	G	G	G	G							
Metam sodium fumigant	G	G	G	F	F	F	G	G	G	G	G	G							

Table 3a (continued). Efficacy ratings for various pest management tools against Christmas tree broadleaf weeds and grasses. Rating scale: E = excellent; G = good; F = fair; P = poor; ? = unknown / research needed; NU = not used; * = used, but not a stand alone tool.

Pest Management Tools	Christmas Tree Broadleaf Weeds and Grasses																			
	Aster	Brambles / Briars	Cocklebur	Eveningprimrose	Bindweed	Goldenrod	Horseweed	Lambsquarters	Morningglory	Pigweed	Poison ivy	Pokeweed	Ragweed	Smartweed	Thistles	Vetch	Fall panicum	Foxtail	Kentucky bluegrass	Orchardgrass
Registered Postemergence Herbicides																				
clethodim (Envoy)	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	G	G	G	G
clopyralid (Stinger)	F	P	E	P	F	G	E	P	P	P	P	P	E	P-F	E	E	NU	NU	NU	NU
fluazifop-butyl (Fusilade)	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	G	G	F	G
glyphosate (Roundup)	E	F	G	P	F	G	E	E	F	E	G	F	E	E	E	F	E	E	E	E
glyphosate (Roundup) suppression	E	F	?	P	F	E	E	F	P	E	F	P	E	G	G	G	E	E	E	E
oxyfluorfen (Goal)	F	P	F	F	P	P	F	F	P-F	F	P	P-F	F	F	F	P	P-F	P-F	P	P
pronamide (Kerb)	P	P	P	P	P	P	P	P	P	F	P	P	P	P	P	P	F	F	E	E
sethoxydim (Vantage)	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	E	E	F	F
triclopyr (Garlon)	G	E	G	G	G	G	E	E	E	E	E	E	E	E	E	E	NU	NU	NU	NU
2,4-D + triclopyr (Crossbow) used for site preparation	E	E	E	E	G	E	E	E	E	E	E	E	E	E	E	E	P	P	P	P
2,4-D used for site preparation	F	F	F	F	F	G	G	G	F	G	F	F	F	F	F	P	P	P	P	P
bentazon (Basagran T/O)	F	P	G	P	P	P	F	P	F	F	P	P	F	F	F	P	NU	NU	NU	NU
flumioxazin (Sureguard)	F	P	?	?	P	P	P	F	F	F	P	P	F	F	P-F	?	P	P	P	P

Table 3a (continued). Efficacy ratings for various pest management tools against Christmas tree broadleaf weeds and grasses. Rating scale: E = excellent; G = good; F = fair; P = poor; ? = research needed; NU = not used; * = used, but not a stand alone tool.

Pest Management Tools	Christmas Tree Broadleaf Weeds and Grasses																		
	Quackgrass	Tall fescue	Catchweed Bedstraw	Yellow Nutsedge	Black Locust	Hardwood Sprouts	Buckwheat	Mugwort	Bittersweet	Woody Vines	Knapweed	Dayflower							
Registered Postemergence Herbicides																			
clethodim (Envoy)	F	F	NU	P	NU	NU	NU	NU	NU	NU	NU	NU							
clopyralid (Stinger)	NU	NU	P	P	E	P	P	P-F	P	P	E	P							
fluazifop-butyl (Fusilade)	F	F	NU	P	NU	NU	NU	NU	NU	NU	NU	NU							
glyphosate (Roundup)	G	E	F	F	E	E	E	F	F*	F*	F	P							
glyphosate (Roundup) suppression	G	E	G	F	G	G	E	F	P	F	F	P							
oxyflourfen (Goal)	P	P	F	P	P	F*	E	P	P	P	?	P							
pronamide (Kerb)	G	G	P	P	P	P	P	P	P	P	?	P							
sethoxydim (Vantage)	G	F	NU	P	NU	NU	NU	NU	NU	NU	NU	NU							
triclopyr (Garlon)	P	P	E	P	E	E	E	E	G	E	?	P-F							
2,4-D + triclopyr (Crossbow) used for site preparation	P	P	E	P	E	E	E	G	F	G	G	F							
2,4-D used for site preparation	NU	NU	F	NU	E	E	E	?/G	E	E	?	P							
bentazon (Basagran T/O)	NU	NU	F	E	P	P	E	P	P	P	P	F							
flumioxazin (Sureguard)	NU	NU	?	P	P	P	?	P	P	P	?	?							

Table 3b. Efficacy ratings for various pest management tools against Christmas tree broadleaf weeds and grasses. Rating scale: E = excellent; G = good; F = fair; P = poor; ? = research needed; NU = not used; * = used, but not a stand alone tool.

Pest Management Tools	Christmas Tree Broadleaf Weeds and Grasses																			
	Aster	Brambles / Briars	Cocklebur	Eveningprimrose	Bindweed	Goldenrod	Horseweed	Lambsquarters	Morningglory	Pigweed	Poison ivy	Pokeweed	Ragweed	Smartweed	Thistles	Vetch	Fall panicum	Foxtail	Kentucky bluegrass	Orchardgrass
Unregistered/New Herbicides																				
Methyl Iodide	E?	E?	E?	E?	E?	E?	E?	E?	E?	E?	E?	E?	E?	E?	E?	E?	E?	E?	E?	E?
Oust for site prep only	E	P	P	E	P	E	E	E	E	E	P	E	E	E	P	E	E	E	E	E
Arsenal (low rates)	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E
dimethenamid (Outlook)	?	P	P	?	P	P	F	P	P	F	P	P	P	P	?	?	G	G	P	P

Table 3b (continued). Efficacy ratings for various pest management tools against Christmas tree broadleaf weeds and grasses. Rating scale: E = excellent; G = good; F = fair; P = poor; ? = research needed; NU = not used; * = used, but not a stand alone tool.

Pest Management Tools	Christmas Tree Broadleaf Weeds and Grasses																	
	Quackgrass	Tall fescue	Catchweed bedstraw	yellow nutsedge	black locust	hardwood sprouts	Buckwheat	Mugwort	Bittersweet	Woody Vines	Knapweed	Dayflower						
Unregistered/New Herbicides																		
Methyl Iodide	E?	E?	E?	E?	E?	E?	E?	E?	E?	E?	E?	E?						
Oust for site prep only	G	E	E	E	F	G	E	?	?	F	G	?						
Arsenal (low rates)	E	E	E	E	E	E	E	E	E	E	E	?						
dimethenamid (Outlook)	P	P	?	G	P	P	?	P	P	P	?	P-F						

Table 3c. Efficacy ratings for various pest management tools against Christmas tree broadleaf weeds and grasses. Rating scale: E = excellent; G = good; F = fair; P = poor; ? = research needed; NU = not used; * = used, but not a stand alone tool.

Pest Management Tools	Christmas Tree Broadleaf Weeds and Grasses																			
	Aster	Brambles / Briars	Cocklebur	Eveningprimrose	Bindweed	Goldenrod	Horseweed	Lambsquarters	Morningglory	Pigweed	Poison ivy	Pokeweed	Ragweed	Smartweed	Thistles	Vetch	Fall panicum	Foxtail	Kentucky bluegrass	Orchardgrass
Cultural/Nonchemical Pest Management Practices																				
Use of mower and/or weed-eater	F	P	F	F	P	F	F	F	G	F	P	F	F	P	P	P	P	P	G	G
Sown groundcover	F	P	?	G	G	G	E	E	E	E	P	G	E	F	F	G	G	G	F	G
Herbicide suppression	E	E	?	G	G	E	E	E	E	E	F	G	E	E	E	E	E	E	E	E
Fabric Mulches	F	P	F	F	P	F	F	F	F	F	P	P	F	F	F	F	F	F	F	F
Organic Mulches	F	P	P	F	P	P	F	F	F	F	P	P	F	F	P	F	P	F	P	F

Table 3c (continued). Efficacy ratings for various pest management tools against Christmas tree broadleaf weeds and grasses. Rating scale: E = excellent; G = good; F = fair; P = poor; ? = research needed; NU = not used; * = used, but not a stand alone tool.

Pest Management Tools	Christmas Tree Broadleaf Weeds and Grasses																		
	Quackgrass	Tall fescue	Vetch	Catchweed bedstraw	yellow nutsedge	black locust	hardwood sprouts	Buckwheat	Mugwort	Bittersweet	Woody Vines	Knapweed	Dayflower						
Cultural/Nonchemical Pest Management Practices																			
Use of mower and/or weed-eater	P	P	P	P	P	F	F	F	P	F	F	F	P						
Sown groundcover	F	G	G	E	F	P	P	F	P	P	F	P	G						
Suppressed Groundcovers	F	E	E	F	P	P	P	G	P	P	F	F	P						
Fabric Mulches	P	F	P	P	P	P	P	G	P	P	P	F	G						
Organic Mulches	P	P	F	F	P	P	P	F	P	P	P	F	P						

Table 3d. Efficacy ratings for various pest management tools against Christmas tree broadleaf weeds and grasses. Rating scale: E = excellent; G = good; F = fair; P = poor; ? = research needed; NU = not used; * = used, but not a stand alone tool.

Pest Management Tools	Christmas Tree Broadleaf Weeds and Grasses																			
	Aster	Brambles / Briars	Cocklebur	Eveningprimrose	Bindweed	Goldenrod	Horseweed	Lambsquarters	Morningglory	Pigweed	Poison ivy	Pokeweed	Ragweed	Smartweed	Thistles	Vetch	Fall panicum	Foxtail	Kentucky bluegrass	Orchardgrass
Biological Controls																				
Weevils	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	F	NU	NU	NU	NU	NU

Table 3d (continued). Efficacy ratings for various pest management tools against Christmas tree broadleaf weeds and grasses. Rating scale: E = excellent; G = good; F = fair; P = poor; ? = research needed; NU = not used; * = used, but not a stand alone tool.

Pest Management Tools	Christmas Tree Broadleaf Weeds and Grasses																		
	Quackgrass	Tall fescue	Vetch	Catchweed Bedstraw	Yellow Nutsedge	Black Locust	Hardwood Sprouts	Buckwheat	Mugwort	Bittersweet	Woody Vines	Knapweed	Dayflower						
Biological Controls																			
weevils	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	F	NU						

Table 4a. Efficacy ratings for various pest management tools against Christmas tree vertebrate pests. Rating scale: E = excellent; G = good; F = fair; P = poor; ? = research needed; NU = not used; * = used, but not a stand alone tool.

Pest Management Tools	Christmas Tree Vertebrate Pests																			
	Birds	Bears	White-tailed deer	Groundhogs	Mice (field, deer and white-footed)	Moles	Rabbits	Meadow voles (meadow mice)	Pine voles (orchard rats)											
Registered Pesticides																				
chlorophacinone (rodent bait)	NU	NU	NU	NU	E	NU	NU	E	E											
diphacinone (rodent bait)	NU	NU	NU	NU	E	NU	NU	E	E											
zinc phosphide (rodent bait)	NU	NU	NU	NU	E	NU	NU	E	E											
Hinder																				
Avitrol (permit only)																				

Table 4b. Efficacy ratings for various pest management tools against Christmas tree vertebrate pests. Rating scale: E = excellent; G = good; F = fair; P = poor; ? = research needed; NU = not used; * = used, but not a stand alone tool.

Pest Management Tools	Christmas Tree Vertebrate Pests																			
	Birds	Bears	White-tailed deer	Groundhogs	Mice (field, deer and white-footed)	Moles	Rabbits	Meadow voles (meadow mice)	Pine voles (orchard rats)											
Unregistered/New Pesticides																				

Table 4c. Efficacy ratings for various pest management tools against Christmas tree vertebrate pests. Rating scale: E = excellent; G = good; F = fair; P = poor; ? = research needed; NU = not used; * = used, but not a stand alone tool.

Pest Management Tools	Christmas Tree Vertebrate Pests																			
	Birds	Bears	White-tailed deer	Groundhogs	Mice (field, deer and white-footed)	Moles	Rabbits	Meadow voles (meadow mice)	Pine voles (orchard rats)											
Cultural/Nonchemical Pest Management Practices																				
Ground cover management to avoid providing habitat for pests	P	P	F	P	?	?	P	?	?											
Traps to capture pests	P	F	NU	G	F	F	F	F	F											
Fencing to exclude pests	P	P	G/?	P	P	P	G	P	P											
Providing alternative food sources for pests to discourage their feeding on trees	P	P	?	P	P	P	P	P	P											
Repelling pests through use of putrescent chemical repellents	G	?	G	P	P	P	G	?	?											
Repelling pests through use of bitter chemical repellents	P	P	P	P	P	P	P	?	?											
Repelling pests through use of carnivore scent repellents	P	P	F	F	F	F	F	?	?											

Table 4c (continued). Efficacy ratings for various pest management tools against Christmas tree vertebrate pests. Rating scale: E = excellent; G = good; F = fair; P = poor; ? = research needed; NU = not used; * = used, but not a stand alone tool.

Pest Management Tools	Christmas Tree Vertebrate Pests																			
	Birds	Bears	White-tailed deer	Groundhogs	Mice (field, deer and white-footed)	Moles	Rabbits	Meadow voles (meadow mice)	Pine voles (orchard rats)											
Cultural/Nonchemical Pest Management Practices																				
Repelling pests through use of hair, garlic, soap, etc.	P	P	P	P	P	P	P	?	?											
Legal hunting	P	E	F	G	P	P	F	P	P											

Table 4d. Efficacy ratings for various pest management tools against Christmas tree vertebrate pests. Rating scale: E = excellent; G = good; F = fair; P = poor; ? = research needed; NU = not used; * = used, but not a stand alone tool.

Pest Management Tools	Christmas Tree Vertebrate Pests																			
	Birds	Bears	White-tailed deer	Groundhogs	Mice (field, deer and white-footed)	Moles	Rabbits	Meadow voles (meadow mice)	Pine voles (orchard rats)											
Biological Controls																				