Pest Management for the Future

A Strategic Plan
for the
Michigan Christmas Tree Industry

Workshop Summary
October 11-12, 2001
Michigan State University
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About the Workshop

Growers, university specialists, agency, industry and technical representatives met in East Lansing, Michigan for one and a half days to review, determine and summarize the critical needs of Michigan's Christmas tree industry. The group looked at the efficacy of current pest management tools and practices along with the feasibility of any identified alternatives. The entire group reviewed insects, fungal, weed and vertebrate pest management in Christmas trees. Then top critical research, regulatory and educational needs were determined.

Christmas Tree Pest Management Strategic Plan
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MICHIGAN CHRISTMAS TREE INDUSTRY PRIORITIES

g **Research:**

1. Identify effective reduced-risk herbicides and develop weed control methods, options and recommendations.
2. Assess viable alternatives for chlorothalonil (Bravo) and chlorpyrifos (Lorsban 4E).
3. Improve existing spray technology and develop equipment needed to enhance coverage and efficiency of pesticide applications while minimizing risk of phyto-toxicity.
4. Develop disease and insect management strategies:
   - Determine action thresholds for specific pests;
   - Evaluate methods to conserve or enhance natural enemies of insect pests;
   - Refine crop modeling and predictors for pathogens;
   - Evaluate potential resistance of tree species, varieties or genotypes for common insect and pathogen pests;
   - Identify efficient, economically viable cultural management methods to reduce pest incidence or density.

g **Regulatory:**

Pesticide Labels:

• Develop consistent, uniform definition of site designations that are acceptable for application of pesticide products on Christmas trees. Currently, interpretations of acceptable sites vary depending on ultimate use of trees, rather than tree species. For example; a spruce should be treated as a spruce throughout its rotation, because it could eventually become an ornamental tree or a Christmas tree. Similarly, data collected in product evaluations conducted on spruce ornamental trees should be applicable to spruce Christmas trees.

• Label Sureguard (flumioxazin) for Christmas tree use.

• Many of the insecticide and fungicide products currently used in Christmas tree production are under FQPA review . These products need to remain available for use on Christmas trees until safe, cost-effective alternatives become available.

Quarantines:

• Establish balsam woolly adelgid quarantine for nursery stock, seedlings, Christmas trees and other firs originating in states and provinces with known populations of this exotic pest.

• More stringent control over nursery stock is needed to ensure that seedlings remain phytophthora free.

• Maintain existing federal pine shoot beetle quarantine and compliance program.

• Revisit federal and state gypsy moth regulations, particularly the mandatory insecticide applications. Consider expanding list of acceptable insecticide products. Alternative methods to meet regulatory concerns (other than mandatory insecticide sprays) should be identified and evaluated.

g Education:

• Educate and provide technical support to growers and consultants as new products, materials and strategies are developed.

• Continue IPM workshops and field demonstrations.

• Update and revise 1995 bulletins with information on pesticides registered for use on Christmas trees.

• Compile efficacy trial data collected in the north central and northeastern regions.

• Educate public officials (EPA, APHIS, MDA, Plant Boards, legislators, other public agencies) about realities of producing Christmas trees, including actual pesticide use rates, worker activities, etc.

Background

Each year American consumers purchase more than 35 million natural Christmas trees. Most of these trees are produced in plantations, and an estimated 50 million trees are planted annually by Christmas tree producers in the United States.

Since the mid-1950's, Michigan has been one of the leading states in Christmas tree production. A favorable climate, variety of soil and growing conditions, varied topography and a relatively centralized location combine to produce conditions suitable for the intensive culture of several conifer species. Although yearly production has declined from the 6 million trees harvested annually in the late 1980's, nearly 4 million trees continue to be harvested annually by some 900 producers located throughout the state. The production and marketing of plantation produced Christmas trees contribute more than $60 million annually to the economy of the state. In addition, Christmas tree foliage is used to produce wreaths, swags, roping, garlands and floral arrangements.

Christmas Tree production is an input and labor-intensive activity. Several management activities are necessary throughout the average 8-year production period. Christmas tree production begins with site selection followed by site preparation that may consist of management of potentially competitive vegetation, tillage, soil testing and pre-plant fertilization, and establishment of a cover crop. This usually takes place in the year before planting and may involve the use of one or more pesticides. Following site preparation seedlings and/or transplants are planted by hand or through the use of a tractor-drawn planting machine that still requires significant hand labor. Over the course of the next 8 years, operations include basal pruning, control of competing vegetation, and management of insect, pathogen and animal pests. Additionally, beginning the third year after planting, shearing or trimming must be completed annually to develop the characteristic shape and density associated with high quality Christmas trees.

Christmas tree producers in Michigan and elsewhere throughout the country typically use several different types of pesticides over the course of a rotation, including insecticides, fungicides, herbicides

and rodenticides. The value and salability of Christmas trees is determined largely by tree appearance. Therefore, any organism that affects foliage quality, tree form or other aspects of tree appearance can substantially reduce the value of trees. In addition, some pests may slow growth of trees, thereby increasing the length of the rotation period. Longer rotations reduce the margin of profit for growers, and require additional inputs of labor and pesticides.

One of the challenges that Christmas tree producers face is the lack of a broad collection of effective pesticides. For most major pests there are only a few registered pesticides that provide effective control. Accordingly, these products are used repeatedly thereby raising the possibility of developing resistance in the target pest as well as increasing dependency by growers on having this product being continually available. Of particular concern is the fact that several of the commonly used pesticides are now targeted for review by FQPA-EPA because of possible concerns related to environmental contamination as well as possible carcinogenic properties. Insecticides in the organophosphate and carbamate groups are especially vulnerable.

INSECTS

Introduction: In 1998, we acquired a substantial amount of data on insecticide use by Christmas tree growers in Michigan. The primary goal of collecting this data was to provide EPA with objective information on the number of sprays and acres sprayed with insecticides, target pests for each major conifer species, the products used and the application equipment. The information we collected is summarized at the end of this document. We have also provided some general comments here about insect pest control. An additional source of information is the Christmas Tree Pest Manual[1], which includes information to help growers identify and manage a wide variety of insect and pathogen pests, along with abiotic problems such as frost or salt damage.

Difficulties of Managing Insect Pests

[1]Christmas Tree Pest Manual, 2nd Edition. 1998. McCullough, D.G., S.A. Katovich, M..E. Ostry and J. Cummings-Carlson. USDA Forest Service and Michigan State University Extension Bulletin E-2676. East Lansing, MI. 143 p.

Pest Identification and Action Thresholds: A diverse complex of insect pests affect Christmas trees, and nearly every part of the tree from the terminal leader to the roots and root collar, can be infested by at least one insect pest. Some insects affect multiple conifer species while others are specialists and affect only one species. Growers must, therefore, be able to identify several insects and assess the potential damage that will be caused by each pest. This can be especially difficult because very few economic or action thresholds have been developed for insects that affect Christmas trees. Like all farmers, Christmas tree growers tend to be risk averse and if reliable thresholds for a particular pest are not available, the tendency of most growers is to apply an insecticide - just in case.

Timing Insecticide Applications: Obtaining effective control of insect pests with insecticide applications can be difficult to achieve in Christmas tree fields because of improper timing. Scale insects, for example, are common pests on several conifer species. Insecticides must be applied when the susceptible stage of the insect is present to control the pest. This can be difficult to scout and monitor effectively and often results in repeated insecticide applications, when a single, well-timed application would provide adequate control. The guidelines and recommendations that are available for many insect pests are broad and overly general because there has not been intensive research on the phenology of individual insect species.

Coverage Affects Efficacy: Obtaining adequate coverage when insecticides are applied can also be problematic. Many Christmas tree insect pests such as mites, aphids, adelgids and scales, are very small or are found under the bark, within buds, or other protected locations. Spray equipment used by Christmas tree growers is frequently incapable of delivering an adequate amount of the product to the portions of the tree inhabited by the target pest. In addition, the dense foliage of many Christmas tree species can prevent insecticide sprays from reaching the inner foliage, tree branches and stems where common pests such as Zimmerman pine moth or spruce spider mite thrive. If growers do not recognize the problem, this situation can lead to multiple spray applications in attempts to control the pest.

Need for Applied Research: These difficulties are not insurmountable. Research and enhanced technology have the potential to substantially reduce insecticide use by identification of pest-specific economic/action thresholds, improved understanding of the phenology and biology of specific pests, and development of spray equipment designed for Christmas tree fields. We have first-hand experience to show that cultural controls can be developed that are economically effective in reducing

some insect pest problems. In addition, Christmas tree fields are relatively stable ecosystems with high structural diversity when compared with traditional agriculture systems. There is much untapped potential to implement biological control in Christmas tree production, including conservation of natural enemy populations and augmentation directed at specific pests. The long-term impacts of FQPA implementation, including reduced availability of OP and carbamate insecticide products, will be much less problematic if funding is provided specifically to develop viable, alternative methods to manage insect pests of Christmas trees and other minor-use commodities.

Regulatory Pests and Mandatory Insecticide Applications

One relatively unique aspect of large scale Christmas tree production for wholesale markets is the impact of regulatory pests. In Michigan, Christmas tree growers who ship trees out of the state must currently deal with federal and parallel state quarantines for gypsy moth and pine shoot beetle. Neither of these pests cause economic or even noticeable damage in managed Christmas tree fields. Their importance lies in the fact that they are exotic and not yet distributed throughout the country.

The gypsy moth situation is particularly problematic. Trees must be inspected by state regulatory officials just before harvest and certified to be free of gypsy moth before they can be shipped. Trees will be inspected only if growers apply at least one insecticide spray during the gypsy moth larval development period. The product applied must be one of the products that has been approved by state and federal regulatory agencies for this treatment. The majority of the products currently approved for this treatment are either OP or carbamate insecticides. It is noteworthy that this insecticide treatment must be applied regardless of the actual gypsy moth population in the area. Trees that do not pass the inspection process cannot be sold outside the area under the gypsy moth quarantine. If trees are inspected and certified, then found to contain egg masses, growers may still face stiff fines or penalties.

The net effect of these regulations has been to substantially increase the amount of insecticide used in the largest Christmas tree fields. In addition, spraying trees with an insecticide in early summer is likely to harm populations of natural enemies. Subsequent problems with secondary pests such as spruce spider mites, scales and aphids, appear to be increasing in frequency and severity since the advent of mandatory spray regulations.

The pine shoot beetle situation is somewhat better in that the regulations apply only to pines. In addition, the Pine Shoot Beetle Compliance Program involves a field-tested, integrated management

program that relies primarily on cultural controls such as trap logs and destruction of brood material. It does, however, mandate one insecticide application, even if pine shoot beetle populations are low or undetectable within the field.

It is frustrating and hypocritical to encourage growers to implement IPM programs or to develop methods to enhance biological control of insect pests, when regulatory agencies require mandatory applications of broad spectrum insecticides. Alternative methods of minimizing the risk of transporting exotic pests on cut Christmas trees need to be developed and evaluated. The risk associated with cut trees, relative to other pathways of exotic pest introduction, should be assessed. The regulatory community, at both the federal and state levels, should be invited to participate in efforts to reduce reliance on pesticides.

DISEASES

Diseases of concern to the Christmas tree industry are primarily caused by fungal pathogens and water molds. Most of the diseases of Christmas tree are caused by spore-forming fungi. To infect plant parts, spores require high humidity and wet leaf surfaces which are common in both the spring and fall in the Great Lakes. Because there are several different species of conifers grown for the Michigan Christmas tree industry there are many diseases that the growers must attempt to manage. There are different ways to catagorize these diseases, but tissue-type or part of the tree subject to infection is generally the most common method used and as such can be broken down into the diseases of needles, diseases of shoots and branches, and diseases of roots and lower stem. It should be remembered that this not the most scientific means to discuss diseases of Christmas trees, but one of convenience.

Needle diseases can occur in one or more tree species throughout the growing season. Needle disease management is important for three basic reasons; first, needles provide the tree with photo-synthetic energy for growth and vigor; second, other than shape; needle color and density are primary characteristics in consumer decisions for purchases; and third, diseased needles will cast (fall off) prematurely reducing needle retention and thus marketability of the product. Severe needlecast problems occur with Douglas fir (Rhabdocline and Swiss needlecast), Scotch and red pine (Lophodermium needlecast and needle rust), Austrian pine (Dothistroma needle blight), spruce

(Rhizosphaera needlecast) and true firs (needle rust). The fungi that cause these diseases are not related and represent different taxonomic groups (ascomycetes and basidiomycetes).

Diseases of shoots and branches are caused by several different fungal pathogens infecting all species of conifers grown by Christmas tree producers in Michigan. Some of these diseases will kill trees or reduce quality to the point that the trees are unmarketable. For example, pine gall rust on Scotch pine will not only slow the growth of trees, it will kill branches and ultimately kill trees. Leucostoma canker of spruce, Scleroderris canker, and white pine blister rust are all diseases of Christmas trees that can infect and girdle several species of conifer grown for Christmas trees. In addition, Sphaeropsis tip and shoot blight, commonly associated with pine, is also isolated on spruce in Michigan. This disease will cause shoot death and stems cankers, and it also causes the death of nursery plants.

Diseases of roots and lower stem are less common but just as devastating. Phytophthora root rot of Fraser and less commonly Douglas fir, is caused by several species of the water mold, *Phytophthora*. Found in both nursery beds and plantations, this disease limits the sites on which Fraser fir can be grown thereby limiting the amount of fir that can be produced in Michigan. Armillaria root rot is caused by a fungal pathogen that can infect all known conifers (and hardwood tree species) used in the Christmas tree industry. In most cases, the fungus is native to the soils in which Christmas trees are planted.

Finally, there are known diseases of conifers in other states that have not been found in Michigan or in the Lower Peninsula. For example, brown spot needlecast of Scotch pine is found in the Great Lakes north-central United States, but has not been found in the Lower Peninsula. Lirula needlecast is also absent from Michigan true firs. These examples and others, along with unknown diseases that are bound to show up from time to time offer Christmas tree diagnostics many challenges in the future.

Standard and specialized cultivation practices, planting less susceptible varieties, removing older infected trees and avoiding infested fields are common practices for most Christmas tree producers. When these efforts fall short, chemical intervention is warranted when economically practical and environmentally sound. However, research efforts must be continuously focused on reducing chemical input and on improving non-chemical management schemes as it is well known that diseased trees become more susceptible to other diseases and insects.

WEEDS

Christmas tree production has developed into an intensively managed agricultural crop. Consumer demands and production costs necessitate that growers maximize the production of high quality trees in as few years as possible. Management includes the effective use of herbicides that will contribute to increased survival, more rapid annual growth, less needlecast disease problems, and generally improved foliage and tree quality. When properly used, herbicides provide benefits not only during initial establishment and growth of the tree but also through the rotation when annual shearing and eventual harvest of the trees is completed. Major weed problems include various perennial and annual grasses (quackgrass, foxtail, fall panicum, etc), annual and perennial broad-leaved weeds (hoary alyssum, ragweed, milkweed, red root pigweed, lambsquarter, velvetleaf, spotted knapweed, Canada thistle, marestail, etc.).

VERTEBRATE

Christmas trees can be weakened, killed or tree quality decreased by feeding from deer, rabbits and voles. Heavy snow cover and hard winters cause damage to be more severe with all of these pests.

Deer will eat branches and buds, and bucks will rub the trees in the fall. Grazing by deer has been known to destroy whole fields of seedling trees. In areas where they have large deer numbers growers have resorted to installing 8-10 foot tall woven wire deer fencing. This can cost a grower over $15,000 to fence a 40 acre parcel.

Voles and rabbits feed on the bark of the trunk or on lower branches, weakening trees or in many cases completely girding the tree. Most of the damage occurs during winter months and will increase when you have grass and weed problems. Voles also have been found to chew the plastic piping of trickle irrigation systems causing holes and expense to the grower to find and repair this damage.

Outline of Plan

The remainder of this document is a pest by pest analysis of the current role of organophosphates (OP's), carbamates and pesticides classified a B2 carcinogens, the use of other pest management tools that offer some control but are not "stand alone" tools, pipeline pest management tools and a "To Do" list for research, regulatory and education needs. Depending on the tree species and weather, there can be over 70 insects, diseases along with weeds and/or vertebrate that can affect the quality of a Christmas tree each year. Therefore, we selected only major pests that are common and/or cause substantial damage to trees. These are presented by taxa and in alphabetical order.

g Fungal Pathogens

1. Gall Rust (*Cronartium quercuum*) on Scotch pine is the number one problem reducing the number of trees harvested by 40% over the rotation. Rust infections on stems slowly grow and will gradually kill branches and older trees. Growers no longer spray for this disease because of the poor control and high cost of fungicide materials.

B1 and B2 Potential Carcinogens currently registered:

• Chlorothalonil (Bravo, Daconil)

- Has not been shown to be effective

• Mancozeb (Dithane, Fore, Mancozeb)

- Unknown

Other fungicides currently registered:

• Triadimefon (Bayleton)

- Control is variable

Other pest management aids:

• Remove heavily galled trees before May 1

Pipeline pest management tools:

• None identified

"To do" list for :

Research needs:

• Identify and evaluate alternative fungicides.

• Identify other possible control options.

Regulatory needs:

• Monitor nursery stock entering the state.

Education needs:

• Educate growers on disease symptoms, identification and updated recommendations.

2. **Other Rusts**: For all these rusts it is very hard to determine when an outbreak will occur and to find the alternate host. In most years this is a minor problem and does not affect the tree's quality. However in some years these have caused extensive damage and make the trees unfit for sale.

• **Coleosporium spp. Pine Needle Rusts -** 80 described species, many are morphologically indistinguishable.

Host: Pine

Alternative hosts**:** Often weedy composite species

• **Chrysomyxa Rusts of Spruce -** infected trees will lose 25 to 75 percent of their new needles, leaving trees unfit for Christmas tree sale.

Host: Picea (spruce)

Alternative hosts: Ericaceae (Heath family)

• **Pucciniastrum Rusts**

- **Fir - fireweed** ***Pucciniastrum epilobii*** (yellow spores)

Hosts: Alpine, **balsam**, grand, noble, pacific silver, **white (concolor)** and **Fraser** firs.

Alternative host: Fireweed

- **Fir-Blueberry** ***Pucciniastrum goppertianum***

Hosts: Alpine, **balsam**, grand, noble, pacific silver, **white (concolor)** and **Fraser** firs.

Alternative Hosts: Bilberry, blueberry, cranberry, huckleberry

• **Uredinopsis and Meilesina spp. Rusts** - For diagnostic purposes, these fall into two groups, those with white aeciospores and those with yellow aeciospores. The white-spore rusts cannot be differentiated in their aecial states on fir.

- **White spore:** Ten species of Uredinopsis and four of Milesina, each are able to infect several species of fir, including balsam and white.
- Alternative hosts: Fern, various species for various species of rusts. (A specific rust listed in the references for white fir and balsam fir; *Uredinopsis pteridis*, alternative host is bracken fern.)

B1 and B2 Potential Carcinogens currently registered:

• None

Other fungicides currently registered:

• None

Other pest management aids:

•Remove alternative hosts species

Pipeline pest management tools:

• None identified

"To do" list for :

Research needs:

• Models to predict outbreak years

• Refers to all rusts above - identification of alternate hosts

• Use of Actigard

Regulatory needs:

• None identified

Education needs:

• Educate growers on disease identification, symptoms, identification of alternative hosts and updated recommendations.

3. Leptographium Root Rot (*Leptographium procera)* causes girdling basal cankers, wilt and eventual death of white pine. We are beginning to see more of this throughout the state.

B1 and B2 Potential Carcinogens currently registered:

• None

Other fungicides currently registered:

• None

Other pest management aids:

• Unknown at this time

Pipeline pest management tools:

• None identified

"To do" list for :

Research needs:

• Determine how large of a problem this is in the state

• Identify how this pathogen is entering the tree and causing tree mortality

• Determine other pathogens that may be involved

• Evaluate possible fungicides for control

• Develop recommendations for control

Regulatory needs:

• Possible regulation of nursery stock

Education needs:

• Educate growers on disease symptoms and identification

4. Lophodermium Needlecast (*Lophodermium seditiosum*)

- Occurs every year, severity varies as a function of weather and among varieties

- Exclusive to Scotch Pine, Spanish variety highly susceptible

- Late summer/early fall infection (wet weather) and shows up following spring

- Found throughout the state

- Needles fall in spring on second year and older foliage, whole tree turns brown

- New growth looks good but inner foliage gone, depending on severity

- Controls are preventative

B1 and B2 Potential Carcinogens currently registered:

• Chlorothalonil (Bravo, Daconil,)

- Growers have experienced fair to poor control
- Expensive

• Mancozeb (Dithane, Fore, Mancozeb)
- Excellent control when it is used in combination with Bayleton
- Needs to be sprayed every 2-3 weeks depending on rainfall at the end of summer/early fall
- Inexpensive

Other fungicides currently registered:

• Azoxystrobin (Quadris)
- Effectiveness is unknown
- Too expensive to use on Scotch Pine

• Triadimefon (Bayleton)
- Control is good to excellent at high rate
- Better if used with Dithane or Maneb
- Some injury has been observed
- Does have some back action

Other pest management aids:

• Poor weed control restricts air flow, traps moisture and can cause more disease problems. Control weeds either chemically and/or mechanically

• Choose less susceptible varieties of Scotch Pine. Highly susceptible species include short needled varieties such as: Spanish, Turkish or French

• Bare ground which reflects heat back into trees with Scotch pine

• Scouting and monitoring

Pipeline pest management tools:

• None identified

"To do" list for :

Research needs:

• Evaluate Folicur and Quadris efficacy and application

• Improve spray application techniques and coverage

• Investigate the use of Actigard to enhance plant resistance

Regulatory needs:

• Regulate the removal of abandoned plantations

Education needs:

• Educate growers on disease symptoms and identification

• Update fungicide recommendations

5. Phytophthora Root Rot (*Phytophthora spp.*)

- Kills Fraser fir
- Unknown response by other fir
- Phytophthora species responsible unknown in Michigan and potentially 4 different species
- Found on nursery stock and kills nursery material as well as 10 year old trees
- Very environmentally sensitive, wet and poorly drained soils show more than well drained soils
- Shows up more commonly as growers push limits on Fraser fir plantations
- Occurs every year in poorly drained soils
- Could be irrigation related - pond water irrigation vs. well water irrigation
- Possible movement of pathogen from nursery to plantations

B1 and B2 Potential Carcinogens currently registered:

• None

Other fungicides currently registered:

• Fosetyl-AL (Aliette WDG)

- Good results in nurseries beds, but long term plantations unknown and not expected to be good
- Soil drench, dip nursery stock
- Costly to use in field conditions

• Metalaxyl (Subdue)

- Good to excellent in nurseries
- Short term efficacy due to short period of time to get to roots

- Not used commonly due to expense
- Material of choice if disease is a problem

Other pest management aids:

• Avoid contaminated nursery stock

• ELISA - laborious and indicator only

• Plant on well drained soils

Pipeline pest management tools:

• None identified

"To do" list for :

Research needs:

• Determine species in Michigan

• Develop testing method for Phytophthora that is easy, quick and inexpensive

• Evaluate Mychorrizae inoculation

• Work with nurseries to introduce fungicides to control it

Regulatory needs:

• Nursery screening

Education needs:

• Educate growers on disease symptoms and identification

• Update fungicide recommendations

• Educate growers and company representatives once a method is developed for quick field identification

6. Sphaeropsis shoot blight and canker (*Sphaeropsis sapinea*)

- Formally known as Diplodia Tip Blight
- Periodically serious on Scotch pine, Austrian pine, Douglas fir and Spruce (nursery)
- Can be transferred through nursery stock
- Timing of fungicide application is critical
- Will kill nursery stock, will reduce growth of larger trees
- Austrian pine planted along highways are abundant sources of inoculant

B1 and B2 Potential Carcinogens currently registered:

• Mancozeb (Dithane, Fore,)

- Effectiveness is unknown

Other fungicides currently registered:

• Benomyl (Benlate)

- This has been the standard treatment

- Dupont will no longer be producing this product

• Propiconazole (Banner MAXX)

- Not used

• Thiophanate-methyl (Clearys 3336, Fungo Flo)

- Research in other states and Canada show this can be an effective alternative to Benlate

Other pest management aids:

• Destroy cones, old Scotch pine windbreaks or plantations

Pipeline pest management tools:

• None identified

"To do" list for :

Research needs:

• Evaluate new era materials such as Actigard

Regulatory needs:

• Watch for nursery beds planted along infected wind breaks

Education needs:

• Educate growers on disease symptoms and identification

• Update fungicide recommendations

7. Swiss Needlecast (*Phaeocyptopus gaumanni*) is a major problem on Douglas-fir through out Michigan. Infection causes needles to discolor and fall off the next year in May/June. We do see some difference by variety in susceptibility due to bud break. Infection is environmentally sensitive and dependent on rainfall during bud elongation. Trees with infected needles will also exhibit poor needle retention when cut for Christmas trees. Spray coverage is critical and is not corrective but preventative.

We see less susceptibility to Swiss needlecast with Pacific Coastal varieties which don't survive in Michigan.

B1 and B2 Potential Carcinogens currently registered:

• Chlorothalonil (Bravo, Daconil)

- This is the standard treatment, provides good to excellent control
- Timing and spray coverage are critical for effective control
- Have to spray, can't take a chance
- Occasional phyto-toxicity problems can occur
- Expensive but cost effective
- Typically spray twice, in very wet springs may need three sprays

• Mancozeb (Dithane, Fore, Mancozeb)

- Effectiveness of control is variable
- To get excellent control you have to spray more often, every two weeks minimum
- Poor control observed where disease pressure is high

Other fungicides currently registered:

• Benomyl (Benlate)

- Not typically used
- No longer being produced by Dupont

• Azoxystrobin (Quadris)

- New registration and has not been used
- Expensive

Other pest management aids:

• Good weed control helps reduce disease pressure due to moisture retention and restricttion of air movement.

• Remove older trees that may be a disease source

• Do not plant in wet or shaded areas

• May not need to spray in first 3-4 years typically

• Scouting and monitoring

• Good air movement through plantation

Pipeline pest management tools:

• None identified

"To do" list for :

Research needs:

• Evaluate resistance to Bravo

• Determine and evaluate replacements for Bravo

• Predictive models for disease development

• Plant growth regulators to delay bud break

• Systemic induced resistance (Actigard)

• Develop resistant varieties

Regulatory needs:

• Maintain Bravo until replacement can be found

• Remove abandoned plantations

Education needs:

• Educate growers on disease symptoms, identification and proper timing of fungicide applications

• Update fungicide recommendations

8. Rhabdocline Needlecast (*Rhabdocline pseudotsuga*) is a major problem in plantations close to Lake Michigan and on high elevations in other locations in Michigan. It is often found in conjunction with Swiss needlecast. We do see some difference by variety in susceptibility due to bud break. Infection is environmentally sensitive and dependent on rainfall during bud elongation.
In years with high disease pressure and infection will cause early needle loss and make the tree unsalable. Also, trees with infected needles will exhibit poor needle retention when cut for Christmas trees.

B1 and B2 Potential Carcinogens currently registered:

• Chlorothalonil (Bravo, Daconil)

- This is the standard treatment, provides good to excellent control
- Timing and spray coverage are critical for effective control
- Have to spray, can't take a chance

- Occasional phyto-toxicity problems can occur
- Expensive but cost effective
- typically spray twice to three times, in very wet springs may need more

Other fungicides currently registered:

• Benomyl (Benlate)
- Not used much
- Dupont is no longer producing this chemical

Other pest management aids:

• Good weed control helps reduce disease pressure due to moisture retention and restriction of air movement

• Remove older trees that may be a disease source

• Not planting in wet or shaded areas

• May not need to spray in first 3-4 years typically

• Scouting and monitoring

• Good air movement through plantation

Pipeline pest management tools:

• None identified

"To do" list for :

Research needs:

• Evaluate possible resistance to Bravo

• Determine and evaluate replacements for Bravo

• Predictive models for disease development

• Plant growth regulators to delay bud break

• Systemic induced resistance (Actigard)

• Develop resistant varieties

Regulatory needs:

• Maintain Bravo until replacement can be found

• Remove abandoned plantations

Education needs:

• Educate growers on disease symptoms, identification and proper timing of fungicide applications

• Update fungicide recommendations

9. Rhizosphaera Needlecast (*Rhizosphaera kalkhoffii*) is a major wide spread disease problem of spruce. It can occur every year. Rainy conditions during bud elongation favor disease development especially when air movement is reduced and older trees are nearby. This mainly affects second year and older foliage at the bottom of the tree.

B1 and B2 Potential Carcinogens currently registered:

• Chlorothalonil (Bravo, Daconil, Thalonil)

- This is the standard treatment and it can provide excellent control
- Costly, use a higher rate on Spruce than Douglas fir
- May need more than one application
- Bravo has multiple sites of action

Other fungicides currently registered:

• None

Other pest management aids:

• Good weed control helps reduce disease pressure due to moisture retention and restriction of air movement

• Remove older trees that may be a disease source

• Do not plant in wet or shaded areas

• Scouting and monitoring

• Good weed management improves air movement through the plantation

Pipeline pest management tools:

• Actigard

• BAS 500

"To do" list for :

Research needs:

• Evaluate possible resistance to Bravo

• Determine and evaluate replacements for Bravo

• Predictive models for disease development

• Systemic induced resistance (Actigard)

Regulatory needs:

• Maintain Bravo until replacement can be found

• Remove abandoned plantations

Education needs:

• Educate growers on disease symptoms, identification and proper timing of fungicide applications

• Update fungicide recommendations

g **Insects**

1. Balsam Twig Aphid (*Mindarus abientinus*) - Major pest of true firs including balsam, Fraser, concolor and other varieties. Significance will increase over next 10-20 years due to increase in acreage of fir species and increased use of nitrogen fertilizers (which typically increases aphid fecundity). Present annually and can affect trees of all ages. Heavy feeding reduces tree appearance, value and growth rate. Effective control is dependent on proper timing and coverage. Appropriate timing of sprays can be problematic because spray must be applied well before damage becomes apparent.

Organophosphate insecticides currently registered:

•Acephate (Orthene 75 SP, Orthene 97)

- Efficacy likely good but seldom used

- Short residual so timing is important

• Chlorpyrifos (Lorsban 4EC)

- Highly used, efficacy is excellent

- Has longer residual than Acephate; single application effective if timing and coverage are appropriate

- Relatively inexpensive

• Diazinon (Diazinon 50WP, 4E)

- Seldom used
- Efficacy not evaluated by likely good
- May be removed from market

• Dimethoate (Cygon)
- Not used

• Disulfoton (Di-syston 15% G)
- Efficacy probably good to excellent
- Widely used in North Carolina; not widely used in MI
- Cost prohibitive
- Exposure problem, worker protection issues, non-target effects of concern

• Malathion (Malathion 57)
- Seldom used
- Short residual so timing is important

• Oxydemeton-methyl (Metasystox-R)
- Efficacy good to excellent; some systemic properties
- Negative impacts on natural enemies and other beneficial insects

Carbamate insecticides currently registered:

• Carbaryl (Sevin XLR)
- Efficacy good; commonly used
- Impacts on non-target species including predatory mites and honey bees of concern

Other insecticides currently registered:

• Bifenthrin (Talstar 20 WP, F)
- Efficacy very good to excellent
- Persistent; potential effects on natural enemies and beneficial insects a concern
- Relatively expensive
- SLN label for Michigan
- Some use by growers

• Esfenvalerate (Asana XL)
- Rarely used

- Potential effects on natural enemies and beneficial insects a concern

• Imidacloprid (Provado 1.6F)

- Efficacy excellent
- Relatively few impacts on natural enemies and beneficial insects
- Use limited by relatively high cost
- Reports from other states suggest use can lead to increased spruce spider mite densities but not observed in Michigan

• Insecticidal Soap (M-Pede)

- Not commonly used
- Adequate coverage difficult to achieve given mobility of aphids

• Permethrin (Pounce 3.2EC)

- Not commonly used
- Potential effects on natural enemies and beneficial insects a concern

Other pest management aids:

• Insect predation by ladybird beetles, syrphid fly larvae and lacewings can be substantial

• Research in progress to identify economic threshold, degree day recommendations for insecticide applications, and efficacy of natural enemies and augmentative biological control using lacewing larvae.

Pipeline pest management tools:

None identified

"To do" list for :

Research needs:

• Screen fir species, varieties and genotypes for bud break phenology; relatively late bud break functions as a mechanism of host plant resistance and appears to be genetically based

• Continue to evaluate use of augmentative bio-control and methods to conserve or enhance populations of insect predators

• Refine action thresholds for wholesale and choose-and-cut production fields

• Develop alternative methods to meet gypsy moth quarantine requirements that do not require insecticide application; such applications are detrimental to predator populations

• Modify or refine application equipment to ensure good coverage

• Evaluate interactions between spruce spider mite damage and insecticides applied for balsam twig aphid control or gypsy moth regulations

• Evaluate potential influence of nitrogen fertilizer on aphid survival, development and fecundity

Regulatory needs:

• Regulations for state and federal gypsy moth quarantine substantially increases insecticide application, resulting in loss of beneficial insect predators (and predatory mites)

• Expedited review of pipeline products

Education needs:

• Educate growers about scouting and monitoring methods, action thresholds, optimal timing of insecticide sprays and recognition of natural enemies

• Educate pesticide dealers, as well as growers, on relevant aspects of action thresholds, timing, etc

• Educate state and federal regulatory officials about impacts of mandatory gypsy moth spray requirements on predatory insects and mites, which likely contributes to sustained balsam twig aphid problems

2. Balsam Woolly Adelgid *(Adelges piceae)* Not currently known to be established in Michigan. In other states, however, it disfigures, reduces growth and kills fir trees. Fraser and balsam fir are two of the most vulnerable fir species. Could be highly damaging to Christmas tree industry as well as native balsam fir stands if it becomes established. Risk of accidental introduction via importation of infested fir seedlings, nursery stock, B&B trees, etc. from other states is a concern.

Organophosphate insecticides currently registered:

• Disulfoton (Di-syston 15% G)

- Efficacy good to excellent in southern states; not used in Michigan
- Relatively high toxicity, applied by hand, significant concerns about human safety and worker protection
- Non-target effects on birds, beneficial insects and other organisms are concern

Carbamate insecticides currently registered:

- None

Other insecticides currently registered:

• Esfenvalerate (Asana XL)

- No efficacy data

• Cyfluthrin (Baythroid)

- No efficacy data

- Not used in southeastern states where topography increases risk of run-off

Other pest management aids:

• No experience here in Michigan

• North Carolina suggests removing all ornamentals (host plants) close to plantations, but this is not likely to be practical or feasible and efficacy not demonstrated

Pipeline pest management tools:

• None identified

"To do" list for:

Research needs:

• Identify potential pathways for introduction into Michigan

Regulatory needs:

• Establish and implement quarantine on fir imports from all states and provinces with known Balsam Wooly Adelgid populations

• Increased inspection of nursery, Christmas trees and other firs brought into the state, including tree lots

Education needs:

• Improve ability of regulatory officials to recognize balsam woolly adelgid life stages and damage, and potential impacts

• Develop fact sheet and related materials to increase awareness among retailers (tree lots), growers, and tourists about the possibility of balsam woolly adelgid introduction and spread

3. Cooley Spruce Gall Adelgid (*Adelges cooleyi*) Common pest of blue spruce and Douglas-fir; occurs annually and can affect trees of all ages. On spruce, feeding by nymphs in spring causes large

persistent galls to form on the distal tip of new shoots. Galls reduce the appearance and value of spruce trees, and can affect tree growth if densities are high. On Douglas-fir, nymphs do not cause galls to form, but feeding discolors and distorts needles. Adelgids can complete their life cycle on either host. Timing is an issue, especially for Douglas-fir. Coverage can be problematic on both species.

Organophosphate insecticides currently registered:

• Chlorpyrifos (Lorsban 4 E.C.)
  - Broad spectrum
  - Blue spruce will be removed from the label because of occasional phyto-toxicity when applied at relatively cool or warm temperatures or during droughty conditions. Control good to excellent on Douglas-fir
  - Relatively inexpensive
• Endosulfan (Thiodan)
  - Used widely is some regions in past years; not commonly used currently
  - Control on Douglas-fir poor, possibly due to development of resistant adelgid populations
• Oxydemeton-methyl (Metasystox-R)
  - Efficacy good to excellent; some systemic properties
  - Negative impacts on natural enemies and other beneficial insects
  - Relatively inexpensive

Carbamate insecticides currently registered:

• Carbaryl (Sevin XLR Plus)
  - Excellent on spruce, not widely used on Douglas-fir
  - Impacts on non-target species including predatory mites and honey bees of concern
  - Relatively inexpensive

Other insecticides currently registered:

• Cyfluthrin (Baythroid 2)
  - Efficacy good to excellent
  - Negative impacts on natural enemies and other beneficial insects
• Imidacloprid (Provado 1.6F)

- Efficacy good to excellent
- Relatively few impacts on beneficial insects and predators
- Not approved by state and federal regulatory agencies for gypsy moth treatment
- Relatively expensive

• Insecticidal Soap (M-Pede)
- Dependent on excellent coverage, control will be variable
- Rarely used, not readily available

Other pest management aids:

• On Colorado blue spruce, green galls can be removed and destroyed before they open in summer, but this is labor intensive and unlikely to be feasible if more than a few trees are affected

• Cut and chip or burn heavily infected trees, if only a few trees are affected

• Horticultural oil may be effective, but can affect foliar color on spruce

Pipeline pest management tools:

• None identified

"To do" list for:

Research needs:

• Evaluate potential resistance of Colorado blue spruce and Douglas-fir provenances and genotypes

• Improve application technology to enhance coverage

• Improve scouting techniques and degree day information to enhance timing of sprays

• Few natural enemies are known to prey on this adelgid; research is needed to assess mortality sources including natural enemies and weather-related factors

Regulatory needs:

• Widely distributed, native insect but nursery trees are still subject to regulations imposed by Michigan Dept. of Agriculture; development of tolerance levels needed for nursery and B&B trees

Education needs:

• Work with growers on scouting techniques and application methods to improve timing and coverage of pesticide applications

4. Eastern Spruce Gall Adelgid (*Adelges abietis*)- this adelgid is primarily a pest of white and Norway spruce. Feeding by nymphs causes galls to form at the base of current-year shoots. Galls turn brown in summer, reducing tree appearance and value and affecting shoot growth at high densities.

Organophosphate insecticides currently registered:

• Chlorpyrifos (Lorsban 4 EC)

- Efficacy good to excellent
- Widely used
- Relatively inexpensive

• Oxydemeton-methyl (Metasystox-R)

- Efficacy good to excellent, some systemic action
- Negative impacts on natural enemies and other beneficial insects
- Relatively inexpensive

Carbamate insecticides currently registered:

• Carbaryl (Sevin XLR, 80WSP)

- Efficacy good to excellent
- Impacts on non-target species including predatory mites and honey bees of concern
- Relatively inexpensive

Other insecticides currently registered:

• Cyfluthrin (Baythroid 2)

- Efficacy good to excellent
- Negative impacts on natural enemies and other beneficial insects

• Imidacloprid (Provado 1.6F)

- Efficacy good to excellent
- Relatively few impacts on beneficial insects and predators
- Not approved by state and federal regulatory agencies for gypsy moth treatment
- Relatively expensive

• Insecticidal Soap (M-Pede)

- Dependent on excellent coverage, control will be variable

- Rarely used, not readily available

Other pest management aids:

• Galls can be removed and destroyed before they dry and open in the summer. This is rarely an acceptable option, however, because galls form distal to current-year shoots; removing galls would require substantial loss of foliage if adelgid density was high. This option is also labor intensive and not practical if more than a few trees are affected.

• Cut and chip heavily infected trees, if only a few trees are affected. Anecdotal evidence indicates strong genotypic variability in susceptibility.

Pipeline pest management tools:

• None identified

"To do" list for:

Research needs:

• Evaluate provenance, varietal and genotypic vulnerability to this exotic pest; variation in resistance exists but mechanism unknown

• Improve application technology to enhance coverage

• Improve scouting techniques and degree day information to enhance timing of sprays

• Few natural enemies are known to prey on this adelgid; research is needed to assess mortality sources including natural enemies and weather-related factors

Regulatory needs:

• None identified

Education needs:

• Work with growers on scouting and improved timing of pesticide applications

5. Gypsy Moth (*Lymantria dispar*)- Gypsy moth larvae feed on the foliage of many species, but rarely cause noticeable damage to Christmas tree species. This exotic insect is currently regulated by federal and state quarantines and the strict nature of these regulations causes gypsy moth to account for more insecticide sprays than any other insect pest.

Christmas trees must be inspected by the Michigan Department of Agriculture (MDA) a few weeks (or days) preceding harvest. If gypsy moth egg masses or any other life stages are found during inspections,

the field will be restricted and trees cannot be shipped outside of the quarantined area. Growers will also face stiff penalties if egg masses are found by inspectors in receiving states.

Currently, spruce, fir and Douglas-fir destined for areas beyond the known gypsy moth infestation ***must*** be treated with an approved insecticide before they will be inspected and certified by the MDA, regardless of the density of local gypsy moth populations. Regulations stipulate that at least 1-2 sprays must be applied during the larval development period of gypsy moth with an insecticide product that has been approved by APHIS. These products include one insect growth regulator (diflubenzuron), 2 pyrethroid products (cyfluthrin and bifenthrin) and 3 OP or carbamate products (acephate, chlorpyrifos, oxymedton-methyl, phosmet, carbaryl). Growers who ship fir and pine species are also likely to spray their trees, because of fears that egg masses will be found in receiving states.

Organophosphate insecticides currently registered:

• Acephate (Orthene 75S, 97)
- Efficacy is good to excellent
- Short residual
- Relatively inexpensive

• Chlorpyrifos (Lorsban 4E)
- Efficacy is good to excellent; most commonly used product in Michigan
- Relatively inexpensive

• Phosmet (Imidan 70W, 70WPS)
- Efficacy is fair to good
- Not commonly used

Carbamate insecticides currently registered:

• Carbaryl (Sevin XLR, 80 WSP)
- Efficacy is fair to good
- Need to use the XLR formulation for best control, other formulations have short residual and may be less effective

Other insecticides currently registered:

• *Bacillus thuringiensis* var. *kurstaki* (Btk)

- Not acceptable for gypsy moth treatment by regulatory agencies

• Cyfluthrin (Baythroid 2)

- Efficacy good to excellent
- Negative impacts on natural enemies and other beneficial insects

• Diflubenzuron (Dimilin 25W)

- Efficacy good to excellent
- Cannot be used near open water because of impacts on non-target invertebrates
- Long persistence - potential effects on predators and other beneficial insects a concern
- Safe for workers and applicators

• Insecticidal Soap (M-Pede)

- Effectiveness variable, but can be poor
- Not acceptable for gypsy moth treatment by regulatory agencies

• Spinosad (Spintor 2SC)

- Not used in Christmas tree fields because it is not acceptable for gypsy moth treatment by regulatory agencies
- Selective; relatively few impacts on beneficial insects and other non-target species
- Relatively expensive
- Relatively safe for workers; re-entry time is only 4 hours

• Tebufenozide (Mimic 2LV)

- Not used in Christmas tree fields because it is not acceptable for gypsy moth treatment by regulatory agencies
- Selective; relatively few impacts on beneficial insects and other non-target species
- Relatively expensive
- Relatively safe for workers; re-entry time is only 4 hours

Other pest management aids:

• Scouting, monitoring very important not only in the plantation but in surrounding woodlots and fence rows. Consider removal of gypsy moth preferred hosts from plantations.

Pipeline pest management tools:

• None identified

"To do" list for:

Research needs:

• Identify alternative options to current mandatory application of broad spectrum insecticides

Regulatory needs:

• Evaluate additional products for approval by regulatory agencies, including products that are relatively selective and less harmful to workers

• Develop consistent criteria for identification of infested counties; currently Cook County, Illinois is not included in the gypsy moth quarantine despite the presences of well-publicized, high density, established gypsy moth populations. Many Christmas trees from Michigan and the north central region are shipped to Chicago. Insecticide applications could be substantially reduced if a set of uniform criteria for adding new counties to the gypsy moth regulated area were applied consistently.

• Alternative options to the current mandatory insecticide applications are needed. These mandatory sprays are costly for growers. They negatively impact beneficial predators and parasitoids, which leads to additional insecticide application to control other pests.

• A thorough risk analysis of the hazard posed by Christmas trees relative to other sources of gypsy moth introduction (e.g. tourists, new residents, etc.) should be considered by USDA APHIS.

Education needs:

• Work with growers on scouting techniques to detect presence of gypsy moth egg masses in the field and on harvested trees

• Continue to provide information to growers about the status of local gypsy moth populations and appropriate timing of pesticide applications to meet regulations

6. Spruce spider mites (*Oligonychus ununguis*) can degrade the vigor, appearance and value of all species grown for Christmas trees. Feeding causes needle loss and discoloration. Webbing, discolored needles and lost foliage can substantially reduce tree appearance. Multiple years with high density populations can result in mortality of nursery stock and Christmas trees of all ages. Populations typically begin feeding on older needles near the tree stem. Adequate coverage of inner foliage with standard spray equipment can be problematic.

Organophosphate insecticides currently registered:

• Chlorpyrifos (Lorsban 4E)

- Efficacy good to excellent on larval and adult mites

- Repeated applications may be necessary

- May be used with Savey (see below) to control adult mites if trees are to be harvested in current year

- Occasional phyto-toxic to some conifer species;

• Dimethoate (Cygon)

- Not widely used

- Efficacy good to excellent, locally systemic

- Relatively inexpensive

- Impacts on predators and beneficial insects a concern

• Disulfoton (Di-syston 15% G)

- Efficacy variable

- Not used

• Oxydemeton-methyl (Metasystox-R)

- Efficacy variable from fair to excellent

- Impacts on predators and beneficial insects a concern

Carbamate insecticides currently registered:

• None

Other insecticides currently registered:

• Bifenthrin (Talstar 20 WP, F)

- Efficacy good to excellent

- Impacts on predators and beneficial insects a concern

• Hexythiazox (Savey)

- Efficacy excellent

- Controls eggs and immature stages but not adults; sometimes a problem when trees will be harvested within a few months

- Conserves predator mites

- Relatively expensive
- Should not be applied more than once a year to prevent resistance from developing

• Insecticidal Soap (M-Pede)
- Rarely used, efficacy unknown
- Coverage would have to be extremely good - difficult to achieve in Christmas tree production fields

• Propargite (Omite CR, Ornamite)
- Efficacy good to excellent

Other pest management aids:

• Scouting, monitoring to identify low density mite population before damage occurs

Pipeline pest management tools:

• None identified

"To do" list for :

Research needs:

• Identify cultural methods to conserve or enhance predatory mite populations (e.g. cover crops such as white clover)

• Develop better application systems to ensure inner foliage is treated adequately

Regulatory needs:

• Develop alternatives to existing gypsy moth requirements that mandate insecticide applications, leading to loss of predatory mites

Education needs:

• Teach growers how to effectively scout for mite problems, particularly on spruce and firs

• Educate growers about the need to limit insecticide applications and cultural methods to conserve predatory mites

7. Pine Root Collar Weevil (*Hylobius radicis*)- Larval feeding girdles the root collar of pine trees causing trees to break off or die. It is especially common in sandy soils and high hazard zones in northern lower Michigan. The weevils are well protected within the root collar, large roots or soil and litter for most of their life, making control difficult to achieve.

Organophosphate insecticides currently registered:

• Acephate (Orthene 75 SP)

- Efficacy not established but likely poor due to short persistence of product and long period of adult weevil emergence and feeding.
- Labeled for control of adult weevils
- Used as a foliar spray

• Chlorpyrifos (Lorsban 4EC)

- Efficacy can be fair to good as a foliar spray; good to excellent as a root collar treatment
- Relatively inexpensive
- Widely used

• Lindane

- No longer registered; provided excellent control as a root collar drench, but impacts on non-targets (e.g. soil invertebrates) likely severe and long-lasting

Carbamate insecticides currently registered:

• None

Other insecticides currently registered:

• Cyfluthrin (Baythroid)

- Efficacy likely good as a foliar spray, but not evaluated

Other pest management aids:

• Scouting and removal of infested trees important to detect new weevil populations

• Basal pruning creates warm and dry conditions that are unsuitable for weevils, but time and labor-intensive to implement - rarely done in production field

Pipeline pest management tools:

• None identified

"To do" list for :

Research needs:

• Identify degree day phenology of weevils and evaluate products and timing for control of adult weevils via a foliar spray

• Evaluate terpene-baited lures and traps to determine if population density can be reduced by

trapping out strategy

• Evaluate entomopathogenic nematodes for control of adults or larval weevils in soil

• Determine if predators or parasitoids contribute to weevil mortality

Regulatory needs:

• None identified

Education needs:

• Educate growers about cultural control (e.g. basal pruning); high hazard zones within the state

8. Pine Shoot Beetle (*Tomicus piniperda*)- An exotic scolytid that can develop in phloem and feed in shoots of nearly all pine species grown in North America. Shoot-feeding by teneral adult beetles during the summer kills shoots and can reduce tree growth and vigor if populations are high for multiple years. However, pine shoot beetle rarely causes noticeable damage in managed pine Christmas tree fields. It is primarily important to growers because it is regulated by federal and state quarantines that prohibit shipping infested trees outside the area known to have established pine shoot beetle populations.

Organophosphate insecticides currently registered:

• Acephate (Orthene 75 SP)

- Efficacy fair

• Chlorpyrifos (Lorsban 4EC)

- Efficacy is good to excellent

- Commonly used

Carbamate insecticides currently registered:

• None

Other insecticides currently registered:

• Bifenthrin (Talstar 20 WP, F)

- Efficacy good

• Cyfluthrin (Baythroid)

- Efficacy - good to excellent, commonly used;

Other pest management aids:

- A comprehensive, integrated management program for pine shoot beetle was developed and tested in a two-year, replicated pilot study. This IPM program was accepted by USDA APHIS and the National Plant Board and implemented nationally as the Pine Shoot Beetle Compliance Program.
- Primary components of the Compliance Program include: (1) reducing the availability of brood material by chipping or burning cut or dying trees, tree tops or branches and similar material by late spring; (2) cutting stumps nearly flush to the ground; (3) setting freshly cut pine trees or logs (trap logs) along edges of fields in early spring to attract parent beetles, then collecting and chipping or burning the trap logs before the progeny beetles emerge; (4) applying a foliar insecticide spray at the time teneral beetles begin shoot-feeding, and (5) scouting and monitoring trees throughout the summer and fall for evidence of shoot-feeding beetles.

Pipeline pest management tools:

- None identified

"To do" list for:

Research needs:

- Evaluate abundance of clerid beetles and other natural enemies in Christmas tree fields, their impact on PSB populations and methods to conserve or enhance predator populations

Regulatory needs:

- Recent research shows PSB preferentially breed in Scotch pine compared with native pines. Regulatory agencies need to implement programs to encourage removal and destruction of declining Scotch pine trees in abandoned Christmas tree plantations, along roadsides, in hedgerows, etc.
- Sale of Scotch pine seedlings for hedgerow or roadside plantings should be prohibited
- Need for continuing to enforce a PSB quarantine should be re-visited periodically, but federal quarantines should be lifted only if individual states do not impose their own quarantines

Education needs:

- Notify growers of changes in the quarantine areas and regulations and teach them how to access

regulatory information via the internet

- Encourage growers to prevent "cheating" by some growers that could threaten the acceptance of the Compliance Program in the U.S. and Canada
- Educate growers to ensure that they know how to recognize and scout for pine shoot beetle
- Ensure that growers understand the need to continue PSB management to prevent population density from building to damaging levels
- Educate landowners (including state and federal land management agencies) about the need to manage or destroy declining Scotch pine

9. Scale Insects

Pine Needle Scale (*Chionaspis pinifoliae*) This insect weakens pines of all ages by sucking sap from the needles. It sometimes infests spruce and other species. An abundance of white scales on needles affects tree appearance and value. Severely infested trees may have sparse, discolored foliage. There are 2 generations per year.

Pine Tortoise Scale *(Toumeyella parvicornis)* This scale feeds on sap from the phloem of woody shoots and branches of Christmas trees. Feeding scales excrete honeydew and the foliage and branches of infested trees will become coated with black sooty mold. Black sooty mold will cause the trees to be unfit for sale and heavy scale density may cause entire branches to die. There is one generation per year.

Horticultural oil and most insecticides are likely to be effective if applied at the appropriate time (e.g. when crawlers are present) and if coverage is adequate. Pine needle scale must be controlled with horticultural oil or contact insecticides; applications will be effective when applied after eggs have hatched but before nymphs have produced the white armor. Pine tortoise scale can be controlled by applying oil or contact insecticides to control crawlers. Systemic products in phloem (e.g. imidacloprid) will be at least somewhat effective on feeding nymphs and adults. Numerous insect predators and parasitoids attack both species.

Organophosphate insecticides currently registered:

- Acephate (Orthene 75 SP, 97)

- Efficacy probably good
- Not commonly used

• Chlorpyrifos (Lorsban 4EC)
- Efficacy good to excellent
- Widely used
- Relatively inexpensive

• Diazinon (Diazinon 50WP, 4E)
- Efficacy probably good
- Rarely used

• Malathion (Malathion 57)
- Efficacy good if timing appropriate

• Phosmet (Imidan 70, 70 WSB)
- Efficacy usually good

• Oxydemeton-methyl (Metasystox-R)
- Registered for pine needle scale
- Efficacy likely good

Carbamate insecticides currently registered:

• Carbaryl (Sevin)
- Efficacy good

Other insecticides currently registered:

• Horticultural Oil
- Efficacy good to excellent if coverage adequate

• Imidacloprid (Provado)
- Efficacy good to excellent on pine tortoise scale

• Bifenthrin (Talstar 20 WP, F)
- Registered for pine needle scale
- Efficacy likely good

• Cyfluthrin (Baythroid 2)
- Efficacy good to excellent

• Insecticidal Soap (M-Pede)

- Efficacy variable

Other pest management aids:

• Many ladybird beetles and parasitoids prey on pine needle scale and pine tortoise scale. Predator species include specialists, as well as generalists, and can be highly effective in controlling scale populations.

• Heavily infected trees can be removed and destroyed if only a few trees are affected.

Pipeline pest management tools:

• None identified

"To do" list for:

Research needs:

• Increase information about the biology of specialist predators and parasitoids and methods to enhance their populations

• Improve understanding of scale population dynamics and economic threshold levels for both scale species

• Develop thresholds for predation and parasitism of pine needle scale; e.g identify and develop ability to predict whether natural enemies can be expected to control the scale population based on surveys of predation/parasitism rates in the field.

• Refine understanding of pine tortoise scale phenology and develop degree day recommendations when control is needed;

• Improve application equipment to provide uniform application of horticultural oil at effective rates

Regulatory needs:

• None identified

Education needs:

• Educate growers about how to scout or monitor scale populations

• Improve ability of growers to recognize insect predators and evidence of predator or parasitism

• Improve grower's understanding of scale phenology and biology to improve product selection and timing of insecticide applications

10. White Grubs (Coleoptera: Scarabidae)- Scarab beetle larvae feed on root systems of conifer seedlings and young trees. Difficult to control once trees have been planted. Can cause high rates of mortality in fields with recently planted seedlings. Damage especially common when conifers are planted into agricultural fields or other areas where herbaceous vegetation was abundant.

Organophosphate insecticides currently registered:

• Chlorpyrifos (Lorsban 4EC)

- Efficacy fair to good when applied before planting; relatively little worker exposure
- Soil treatment after planting provides variable control; efficacy poor to good
- Approved regulatory treatment (root ball dip) for Japanese beetle control

• Diazinon (Diazinon 50WP, 4E)

- Apparently effective in landscape situations; likely effective in Christmas tree fields but non-target impacts are of concern

Carbamate insecticides currently registered:

• None

Other insecticides currently registered:

• None

Other pest management aids:

• Apply herbicide and disc fields 1-2 years before planting

• Leave fields fallow for 1-2 years before planting; this option, however, is rarely practical

Pipeline pest management tools:

• None identified

"To do" list for:

Research needs:

• Evaluate efficacy of imidacloprid (Provado) and related products; encourage producers to add Christmas tree site to product labels if effective

• Evaluate potential cultural controls including maintenance of grass strips to attract feeding larvae away from conifers or for use as a "trap crop"

Regulatory needs:

• New products need to be registered for this use; encourage and/or provide funding to collect efficacy data and registration process

Education needs:

• Educate growers on recognition and scouting methods

11. White Pine Weevil - Larvae feed on the phloem of the terminal leader of pines and spruce trees. Larval feeding girdles the terminal and typically kills 1 to 3 years of growth. Weevils preferentially attack young, vigorously growing trees in full sunlight, so conditions are ideal in Christmas tree fields. Weevils are vulnerable to insecticides only if encountered immediately after hatching from eggs in spring. Weevil eggs may hatch over several weeks, however, so a persistent product or multiple applications can be required. Insecticides must be applied several weeks before damage becomes apparent. Only the terminal leader requires treatment, but application equipment may result in application of insecticide over much of the upper canopy.

Organophosphate insecticides currently registered:

• Chlorpyrifos (Lorsban 4EC)
- Efficacy good to excellent
- Commonly used
- Relatively inexpensive

•Oxydemeton-methyl (Metasystox-R)
- Efficacy good to excellent; some systemic activity
- Negative impacts on natural enemies and other beneficial insects are a concern if application is not limited to terminal leader
- Relatively inexpensive

Carbamate insecticides currently registered:

• None

Other insecticides currently registered:

• Bifenthrin (Talstar 20 WP, F)
- Efficacy probably good to excellent but not often used

• Cyfluthrin (Baythroid 2)

- Efficacy probably good to excellent but not often used

• Diflubenzuron (Dimilin 25W)

- Efficacy good to excellent
- Persistent, only one application necessary
- Relatively few impacts on beneficial predators or parasitoids
- Less risk for applicator and workers
- Cannot be used near water

Other pest management aids:

• Infested leaders can be cut out and destroyed, then corrective pruning is used to restore apical dominance. These methods, however, are labor intensive and not practical on a large scale.

Pipeline pest management tools:

• None identified

"To do" list for :

Research needs:

• At least 2 predators and a parasitoid attack white pine weevil larvae, but little is known about methods to attract or enhance these populations

• Develop improved methods for scouting in fields with previous white pine weevil infestation, using available information on weevil behavior and flight abilities

• Assess influence of weed control and other cultural practices on white pine weevil survival and density

• Assess spruce species, varieties and genotypes for resin production or other potential mechanisms of host resistance

Regulatory needs:

• None identified

Education needs:

• Educate growers about white pine weevil biology, appropriate times and methods for scouting, and improve grower's ability to recognize white pine weevil;

12. Zimmerman Pine Moth *(Dioryctria zimmermani)*- Larvae feed for several weeks in phloem on

the stem, large branches or sometimes terminal leaders of Scotch and Austrian pine. Feeding sites are commonly at branch whorls and multiple larvae may feed at a given location. Pitch oozes from the feeding site during the feeding period. Accumulations of pitch can remain on trees for years and are unsightly. Branches may be killed or break off at the point of injury. Photosynthates accumulate above feeding sites on tree stems, causing the stem to appear constricted below the feeding tunnel. Such stems often break in high winds or after trees are harvested and placed on needle-shaking equipment. Control is difficult to achieve because larvae are exposed for a short period of time in spring, when wet weather often limits the ability of growers to bring heavy equipment into fields. Insecticides must be applied to the bark of the stem and thoroughly cover bark on large branches. This is difficult to achieve on tightly sheared pine Christmas trees with dense canopies. Research trials in heavily infested fields indicate that even when persistent products are applied properly, roughly 50% control can be expected. Resistance is known to vary among Scotch pine varieties and genotypes, but mechanisms are not known.

Organophosphate insecticides currently registered:

• Chlorpyrifos (Lorsban 4EC)
  - Efficacy potentially good, but depends on timing and coverage
  - Commonly used
  - Relatively persistent
• Dimethoate (Cygon)
  - Efficacy variable and depends on timing and coverage
  - Not commonly used

Carbamate insecticides currently registered:

• None

Other insecticides currently registered:

• Cyanfluthrin (Baythroid 2)
  - Efficacy potentially good to excellent, but depends on timing and coverage
  - Use is increasing
  - Persistent

• Tebufenozide (Mimic 2LV)

- Efficacy has not been evaluated

Other pest management aids:

• Scotch pine varieties originating in southern Europe appear to be consistently more resistant than varieties from the British Isles

• Individual trees within a field are often infested repeatedly, year after year. These trees should be removed and destroyed

• Emphasize scouting to locate new infestations or repeatedly attacked trees

• Cultural practices that enable growers to harvest most Scotch pine trees within 5 -6 years should reduce opportunity for Zimmerman pine moth populations to build to high densities

Pipeline pest management tools:

• None identified

"To do" list for :

Research needs:

• Some early development on identification of adult sex pheromones. Such a pheromone could be used for monitoring adult activity and perhaps for trapping

• Consistent evidence of genetic-based host plant resistance, but mechanism of resistance needs to be determined

• Two or more parasitoids and an entomopathogenic fungus transmitted by mites are known to attack Zimmerman pine moth larvae or pupae, but little is known about the biology or impact of these natural enemies or how populations could be conserved or enhanced

• Refine understanding of Zimmerman pine moth biology and phenology; improve degree day recommendations for insecticide applications in spring or in late summer

• Genetics of *Dioryctria* genus are complicated; could be dealing with a complex of species

• Effects of winter weather on survival of overwintering larvae in hibernaculae could be important but not yet investigated

• Evaluate Mimic or other selective products as control options

• Develop spray equipment to enhance coverage, particularly on the trunk of the tree

Regulatory needs:

• None identified

Education needs:

• Educate growers on the need and methods for Zimmerman pine moth scouting

g WEEDS

Annual/Perennial Broadleaf and Grass Weeds -

Weed competition in Christmas tree plantations;

< compete for moisture and nutrients

< make the environment favorable for disease development

< may be an alternate host for rusts

< provide cover for damaging animals

< increase the fire hazard level

< interfere with shearing and other field operations

< can shade plants and negatively impact growth and foliage quality

< may impact the ability to dig and ship trees for the landscape market

< seed heads (fall panicum, witchgrass) and other plant materials get lodged in the tree in the fall and are difficult to remove

Weeds also can benefit by;

< minimizing soil erosion

< keeping the soil cooler for some Christmas tree species

< provide alternative food source for beneficial insects and white grubs (grass roots).

Herbicides currently registered:

Pre-emergence herbicide

• Atrazine (Atrazine 4L, Aatrex 4L)

- Provides good to excellent control, the old standby
- Need to use low rates
- Often mixed with simazine for broadleaf weed program
- Will not give season long control
- Seeing some triazine resistant weeds

- Presently don't have a good broadleaf alternative

• Hexazinone (Velpar)

- Highly effective, broad spectrum on grasses and broadleaves, use on Scotch pine only - not in the first 2 years
- Rates are variable depending on soil texture, sand restrictions
- Leaching potential concern
- pre-emergent as well as post
- can be applied over the top without phyto-toxicity
- Reasonable cost

• Isoxaben (Gallery)

- Good to excellent on broadleaf weeds, similar to simazine spectrum
- Expensive, not widely used
- Would be used more if atrazine and simazine are lost
- May be used in tank mix
- Fall application can control marestail

•Lactofen (Cobra)

- Good to excellent as pre-emergent and post broadleaf weed control
- Problems with phyto-toxicity as post application
- Could be used in seed beds and nursery plantations
- Has not been used much because of cost

• Metolachlor (Pennant)

- Good to excellent on annual grasses and nutsedge
- Needs water to activate the herbicide
- Reasonable cost

• Oryzalin (Surflan)

- Good to excellent on annual grasses
- Applied earlier and usually tank mixed with simazine
- Can't be used on Douglas fir, need ½" rain within 21 days after application
- Expensive

- High rates needed

• Oxyfluorfen (Goal)

- Good to excellent control on various broadleaves
- Widely used in nursery production and not as much in field
- Most important herbicide in nurseries
- Expensive
- Forms a barrier so can't disturb after application

• Pendimethalin (Pendulum)

- Excellent on annual grasses
- Prevents germination, timing important - window of application is few weeks
- Needs rainfall to activate (½ to 1")
- Cost not excessive
- Stains equipment

• Pronamide (Kerb)

- Not used much any more, only for quack grass
- Fall applied below soil temp of 55 degrees
- Expensive, reason for limited use

• Simazine (Princep)

- Variable depending on soil texture, rate, time of application, moisture - good at best
- Narrow zone on getting too much and phyto-toxicity
- Timing critical - early spring, earlier than strictly annual grass products
- Inexpensive
- Potential problem with groundwater, no data indicating a problem in Christmas tree production
- Triazine resistant weeds showing up (broadleaves - marestail, lambsquarter, pigweed, etc)
- Most commonly used herbicide in Christmas trees due to low cost, would be a problem if this product was lost, especially for broadleaves
- Not a season long product, late season weeds are not controlled
- Not effective against all weeds, e.g. velvetleaf,

- Will suppress quackgrass but won't kill
- Highly sensitive to moisture, needs some moisture but not too much

Post emergence herbicides

• Clethodim (Envoy)
- Good to excellent on annual grasses and quackgrass, height of the grass will determine the degree of control
- Not as widely used
- Expensive, prices coming down
- Safe to use

• Clopyralid (Stinger)
- Very selective broadleaf herbicide
- Great on alfalfa, marestail, spotted knapweed etc
- Low rates, relatively expensive, but cost effective due to low rates
- Need to control weeds when small

• Fluazifop-P-Butyl (Fusilade DX)
- Excellent annual grass and quackgrass control, slow affect
- One of few post herbicides that can be applied over the top without phyto-toxicity
- Can be applied to all species except Fraser Fir
- Grass needs to be actively growing and not under stress
- Can be used in combination with other herbicides
- Widely used
- Timing critical, more effective on smaller grasses
- No residual

• Glyphosate (Round-up and others)
- Excellent on a wide variety of weeds, non-selective
- Caution should be exercised depending on species, use directed sprays during season
- Most important herbicide Christmas tree growers have available
- Widely used

- Inexpensive, cost effective
- No residual

• Hexazinone (Velpar)
- Good, Scotch pine (two needle pines), broad spectrum, grasses, broadleaves, some woody
- Contact and some residual activity
- Widely used
- Cost effective
- Woody control early in season
- Safer to trees when applied over top than Roundup

• Oxyfluorfen (Goal)
- Good to excellent control on various broadleaves
- Widely used in nursery production and not as much in field, most important herbicide in nurseries
- Expensive
- Forms a barrier so can't disturb after application

• Pronamide (Kerb)
- Good, not used much anymore due to cost and better products now available
- Post applied but works as a pre-emergent control of quackgrass
- Usually applied in the fall to control spring quackgrass

• Sethoxydim (Vantage)
- Good to excellent grass control, no residual
- One of few post herbicides that can be applied over the top without phyto-toxicity
- Can be applied to all species
- Grass needs to be actively growing and not under stress
- Can be used in combination with other herbicides
- Not as widely used as Fusilade
- Timing critical, more effective on smaller grasses
- May suppress small quackgrass, less effective than Fusilade

Other pest management aids:

• Mowing - significant for choose and cut where need access to trees

• Cultivation - can injure tree roots

• Mulching - plastic and natural (chips)

• Slab of hay around tree

Pipeline pest management tools:

• Sureguard - can be applied over top of dormant trees, wide variety of grasses and broadleaves, long residual, reduce use of triazine, could apply only one application of herbicide annually with this product. Ohio has a 24(c) label. Hoary alyssum isn't controlled by other herbicides.

"To do" list for :

Research needs:

• Evaluate various application techniques and equipment

• Need over the top, broad spectrum, pre and post emergent herbicides

• Desperately need weed specialist at MSU for Christmas trees, nurseries, etc.

• Evaluate alternative control methods such as biological controls, corn gluten, cover crops, etc.

Regulatory needs:

• Expanded label definitions of Christmas tree

• Products to apply aerially

• Sureguard as a priority at EPA

• Keep growers aware of potential noxious weed problems, monitor movement into Michigan

Education needs:

• Hold educational workshops and demonstration plots with growers and technical reps as new products are developed

• Develop Michigan specific weed control recommendations and publications

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g **VERTEBRATE**

Deer - Deer destroy the marketability of the trees eating branches and rubbing the tops. Deer destroy whole fields of seedling trees.

Pine Voles - Pine Voles girdle trees during winter thereby killing trees, sometimes even killing whole plantations. Grass and weed problems increase vole problems.

Rabbits - Rabbits will also eat whole seedlings, but are more minor. Damage is usually basal pruning.

Heavy snow cover and hard winters make the problems are more severe with all of these pests. Porcupines will sometimes damage trees.

B1 and B2 Potential Carcinogens currently registered:

• None

Other rodenticide currently registered:

• Thiram (repellent)
  - Not Used

• Zinc Phosphide Bait
  - Excellent, but only for mice and voles, safe when used properly, is presently the only control available. Very important for nurseries

Other pest management aids:

• Fencing - Used under high deer pressure situations. Very expensive, but is sometimes only way.

• For voles, control of weeds is important.

• Increased harvest of deer by use of shooting permits. Utilized under the direction of the Michigan Department of Natural Resources.

• There are many repellents available but they require constant re-application, and are very expensive. In most cases these are not practical for commercial growers. Products include tankage, Miller's hot sauce, Hinder, garlic sprays, etc. Phyto-toxicity concerns with some of these products.

Pipeline pest management tools:

• None identified

"To do" list for :

Research needs:

• The industry is very dependant on zinc phosphide for vole control. Since this is the only product registered, an alternative product needs to be found.

• If a reliable, cost-effective repellent for deer could be developed it would greatly increase yields and quality of Christmas trees in many parts of the State.

Regulatory needs:

• Clarify the zinc phosphide label for use on Christmas trees

• Maintain zinc phosphide or find an acceptable alternative
• Cost-share on deer fencing
• Maintain good deer management in all deer management units

Education needs:

• Educate growers on current recommendations and update them as any changes occur

Christmas Tree Worker Activities

Worker activities in Christmas tree plantations vary considerably depending on the species grown, conditions under which the trees are being produced and harvest size. While some of these activities are partially mechanized, most of the field activities are done by hand, or with equipment that requires some hand labor input. This includes planting, fertilizer and herbicide application, pruning, tree tinting and harvest. The majority of these activities occur from March through mid- December however, some pruning is done in the winter months. Approximately 85% of pesticide applications are done by the grower or their employees and 15% by commercial applicators.

Planting

Although young trees are planted in both the fall and spring, most planting of new trees occurs in the spring. Most planting is done with the aid of a planting machine. Most trees are planted during the months of April/May. If trees are planted in the fall, planting occurs in September and early October. Using a planting machine an experienced planting crew can plant 1000 trees per hour on favorable sites. Hand planting is mostly done to replace trees that died during the initial growing season. Occasionally hand planting may be done on steep slopes, or in small, inaccessible areas. A variety of planting tools are used, although power augers are the most common method of digging holes for replanting new trees, especially transplants. An experienced hand planter can plant 800 to 1000 trees per day.

Fertilizer Application

Not all conifers planted for the purpose of producing Christmas trees require fertilizer applications during the production period. Fertilization is more common with true firs, spruce and Douglas-fir. Most pine species are produced without fertilizer applications. Fertilizer applications are typically by machine, although some growers will provide small amounts to each individual tree. Nitrogen is the nutrient required in the largest amount and accordingly, is the most commonly applied plant nutrient. Applications are made both during the spring and fall, although spring applications are more common. For Fraser fir of harvestable size, nitrogen is often applied in August to enhance tree color.

Staking

In a small percentage of plantations it may be necessary to stake individual trees to produce straight stems. This is most common with Scotch pine, although staking is occasionally done for other species, depending on soil types and individual tree condition, eg. where frost heaving has occurred when trees are planted on heavier soils.

Weed Control – Chemical

Chemicals to control competing vegetation are commonly used by many Christmas tree growers. In that there is not a single product that will provide either season-long or rotation-long control, it is necessary to make not only annual but frequently two or more herbicide applications in the same growing season. Weed control chemicals used in Christmas tree production are of two types; residual chemicals that have a pre-emergent effect and contact or post-emergent materials that may or may not have residual characteristics. Herbicide materials are applied from early spring before growth begins throughout the spring and summer growing season, and in early to mid-fall.

Most applications are made using mechanical spray equipment of one kind or another. Limited aerial applications are made on some large operations. More commonly used equipment includes boom sprayers, air-blast sprayers and shielded broadcast and band sprayers. Boom sprayers are used until the trees get too tall which is about 3 feet in height. Some hand operated equipment, including back-pack sprayers and concentrated micro-droplet sprayers, is also used. Most hand equipment is used to apply herbicides as a directed-spray in which the spray solution is directed away from tree foliage. Typically, backpack sprayers are used to spot treat problem areas, or used when the trees are too large for mechanical equipment to get through without injury. The amount of area that can be treated in a single day varies greatly depending on the equipment used.

More than a dozen different herbicide products are registered and available for Christmas tree producers. Each is designed to serve either a pre-emergent or post-emergent need and/or to respond to a particular weed species problem present in the plantation.

Weed Control - Mowing

Some growers use mowing to control vegetation between and among rows of trees in plantations, and in the fire or access lanes that separate blocks of trees in most plantations. A few growers rely on mowing for control of all vegetation while others will only mow prior to harvest. Mowing prior to harvest is especially common in choose-and-cut operations. Mowing is done with various kinds of equipment including small tractors with “brush-hog” type cutters that operate between the rows to several different kinds of hand-operated equipment. Hand operated equipment includes rotary mowing units, sickle-bar type mowers, and string-type trimming units.

Insect and Disease Management

Since the value of a Christmas tree is related to the condition of its foliage control of those insect and/or disease organisms that detract from foliage/twig quality and appearance is an essential part of cultural operations. Insect/disease problems vary depending on the species of tree being produced, however, all species grown in the state are vulnerable to at least one or two potentially serious problems with some species such as Scotch pine susceptible to more than a dozen serious pest concerns. Insecticides, fungicides, and miticides are routinely applied to Christmas trees, especially in the latter years of the rotation period. Several different types of equipment are used including aircraft, air-blast sprayers, boom sprayers, and back-pack sprayers. Hand-operated sprayers are less common as most applications are made using tractor-drawn, mechanized equipment.

Irrigation

Irrigation is used by an increasing number of Fraser fir Christmas tree growers. This species has higher water requirements than most other species and will respond to supplemental water applications. Water is provided through several different types of irrigation systems including center-pivots, hard and soft-hose travelers, fixed pipe installations, and drip-type tubing networks. Each has its unique advantages and disadvantages and is best suited to different types of situations. Aside from the labor required in initial set up, moving, and maintenance labor requirements during actual operation are minimal.

Shearing and Pruning

To develop quality trees with a characteristic "Christmas tree shape" it is necessary that each tree be sheared (pruned and/or shaped) annually. This practice usually begins when the trees are between two and three feet tall. Initial pruning focuses on removing double stems and developing a removal of the lowermost branches to form a "handle" on each tree. Shearing must continue for each year of the rotation including the year of harvest. Timing of shearing will vary with tree species. For pines shearing is done during the period of mid-June through July. This timing is critical for good bud development. Late shearing results in the development of fewer and weaker buds. For Douglas-fir, blue and white spruce, and the true firs shearing generally begins around the first of August and will continue as necessary through the fall, winter and early spring.

Several types of tools and equipment are used to prune Christmas trees although the majority of shearing utilizes hand tools including knives, hedge-type clippers, and hand operated pruners. Some mechanical shearing equipment is available including Saje units, Trimmit machines and Yule-tree trimmers. However, all of these units require manual labor for operation. Limited hand trimming is still necessary even when mechanical trimming units are used.

De-coning

It is not unusual for some conifer species grown for Christmas trees to bear moderate to heavy numbers of cones on a more or less regular basis. This is particularly true for species such as Fraser and Balsam

fir. The presence of cones is considered undesirable on these species. If they are allowed to remain on the tree during the year in which they are formed their presence will result in significantly less growth in the tree. Additionally, since cones of all *Abies sp.* disintegrate when mature the scales and seeds are messy and result in much undesirable debris in the tree. Lastly the central axis of the cone or cone spike remains attached to the individual twigs of the tree where it detracts from the appearance of the tree. As part of the management of fir plantations, especially Fraser fir, most growers will remove cones from each tree every year they are present. Removal is done by hand in the spring as soon as the cones are identifiable. At this time of the year they can be easily picked or pulled from the twig and have not begun to pull nutrients from other portions of the tree. The number of trees that an individual worker can cover each day depends on tree size and the number of cones present.

Pest Scouting

Scouting for pests occurs throughout the season, beginning after the snow melts in the spring and going up until harvest. Scouting is typically done by the grower or a trained employee. Scouting is done to monitor pest problems before widespread damage can occur or to time pesticide applications.

Marking Trees

In most wholesale operations it is necessary to identify those trees that will be harvested in the current year. This is usually done by experienced personnel including field managers or owners. Trees identified for harvest are usually marked with ribbons or flagging of different colors. Colors are used to distinguish species from one another as well as trees of different size and quality. Marking or tagging is typically done in late summer or early fall.

Tinting

With the approach of winter many conifers develop a yellowish tint or color in their foliage. For Christmas trees this is not a desirable characteristic as consumers often interpret a yellowish color as an indication of dryness. For species including Scotch pine, Douglas-fir and occasionally spruce, an application of a dilute water-based latex pigment solution is applied in late summer and early fall while the foliage is still a normal dark green color. This tinting process results in a green coating being applied to the needles that will mask or cover the normal yellowing that will occur later. Tinting or coloring of the foliage is normally done by hand using power spray equipment.

Harvesting

Large commercial operations begin harvesting Scotch pine in late October and will continue through November and early December as necessary. Typically, harvesting of true firs, Douglas-fir and spruce occurs after the first part of November. Harvest involves a crew that cuts and moves trees to access roadways. This is followed by shaking to remove dead needles and debris from the tree, and baling to

compact the tree into a smaller size. Following baling, trees will be transported from the plantation to a loading yard where they will be stored until shipment to retail markets.

Table 1. Classification of Pesticides

Chemical group	Human Risk Assessment
Carbamate.....	Acetylcholinesterase inhibitor; disrupts the nervous system.
Organophosphate....	Acetylcholinesterase inhibitor; disrupts the nervous system.
B2 carcinogen.....	Likely human carcinogen.
C carcinogen.....	Possible human carcinogen for which there is limited animal evidence.
D carcinogen.....	There is inadequate evidence to determine carcinogenicity in humans.
E chemical.....	Evidence of non-carcinogenicity in humans.

Table 2. Registered Pesticides for Christmas Trees in Michigan

, Registered **Fungicides** for Christmas Trees in Michigan

Active Ingredient	Trade Name	Company
Azoxystrobin	Quadris	Syngenta
Chlorothalonil	Bravo 500, Ultrex	Syngenta
	Daconil Ultrex, Weather Stik, Zn	Syngenta
Chlorothalonil & thiophanate-methyl	Reach	Syngenta
Fosetyl-AL	Aliette WDG	Aventis CS
Mancozeb	Dithane DF, F-45, M-45, WF	Dow Agro Sciences
	Fore	Dow Agro Sciences
	Mancozeb 4F	Lesco
Propiconazole	Banner Maxx	Syngenta
Thiophanate-methyl	Cleary's 3336	W A Cleary
	Fungo Flo	Anderson
Triadimefon	Bayleton	Bayer

, Registered **Insecticides** for Christmas Trees in Michigan

Active Ingredient	Trade Name	Company
Acephate	Acephate Pro 75	Top Pro
	Orthene 75S, 97	Syngenta, Valent
Bifenthrin	Talstar 10WP	

Active Ingredient	Trade Name	Company
Carbaryl	Sevin 80WSP,XLR	Aventis CS
Chloropyrifos	Lorsban 4EC	Dow AgroSciences
Cyfluthrin	Baythroid	Bayer Corporation
Diazinon	Diazinon 50W	Syngenta, Agriliance
Diflubenzuron	Dimilin 4L, 25W	Uniroyal Chemical
Dimethoate	Dimethoate 4 EC Dimethoate 400	Helena UAP
Disulfoton	Di-syston 15%G	Bayer
Endosulfan	Thiodan	FMC
Esfenvalerate	Asana XL	Dupont
Hexythiazox	Savey	Gowen
Imidacloprid	Provado 16F	Bayer Corporation
Insecticidal Soaps	Insecticidal Soap M-Pede	Olympic
Malathion	Malathion	Gowen
Oxydemeton-metyl	Metasystox-R	Gowen
Permethrin	Pounce	FMC Agriliance
Phosmet	Imidan 70W, 70WSB	Gowen
Propargite	Omite CR, Ornamite	Uniroyal
Spinosad	Spintor 2SC	Dow Agro Sciences
Tebufenozide	Mimic 2LV	Dow Agro Sciences

, Registered **Herbicides** for Christmas Trees in Michigan

Active Ingredient	Trade Name	Company
Asulam	Asulox	Aventis CS

Active Ingredient	Trade Name	Company
Atrazine	Aatrex 4L	Syngenta
	Atrazine 4L	Agriliance, Helena, UAP
Clethodim	Envoy	Valent
Clopyralid	Stinger	Dow Agro Sciences
Fluazifop-P-Butyl	Fusilade	Syngenta
Glyphosate	Accord	Monsanto
	Glypro	Dow Agro Sciences
	Round-up	Monsanto
Hexazinone	Velpar DF, L	Dupont
Isoxaben	Gallery 75 DF	Dow Agro Sciences
Lactofen	Cobra	Valent
Metolachlor	Pennant 7.8 EC	Syngenta
Oryzalin	Surflan 4 AS	Dow Agro Sciences
Oxyfluorfen	Goal	Dow Agro Sciences
Pendimethalin	Pendulum 2G,3.3 EC, WDG	BASF
Pronamide	Kerb 50W, WSP	Dow Agro Sciences
Sethoxydim	Vantage	Top Pro
Simazine	Princep	Syngenta
	Princep Caliber 90	Syngenta
	Simazine4L, 90	Agriliance, UAP

Table 3.

Description of Pests and Pathogens of Christmas Trees

Pest/Pathogen	Symptoms
, Fungi/Water Molds	
Lophodermium needlecast (*Lophodermium seditiosum*)	The needles are infected in the fall during the annual release of spore into the air from July to October. Most spore release occurs in September. Spores are air-blown but are released on days following rainfall. As a result of the previous year's fall infections, the infected needles show symptoms in spring. Brown spots with yellow borders appear and enlarge, causing the needle to turn yellow, then brown in May and June. This is a severe needlecast disease that can cause the entire tree to brown during the spring. Needles are cast in June and July. In severe infections, only the current year's needles remain by late fall.

Swiss needlecast (*Phaeocyptopus gaumanni*)	The needles are infected in the spring. Symptoms occur a year after infection. Needles show a typical yellowing and browning of the tips in spring and summer but never a mottling. Needles are cast one or two years after infection during late fall and winter. In severe infections, only the current years needles remain. On the undersides of the needles in spring, two rows of minute black fruiting bodies, one on each side of midrib, is diagnostic.
Rhabdocline needlecast (*Rhabdocline pseudotsugae*) (*Rhabdocline weirii*)	Needles are infected in the spring, The symptoms of the disease on the current year's needles being as pale yellow lesions 1/16 inch in diameter in late July. The yellow lesions turn red-brown by about September-October. Finally, the infected needles have a mottled, green-brown appearance. Cushion -like fruiting bodies form the following spring on the surface of the mottled spots. By early June, the epidermis of the needle ruptures over the fruiting bodies, exposing orange masses of spores. Mature spores are released in wet weather and cause new infections.
Rhizosphaera needlecast (*Rhizosphaera kalkhoffii*)	Current-year needles are infected in May and June. The following year, the infected needles turn yellow in July and purplish brown in late August or early September. The two-year-old needles are cast in late summer. During the change in color to purplish brown, the fruiting bodies appear in the stomata of infected needles.
Gall rust (*Cronartium coleosporrioides*)	Galls are formed at the end of the first or second growing season following infection through needles. Galls on the main stem will kill the tree, and multiple galls on branches can decrease the value of Christmas trees. During May and June, light orange masses of spores occur on the galls. Other fungi, frequently enter the pine through the galls, causing other problems.

White pine blister rust (*Cronartium ribicola*)	Symptoms include branch and stem cankers which can lead to girdling and death of distal tissues. Cankers are most easily seen in the spring when orange-yellow pustules protrude from the bark of the cankers. In late spring and early summer, these areas will form blisters containing a sticky, yellow-orange fluid which later turns dark and hard.
Balsam needle rust (*Uredinopsis* spp., *Milesina* spp.) **Concolor rust** **Spruce needle rust** **Sweet fern rust** **Pine needle rust (*Coleosporuim asterum)***	In late summer and the following spring, infected trees will show browning of the lower needles on the trees. Orange or white droplets appear on infected foliage, and in May through July, orange or white blisters become evident. The blisters are masses of spore that cannot infect conifers but infect other plant species like fern or goldenrod, etc. Each rust species has a specific second host.
Armillaria root rot (*Armillaria spp.*)	Trees infected with this pathogen show yellowing needles which is followed by browning of all needles. Resin will be on the bark on the root collar. Bark, if removed, will reveal white sheets of fungus.
Leptographium root rot (*Leptographium procera)*	Basal cankers forming at and slightly below the soil line. Trees may lodge on these skinny stems.
Phytophthora root rot (*Phytophthora spp.*)	Fir will begin to show signs of wilt, turn from dull green to orange in a matter of two weeks. Branch tips may turn up slightly. Seedlings and mature trees are susceptible.

Pest/Pathogen	Symptoms
, Insects	

Balsam Twig Aphid ***(Mindarus abietinus*)**	Hosts: firs Aphids feed on the sap of developing needles causing them to twist and become distorted. Feeding affects tree appearance and can stunt new growth. Value of Christmas trees can be reduced for up to three years following a year with high population density.
Balsam Woolly Adelgid ***(Adelges piceae)***	Hosts: firs, especially Fraser and balsam fir Sap-feeding insect causes needles to yellow and premature needle loss may occur. Ends of twigs or shoots may swell and appear "gouty". Toxin injected by feeding adelgids inhibits bud development and causes tree vigor to decline, eventually leading to mortality.
Cooley Spruce Gall Adelgid ***(Adelges cooleyi)***	Hosts: Colorado blue spruce and Douglas fir Spruce - Feeding by nymphs cause galls to form on the distal ends of current-year shoots on spruce. Galls are cone-like purple, green or brown swellings, 2 to 2 ½ inches long. Galls are unsightly, and reduce tree appearance and value. Douglas-fir - Feeding by nymphs discolors and distorts the needles but no galls are formed. Adelgids feed within small, white cottony masses on needles. Necrotic spots occur at feeding sites and needles may be curled, distorted and stunted. Tree value and growth are reduced.

Eastern Spruce Gall Adelgid ***(Adelges abietis)***	Hosts: Norway, white and Black Hills spruce. Nymphs cause swellings or galls to form at the base of current-year shoots. The galls become brown and cause shoots to appear deformed or unsightly. Tree appearance and value are reduced and trees with an abundance of galls are unfit for sale.

Gypsy Moth ***(Lymantria dispar)***	**REGULATORY PEST** Hosts: All species Gypsy moth larvae feed on foliage of many species but rarely cause noticeable damage to Christmas tree species. This exotic insect is currently regulated by federal and state quarantines. Regulations include 1-2 mandatory applications of broad-spectrum insecticides during the gypsy moth larval feeding period, regardless of local gypsy moth populations. Trees that are to be shipped to un-infested areas must be inspected by the Michigan Department of Agriculture just before harvest. If gypsy moth egg masses are found during inspection, the field will be restricted and trees cannot be shipped outside of the quarantined area. This can cause economic hardship for growers, who must try to locate a market for these trees in a short time frame. If egg masses are found on trees outside the quarantined area, the grower faces fines, destruction of the trees and possible loss of their market.
Spruce Spider Mites ***(Oligonychus ununguis)***	Hosts: all Christmas trees species but most often a problem on fir and spruce Injury is most common in the spring and late summer or early fall. Feeding causes the needles to look yellowish to bronze in color. Needles or entire shoots may be killed. Damage to foliage and mite webbing affects tree appearance and value. At high densities, mites can discolor, degrade or kill nursery stock and Christmas trees of all ages.
Pales Weevil ***(Hylobius pales)***	Hosts: breeds in pine stumps but adult feeding affects all species. This insect is a chronic problem in Christmas tree plantations where periodic harvests leave many pine stumps suitable for weevil breeding. Adults feed on the bark of seedlings and shoots of pines, Douglas-fir and spruce. Shoots often die and "flagging" reduces tree appearance and value. Seedlings can be girdled and killed.

Pine Needle Scale ***(Chionaspis pinifoliae)***	Hosts: Pines, spruces Sap-feeding insect that feeds on needles. At high densities, the whitish, elongate scales, each about 0.1 inch long, may cover the needles affecting tree appearance and value. Severely infested trees may have sparse, discolored foliage, dead shoots and low vigor.
Pine Root Collar Weevil ***(Hylobius radicis)***	Hosts: Pines Larvae feed in the large roots and root collar area of young pine trees. Trees may be completely girdled and killed. Trees weakened by weevil feeding may break off at the root collar.
Pine Shoot Beetle ***(Tomicus piniperda* L.)**	**REGULATORY PEST** Hosts: pines Pine shoot beetle is an exotic pest that can develop and shoot-feed in nearly all pine species grown in North America. Shoot-feeding by adult beetles kills the shoot and could reduce growth if populations were high for multiple years. Noticeable damage is rare, however, in managed Christmas tree fields. Federal and state quarantines regulate shipments of pine Christmas trees from infested areas.
Pine Tortoise Scale ***(Toumeyella parvicornis)***	Hosts: pines, especially Scotch pine This scale sucks sap from the phloem of woody shoots and branches. Infested trees often become coated with black sooty mold, making them unfit for sale. High scale populations stunt tree growth and can cause branches to die.
White Grubs ***(Phyllophaga spp.)***	Hosts: all species Larvae feed on the roots of conifer seedlings and young trees. Feeding may kill seedlings and slow growth of older trees.
White Pine Weevil **(*Pissodes strobi)***	Hosts: pines and spruces Larval feeding kills the terminal leader and the top 2 to 4 years of growth. Damage can affect tree form and will delay harvest for at least 1 to 3 years. Maggot like larvae feed under the bark.

Zimmerman Pine Shoot Moth ***(Dioryctria zimmermani)***	Hosts: pines, especially Scotch and Austrian pine Larvae feed on phloem under the bark of stems, large branches or the terminal leader of trees. Feeding may cause shoots or branches to die. Feeding often occurs at branch whorls and entire branches may break off. Large pitch masses on the stem reduce tree appearance and value. Repeated stem attacks may cause trees to break off at the injury site.

Pest/Pathogen	Symptoms
, Vertebrate	
Deer	Deer destroy the marketability of the trees eating buds, branches and rubbing tree tops. Deer can destroy whole fields of seedling trees.
Rabbits	Rabbits and hares feed on the bark and lower branches of young pines. In large numbers they can cause great damage to pine plantings. Severely injured trees are girdled and killed.
Pine and Meadow Voles	Voles feed on the bark around the base of the trunk, bark of tree roots or on lower branches, slowing growth and discoloring needles. Trees may be killed or weakened, making them vulnerable to other pests.

Table 4. Advantages and Disadvantages of Pesticides for Christmas trees

Active Ingredient	Disease/Pest	Advantages/Disadvantages
, Fungicides		

Active Ingredient	Disease/Pest	Advantages/Disadvantages
azoxystrobin	Lophodermium needlecast Sphaeropsis shoot blight and canker Swiss needlecast	• Effectiveness is unknown • Expensive
benomyl	Sphaeropsis shoot blight and canker Rhabdocline needlecast	• Dupont is stopping production of this product. • Carbamate fungicide
chlorothalonil	Lophodermium needlecast Swiss needlecast Rhabdocline needlecast Rhizosphaera	• Broad spectrum foliar protectant fungicide • Group B2 carcinogen
fosetyl-AL	Phytophthora root rot	• Excellent in nursery production • Not used in field production due to cost
mancozeb	Gall rust Lophodermium needlecast Sphaeropsis shoot blight and canker Swiss needlecast	• Inexpensive • Needs to be reapplied 10 to 14 days • Group B1 or B2 carcinogen
propiconazole	Sphaeropsis shoot blight and canker	• Not used • Expensive
thiophanate-methyl	Sphaeropsis shoot blight and canker	• Effective alternative to Benelate
triadimefon	Gall rust Lophodermium needlecast	• Control is variable for gall rust • Control good to excellent on Lophodermium • Some injury observed on Scotch pine

, Insecticides

Active Ingredient	Disease/Pest	Advantages/Disadvantages
acephate	Aphids, gypsy moth, pine root collar weevil adults, pine shoot beetle, pine needle scale, pine tortoise scale,	• Fairly short residual so timing more important • Relatively inexpensive • Organophosphate
bifenthrin	Aphids, mites, pine shoot beetle, pine needle scale, weevil adults	• Impacts on beneficial insects a concern • Relatively expensive • Pyrethroid
carbaryl	Aphids, adelgids, gypsy moth, scale	• Impacts on beneficial insects and predatory mites a concern • Carbamate
chlorpyrifos	Aphids, adelgids, gypsy moth, mites, scale insects, white grubs, weevils, Zimmerman pine moth	• Fairly long residual • Impacts on beneficial insects and predatory mites a concern • Relatively inexpensive • Organophosphate
cyfluthrin	Adelgids, gypsy moth, pine root collar weevil, pine shoot beetle, scale insects, Zimmerman pine shoot moth	• Relatively long residual • Impacts on beneficial insects and predatory mites a concern • Cost moderate • Pyrethroid
diazinon	Aphids, scale insects, white grubs	• Impacts on beneficial insects and predatory mites a concern • Moderate residual • Organophosphate

Active Ingredient	Disease/Pest	Advantages/Disadvantages
diflubenzuron	Gypsy moth, white pine weevil	• Long persistence • More selective - does not affect vertebrates or adult invertebrates • Relatively safe for applicator/workers • Affects invertebrates, including aquatic organisms - cannot be used near water
dimethoate	Aphids, Zimmerman pine moth,	• Some systemic activity • Relatively inexpensive • Organophosphate
disulfoton	Aphids, adelgids, mites	• Organophosphate
endosulfan	Adelgids	• Some resistant adelgid populations may have developed in recent years • Relatively non-toxic to bees, highly toxic to fish, corrosive to iron • Organophosphate
esfenvalerate	Pine needle midge	• Impacts on beneficial insects and predatory mites a concern • Not as effective at high temperatures
hexythiazox	Mites	• Very effective against egg and larval stages of mites • Does not affect predatory mites and beneficial insects • Resistance can develop if applied improperly • Relatively expensive

Active Ingredient	Disease/Pest	Advantages/Disadvantages
imidacloprid	Aphids, adelgids	• Especially effective on sap-feeding insects • Not effective on some other groups of insects • Fewer impacts on predatory mites and beneficial insects • Relatively expensive • Nicotine-like chemistry
insecticidal soap	Aphids, adelgids, mites, scale insects	• Often not effective on mobile insects • Coverage must be excellent for effective control • May be phyto-toxic to some species in some situations
lindane	Weevils	• No longer manufactured in US • Organochloride
malathion	Aphids	• Relatively short residual • Impacts on beneficial insects and predatory mites a concern • Relatively low mammalian toxicity • Organophosphate
oxydemeton-methyl	Aphids, pine needle scale	• Some systemic activity • Impacts on beneficial insects and predatory mites a concern • Relatively inexpensive • Organophosphate
permethrin	Aphids	• Not commonly used • Impacts on beneficial insects and predatory mites a concern

Active Ingredient	Disease/Pest	Advantages/Disadvantages
phosmet	Gypsy moth, scale insects	• Impacts on beneficial insects and predatory mites a concern • Relatively inexpensive • Organophosphate
propargite	Mites	• Efficacy good to excellent
spinosad	Gypsy moth	• Efficacy not evaluated in Christmas tree fields • Relatively expensive • Selective on Lepidoptera • Few impacts on beneficial insects and predatory mites
tebufenozide	Gypsy moth, Zimmerman pine shoot moth	• Efficacy not evaluated • Relatively expensive • Selective on Lepidoptera • Few impacts on beneficial insects and predatory mites
, Herbicides		
asulam	Bracken fern	• Only herbicide for bracken fern control • Carbamate
atrazine	Annual grasses and broadleaf weeds	• Broadleaf weed control • Resistance of some weeds • Concerns for ground water
clethodim	Grasses	• Broadleaf crops are tolerant • Timing for grass height is critical for control.
clopyralid	Selected broadleaf weeds	• Only effective on broadleaf weeds in the composite family • Somewhat costly

Active Ingredient	Disease/Pest	Advantages/Disadvantages
fluazifop-P-butyl	Grasses	• Broadleaf crops are tolerant • Timing for grass height is critical for control, high rate needed for quackgrass • Limit 6 pt/ac/yr
glyphosate	Annual and perennial grasses and broadleaf weeds	• Excellent efficacy, non-residual • Systemic, can control dense stands of perennials • Slightly toxic to birds, practically nontoxic to fish, aquatics, honey bees • Group E chemical
hexazinone	Annual grasses and broadleaf weeds	• Scotch pine only • Excellent over the top, broad spectrum herbicide • Groundwater concerns
isoxaben	Broadleaf weeds and some annual grasses	• Expensive
lactofen	Annual grasses and broadleaf weeds	• Group B1or B2 carcinogen
metolachlor	Annual grasses and some broadleaf weeds	• Concern about groundwater • Expensive • Group B1 or B2 carcinogen
oryzalin	Annual grasses and some broadleaf weeds	• Can't use on Douglas-fir • Expensive
oxyfluorfen	Broadleaf weeds and some annual grasses	• Most important for nursery production
pendimethalin	Annual grasses and some broadleaf weeds	• Good on grasses
pronamide	Annual and perennial grasses	• Group B1 or B2 carcinogen

Active Ingredient	Disease/Pest	Advantages/Disadvantages
sethoxydim	Grasses	• Good on grasses • Less effective on some grasses than Fusilade
simazine	Annual grasses and broadleaf weeds	• Resistance of certain weeds • Not season long control • Concerns for ground water contamination
, Rodenticides		
zinc phosphide	Voles, mice	• Only effective material available • Concerns for non-target birds and animals • Some confusion on whether it is labeled for Christmas trees

Table 5: Efficacy table for disease management options.

Rating Scale: **E**=excellent; **G**=good; **F**=fair; **P**=poor; **?**=More research needed; **NU**=Not used; *****=Used, but not necessarily a stand alone management tool.

DISEASES:	Lophodermium Needlecast	Swiss Needlecast	Rhabdocline Needlecast	Rhizosphaera Needlecast	Gall Rust	White Pine Blister Rust	Needle Rusts	Leptographium Root Rot (Procera)	Phytophthora Root Rot	Sphaeropsis Shoot Blight/Canker (Diplodia)
FUNGICIDES:										
Azoxystrobin (Quadris)	?	?	?	?						
Benomyl (Benlate)		NU	NU							E
Chlorothalonil (Bravo, Daconil)	F-P	E	E	E	?		?			?
Fosetyl-AL (Aliette)*									G	
Mancozeb (Dithane 45, Fore, Mancozeb 4F)	E	P-E			?		?			?
Metalayxl (Subdue)*								?	G-E	
Propiconazole (Banner MAXX)										?
Thiophanate-methyl (Cleary's 3336, Fungo Flo)							?	?		G?
Triadimefon (Bayleton)	G-E			P-F	P?					?
*nursery production										
CULTURAL CONTROLS										
Remove alternate host						P-E	P-E			
Sanitation	0				P-F				?	
Variety selection	P-G	P-F	P-F							
Weed control	F-G	F-G	F-G	F-G						

Table 6: Estimated efficacy rating of insecticide products for selected groups of insect pest. Rating scale: E=excellent control; G=good; F=fair; P=poor; ?= indicates this product has not been evaluated or we have no experience with it for this pest, more research needed, NU=product not used.

INSECTS: / INSECTICIDES:	Aphid	Balsam Twig Aphid	Balsam Wooly Adelgid	Cooley Spruce Gall Adelgid	Eastern Pine Shoot Borer	Eastern Spruce Gall Adelgid	European Pine Sawfly	Gypsy Moth	Pine Chafer (Anomala Beetle)	Pine Needle Midge	Pine Needle Scale	Pine Root Collar Weevil	Pine Shoot Beetle	Pine Tortoise Scale	Introduced Pine Sawfly	Redheaded Pine Sawfly	Yellow Headed Spruce Sawfly	Pales Weevil	Spruce Spider Mite	White Grubs	White pine Weevil	Zimmerman Pine Moth
REGISTERED MATERIALS																						
Acephate (Orthene)	G-E	G-E	?	G	P	G	E	G-E	?	?	G-E	?	P-F	F-G	E	E	E	?	?	P	?	?
Bifenthrin (Talstar)	G-E	G-E	?	?	?	?	E	G-E	?	?	G-E	?	?	G-E	E	E	E	?	E	?	?	F-E
Carbaryl (Sevin)	F-G	G	?	G-E	?	G-E	E	F-E	?	?	G-E	?	P-F	G-E	E	E	E	NU	P	?	NU	?
Chlorpyrifos (Lorsban)	E	E	?	E	?	E	E	E	?	G-E	E	F-E	G-E	E	E	E	E	E	G-E	E?	E	F-E
Cyfluthrin (Baythroid)	E	E	?	E	?	E	E	E	?	?	G-E	F-E	G-E	E	E	E	E	?	?	?	?	F-E
Diazinon	E	E	?	?	?	?	?	NU ?	?	?	G-E	NU	NU	G-E	E	E	E	?	NU	?	?	?
Diflubenzuron (Dimilin)	NU	NU	?	NU	NU	NU	NU	G-E	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	G-E	?
Dimethoate	NU	NU	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	P-G
Disulfoton (Di-syston)	NU	NU	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	NU	?	?	?
Endosulfan (Thiodan)	G-E	?	?	F-G	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Esfenvalerate (Asana)	G-E	G-E	?	?	NU	NU	G-E	NU	?	G-E	G-E	?	?	G-E	NU	NU	NU	?	?	?	?	?
Hexythiazox (Savey)	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	G-E	NU	NU	NU
Imidacloprid (Provado)	E	E	?	E	?	E	?	NU	P	?	?	?	P	?	?	?	?	?	P	?	?	?
Insecticidal Soaps (M-Pede)	P-G	P-G	?	P-E	?	P-E	P-E	P-E	P	?	P-E	P	P	P-E	P-F	P-F	P-F	NU	?	P	P	P

Malathion	G	G	?	F-G	?	F-G	G-E	G	?	?	P-E	P	P-F	P-E	G-E	G-E	G-E	?	P-F	?	?	?
Oil (horticulture, dormant)	F-G	P-G	?	F-G	NU	F-G	NU	NU	NU	?	G-E	NU	NU	F-E	NU	NU	NU	NU	?	NU	NU	?

Table 6: Estimated efficacy rating of insecticide products for selected groups of insect pest. Rating scale: E=excellent control; G=good; F=fair; P=poor; ?= indicates this product has not been evaluated or we have no experience with it for this pest, more research needed, NU=product not used.

INSECTS: / INSECTICIDES:	Aphid	Balsam Twig Aphid	Balsam Wooly Adelgid	Cooley Spruce Gall Adelgid	Eastern Pine Shoot Borer	Eastern Spruce Gall Adelgid	European Pine Sawfly	Gypsy Moth	Pine Chafer (Anomala Beetle)	Pine Needle Midge	Pine Needle Scale	Pine Root Collar Weevil	Pine Shoot Beetle	Pine Tortoise Scale	Introduced Pine Sawfly	Redheaded Pine Sawfly	Yellow Headed Spruce Sawfly	Pales Weevil	Spruce Spider Mite	White Grubs	White pine Weevil	Zimmerman Pine Moth
Oxydemeton-methyl (Metasystox-R)	E	E	?	G-E	?	G-E	?	NU	?	?	G-E	?	?	?	?	?	?	?	G-E	?	E	?
Permethrin (Pounce)	NU	NU	?	?	?	?	?	NU	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Phosmet (Imidan)	?	?	?	?	?	?	NU	F-G	?	?	?	?	?	NU	NU	NU	NU	?	?	NU	?	NU
Propargite (Omite)	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	G-E	NU	NU	NU
Spinosad (Spintor)	NU	NU	NU	NU	NU	NU	?	?	NU	NU	NU	NU	NU	NU	?	?	?	NU	NU	NU	NU	NU
Tebufenozide (Mimic)	NU	NU	NU	NU	NU	NU	?	?	NU	NU	NU	NU	NU	NU	?	?	?	NU	NU	NU	NU	?
CULTURAL CONTROLS																						
Crop Rotation	P	P	?	P	P	P	P	P	P	P	P	F-G	P	P	P	P	P	P	P	P	P	P
Sanitation	P	P	?	P-F	P	F-G	P	P	P	P	F-G	F-G	G-E	G-E	P	P	P	F-E	P	?	P	F
Scouting/Monitoring	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	F-G	E	F-E	F-G	F-G
Trap Logs	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	E	NU	NU	NU	NU	NU	NU	NU	NU	NU
BIOLOGICAL CONTROLS																						
Bacillus thuringiensis var. kurstaki	P	P	P	P	P	P	P	F-E	P	P	P	P	P	P	P	P	P	P	P	P	P	?
Lacewings	E	E	P	?	P	?	P	P	P	P	P	P	P	P	P	P	P	P	?	P	P	P
Ladybird Beetles	E	E	?	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	?	P	P	P
Parasites/Predators (Other)	P-G	P-E	?	P	?	P	F-E	P-E	?	?	F-G	?	P	F-E	F-E	F-E	F-E	?	P-E	?	P-F	F-G

Predator Mites	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	F-E	P	P	P
Syrphid Fly Larvae	E	E	?	?	P	?	P	P	P	P	P	P	P	P	P	P	P	P	P	?	P	P	P

Table 7: Estimated effect of insecticide products and cultural controls on selected groups of beneficial or non-target organisms. **N**=no risk or minimal risk; **M**= some effects possible but unlikely to affect entire population; **H**= Harmful, likely to affect local population.

INSECTS: / INSECTICIDES:	Bacillus thuringiensis var. kurstaki	Bees	Lacewings	Ladybird Beetles	Parasites/Predators (Other)	Predatory Mites	Syrphid Fly Larvae	INSECTS: / INSECTICIDES	Bacillus thuringiensis var. kurstaki	Bees	Lacewings	Ladybird Beetles	Parasites/Predators	Predatory Mites	Syrphid Fly Larvae
REGISTERED MATERIALS															
Acephate (Orthene)	N	H	H	H	H	H	H	Phosmet (Imidan)	N	H	H	H	H	H	H
Bifenthrin (Talstar)	N	H	H	H	H	H	H	Propargite (O-mite)	N	M	M	M	M	M	N-M
Carbaryl (Sevin)	N	H	H	H	H	H	H	Spinosad (Spintor)	N	N	N	N	N	N	N
Chlorpyrifos (Lorsban)	N	H	H	H	H	H	H	Tebufenozide (Mimic)	N	N	N	N	N	N	N
Cyfluthrin (Baythroid)	N	H	H	H	H	H	H								
Diazinon	N	H	H	H	H	H	H	**CULTURAL CONTROLS**							
Diflubenzuron (Dimilin)	N	M	M-H	M-H	M-H	H	M-H	Crop Rotation	N	N	N	N	N	N	N
Dimethoate	N	H	H	H	H	H	H	Sanitation	N	N	N	N	N-M	N	N
Disulfoton (Di-syston)	N	H	H	H	H	H	H	Scouting/Monitoring	N	N	N	N	N	N	N
Endosulfan (Thiodan)	N	H	H	H	H	H	H	Trap Logs					M		
Esfenvalerate (Asana)	N	H	H	H	H	H	H								
Hexythiazox (Savey)	N	N	N	N	N	N	N								
Imidacloprid (Provado)	N	M	M	M	M	M-H	M								
Insecticidal Soaps (M-Pede)	N	N	M	M	M	M	M								
Malathion	N	M	M	H	H	H	H								
Oil (horticulture, dormant)	N	N	M	M	M	M	M								

INSECTS: / INSECTICIDES:	Bacillus thuringiensis var. kurstaki	Bees	Lacewings	Ladybird Beetles	Parasites/Predators (Other)	Predatory Mites	Syrphid Fly Larvae	INSECTS: / INSECTICIDES	Bacillus thuringiensis var. kurstaki	Bees	Lacewings	Ladybird Beetles	Parasites/Predators	Predatory Mites	Syrphid Fly Larvae
Oxydemeton-methyl (Metasystox-R)	N	H	H	H	H	H	H								
Permethrin (Pounce)	N	H	H	H	H	H	H								

Table 8: Estimated efficacy rating of weed management products for selected groups of weed. Rating scale: **E**=excellent control; **G**=good; **F**=fair; **P**=poor; **?**= indicates this product has not been evaluated or we have no experience with it for this pest, more research needed, **NU**=product not used.

	PRE-EMERGENCE HERBICIDES									POST-EMERGENCE HERBICIDES									CULTURAL CONTROL	
HERBICIDES: / WEED CONTROL:	Atrazine (Atrazine)	Isoxaben (Gallery)	Hexazinone (Velpar)	Metolachlor (Pennant)	Oryzalin (Surflan)	Oxyfluorfen (Goal)	Pendimethalin (Pedulum)	Pronamide (Kerb)	Simazine (Princep)	Clethodim (Envoy)	Clopyralid (Stinger)	Fluazifop-P-Butyl (Fusilade)	Glyphosate (Roundup)	Halosulfuron (Manage)	Hexazinone (Velpar)	Lactofen (Cobra)	Oxyfluorfen (Goal)	Pronamide (Kerb)	Sethoxydim (Vantage)	Cultivation	Mowing
BROADLEAF WEEDS																					
Bindweed, field		P								P									P		%
Chickweed		G-E		F	G	G-E				P	P	P	E	P	E		F	G	P		%
Dandelion		G-E			G					P	G	P	E		E		F		P		%
Hoary Alyssum									P-G						E						%
Horseweed (marestail)		G-E		F		F					E										%

HERBICIDES: WEED CONTROL:	Atrazine (Atrazine)	Isoxaben (Gallery)	Hexazinone (Velpar)	Metolachlor (Pennant)	Oryzalin (Surflan)	Oxyfluorfen (Goal)	Pendimethalin (Pedulum)	Pronamide (Kerb)	Simazine (Princep)	Clethodim (Envoy)	Clopyralid (Stinger)	Fluazifop-P-Butyl (Fusilade)	Glyphosate (Roundup)	Halosulfuron (Manage)	Hexazinone (Velpar)	Lactofen (Cobra)	Oxyfluorfen (Goal)	Pronamide (Kerb)	Sethoxydim (Vantage)	Cultivation	Mowing
Knapweed, spotted										P	G	P							P		%
Lambsquarter	E	F		F		G-E	E		E	P	P	P	G	F	E	P	E		P		%
Milkweed																					%
Mustard, wild	E	G-E		P	G-E	G-E			E	P	P	P	G		E	E	E		P		%
Pigweed	G	G-E		G	G-E	G-E	F		G	P	P	P	G		E	E	F		P		%
Ragweed, common	E	G-E		F	F	F	P		G	P	G	P	G		E	E			P		%
Ragweed, giant	G	G-E		P					F	P	E	P	G		E	E			P		%
Smartweed	G	G-E		F	G	F			G	P		P	G		E	P			P		%
Thistle, Bull		G				G				P	G	P	G		F	P			P		%
Thistle, Canada										P	G	P	G		F	P			P		%
Velvetleaf	F	F		G	F	G	F	F	F		P		G		G	F					%
Grasses																					
Foxtail (yellow, green)	F	P		G-E	G-E		G-E		G	G-E		E	E		E				G-E		%
Foxtail, giant	F	P		G-E	G-E	F	G-E		F-G	G-E		E	E		E		F		G-E		%
Horsetail (Equisetum)		P			P				P					G?							%
Nutsedge, yellow	F	P		F-G	P	P			P-F				F	G?	F				P		%
Panicum, fall	P	P		G-E	G-E		G-E	G	P	G-E		E	G		E				G-E		%
Quackgrass	P	P			P			G	F	G		G	E		F				F-G		%
Witchgrass	P	P		G-E	G-E	F	G-E		G	G-E		E	G		E				G-E		%

Table 9 : Efficacy table for vertebrate pests.

Rating Scale: E=excellent; G=good; F=fair; P=poor; ?=More research needed; NU=Not used; *=Used, but not necessarily a stand alone management tool.

VERTEBRATE PESTS:	Deer	Pine Vole	Rabbits																	
REGISTERED MATERIALS																				
Thiram / Repellants	?	NU	NU																	
Zinc Phosphide		E																		
CULTURAL CONTROLS																				
Fencing	G-E																			
Hunting Permits	F-G																			
Mowing		G*	P-G																	
Weed Control		G*	P-G																	

Table 10. Worker activities for Fraser fir, balsam fir, spruces and Douglas-fir.

	Jan.	Feb	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Weed Control Chemical Mowing												
Fertilizer Application												
Planting												
Pest Scouting												
Insect and Disease Control												
Shearing												
De- coning												
Marking Trees												
Tinting												
Harvesting Landscape (B&B)												

Table 11. Worker Activities in Scotch and white pine.

	Jan.	Feb	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Weed Control												
Planting												
Staking												
Pest Scouting												
Insect and Disease												
Shearing												
Marking Trees												
Tinting												

Harvesting												

FQPA and Insecticide Use in Michigan Christmas Tree Fields: Results From 1998 Survey

by
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Most Michigan Christmas tree growers were made aware of the Food Quality Protection Act (FQPA) and the potential impact of FQPA on the availability of pesticide products for crop production by 1997 or 1998. In 1998, we began a project to compile accurate data on insecticide use by Michigan Christmas tree growers. Growers attending the Michigan Christmas Tree Association winter meeting and the 1998 Northern Christmas Tree Growers meeting were invited to participate in the project. Growers willing to participate were asked to provide information for at least one field that had been harvested in the previous year or a field that was designated for harvest within one year. Separate forms were provided for Scotch pine, Colorado blue spruce, Douglas-fir and Fraser fir fields. Therefore, each grower could provide data for up to 4 fields. Because the complex of insect pests and production practices vary among the four tree species, we analyzed all data separately for each tree species.

A total of 46 growers participated in the project. Data represent a total of 107 fields and a total acreage of 2,192 acres. The number of fields and number of acres represented by the surveys for each species are presented in Table 1. We also determined if the trees in each field would be sold within Michigan or if they were destined for out-of-state markets, because trees shipped out-of-state are subject to different regulations (e.g. gypsy moth, pine shoot beetle).

Table 1. Number of fields and acres by species represented in the survey.

	Scotch pine	Blue spruce	Douglas-fir	Fraser fir
No. of fields	**32**	**30**	**27**	**18**
Total acres	924.5	511.5	452.0	304.0

Growers were asked to list the insecticide products that they used. Each time an insecticide was applied, we counted it as one spray. For example, if a field was sprayed twice with Lorsban and once with Sevin, the field was sprayed 3 times. Note that insecticide products are referred to only by their abbreviated trade name for this report.

Insecticide Products by Tree Species

Figures 1a, 1b, 1c and 1d show the insecticide products used by each tree species. Although a variety of products were used on at least one field, Lorsban 4 E (chlorpyrifos) was clearly the most commonly used insecticide. This is a concern, given the wide use of this organophosphate insecticide on other commodities, its new status as a restricted use product, and the potential for further changes in registration. Data also indicates that relatively few growers are using more recently developed products, even though these products may be relatively safe for workers, conserve natural enemies, and still provide effective and economical pest control.

Insecticide Products by Acres

In the second set of figures, Fig. 2a, 2b, 2c and 2d, we present the number of acres treated with each pesticide product. As before, if a one acre field was sprayed three times during the summer, we counted that as 3 acres in this report. Once again, Lorsban was used to treat more acres than any other product. However, considerable acreage was also treated with other pesticide products, especially Baythroid (cyfluthrin) and Sevin (carbaryl). The number of acres that were not sprayed with any pesticide are almost certainly under-represented in our data. The percentage of fields and the number of acres that were not sprayed at all, therefore, may or may not be representative of the Christmas tree industry as a whole.

Substantially more Douglas-fir acres were treated with Lorsban than with any other product (Fig. 2d). This is a concern because insects, especially those that have more

than one generation in a year, can develop resistance to a class of insecticides, such as OP's. Cooley's spruce gall adelgid is the most important insect pest affecting Douglas-fir and it has several generations each year. Douglas-fir growers have been encouraged to consider alternating classes of insecticides to prevent resistant adelgid populations from developing.

Application Equipment

Most growers who completed surveys applied the pesticides with an air blast sprayer, although various other kinds of equipment were also used (Fig. 3). Application equipment in standard Christmas tree production is often relatively out-dated when compared with commodities such as apple production. This may be part of the reason why growers often have difficulty in obtaining adequate coverage when insecticides are applied to control small or protected insects.

Major Insect Pests

The percentage of sprays directed at specific pests were determined for the four tree species and data are presented in figures 4a, 4b, 4c, and 4d. We also determined the number of acres that were treated with insecticide to control specific pests; these data are summarized in figures 5a, 5b, 5c and 5d.

Scotch pine obviously had the most diverse pest complex (Fig. 4a), while Douglas-fir had only two pests that required insecticide control (Fig. 4d). If gypsy moth is excluded, then pine needle scale and pine sawflies required the most sprays in Scotch pine fields. Cooley's spruce gall adelgid and white pine weevil were most often sprayed in Colorado blue spruce fields, balsam twig aphid and spruce spider mites were commonly treated in fir fields, and Cooley's spruce gall adelgid was by far the most important pest in Douglas-fir fields.

Regulatory Pests

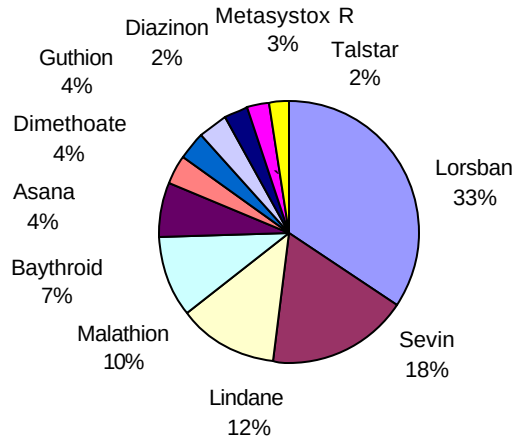
Gypsy moth and pine shoot beetle are two insects that are of great significance in Michigan Christmas tree production, not because they damage or injure trees, but because they are "regulatory pests." State and federal regulatory agencies have instituted various requirements that growers must meet if they wish to ship trees out-of-state to areas that are not known to be infested with gypsy moth or pine shoot beetle. Some tree species, such as Colorado blue spruce and Fraser fir, must be sprayed with an approved, broad-spectrum insecticide, during an appropriate period, before fields will even be inspected.

This regulatory situation appears to substantially increase the insecticide load in

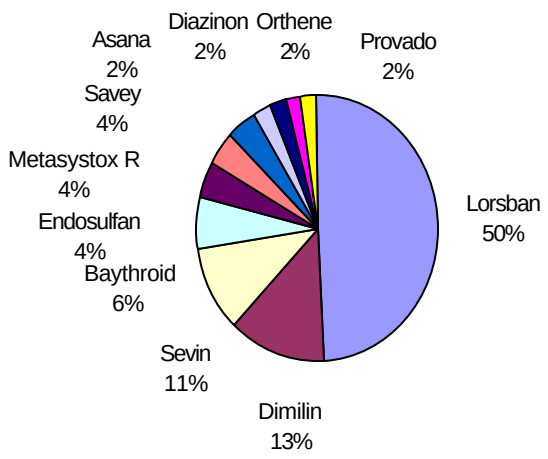
Michigan Christmas tree fields. In the Scotch pine fields included in our survey, more than one-third of the sprays were applied for gypsy moth or pine shoot beetle. Blue spruce, Fraser fir and Douglas-fir are not affected by pine shoot beetle. However, 33 to 44% of sprays in these fields were applied to meet gypsy moth requirements (Fig. 4b, 4c and 4d).

The effect of regulatory pest management is also apparent when we examine the number of acres treated for specific pests. In Scotch pine fields, 33% of all acres treated were sprayed for either gypsy moth or pine shoot beetle (Fig. 5a), although the damage to trees caused by these insects is minimal. In Douglas-fir fields, 47% of acres were treated for gypsy moth (Fig. 5d), and 41% and 37% of acres were treated for gypsy moth in Fraser fir (Fig. 5c) and blue spruce (Fig. 5b) fields, respectively. The regulatory pest situation is especially frustrating given that the majority of approved insecticides that can be used in the gypsy moth certification program are either OP's or carbamates. Neither the EPA, nor federal or state regulatory agencies have yet addressed this issue. The regulatory situation and mandatory sprays also make it difficult to implement alternative pest control options such as biological control. With additional research, it is likely that biological control strategies could be developed for at least some important Christmas tree pests such as spruce spider mite or balsam twig aphid. The insect predators or parasitoids that would control these pests, however, are susceptible to broad-spectrum insecticides used in regulatory programs. Although the current gypsy moth and pine shoot beetle regulations are workable and are acceptable to regulatory agencies in states receiving trees from Michigan, full implementation of FQPA will require consideration of alternative options.

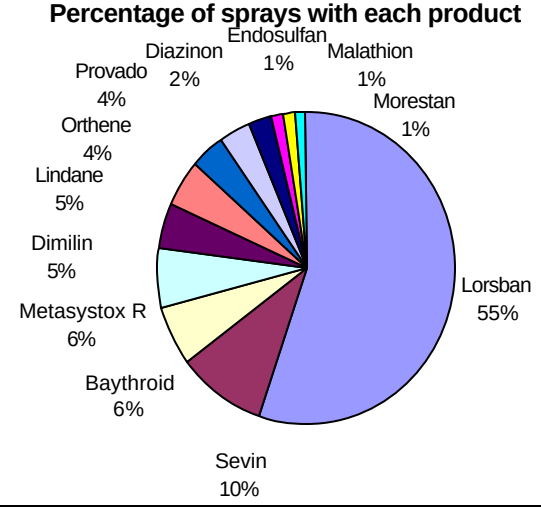
ALL SCOTCH PINE
Percentage of sprays with each product



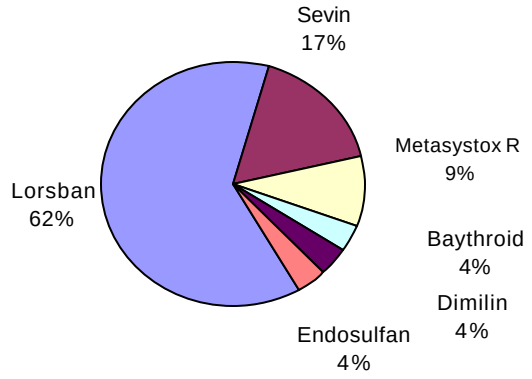
ALL FRASER FIR
Percentage of sprays with each product

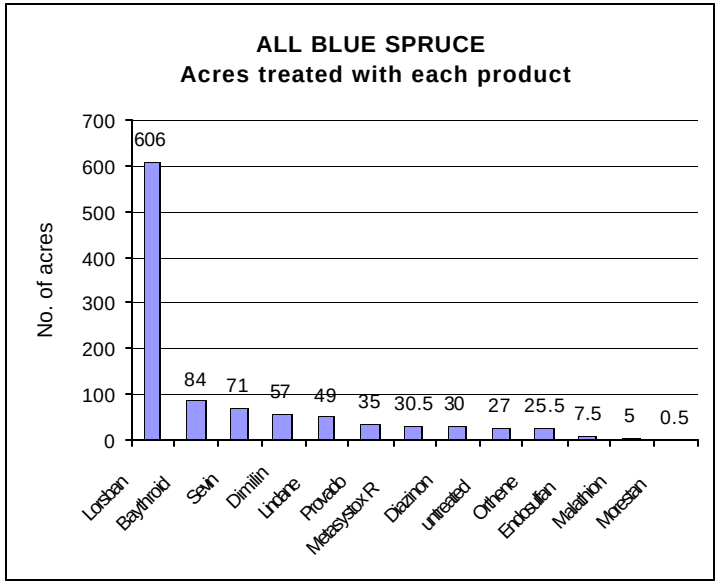


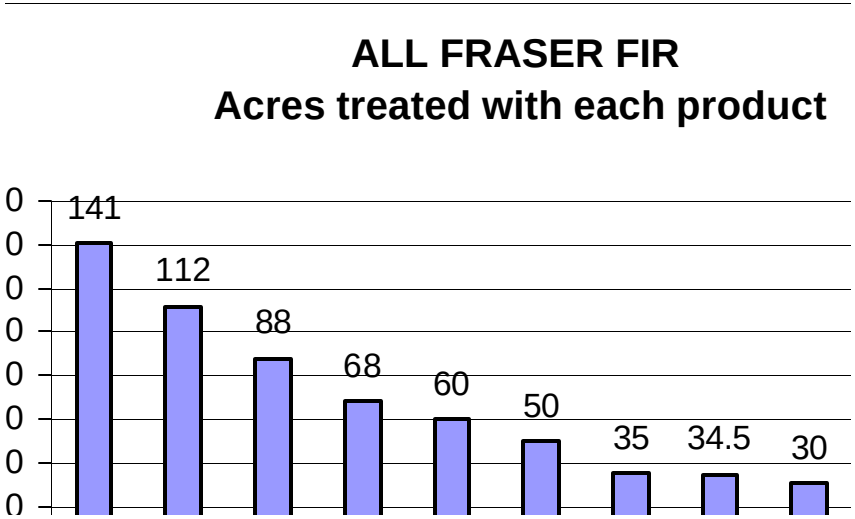
ALL BLUE SPRUCE
Percentage of sprays with each product

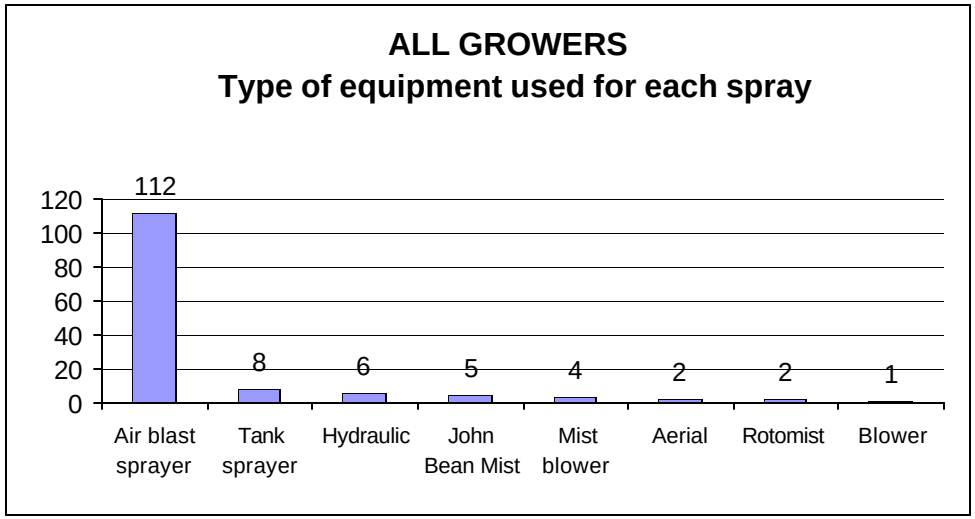


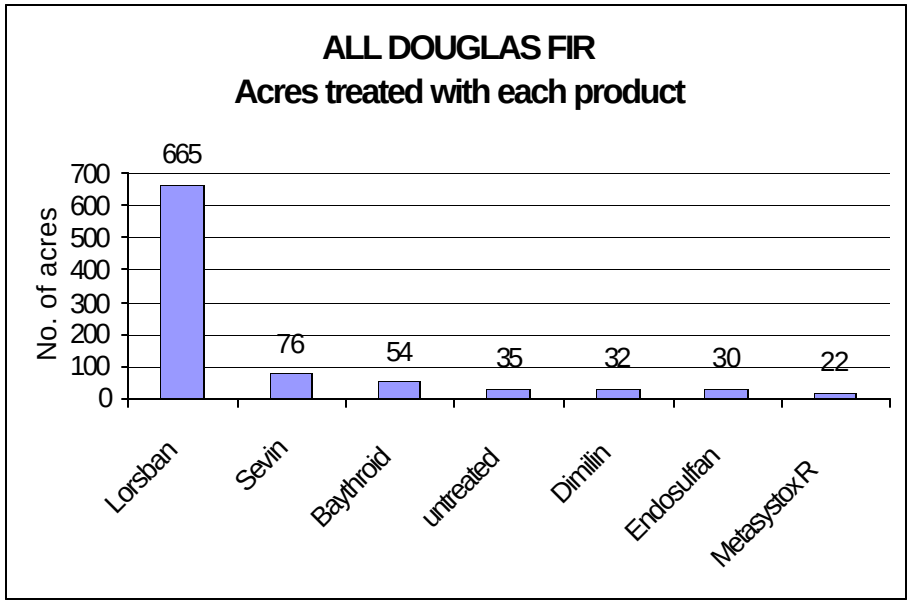
ALL DOUGLAS FIR
Percentage of sprays with each product




ALL BLUE SPRUCE
Acres treated with each product
No. of acres
700
600
500
400
300
200
100
0
606
84
71
57
49
35
30.5
30
27
25.5
7.5
5
0.5
Lorsban
Baythroid
Sevin
Dimilin
Lindane
Provado
Metasystox R
Diazinon
untreated
Orthene
Endosulfan
Malathion
Moresan


ALL FRASER FIR
Acres treated with each product
0
0
0
0
0
0
0
141
112
88
68
60
50
35
34.5
30


ALL GROWERS
Type of equipment used for each spray
120
100
80
60
40
20
0
112
8
6
5
4
2
2
1
Air blast sprayer
Tank sprayer
Hydraulic
John Bean Mist
Mist blower
Aerial
Rotomist
Blower


ALL DOUGLAS FIR
Acres treated with each product
No. of acres
700
600
500
400
300
200
100
0
665
76
54
35
32
30
22
Lorsban
Sevin
Baythroid
untreated
Dimilin
Endosulfan
Metasystox R

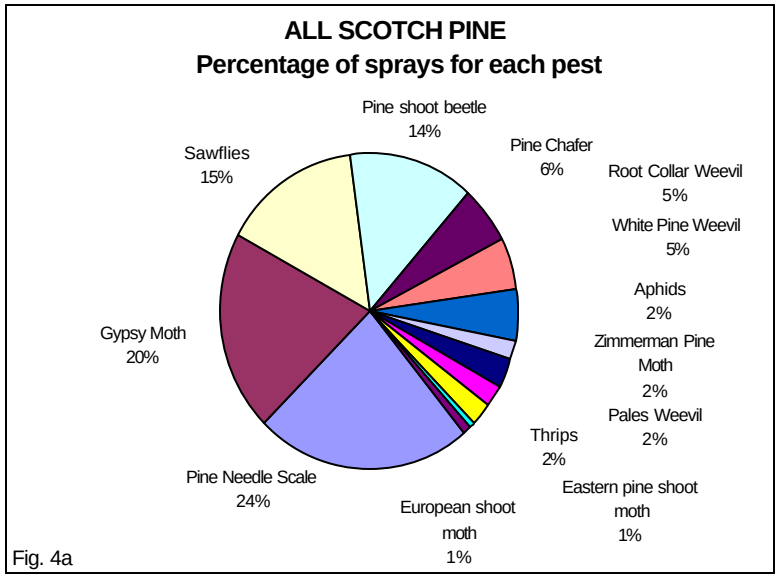


Fig. 4a

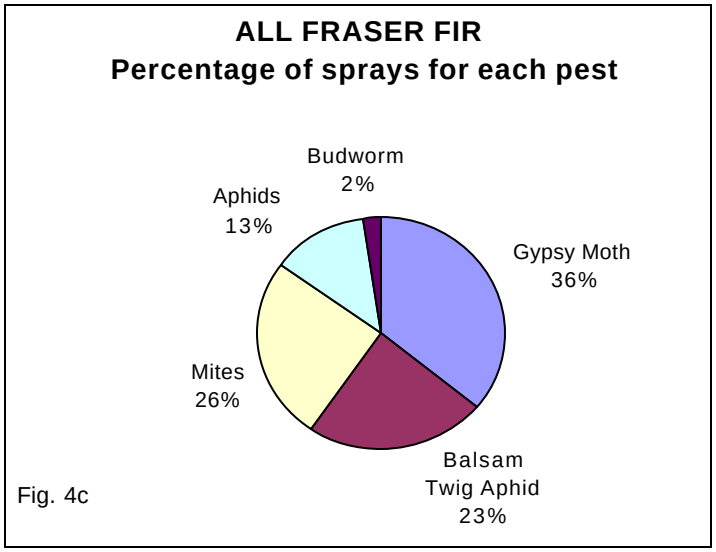


Fig. 4c

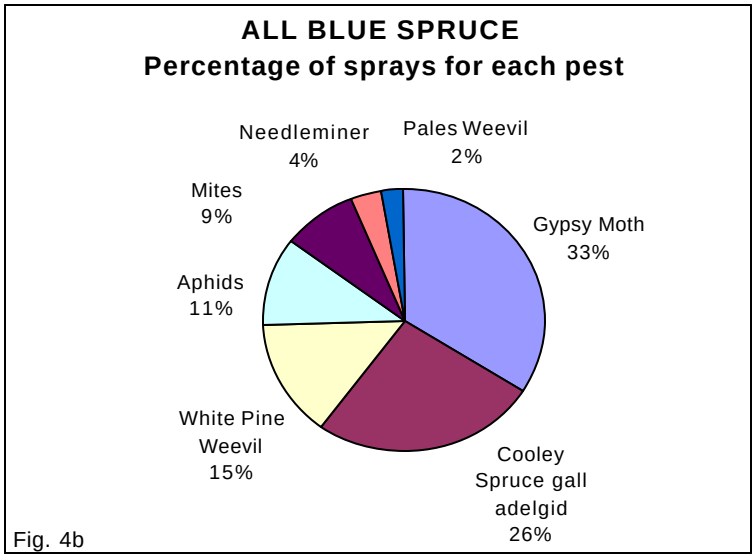


Fig. 4b

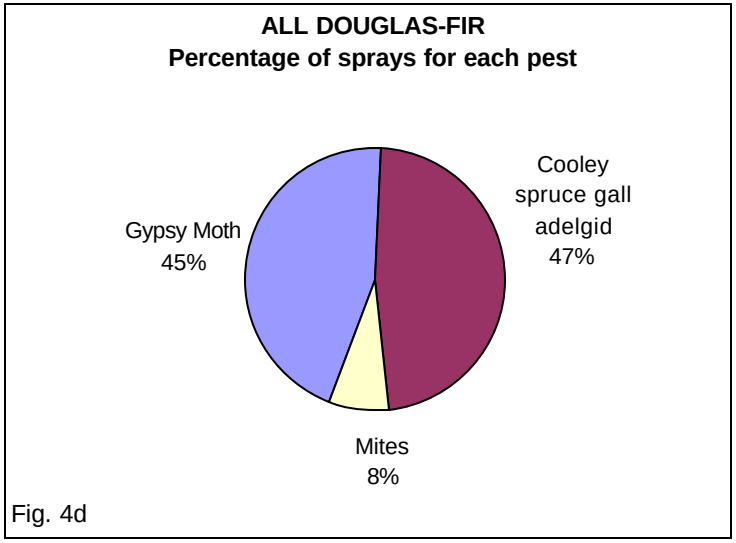
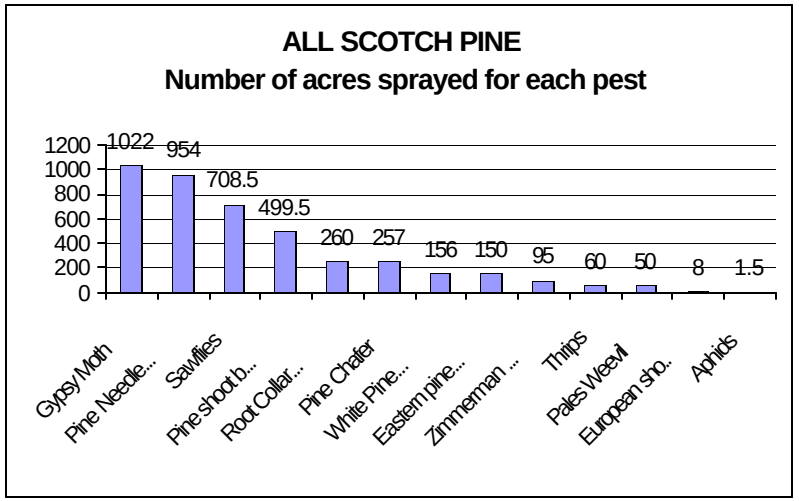
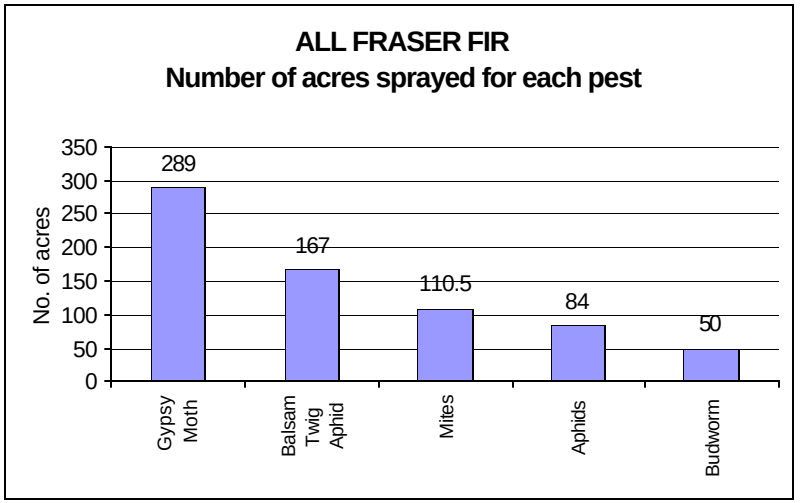
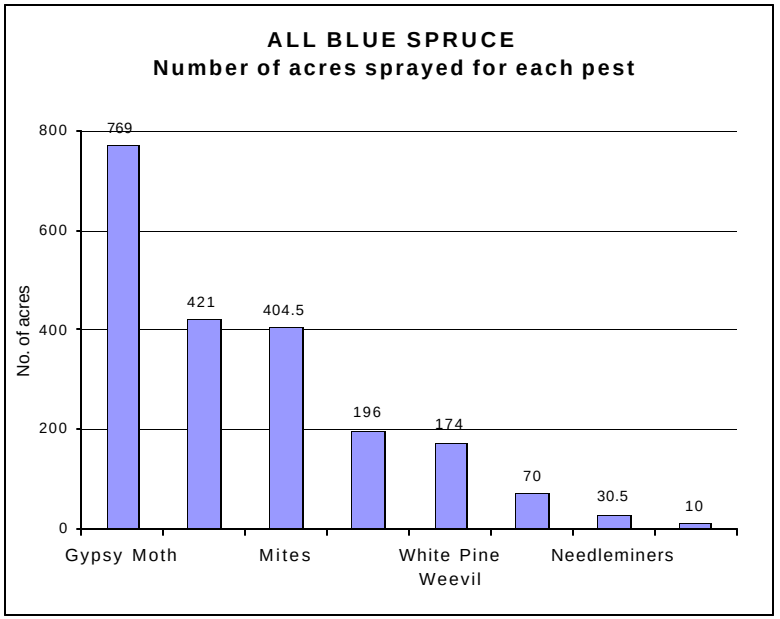
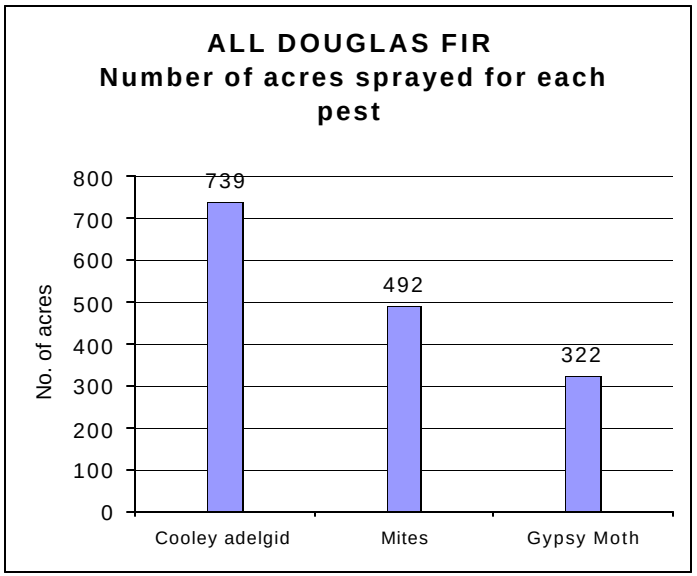


Fig. 4d


ALL SCOTCH PINE
Number of acres sprayed for each pest
1200
1000
800
600
400
200
0
1022
954
708.5
499.5
260
257
156
150
95
60
50
8
1.5
Gypsy Moth
Pine Needle...
Sawflies
Pine shoot b...
Root Collar...
Pine Chafer
White Pine...
Eastern pine...
Zimmerman ...
Thrips
Pales Weevil
European sho..
Aphids


ALL FRASER FIR
Number of acres sprayed for each pest
No. of acres
350
300
250
200
150
100
50
0
289
167
110.5
84
50
Gypsy Moth
Balsam Twig Aphid
Mites
Aphids
Budworm


ALL BLUE SPRUCE
Number of acres sprayed for each pest
No. of acres
800
600
400
200
0
769
421
404.5
196
174
70
30.5
10
Gypsy Moth
Mites
White Pine Weevil
Needleminers


ALL DOUGLAS FIR
Number of acres sprayed for each pest
No. of acres
800
700
600
500
400
300
200
100
0
739
492
322
Cooley adelgid
Mites
Gypsy Moth