

Nursery, Landscape and  
Christmas Tree Research  
Projects and Educational Programs

December 2003



# Note from the editors



Diane Brown-Rytlewski



Jill O'Donnell

How do you make a good publication even better? This year, the Christmas Tree AOE and the Nursery and Landscape subgroup of the Ornamentals AOE have joined forces to bring you an information-packed publication. We share a number of common issues, and quite a few growers produce both nursery stock and Christmas trees, so it made sense to address both groups with a shared publication, *Nursery, Landscape and Christmas Tree Research Projects and Educational Programs*. In these pages a wide range of topics are covered including: nursery production and production systems; evaluation of

new pesticides; plant evaluation; plant disease detection and management; insect biology and management; educational programs; and human resource management. Emerald ash borer research is underway –many of the researchers have completed their first full year of data collection, and are still analyzing results; several EAB research projects are reported on here. We have a record number of articles contributed – 43 in all. We continue to have industry support and industry cooperators for many of these projects.

In these times of lean budgets, we were fortunate to get funding for this publication through our respective Area of Expertise (AOE) teams, and a \$4,000 mini-grant proposal provided to the AOE's through Michigan State University Extension; thank you! To all those who shared information about their research projects and educational programs, we appreciate your time and efforts; names of contributors are listed within the reports. Thanks to Becca Lamb for layout design and Joy Landis for assistance with publication production. Thanks to Ken Fettig for assistance with publishing. Finally, we wish to acknowledge the important contributions of our organizational partners in this endeavor: Michigan State University Extension; the Ornamentals AOE team; the Christmas Tree AOE team; MSU Ag Experiment Stations; Project GREEN; Michigan Nursery and Landscape Association; Michigan Christmas Tree Association; and Michigan Green Industry Association for publishing support and help with distribution of this publication to industry. Without the support of our industry organizations, this publication would not exist.

## Photo credits:

### Cover

Removing Fraser fir cone buds, Fraser fir with heavy cone production, planting ash alternative species-Bert Cregg; Emerald ash borer larvae- Gary Heilig; methyl bromide alternatives trial plots, GREEN sign- Diane Brown-Rytlewski

### Color insert, page 1

Flowering shrubs and herbaceous perennials survey-Kevin Brothers  
Volunteers planting ash replacement species- Bert Cregg  
Volunteers learning to identify Emerald Ash Borer- Gary Heilig  
IR-4 research plots, methyl bromide alternatives research plots- Diane Brown-Rytlewski

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Emerald ash borer adult and larva- Dave Cappaert  
Beech scale, *Entomophaga*- infected gypsy moth larvae, jack pine budworm, pine shoot beetle adult and damage, ash tree infested with EAB- Deb McCullough

Dear Industry Partners:

On behalf of the MSU Extension Ornamentals Area of Expertise Team, I am pleased to share with you this year's summary of Nursery, Landscape and Christmas Tree Research Projects and Education Programs. An exciting development in this year's summary is the addition of research and education programs related to Christmas tree production. With support of a grant proposal developed by Diane Brown-Rytlewski and MSU Christmas Tree Extension Agent Jill O'Donnell, MSU Extension provided additional funds for development and publication of this summary. This partnership recognizes the close alliance between Michigan's landscape, nursery and Christmas tree industries as well as the close relationship among those of use conducting research and extension programs related to nursery and Christmas tree issues. On behalf of all the contributors to this edition, I thank Diane Brown-Rytlewski and Jill O'Donnell for their efforts in successfully competing for the MAES grant and compiling and editing articles in this edition.

As the state of Michigan continues to weather the economic storm, we appreciate, more than ever, the partnerships with our allied industries that make the research and education programs presented here possible. Michigan's nursery, landscape, and Christmas tree industries have remained strong through much of the recent economic downturn. To maintain this competitive position we need to maintain nationally -recognized research and extension programs. Most, if not all, of the research and education programs described here would not be possible without the support of our industry partners. The continued support from our industries will be critical for us to maintain the high level of research and outreach programming our clients expect as state funding for the Michigan Agricultural Experiment Station and Cooperative Extension come under increased scrutiny. We look forward to continuing to work with you to improve the competitiveness of Michigan's nursery, landscape, and Christmas industries and protect Michigan's environment.

Best regards,

Bert Cregg  
Campus Chair, Extension Ornamental Area of Expertise Team  
and Assistant Professor, Departments of Horticulture and Forestry

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Dear Industry Partners:

The Christmas Tree Area of Expertise Team is pleased to be given the opportunity to have our research and educational programs highlighted in this publication. The research and programs summarized in our portion of this report are a result of the priorities set by our industry partnering group. This group is comprised of Christmas tree growers of all sizes and from every part of Michigan. Our hope is that the research and programs highlighted here will help you to meet the many production, environmental, financial and marketing challenges faced by the Michigan Christmas tree industry. This work was made possible by the support of the Christmas tree industry, the Agricultural Experiment Station, Project GREEN and the Michigan State University Cooperative Extension Service. Thank you for your continuing support.

Sincerely,

Norman L. Myers  
Field Co-Chair, Christmas Tree Area of Expertise

## Introduction

On behalf of our Green Industry partners, I'm pleased to bring you the fourth edition of this publication. Featuring the research and Extension projects from personnel and field staff in the College of Agriculture and Natural Resources at Michigan State University, this publication provides information and techniques to deal with the issues and problems we're facing in the Green Industry. We've teamed up this year with the Christmas Tree segment to bring you an even more comprehensive trade tool. Our appreciation goes to Diane Brown-Rytlewski, Jill O'Donnell and the contributors for making this publication possible.

Sincerely,

Amy Frankmann  
Executive Director  
Michigan Nursery and Landscape Association

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The board of directors and the many members of the Michigan Christmas Tree Association are pleased to be involved with this important publication. Research and educational programs are our highest priority. We highly value our relationship with the College of Agriculture and Natural Resources at Michigan State University.

The information presented in this report is critical to the success and profitability of Michigan's Christmas tree industry and reflects on the talented researchers and Extension personnel at Michigan State University.

Our most sincere thanks to everyone involved in the creation of this publication, and for their continued support of Michigan's Christmas tree growers.

Sincerely,

Marsha J. Gray  
Executive Directory  
Michigan Christmas Tree Association

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*A Pocket IPM Scouting Guide for Woody Landscape Plants* order form  
*Landscape Alert* order form

## Hoary allyssum control in Christmas trees

### Authors

Robert J. Richardson, Bernard H. Zandstra, MSU  
Dept. of Horticulture  
Norm Myers and Jill O'Donnell, MSU Extension

### Funding

Project GREEN, Michigan Christmas Tree  
Association

### Significance

Hoary allyssum is an invasive biennial mustard that may form dense stands in Christmas tree plantations. This weed produces numerous small, white flowers and many seeds. Hoary allyssum competes with trees for nutrients and is very difficult to control.

### Materials and methods

A study was conducted in spring 2003 near Hart, Michigan to evaluate hoary allyssum control with various herbicides. Treatments were applied as a directed spray to Fraser fir Christmas trees with established populations of hoary allyssum on April 24, 2003. Weed control and crop injury was visually rated on a 0 to 100% scale with 0 equal to no weed control or no crop injury and 100 equal to complete weed or crop death. Sprayer output was 20 GPA and treatments are listed in Table 1. An untreated control was included for comparison to herbicide treatments.

### Results

Fraser fir injury from herbicide treatments was less than 5% with all treatments. Hoary allyssum control on June 18 was at least 77% with all treatments except Stinger plus Cobra (Table 1). Control with this treatment decreased to 37% at later ratings. On July 17, control was 53 to 63% with Permit, Cobra, and SureGuard plus Roundup Original. Control was 73 to 74% with Roundup Original alone and Princep plus Goal 2XL. Hoary allyssum control was greatest with Garlon at 98% on July 17 and 87% on September 5. Other treatments controlled hoary allyssum 23 to 63% on September 5.

### Conclusions and future research

Season-long control of hoary allyssum was only observed with use of Garlon. Other treatments provided initial suppression of the weed, but hoary allyssum recovered and was able to produce flowers and seed. However, SureGuard and Princep plus Goal 2XL treatments did reduce the amount of new hoary allyssum plants emerging during the summer as compared to other treatments. While the majority of these treatments did not control the weed adequately, fall applications of the same herbicides might produce better results. Hoary allyssum plants would be smaller in the fall than in spring and may be more sensitive to treatment then. This research will be repeated in spring 2004 and a similar study will be established in fall 2003. ☞

**Table 1.** Hoary allyssum control with spring applied herbicide treatments. <sup>a</sup>

Treatment names			Rating date		
Chemical	Trade	Rate <sup>b</sup>	6-18-03	7-17-03	9-5-03
		lb ai/A	%		
Simazine + oxyfluorfen	Princep + Goal 2XL	1.5 + 0.5	83	73	44
Glyphosate	Roundup Original	1.0	92	74	53
Flumioxazin + glyphosate	SureGuard + Roundup Orig.	0.25 + 1.0	87	63	58
Triclopyr	Garlon	1.0	100	98	87
Lactofen <sup>b</sup>	Cobra	0.25	80	63	63
Clopyralid + lactofen <sup>b</sup>	Stinger + Cobra	0.08 + 0.25	49	37	37
Halosulfuron	Permit	0.047	77	53	23
LSD (0.05) <sup>c</sup>			10	14	12

<sup>a</sup> All ratings on 0 to 100% scale with 0% equal to no control and 100% equal to complete weed death.

<sup>b</sup> Non-ionic surfactant (0.25% v/v) included with treatment.

<sup>c</sup> Means separated with Fisher's Protected LSD test at P = 0.05. Differences in rating values must be equal to or greater than the number in the LSD column to be considered significantly different.

## Nursery IR4 projects

### Authors

David Smitley and Terrance Davis, MSU  
Department of Entomology

### Industry partner

Zelenka Nursery

### Funding

IR4 Program

The federal IR4 program provides some funding for assisting in the labeling of pesticides for minor-use crops. The rationale for this program is that companies may not want to spend money needed for obtaining labels on crops like greenhouse and nursery

plants that have a relatively small sales market and high risk for lawsuits. We have participated in the IR4 program to help BASF (SanMite) and Syngenta (Flagship) obtain federal labels for nursery crops. Valent Corporation is pursuing a federal label at this time for dinotefuron.

### 2001 Pyridaben Miticide (Sanmite)

Container-grown plants were treated with 0x, 1x, 2x and 4x rates of pyridaben. Pyridaben is a miticide being developed by BASF. None of the plant species showed a phytotoxic reaction to the chemical. Pyridaben was registered for nursery use as Sanmite in 2000. The label has since been expanded to include many additional plant species.

poker plant, torch lily	<i>Kniphofia</i> 'Flamenco Orange'	purple coneflower	<i>Echinacea purpurea</i> 'Magnus'
Russian sage	<i>Perovskia</i> sp.	alumroot	<i>Heuchera micrantha</i>
peony	<i>Paeonia</i> sp.		'Palace Purple'
yew	<i>Taxus densiformis</i>	alumroot	<i>Heuchera micrantha</i>
plantain lily	<i>Hosta</i> sp. 'Golden Tiara'		'Splendens'
stonecrop	<i>Sedum spurium</i> 'Autumn Joy'	lady's mantle	<i>Alchemilla mollis</i>
weigela	<i>Weigela florida</i> 'Carnival'	bee balm	<i>Monarda didyma</i> 'Gardenview
mallow	<i>Malva sylvestris</i> 'Dema'		Scarlet'
tube clematis	<i>Clematis heracleifolia</i>	tickseed	<i>Coreopsis verticillata</i> 'Zagreb'
burning bush	<i>Euonymus alatus</i> 'Compactus'	false spirea	<i>Astilbe x arendsii</i> 'Deutschland'
butterfly bush	<i>Buddleia davidii</i> 'Pink Delight'	shasta daisy	<i>Chrysanthemum x superbum</i>
gaura	<i>Gaura lindheimeri</i> 'Crimson		'Snow Cap'
	Butterfly'	Missouri primrose	<i>Oenothera missouriensis</i>
gaura	<i>Gaura lindheimeri</i> 'Blushing	blueleaf willow	<i>Salix purpurea</i> 'Nana'
	Butterfly'	wormwood	<i>Artemisia stelleriana</i> 'Silver
bluebeard	<i>Caryopteris x clandonensis</i>		Brocade'
	'Dark Knight'	feather reed grass	<i>Calamagrostis acutiflora</i>
strawberry foxglove	<i>Digitalis x mertonensis</i>		'Karl Foerster'

### 2002 Thiamethoxam insecticide (Flagship)


Container-grown plants were treated with 0x, 1x, 2x and 4x rates of thiamethoxam. Thiamethoxam is a new nicotinyl insecticide being developed by Syngenta. It has excellent activity on sucking insects

and white grubs. None of the plant species showed a phytotoxic reaction to the chemical. Thiamethoxam was registered for nursery use as Flagship 25 WDG at the end of September 2003.

white pine	<i>Pinus strobus</i>	viburnum	<i>Viburnum dentatum</i> 'Christom'
arborvitae	<i>Thuja plicata</i> 'Virescens'	spirea	<i>Spiraea x bumalda</i> 'Goldflame'
dappled willow	<i>Salix integra</i> Thunb. 'Hakuro Nishiki'	Japanese barberry	<i>Berberis thunbergii</i>
rosemallow	<i>Hibiscus</i> x 'Blue River II'		'Atropurpurea Nana'
weigela	<i>Weigela florida</i> 'White Knight'	canna	<i>Canna indica</i> 'Phasion'
rose of sharon	<i>Hibiscus syriacus</i> 'Lucy'	butterfly bush	<i>Buddleia davidii</i> 'Black Knight'
feather reed grass	<i>Calamagrostis acutiflora</i>	silvergrass	<i>Miscanthus sinensis</i> 'Strictus'
	'Karl Foerster'	fountain dwarf grass	<i>Pennisetum alopecuroides</i> 'Hameln'
red twig dogwood	<i>Cornus alba</i> 'Elegantissima'	reed canary grass	<i>Phalaris arundinacea</i> 'Feeseys'
hydrangea	<i>Hydrangea arborescens</i> 'Annabelle'		Form'
yew	<i>Taxus x media</i> 'Densiflora'	purple coneflower	<i>Echinacea purpurea</i> 'Magnus'
lilac	<i>Syringa laciniata</i>	black-eyed susan	<i>Rudbeckia fulgida</i> 'Goldsturm'
white spruce	<i>Picea glauca</i>	sage	<i>Salvia x superba</i> 'East Friesland'
		juniper	<i>Juniperis horizontalis</i> 'Blue Chip'

**2003 Dinotefuron insecticide**

Container-grown plants were treated with 0x, 1x, 2x and 4x rates of dinotefuran. Dinotefuron is a new nicotinyl insecticide being developed by Valent Corp.

It has excellent activity on sucking insects and white grubs. None of the plant species showed a phytotoxic reaction to the chemical. (Related photo, color insert, page 1A.) 

Austrian pine	<i>Pinus nigra</i> 'Austriaca'	Serbian spruce	<i>Picea omorika</i>
Colorado spruce	<i>Picea pungens</i>	sage	<i>Salvia x superba</i> 'East Friesland'
dwarf fountain grass	<i>Pennisetum alopecuroides</i>	dappled willow	<i>Salix integra</i> 'Hakuro Nishiki'
silvergrass	<i>Miscanthus sinensis</i>	arborvitae	<i>Thuja occidentalis</i>
yew	<i>Taxus x media</i> 'Densiformis'		'Woodward Globe'
dianthus	<i>Dianthus</i> 'Bath's Pink'	mugo pine	<i>Pinus mugo</i>
shasta daisy	<i>Chrysanthemum x superbum</i>	althaea	<i>Althaea officinalis</i>
	'Becky'	coreopsis	<i>Coreopsis</i> 'Moonbeam'
black-eyed susan	<i>Rudbeckia fulgida</i> . 'Goldsturm'	purple coneflower	<i>Echinacea purpurea</i>
hydrangea	<i>Hydrangea arborescens</i>	Japanese barberry	<i>Berberis thunbergii</i>
	'Grandiflora'		'Crimson Pygmy'
spirea	<i>Spiraea x bumalda</i> 'Gold Mound'	winged euonymus	<i>Euonymus alatus</i> 'Compactus'
white pine	<i>Pinus strobus</i>	boxwood	<i>Buxus sempervirens</i> 'Winter Gem'
black spruce	<i>Picea mariana</i>	arrowwood viburnum	<i>Viburnum dentatum</i>
reed canary grass	<i>Phalaris arundinacea</i>		'Chicago Lustre'
	'Feeseys Form'	dogwood	<i>Cornus alba</i> 'Ivory Halo'

**Knawel control in seedling conifers**

**Authors**

Robert J. Richardson and Bernard H. Zandstra, MSU Dept. of Horticulture

**Funding**

Project GREEN, Michigan Christmas Tree Association

**Significance**

Knawel is a low-growing annual weed that may form dense stands in seedling conifers. This is another introduced species that has become naturalized in the United States. Knawel is a very adaptable species and has been reported in most states including Michigan, Florida, California and Washington. In Michigan, most knawel germination will occur in spring and fall. It will appear grass-like as a seedling, but will more closely resemble moss as it matures. Knawel has small linear leaves and small flowers that are usually green and rarely white. This weed will form low clumps or mats, and plants are usually less than 5 inches in height. Traditional weed control methods in seedling conifers often fail to control knawel.

**Materials and methods**

Two studies were conducted in 2003 near Manistee, Michigan to evaluate knawel control with various herbicides. In the first study, treatments were

applied to freshly cultivated ground with no crop before knawel emergence. In the second study, treatments were applied to blue spruce seedlings after knawel emergence. Treatments in both studies were applied on May 22, 2003. Weed control and crop injury was visually rated on a 0 to 100% scale with 0 equal to no weed control or no crop injury and 100 equal to complete weed or crop death. Sprayer output was 20 GPA in both studies. Treatments are listed in Table 1. An untreated control was included in both studies for comparison to herbicide treatments.


**Results**

In the preemergence study, knawel control was at least 93% on June 24 and July 17 with all herbicide applications (Table 1). In the postemergence study, control on June 24 ranged 72 to 82% with 0.25 lb ai/A SureGuard, SureGuard plus Surflan, Princep, Princep plus Pennant Magnum, and Image. Control was 87% to 89% with 0.38 lb ai/A SureGuard and Image plus Pennant Magnum. Highest control was observed with SureGuard plus Pennant Magnum at 95%. On September 5, control was still greatest with SureGuard plus Pennant Magnum at 89%. Control ranged 73% to 79% with all other treatments except Image, which controlled knawel only 58%. No injury was observed to the crop from herbicide applications.

**Conclusions and future research**

Knawel was more tolerant to the postemergence applications of the herbicides evaluated than preemergence applications. With postemergence

applications, control was often greater when Pennant Magnum was included than when SureGuard or Image were applied alone. More research is needed to determine if this is an adjuvant effect of the

Pennant Magnum formulation or if Pennant Magnum has activity on this broadleaf weed. Additional studies will be conducted in the field and the greenhouse in 2004 to further evaluate knawel control. 

**Table 1.** Preemergence and postemergence of knawel control with selected herbicides.<sup>a</sup>

Treatment name			Preemergence		Postemergence	
Chemical	Trade	Rate <sup>b</sup>	6-24-03	7-17-03	6-24-03	9-5-03
		lb ai/A	%			
Flumioxazin	SureGuard	0.25	100	100	79	73
Flumioxazin	SureGuard	0.38	98	97	88	79
Flumioxazin + s-metolachlor	SureGuard + Pennant Magnum	0.25 + 1.5	99	98	95	89
Flumioxazin + oryzalin	SureGuard + Surflan	0.25	95	93	76	74
Simazine	Princep	1.5	93	93	82	78
Simazine + s-metolachlor	Princep + Pennant Magnum	1.5	98	96	81	78
Imazaquin	Image	0.375	98	95	72	58
Imazaquin + s-metolachlor	Image + Pennant Magnum	0.375 + 1.5	100	98	87	78
LSD (0.05) <sup>b</sup>			3	6	10	12

<sup>a</sup> All ratings on 0 to 100% scale with 0 equal to no control and 100 equal to complete weed death.  
<sup>b</sup> Means separated with Fisher's Protected LSD test at P = 0.05. Differences in rating values must be equal to or greater than the number in the LSD column to be considered significantly different.

## Liverwort and hosta response to selected herbicides

### Authors

Rob Richardson and Bernard Zandstra, MSU Dept. of Horticulture; Tom Dudek, MSU Extension

### Funding

Crompton, Inc., Project GREEN

### Significance

Liverworts are non-vascular, primitive plants that reproduce through spores. These plants can form dense colonies in greenhouse pots resulting in crop damage and reduced marketability. Control of these plants is very difficult. Traditional herbicides may not be applied in greenhouses and handweeding is a temporary solution at best. Current liverwort controls must focus on prevention, sanitation, and careful regulation of watering.

### Materials and methods

A study was conducted in 2003 to evaluate liverwort control and Hosta 'Great Expectations' tolerance to selected herbicides. Treatments included

two rates of A1656 (an experimental herbicide), Terracyte, BroadStar, and Ronstar G, and a single rate of SureGuard (Table 1). Spray formulations were applied with a backpack sprayer calibrated to deliver 20 gallons per acre of output. Granular formulations were applied using a hand-shaker calibrated for proper rate delivery. Hosta were being held over by the cooperator due to poor vigor and a high infestation of liverwort. Approximate liverwort coverage of pots at time of application was 50%. All pots were watered after application to rinse herbicide from crop foliage and provide adequate moisture for activation. Liverwort control and Hosta injury were rated on a 0 to 100% scale, with 0% equal to no control or no crop injury and 100% equal to complete control or crop death. Ratings were collected on June 19, July 15, August 6, and September 24. Liverwort coverage of the untreated pots on these dates was approximately 70, 85, 90, and 95%, respectively. In addition, Hosta diameter was measured to the nearest inch on September 24. Treatment means are listed in tables 1 and 2 followed by the standard error for each.

## Pesticide evaluation

### Results

Liverwort control on June 19, was 67 to 79% with A1656 (6.8 lb/A), Terracyte (15 lb/1000 ft<sup>2</sup>), and both rates of BroadStar (Table 1). The higher Ronstar G rate controlled 55 to 62% of liverwort on June 19, July 15, and August 6, while control exceeded 86% on June 19, July 15, and August 6, with A1656 (13.6 lb/A) and SureGuard (0.25 lb ai/A). On July 15, control was 61 to 69% with most other treatments. Control on September 24, was 75% with A1656 (13.6 lb/A) and 87% with SureGuard (0.25 lb ai/A). Control did not exceed 44% at any rating with the lower Terracyte rate (5 lb/1000 ft<sup>2</sup>) or the low rate of Ronstar G (150 lb/A).

Hosta injury was high on each rating date with the flumioxazin formulations, BroadStar and SureGuard (Table 2). Injury ranged from 25 to 66% over all rating intervals with these treatments. Hosta injury on June 19 was 12% with the A1656 (13.6 lb/A), 5% with Ronstar G (150 lb/A), and 7 to 9% with other non-flumioxazin treatments. On July 15, injury was 8 to 9% with A1656 (13.6 lb/A) and Ronstar G (150 lb/A), and 5 to 6% with other non-flumioxazin treatments. Hosta injury on August 6 and September 24 was 0 to 1% with both rates of A1656 and Terracyte. Injury with Ronstar G was 4 to 8% on August 6 and 0% on September 24. Hosta diameter

**Table 1.** Liverwort control with selected herbicides.<sup>a</sup>

Herbicide name Common	Trade	Rate	Rating date			
			6/19/03	7/15/03	8/6/03	9/24/03
			%			
Quinoclamine	A1656	6.8 lb/A	74 ± 6	61 ± 6	38 ± 7	18 ± 7
	A1656	13.6 lb/A	92 ± 2	90 ± 4	87 ± 4	75 ± 5
Sodium carbonate peroxyhydrate	Terracyte	5 lb/1000 ft <sup>2</sup>	41 ± 6	30 ± 8	16 ± 8	7 ± 6
	Terracyte	15 lb/1000 ft <sup>2</sup>	79 ± 4	69 ± 6	53 ± 8	20 ± 7
Flumioxazin	BroadStar	150 lb/A	67 ± 6	68 ± 8	58 ± 9	25 ± 8
	BroadStar	200 lb/A	70 ± 5	65 ± 6	58 ± 7	18 ± 5
Flumioxazin	SureGuard	0.25 lb ai/A	93 ± 1	98 ± 1	97 ± 2	87 ± 9
Oxadiazon	Ronstar G	150 lb/A	44 ± 6	42 ± 6	40 ± 9	21 ± 11
	Ronstar G	200 lb/A	55 ± 5	62 ± 8	56 ± 10	32 ± 10

<sup>a</sup> All ratings on 0 to 100% scale with 0% equal to no liverwort control and 100% equal to complete liverwort death. Treatment means are followed by the standard error for that treatment, i.e., Quinoclamine applied at 6.8 lbs, (rated on 6/19/03) gave 74 percent control plus or minus 6 percentage points for an effective range of 68-80% control.

**Table 2.** Hosta response to herbicide treatment.

Herbicide	Rate	Injury <sup>a</sup>				Diameter
		6/19/03	7/15/03	8/6/03	9/24/03	9/24/03
		%				inch
A1656	6.8 lb/A	8 ± 1	6 ± 1	0 ± 0	0 ± 0	12 ± 1
A1656	13.6 lb/A	12 ± 1	9 ± 2	1 ± 1	0 ± 0	14 ± 1
Terracyte	5 lb/1000 ft <sup>2</sup>	9 ± 2	5 ± 1	0 ± 0	0 ± 0	12 ± 2
Terracyte	15 lb/1000 ft <sup>2</sup>	8 ± 1	5 ± 1	0 ± 0	0 ± 0	12 ± 2
BroadStar	150 lb/A	45 ± 10	34 ± 22	25 ± 25	25 ± 25	8 ± 3
BroadStar	200 lb/A	54 ± 10	66 ± 17	48 ± 21	43 ± 25	6 ± 3
SureGuard	0.25 lb ai/A	60 ± 4	64 ± 21	55 ± 27	63 ± 24	5 ± 3
Ronstar G	150 lb/A	5 ± 1	5 ± 1	4 ± 2	0 ± 0	15 ± 1
Ronstar G	200 lb/A	7 ± 2	8 ± 3	8 ± 1	0 ± 0	10 ± 2
Untreated		0	0	0	0	12 ± 1

<sup>a</sup> All ratings on 0 to 100% scale with 0% equal to no injury and 100% equal to complete Hosta death. Treatment means are followed by the standard error for that treatment.

was 12 to 15 inches on September 24 with the untreated control, Ronstar G (150 lb/A), and both rates of A1656 and Terracyte. Diameter was 10 inches with Ronstar G (200 lb/A) and ranged from 5 to 8 inches with the flumioxazin formulations.

### **Conclusions and future research**

In summary, the highest liverwort control with minimal crop injury was observed with A1656 (13.6 lb/A). Suppression of liverwort was achieved with several other treatments, but SureGuard and

BroadStar treatment resulted in high injury to Hosta. A1656 (6.8 lb/A), Terracyte (15 lb/1000 ft<sup>2</sup>), and Ronstar G (200 lb/A) also suppressed liverwort, but control had generally faded by three months after treatment. Hosta injury may have been higher in this study than observed elsewhere due to low crop vigor. The typical injury that was observed with A1656 and Terracyte was minor speckling of the foliage and Hosta rapidly recovered. This foliar injury should not be a concern for fall applications to labeled crops approaching dormancy. ☞

## **Evaluation of herbicidal controls for yellow fieldcress (*Rorippa sylvestris*)**

### **Authors**

Rob Richardson and Bernard Zandstra, MSU Dept. of Horticulture; Tom Dudek, MSU Extension

### **Funding**

Project GREEN, Michigan Nursery and Landscape Association

### **Significance**

*Rorippa sylvestris* is an exotic, invasive perennial weed that is very difficult to control. This weed has invaded many nurseries in Michigan, infesting both field and container-grown stock. Yellow fieldcress has been found in contaminated perennials such as hosta and has also been found in strawberries in other states. It has been found in most states where ornamentals are grown and it is regulated as a noxious weed in California, North Carolina and Oregon.

Yellow fieldcress is very difficult to control. Root segments smaller than one inch may form new plants. Thus, cultivation may spread root segments out of the infested area and result in a greater weed problem than present initially. The herbicides currently used in ornamental production do not control yellow fieldcress. In addition, handweeding is very ineffective for controlling this weed. Yellow fieldcress grows low along the ground and leaves break off if pulled. This results in removal of most of the weed foliage by handweeding, but roots are left intact. Therefore, research studies were conducted to evaluate postemergence herbicides for yellow fieldcress control.

### **Materials and methods**

Field and greenhouse studies were conducted to evaluate control of yellow fieldcress with selected herbicides. The field study was conducted near West Olive, Michigan in a fallow field with no crop present.

Treatments were applied on October 8, 2002, and weed control was evaluated several times after application. Weed control was visually rated on a 0 to 100 percent scale with 0 equal to no weed control and 100 equal to complete weed death. Sprayer output was 20 GPA in both field and greenhouse studies. Treatments for field and greenhouse studies are listed in Table 1. An untreated control was included in all studies for comparison to herbicide treatments. In the greenhouse study, weed control was also visually rated after herbicide application to yellow fieldcress. Pots were harvested at four weeks after treatment to determine the biomass of yellow fieldcress in each treatment. A second harvest to determine regrowth was conducted five weeks after initial harvest. Regrowth data was converted to a percentage of the untreated control. All data was subjected to analysis of variance and Fisher's Protected LSD was used for mean separation.

### **Results**

Initial control of yellow fieldcress exceeded 80% with Clarity, Weedar 64, Finale, Redeem R&P, and Curtail M treatments in the field study. Control with other treatments in October 2002 was not greater than 58%. However, in May 2003 control was 95% or greater with Clarity, Weedar 64, Plateau, Manage, Redeem R&P and Curtail M treatments. Control with Roundup UltraMax was 77%, while SureGuard controlled 63% of the weed. Control with Lontrel, Finale and Muster in May 2003 was only 30 to 33%.

In the greenhouse study, control at four weeks after treatment was at least 82% with Weedar 64, Roundup UltraMax, Finale, Redeem R&P and Curtail M. Regrowth from harvested pots was less than 5% of the untreated control with Weedar 64, Finale, Plateau, Manage, Redeem R&P and Curtail M, indicating death of roots with these treatments. Clarity, Lontrel and Muster provided no control of


## Pesticide evaluation

yellow fieldcress in the greenhouse.

### Conclusions and future research

Excellent control of yellow fieldcress was obtained with Weedar 64, Plateau, Manage, Redeem R&P and Curtail M. While control with Plateau and Manage was slow to develop, these two herbicides have the most potential of those tested for selective control within ornamental crops. In non-crop situations, Weedar 64, Redeem R&P and Curtail M may provide excellent control in a shorter amount of time than Plateau and Manage. These three herbicides are not

safe to use on most ornamental crops, but may be used in certain areas not in crop production.

As Plateau and Manage are not currently labeled for ornamental crops, additional research is needed prior to pursuing a special local needs label for either herbicide. An additional field study was established in October 2003, to repeat the previous study and additional greenhouse studies have been conducted. The results from all studies will be compiled and published. In addition, a bulletin on yellow fieldcress will be published through Michigan State University Extension late in 2003. 

**Table 1.** Control of yellow fieldcress in field and greenhouse studies with selected herbicides.<sup>a</sup>

Herbicide name			Field		Greenhouse	
Chemical	Trade	Rate <sup>b</sup>	10-24-02	5-08-03	Control	Regrowth <sup>c</sup>
		lb ai/A	%			
Dicamba	Clarity	1	83	97	71	90
2,4-D	Weedar 64	2	92	100	93	4
Clopyralid	Lontrel	0.188	38	30	20	136
Glyphosate	Roundup UltraMax	1	51	77	92	11
Glufosinate	Finale	1	89	33	95	3
Flumioxazin	SureGuard	0.38	58	63	54	77
Imazapic	Plateau <sup>b</sup>	0.19	44	100	77	0
Halosulfuron	Manage <sup>b</sup>	0.094	33	95	62	0
Ethametsulfuron	Muster <sup>b</sup>	0.032	27	30	24	113
Triclopyr + clopyralid	Redeem R&P	1	81	100	82	0
MCPA + clopyralid	Curtail M	1	91	100	99	0
LSD (0.05) <sup>d</sup>			9	13	11	15

<sup>a</sup> All ratings on 0 to 100% scale with 0% equal to no control and 100% equal to complete weed death.

<sup>b</sup> Non-ionic surfactant (0.25% v/v) included with treatment.

<sup>c</sup> Regrowth was determined by harvesting fieldcress foliage five weeks after an initial harvest. The initial harvest was conducted at four weeks after treatment. Regrowth data is expressed as a percentage of the untreated control.

<sup>d</sup> Means separated with Fisher's Protected LSD test at P = 0.05. Difference in rating values must be equal or greater than the number in the LSD column to be considered significantly different.

## Chlorophyll fluorescence and needle chlorophyll concentration of fir seedlings in response to pH

### Authors

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### Funding

Project GREEN, Michigan Nursery and Landscape Association

### Introduction

True firs include a number of species that may add diversity to the conifers available for landscape planting. The genus *Abies* includes 50 to 60 species of trees native to North and Central America, Europe, Asia and North America. Most species of true firs occur in cool, moist habitats in northern latitudes or at high elevation in lower latitudes. In the upper Midwest, the use of true firs in landscapes is limited by their fairly exacting site requirements. In general, most firs grow best on sites with good drainage, adequate moisture and low soil pH. For example, Fraser fir (*Abies fraseri*) is native to mountainous sites with extremely acid soils; the pH is about 3.5 to 4.2. Concolor fir (*A. concolor*) and Canaan fir (*Abies balsamea* var. *phanerolepis*), in contrast, may grow on sites with considerably higher pH, indicating that *Abies* spp. vary in their pH tolerance. However, most information on the pH tolerance of firs is based on observational studies of soils in forest stands. Little direct comparative data on the relative pH tolerance of firs has been reported.

Increasing soil pH may induce chlorosis in plants due to reduced uptake of one or more nutrients particularly phosphorus (P), manganese (Mn), boron (B), and copper (Cu). All of these nutrients are involved, either directly or indirectly, in photosynthetic processes. Understanding the effect of increasing soil pH on photosynthetic function may provide an opportunity for identifying species or genotypes that are adapted to relatively alkaline conditions. Chlorophyll fluorescence ( $F_v/F_m$ ) can be used as an estimation of photosynthetic efficiency. Because the function of the photosynthetic system is related to foliar nutrition, variable chlorophyll fluorescence may provide a rapid means to identify physiological response of plants to nutrient imbalances.

The objectives of the present study were to: 1) compare the response of five diverse species of true firs (*Abies* spp.) to varying soil pH and 2) determine

the utility of chlorophyll fluorescence as a tool to measure this response.

### Materials and Methods

The study was conducted in a glass greenhouse at the Michigan State University Plant Science greenhouse complex. We planted plug +2 or 2-2 seedlings of five *Abies* spp. (Table 1) in 8 liter containers filled with a mixture of sphagnum moss and perlite. Seedlings from each species were assigned at random to one of five pH treatments. Treatments were applied in a completely randomized design. Media pH was modified by addition of liquid flowable dolomitic limestone to the irrigation program. Based on a preliminary trial, four concentrations of flowable lime were applied to produce a range of soil pH conditions with at least 0.5 pH difference between each level of treatment. A fifth group of seedlings did not receive dolomitic lime. Media pH was determined weekly or bi-weekly on a subset of plants from each treatment. Flowable lime was applied as needed to maintain the seedlings at the desired pH level. After 30 weeks exposure to the pH treatments, we measured dark-adapted variable chlorophyll fluorescence ( $F_v$ ) and maximum chlorophyll fluorescence ( $F_m$ ) on newly formed needles using a portable chlorophyll fluorescence system. After measuring  $F_v/F_m$ , we collected foliage from each seedling to determine chlorophyll content.

### Results

Flowable lime application produced a consistent range of pH conditions among the treatments (Figure 1). Averaged across the study period, the dolomitic lime application maintained at least a 0.58 unit difference between each pH level. The total pH range achieved was approximately 3.5 pH units (3.38 to 6.80).

Photosynthetic efficiency, as indicated by variable chlorophyll fluorescence ( $F_v/F_m$ ), declined with increasing pH, especially at the highest pH level (Figure 2). (Editor's note: Photosynthetic efficiency is a measure of the ability of the plant's photosynthetic system to capture light energy.) At the highest pH level, chlorophyll fluorescence of *A. lasiocarpa* was significantly higher than *A. borisii regis*.

Chlorophyll concentration in needles decreased significantly with increasing pH (Figure 2). Visible chlorosis symptoms were evident in seedlings at 1:50 lime:water ratio and higher pH treatments. Among the species tested, *Abies veitchii* was the least sensitive

## Nursery production and production systems

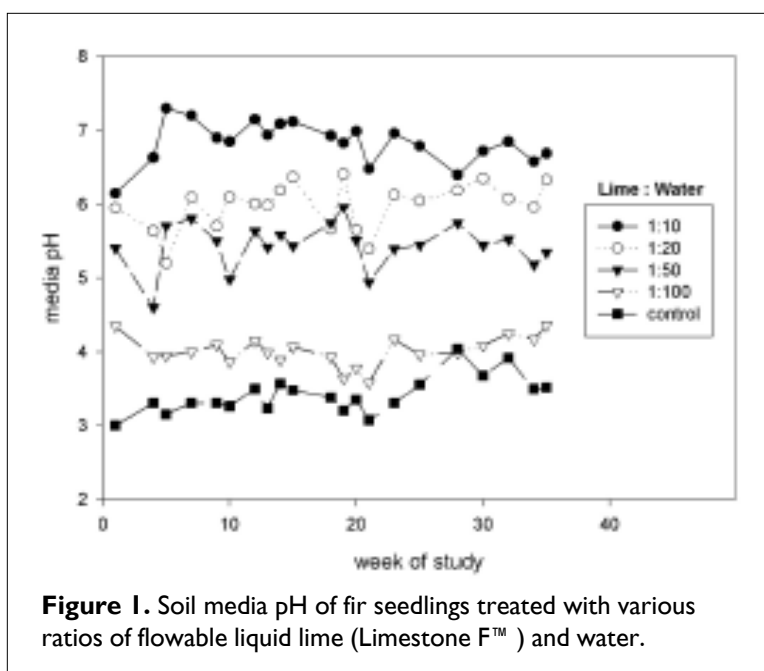
to increasing pH as measured by chlorophyll concentration in needles (Figure 2).

Foliar concentration of several nutrients differed significantly among treatments and species. Nutrient concentrations were generally lower in *A. borisii regis* compared to other species. Foliar concentrations of N (nitrogen), P (phosphorus), Mn (manganese), B (boron), and Cu (copper) declined in response to increasing pH. Foliar Mg (magnesium) and Ca (calcium) increased with pH, due to increased availability of these ions with the dolomitic limestone treatment. Foliar iron, sulfur, zinc and potassium were not significantly affected by lime treatment.

Chlorophyll concentration and Fv/Fm were highly correlated ( $r = 0.71$ ,  $P < 0.001$ ). Analysis of these correlations suggest that photochemical response of *Abies* to increased pH is related to decreased uptake of P, Mn, and Cu (Table 2).

### Discussion

The results of this study indicate that the photochemistry of seedlings of *A. lasiocarpa* and *A. veitchii* is more tolerant of increasing soil alkalinity than the other species tested. Fir species vary widely in their response to various biotic and abiotic stresses including resistance to fungal diseases and drought and cold tolerance. Among North American fir species, optimum pH varies widely. Fraser fir and Pacific silver fir grow on strongly acid soils (pH 3.3 to 4.2). Balsam fir grows under a wide range of soil pH



**Figure 1.** Soil media pH of fir seedlings treated with various ratios of flowable liquid lime (Limestone F™) and water.

**Table 1.** *Abies* species studied in this trial

Scientific name	Common names	Geographic origin
<i>Abies lasiocarpa</i>	Sub-alpine fir	W. North America
<i>Abies veitchii</i>	Veitch fir	Japan: Honshu
<i>Abies sachalinensis</i>	Sakhalin fir	Sakhalin, S. Kuril Islands, Japan
<i>Abies sibirica</i>	Siberian fir	Siberia, Turkestan; Mongolia; China
<i>Abies borisii regis</i>	King Boris Fir	Bulgaria, N Greece, Albania, and the former Yugoslavia

**Table 2.** Simple correlation coefficients for chlorophyll fluorescence, chlorophyll concentration and foliar nutrients of *Abies* spp. seedlings under varying container media pH.

	Fv/Fm	chl a+b	P	Mn	Cu
<b>pH</b>	-0.74***	-0.74***	-0.66**	-0.42*	-0.72***
<b>Fv/Fm</b>	-	0.72***	0.40*	0.36	0.53**
<b>Chl a+b</b>		-	0.46*	0.47*	0.40*
<b>P</b>			-	0.48*	0.65**
<b>Mn</b>				-	0.36

Increasing significance of correlations is indicated by an increased number of asterisks

\*,  $P < 0.05$ ;

\*\*,  $P < 0.01$ ;

\*\*\*,  $P < 0.0001$

**NOTE:** A correlation coefficient range between -1 and 1 indicates how closely the two variables are related. A correlation coefficient of 0 indicates no relationship between variables. The greater the absolute value of a correlation coefficient, the stronger the relationship between variables. A negative correlation coefficient indicates that one variable (e.g. chlorophyll content) decreases while the other one increases (e.g. chlorophyll concentration vs. pH).

conditions and achieves its best growth on soils with pH between 6.5 and 7.0. *Abies lasiocarpa*, which was relatively insensitive to increasing pH in this study, has an extensive native range and occurs across a range of soil pH levels from 4.5 to 5.9.

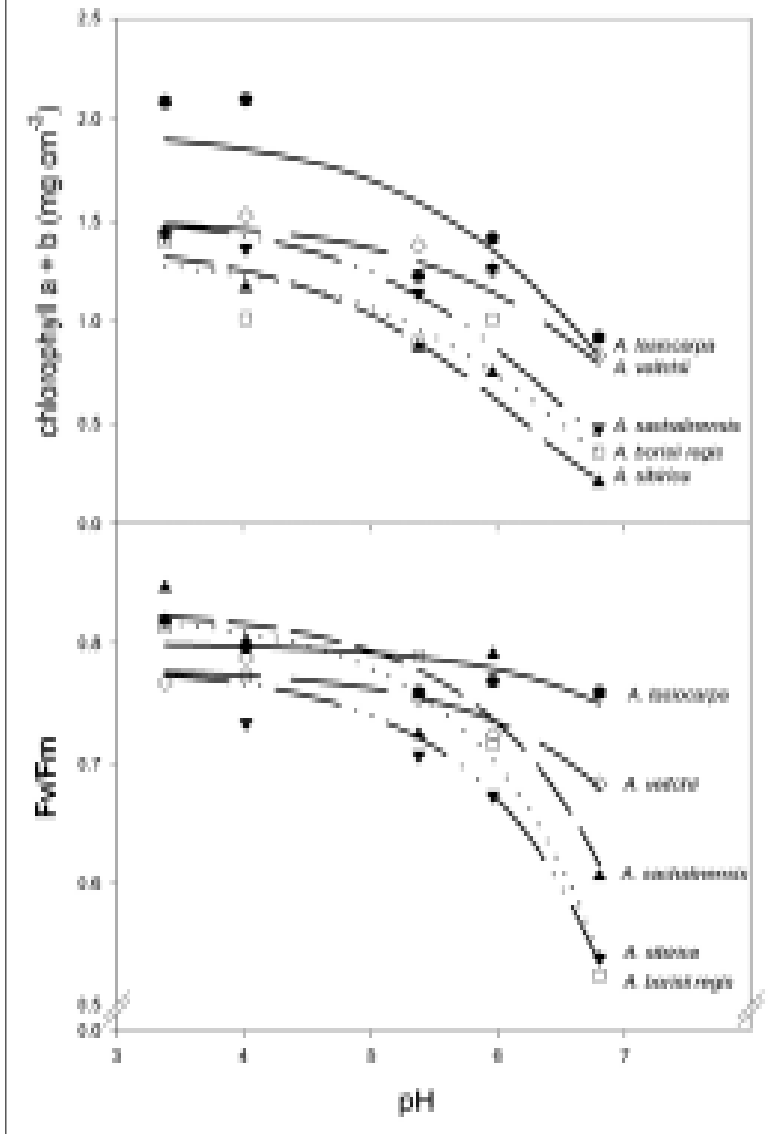
The general decline in chlorophyll concentration and photosystem II efficiency with increasing pH observed here is consistent with the response reported for other firs. Other researchers found that seedlings of Fraser fir grew best at a soil pH between 4.2 and 4.5. Moreover, they noted that the seedlings became visibly chlorotic at soil pH greater than 5.0. Chlorosis of declining *Abies alba* trees in forest stands in Switzerland was attributed to a shift in pH from 3.7-4.4 to 7.0-7.1.

Increasing chlorosis and reduced photosynthetic activity in firs in response to pH is attributed to reduced uptake of several key elements, particularly Mn, P, B, and Cu. B, P, Zn, and Cu are severely reduced as pH increases above 6 and Mn availability declines sharply at pH higher than 5.5. All of these nutrient elements affected by pH are involved with photosynthetic processes and may be associated with the decreases observed in Fv/Fm and/or chlorophyll content. Variable chlorophyll fluorescence appears to provide a rapid and effective mechanism to identify pH tolerance among *Abies* species.

**Summary**

As media pH increased above 6, chlorophyll fluorescence and needle chlorophyll concentration declined in the five *Abies* species tested. The effect of pH on photochemistry was due to decreased nutrient uptake of P, Mn, B, and Cu. Because photosynthetic efficiency may be related to deficiencies of several elements affected by pH, chlorophyll fluorescence (Fv/Fm) may serve as a tool to select for improved pH tolerance, and suggest which fir species may be more tolerant of the higher pH soils found in Midwest landscapes. Among the species examined, *A. veitchii* and *A. lasiocarpa* were most tolerant of increased pH based on the tests used.

**Figure 2.** (top) Relationship between variable chlorophyll fluorescence and soil media pH of seedlings from five *Abies* species. (bottom) Relationship between needle chlorophyll content and soil media pH of seedlings from five *Abies* species.



# Precocious cone production in Fraser fir

### Authors

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### Funding

Project GREEN, Mich. Christmas Tree Association

### Industry partners

Tannenbaum Farms, Slocum Brothers Tree Farm

### Introduction

Heavy cone production is a frequent problem in Fraser fir (*Abies fraseri*) Christmas tree plantations in Michigan. Unlike other members of the Pinaceae, cones of true firs (genus *Abies*) shed their scales in the fall and only the cone stalks remain. The cone stalks are unsightly and can reduce the value of Christmas trees or render them unsalable. The number of cones on a given tree varies from none or a few to several hundred (photo, color insert, page A3). Besides reducing the aesthetic value of a tree, rapidly growing cone buds demand large amounts of the tree's energy reserves. In Christmas tree plantations, growers typically remove cone buds within a few weeks of cone bud-break. When cone buds are less than 3 cm (1.25 inches) long they can be easily pinched off. However, cone picking must be done by hand and can require significant amounts of labor (photo, color insert, page A3).

As part of an on-going program to optimize production of Fraser fir for Christmas trees in Michigan, we are investigating methods to eliminate precocious cone production. In this paper, the biology of cone production in firs, factors influencing cone production, and how these factors may be modified to reduce coning in Fraser fir are reviewed.

### Biology of cone production

The development of cones in firs occurs in a two-year cycle (Table 1 on page 17). In year one, buds develop on the current-year's growing shoots. Initially the buds are undifferentiated and may develop into vegetative (shoot) buds or reproductive (cone or pollen) buds. At about the time the shoots cease elongation, hormonal signals in the tree cause some of the developing buds to differentiate into reproductive buds. These buds continue to develop over the first year but cannot be readily distinguished from vegetative buds. In the second year, cone buds grow and develop rapidly before the vegetative flush.

Cones continue to mature and are pollinated in the summer, and the seeds are shed in the fall.

### Factors affecting cone production

Flowering in *Abies* appears to be even more inconsistent than in other conifers. While environmental and within plant control of conifer flowering is not completely understood, several factors are known to influence flowering. Our knowledge of these factors comes primarily from studies directed at improving flowering of conifers in seed orchard production. Study results indicate hormonal relations, growth patterns within the plant, temperature, water availability, nutrition, and tree size or age may influence cone production.

- **Hormones** – Gibberellins are the hormones most consistently associated with flower production in conifers. Application of gibberellins increases flower cone production in a number of conifer species.
- **Cone crop cycles** – Intervals between heavy cone crops vary from two to seven years for temperate members of the Pinaceae. In a study of forest trees in California, *Abies concolor* produced the most infrequent cone crops compared with Douglas-fir, ponderosa pine and sugar pine.
- **Temperature and water stress** – Both temperature and water stress affect cone development. In the Pacific Northwest researchers increased flower production in an *Abies amabilis* seed orchard by erecting small clear plastic tents over the trees during the late spring and summer. Air temperatures inside the tents increased up to 14°F above ambient. Placing tents over the trees increased the average number of cones per tree from 3 to 8 to 22 to 24 compared to related treatments without tents. Water stress and root pruning are also used in seed orchards to enhance flowering.
- **Nutrition** – Flower production generally increases with improved nutrition, especially nitrogen and phosphorus. The form of nitrogen fertilizer is also important. Nitrate fertilizers may increase flower production up to ten-fold compared to ammonium sources.
- **Tree age/ size** – Most conifers do not produce significant cone crops until age 15 to 45 years. Among North American firs, Fraser fir and balsam fir are considered the earliest to flower. In a test plantation near East Lansing, Michigan we observed cones on trees three years after planting as 2-3 seedlings (i.e., eight years from seed). We also observed extremely early (less than 8 years) flowering in Korean fir and Korean x Balsam hybrids in our exotic fir test plots.

Table 1. Bud development in true firs.

Bud development (year 1)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Dormant vegetative buds												
Bud-scale initiation												
Bud differentiation												
a) initiation and development of pollen-bearing organs; becomes dormant pollen-cone bud												
b) bract initiation												
becomes dormant seed-cone bud												
c) leaf initiation												
becomes dormant vegetative bud												
<b>Shoot development (year 2)</b>												
Dormant flushing of new growth:												
a) bud enlargement												
b) shoot elongation												
shoot maturation												
<b>Cone development (year 2)</b>												
dormant seed-cone bud												
cone-bud development												
pollination												
rapid seed-cone growth												
fertilization												
cone and seed maturation												
seed shed												
Adapted from Owens (1984)												

### Research approaches to reducing flowering

Based on the developmental patterns of cones, we are investigating two approaches to eliminating cone production. First, we are evaluating the use of flower thinning agents commonly used in the tree fruit industry. These caustic chemicals cause fruit tree flowers to abort. Wilthin and ammonium thiosulfate are two products presently on the market for flower thinning of fruit trees. In the spring of 2001 we initiated trials to evaluate the effectiveness of Wilthin to thin Fraser fir cones. Results from an on-farm trial in Ingham County, Michigan, indicated that Wilthin at a high rate (8%) stopped the development of over 60% of the cones on treated trees (Figure 3). A second on-farm trial in Oceana County, Michigan yielded similar results in 2001. In 2002 and 2003, the experiments were repeated at the on-farm site in Ingham County. In subsequent trials, Wilthin and ammonium thiosulfate did not stop cone development and we observed significant needle phytotoxicity.

A second approach to eliminating cone production is to disrupt internal chemical signals that cause some undifferentiated buds on the current year's shoot to become next year's cone buds. From research on promoting flowering in seed orchards, we know that a hormone, gibberellic acid (GA), increases cone production in many conifers, including true firs. Several plant growth retardants used in the floriculture trade are GA inhibitors. These compounds retard growth of greenhouse crops by inhibiting GA synthesis or GA translocation. In the spring of 2003, we treated 50 trees each with one of five PGR's. The trees were treated three times on a bi-weekly basis beginning when current year's short growth was nearly complete. The trees will be scored in the spring of 2004 for cone production.

### Suggestions for growers

Cone flowering in *Abies* is a complex process controlled by a variety of potentially interacting

**Table 2.** Reported ages for first cone crop of North American fir species

Species	Age of first cone crop (years)
<i>A. amabilis</i>	20-30
<i>A. balsamea</i>	15
<i>A. concolor</i>	40
<i>A. grandis</i>	20
<i>A. lasiocarpa</i>	20
<i>A. bifolia</i>	50
<i>A. magnifica</i>	35-45
<i>A. magnifica</i> var. <i>shastensis</i>	30-40
<i>A. procera</i>	20
<i>A. fraseri</i>	15

Compiled from Silvics of North America

factors. Some standard practices in Christmas tree culture may contribute to increased flowering. The typically high level of fertility maintained by growers may promote flowering. It seems unlikely that a single approach will completely eliminate flowering. However, growers may consider modifying cultural practices to reduce flowering.

- Use ammonium sources of nitrogen rather than nitrate
- Irrigate trees to reduce moisture stress when buds are differentiating (current year's shoots are 50% to 100% elongated).
- Overhead irrigation, if available, may be used for cooling on warm days when buds are differentiating.
- Flower thinning agents tested to date are not consistently effective and caused phytotoxicity to needles.
- Pruning reduces the number of cones per tree by reducing shoot length but does not affect cones per length of shoot. ☞

## Controlling size of *Syringa meyeri* 'Palibin' with plant growth regulators

### Authors

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### Funding

Michigan Nursery and Landscape Association, Spring Meadow Nursery, Metro Detroit Flower Growers Association, Western Michigan Greenhouse Association, The Fred C. Gloeckner Foundation, The Ohio Floriculture Foundation

### Background

The objectives of this project were to develop a compact, floriferous dwarf Korean lilac (*Syringa meyeri* 'Palibin') by using plant growth regulators (PGRs). It is part of a larger project focusing on scheduling the flowering of shrubs to meet market windows such as Mother's Day or Valentines Day. Results from these projects will allow repositioning of traditional outdoor woody plants as indoor potted plants, expanding the market for nursery producers.

Dwarf Korean lilac flowers on second year wood. Our previous research provided a schedule to force dwarf Korean lilac into flower as follows: 12 weeks of growing at 68°F under 16 hour photoperiod, 5 weeks in a cooler at 41°F to fulfill the chilling requirement and 4 weeks at 68°F under 16 hour photoperiod to force into flower. During the 12 weeks of growing, plants became elongated and poorly branched and plant quality was unacceptable for the pot plant market. Using plant growth regulators, we hope to produce a compact pot plant without affecting the quality and quantity of the inflorescences. Also, with branching promotion (an effect of some growth regulators) in the earlier stages of the 12-week growing period, we have the possibility of forming more sites for inflorescence development thus increasing flower quantity. Using the PGRs (rate): B-Nine (2500 ppm), BAP-10 (3000 ppm), Bonzi (100 ppm), and Florel (500 ppm) we found promising results.

### Results

The PGRs were applied beginning three weeks after vegetative bud break (appearance of green

tissue at the vegetative buds). Florel at 500 ppm produced the most compact plants at 1, 2, or 3 sprays (Figure 1). This resulted in a plant that was 73.4%, 46.5%, and 42.5% more compact than the control, respectively. However, the quantity of inflorescences produced were dramatically reduced (Figure 2). B-Nine showed the best combination of size control and flowering of all the growth regulators with a 300% increase in the number of inflorescences over the control. The plants treated with B-Nine were 80.7%, 62.2%, and 70.3% more compact than the control, respectively. Bonzi and BAP-10 resulted in minor or no reduction in growth compared to the control.

The results to date look promising for using PGRs to produce a compact, floriferous dwarf Korean lilac. However, this report contains information from only one year of research and will be repeated this winter to provide confidence in the results. The information from this research can benefit growers interested in expanding into the pot plant market as well as those interested in using PGRs to control plant size in nursery production. Additional research is being conducted to refine the schedule needed to force the plants into flower. ✂

## Optimal nutrition of Fraser fir Christmas trees in Michigan

### Authors

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### Funding

Project GREEN and Michigan Christmas Tree Association

### Introduction

Fraser fir (*Abies fraseri*) production is relatively new to Michigan Christmas tree farms, but plantings are increasing each year due to its popularity among consumers and a wholesale price substantially higher than that of other species. However, because Fraser fir is new to Michigan, there is currently inadequate knowledge of appropriate management practices to intensify production in Michigan. In particular, Fraser fir is widely perceived by Michigan growers to be more sensitive to soil conditions, and more likely to experience nutrient disorders than other species. In its native range, Fraser fir is restricted to highly acidic soils in the Appalachian Mountains, but it is currently being grown in Michigan on soils ranging from fine-textured, highly calcareous glacial till to coarse-textured acid sands. We investigated the relationships between soil properties, tree quality and foliar nutrition across the range of growing conditions in the

Lower Peninsula of Michigan. Our goal was to identify the range of soil conditions on which Fraser fir production was viable, as well as to develop foliar nutrition recommendations specific to Michigan growing conditions.

### Materials and methods

In October of 2001 we conducted a survey of 21 Fraser fir plantations scattered throughout the Lower Peninsula of Michigan (Figure 1). We sampled a total of 218 trees (all between 4 to 5 years old). Each tree was assigned a quality ranking along a 4-point scale in which 4 represented perfect color and 1 was severely chlorotic. We took field measurements of height, basal diameter, leader length, and counted the number of lateral buds on the leader. We then collected current-year needles from two branches on the second whorl down from the leader on the north side of the tree, and four soil samples (to 30 cm depth) from around the dripline of the tree. Foliage samples were analyzed for nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), manganese (Mn), zinc (Zn), copper (Cu) and iron (Fe). Soil samples were analyzed for texture, pH and available nutrients. We identified a subset (24 trees) of the highest performing trees based on color ranking and growth rates, which we used to develop foliar

## Nursery production and production systems

nutrition recommendations. This approach differs from previous investigations in Michigan in which foliar nutrition recommendations were developed without regard to tree quality. We identified the most important foliar nutrients as those that differed significantly between the high performing population and the low performing population.

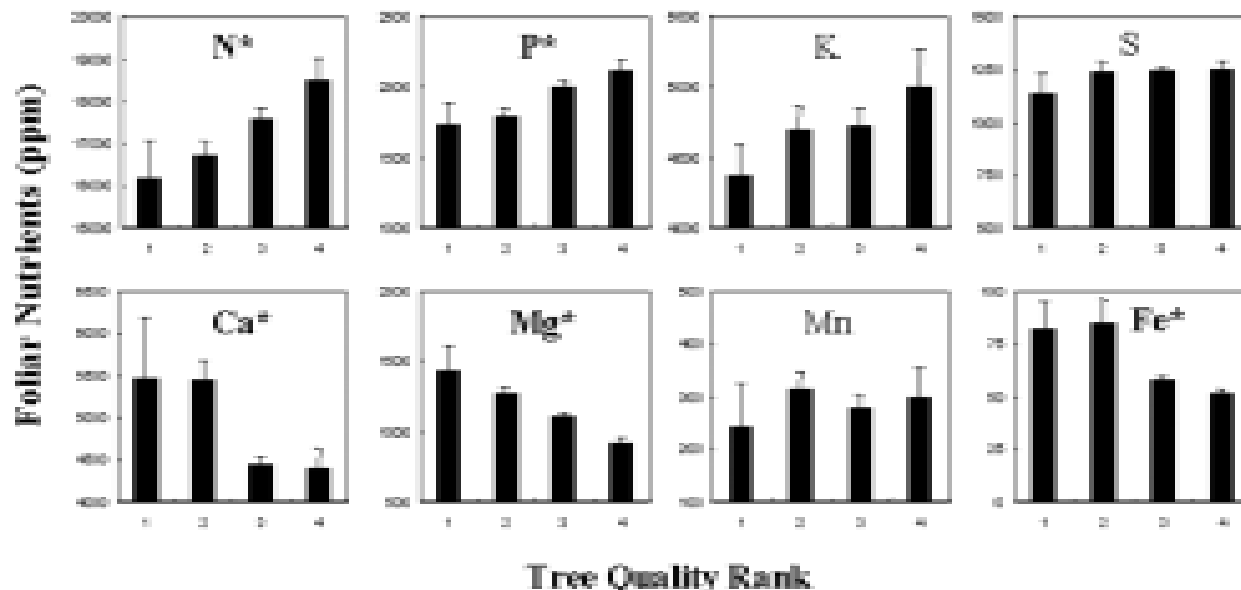
### Results

- High quality Fraser fir trees had higher foliar N and P and lower Ca, Mg and Fe than low quality trees (Figure 1).
- Calcium, Mg and Fe concentrations in poor quality trees are not high enough to indicate toxicity, but rather appear to indicate nutrient imbalances. This is supported by the fact N:Ca, N:Mg, N:Fe, P:Ca, P:Mg and P:Fe ratios all increased with increasing tree quality.
- Nutrient imbalances involving Ca and Mg are most prevalent at high soil pH and likely result from a combination of higher base cation availability and lower N and P availability. In addition,  $Mg^{2+}$  may compete directly with  $NH_4^+$  and  $K^+$  for uptake sites on Fraser fir roots.
- Good growth and color of Fraser fir is possible across a wide range of soil pH, however nutrient deficiencies and imbalances become severe above pH 6.5. In particular, we found severe Mn

**Table I.** Updated foliar nutrition guidelines developed using only high-performing Fraser fir compared to foliar nutrition guidelines developed without consideration of tree quality (Fisher 1996). Data represent optimal ranges of the concentration of each element in the foliage of the high-performing population. Individual element concentrations are reported in units of parts per million (ppm) dry matter.

Nutrient	Updated guidelines	Fisher (1996)	
		Adequate	Optimal
N	16500–20500	15000–18000	18000–22000
<b>P</b>	<b>1750 – 2400</b>	<b>1400 – 2400</b>	<b>2400 – 3300</b>
K	3700–6500	5000–9000	9000–13000
S	1100–1400	1000–1700	1700–2200
Ca	3300–5500	2000–4000	4000–6500
<b>Mg</b>	<b>750 – 1100</b>	<b>400 – 1000</b>	<b>1000 - 2000</b>
Mn	100–600	100–300	300–550
Fe	45–60	30–70	70–100

**Figure 1.** Foliar nutrient concentrations among trees of varying quality rank. Values are means  $\pm$  1 standard error. Foliar nutrients which differed significantly ( $P < 0.05$ ) among quality ranks are indicated with bold font and an asterisk\*. A ranking of 4 represents perfect color and a ranking of 1 was severely chlorotic.



deficiencies in all trees growing in soil with pH greater than 7. The effects of high pH appear to be exacerbated on very heavy textured soils (greater than 50% silt + clay).

- Previous foliar nutrition guidelines developed without regard to tree quality (Fisher 1996) greatly overestimate optimal levels of most nutrients (Table 1). Attempting to maintain foliar nutrient levels in the optimal ranges given by Fisher (1996) will result in excessive fertilization, and in the case of Ca, Mg and Fe, may actually lower tree quality by causing nutrient imbalances.
- Deficiency thresholds for N and P given by Fisher (1996), defined as the bottom of the adequate

nutrition range, appear to be too low (Table 1). Trees with foliar N and P at the low end of this range would likely benefit from added N and P.

**Conclusions**

In order to optimize Fraser fir nutrition in Michigan, growers should use the updated foliar nutrition guidelines presented in Table 1. Trees are most likely to benefit from additions of N and P. Growers should work to maintain soil pH between 5.0 and 6.0; however, the use of lime or dolomitic lime (high Mg content) should be avoided unless trees are deficient in Ca or Mg. ☞

**Growth response of nursery-grown landscape trees to fertigation**

**Authors**

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**Funding**

Michigan Agricultural Experiment Station (MAES) SWMREC Grant Program, J. Frank Schmidt Nursery, Inc.

**Progress report**

For the past three years we have monitored the response of landscape trees to varying resource inputs in a fertigation trial at the Michigan State University Southwest Michigan Research and Extension Center (SWMREC). Bare root whips (4' to 5' tall) of 13 landscape trees species were planted in the spring of 2001. The species list appears in the accompanying figures; data for weeping mulberry is not shown. A total of 40 trees were planted for each species. We applied one of four treatments to 13-tree row plots (1 tree of each species per plot x 10 replications). The treatments were: 1) control (no irrigation: no fertilizer), 2) fertilizer only, 3) irrigation only and 4) irrigation plus fertilizer. Fertilizer was applied at the rate of 150 lbs/ac as ammonium nitrate through the drip system. Irrigated plots received 0.75 inches to 1.5 inches per week depending upon PET (potential evapotranspiration) and rainfall. We measured tree height and stem diameter at 12 inches above ground line at the end of each growing season. Stem volume growth was compared based on stem volume index calculated as  $D^2H$ , where D is stem diameter and H is tree height.

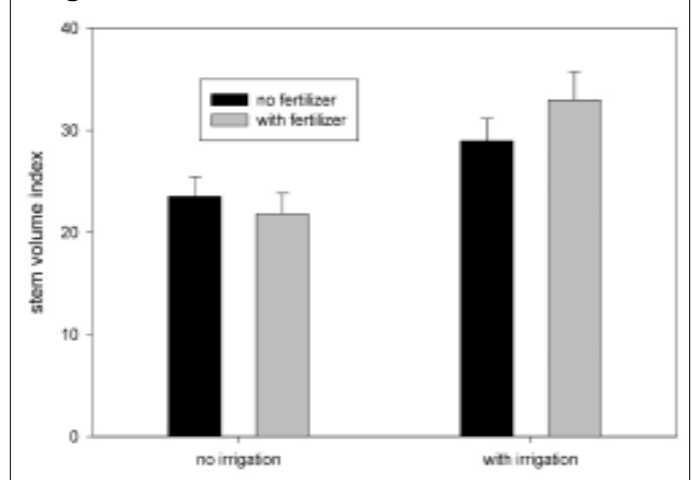
**Fertigation response**

After three years, tree growth response to fertigation was mainly related to irrigation (Figure 1). Stem diameter and stem volume growth was consistently greater for trees receiving irrigation than for non-irrigated trees. Response to fertilization was generally small. However, the interaction of irrigation and fertilization was significant and irrigated trees grew better with fertilization than without.

**Table 1.** Winter mortality of redbud trees at SWMREC following winter 2002-2003

Treatment	Mortality (%)
Control (no irrigation: no fertilizer)	30
Fertilizer only	0
Irrigation only	20
Irrigation + Fertilizer	20

**Figure 1**



**Species response**

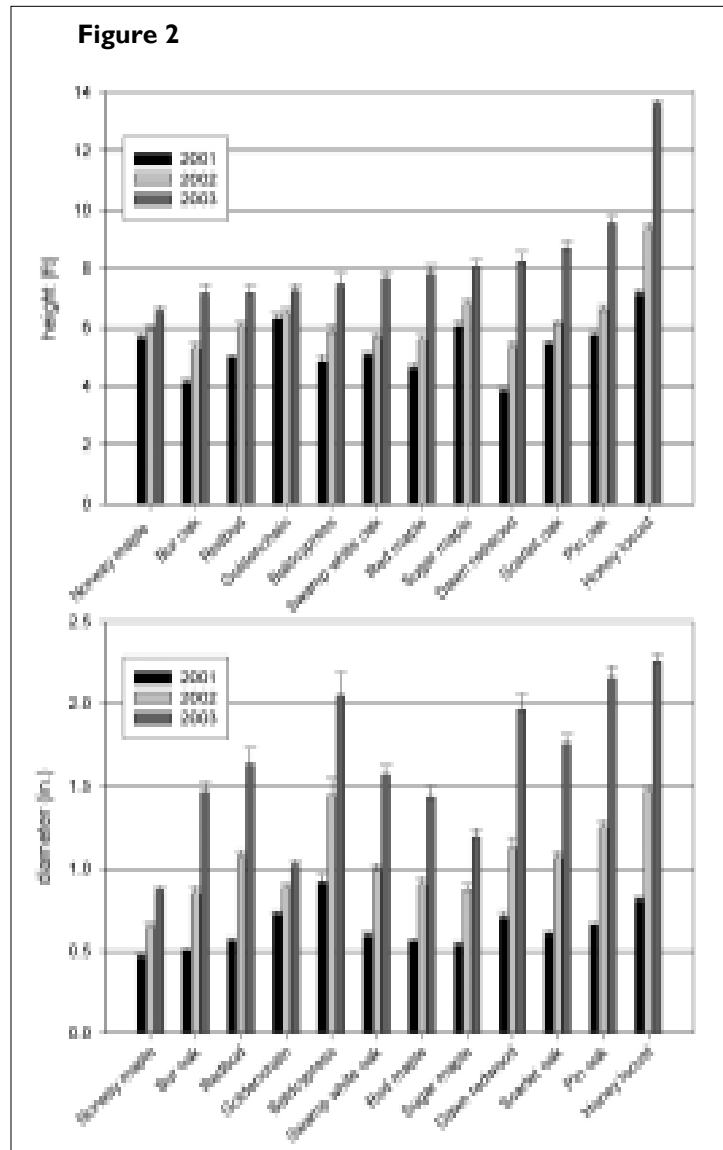
Height and diameter growth varied widely among species (Figure 2). Interaction effects between species and fertigation treatments were not significant, indicating there was no difference among species in response to fertigation. Averaged across all treatments, height growth of swamp white oak, red maple, dawn redwood, scarlet oak and pin oak exceeded two feet in 2003. Honey locust trees grew an average of 4.2 feet in 2003. Height growth of goldenchain and ‘Crimson King’ Norway maple continued to lag behind other species, each growing an average of less than 1 foot per year. Diameter increment exceeded 0.5 inches in 2003 for all species except goldenchain, ‘Crimson King’ Norway maple and sugar maple.

**Winter injury 2002-03**

Severe winter weather during the winter of 2002-03 killed 7 out of 40 redbud trees in the plots. There was not a consistent pattern among fertigation treatments with regard to winter injury (Table 1).

**Continued research**

Research on the SWMREC landscape nursery plots is continuing. Research in 2004 will focus on understanding relative impacts of irrigation and nutrition on tree physiological responses, plant nutrition and leaf area development. 🌱



**Survey of winter damage on herbaceous perennial and woody nursery stock 2002-03**

**Author**

Thomas Dudek, District Extension and Marketing Agent, West Central Region

The winter of 2002-03 was very hard on plant material for nursery growers. The fall was warm and dry until early November when winter moved in. Above-normal temperatures arrived in February followed by below normal temperatures into late March and early April. As a result, perennial and woody plant species suffered significant winter damage across the area. A survey was conducted during June 2003 to determine the extent of the damage and to use the data to plan a Fall 2003

educational meeting addressing the problem. Twenty-two nurseries in West Michigan responded to the survey and reported over three-quarters of a million dollars in lost plant material sales due to damage suffered during the winter of 2002-03. The survey results indicated that small and large sized growing operations were impacted. Plants grown in the field as well as in containers were affected. Reports of winter damage were common, regardless of whether the plants were overwintered outside or under the protection of polyhouses.

According to the survey, the top five herbaceous perennial plants reported with winter damage were

(by dollar volume): *Hemerocallis* (various cultivars); *Astilbe arendsii*; *Papaver orientalis*; *Scabiosa caucasica*; and *Iris germanica*. The top ten woody plants reported with winter damage were (by dollar volume): *Thuja occidentalis* (species and cultivars ‘Woodwardi’, ‘Smaragd’, ‘Pyramidalis’, Dark Green Pyramid’, ‘Emerald Beauty’ and ‘Golden Globe’); *Buddleia davidii* (various cultivars); *Euonymus alatus compactus*; *Buxus microphylla* (‘Winter

Green’ and ‘Winter Gem’); *Rhododendron catawbiense* (various cultivars); *Berberis* ‘Bonanza Gold’; *Viburnum plicatum* (species and cultivars ‘Shasta’ and ‘Newport’); *Cercis canadensis*; *Ilex meserveae* (‘Blue Boy’); and *Forsythia viridissima* ‘Northern Gold’. The accompanying tables on pages 25-29 give a breakdown of injury according to genus/species/cultivar, planting date, growing system, field soil type, and overwintering system. ☞

## Nitrogen management in Michigan Christmas tree plantations

### Authors

David E. Rothstein and Audria L. Holcomb, MSU Dept of Forestry; Jill O’Donnell, MSU Extension

### Funding

Project GREEN and Michigan Christmas Tree Association

### Significance

There is increasing concern over the effects of nitrogen (N) to the global ecosystem. Negative effects of N enrichment include: contamination of drinking water, buildup of algae (and corresponding loss of oxygen) in aquatic ecosystems, losses of biodiversity in terrestrial ecosystems, acidification of soils and groundwater, and global climate change brought about by emissions of nitrous oxide (N<sub>2</sub>O). Nearly 75% of global release of N is associated with fertilizer inputs in food and fiber production. The production of horticultural crops such as Christmas trees has the potential to contribute significant amounts of nitrogen to the environment – one that has received relatively little attention in sustainable agriculture research. In Michigan alone there are 60,000 acres of land devoted to Christmas tree production. Because Christmas trees in Michigan are often planted on sandy soils, the potential for losses of N due to leaching may be particularly high.

### Objectives

- Determine the most efficient level of N application for Fraser fir production.
- Understand fate of N fertilizer applications to Christmas trees.
- Compare the economic and environmental costs.

### About the project

In the spring of 2002, we initiated a study of the response of Fraser fir plantations to varying rates of N addition. We added nitrogen to four-year-old trees at 0, 0.5, 1.0 and 1.5 ounces of N per tree. These

rates correspond to 0, 50, 100, and 150 percent of the amount recommended for four-year-old trees in Michigan. Nitrogen was added as ammonium sulfate ((NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub>) in a single surface application around the drip line of each tree. These trees were planted in 1998 on loam soil at the MSU Forestry Department’s Tree Research Center (TRC) in East Lansing, Michigan. Prior to this experiment the trees had never been fertilized.

Each spring we measured the height, leader length, lateral buds and basal diameter of all trees. (Photo, color insert, page 3A). Throughout the 2003 growing season we collected soil cores (8 in. depth) from the dripline of two randomly-selected trees per plot to determine mineral N (ammonium and nitrate) availability. In October of 2002, we collected foliage to determine foliar N concentrations. We used these estimates, together with measures of N concentration, to estimate the amount of N taken up by each tree (above ground only) over the 2002 growing season.

Tension lysimeters were installed below the rooting zone of three randomly selected trees in each plot to monitor N concentrations that had leached into soil water. Lysimeters were sampled weekly between April and June of both 2002 and 2003 and analyzed for N in the form of ammonium and nitrate.

### Results

We found that springtime applications of fertilizer produced marked increases in available soil N that were sustained throughout the growing season (Figure 1). We also noticed that extractable N levels in soil remained elevated in the 1 and 1.5 oz./tree treatments in early spring of 2003 – a full year after the 2002 fertilization. Control plot trees (which had never been fertilized) had foliar N levels below the 1.5% deficiency threshold defined by Fisher (1996) for Fraser fir in Michigan (Figure 2). Fertilization resulted in a significant increase in foliar N relative to the control; however, there was no apparent response to additions greater than the lowest rate of 0.5 oz./

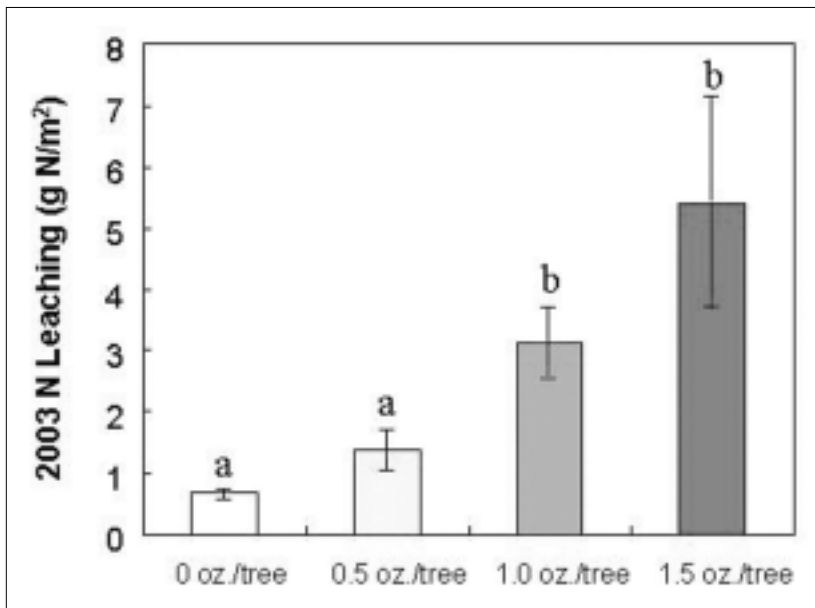
tree. Fertilization had no effect on rates of 2003 height extension or basal diameter growth between 2002 and 2003. In addition, we could find no evidence that fertilized trees took up any more N than control trees. Taken together these data suggest that there is no benefit to adding N at levels above 0.5 oz./tree.

In contrast, the environmental costs of fertilization increase markedly with increasing levels of N addition. Nitrate concentrations of leachate water increased consistently with each increment of added N. Concentrations of nitrate in leachate water were well above the EPA-mandated threshold for safe drinking water (10 mg/L as N). In fact, we frequently recorded concentrations in excess of 200 mg N/L in

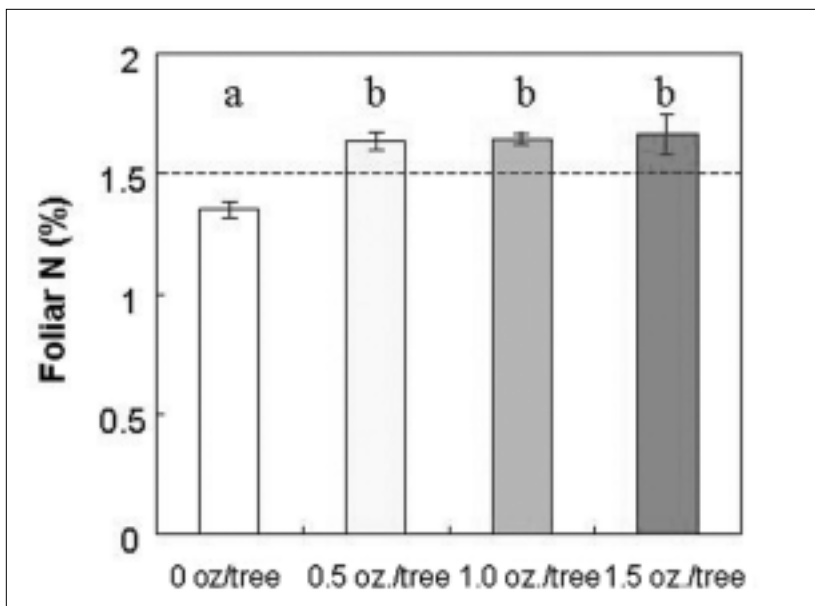
the highest addition rate treatment. This pattern of nitrate concentration detected in the leachate water resulted in clear increases in leaching losses of N with increasing additions of fertilizer.

### Conclusions

- Some N fertilization is necessary, as unfertilized trees appear to be N deficient (yellow).
- We can find no benefit to N additions above 0.5 oz./tree.
- Additions above 0.5 oz. of nitrogen/tree result in significant quantities of N escaping the rooting zone, potentially contributing to groundwater contamination. ☞



**Figure 1.** Spring 2003 N leaching by fertilization treatment. Higher levels of N fertilization significantly increased the amount of N leached ( $P = 0.020$ ).



**Figure 2.** Autumn 2002 foliar N concentrations by fertilization treatment. There was a significant effect of fertilization level on foliar N ( $P = 0.004$ ), however there was no response to N beyond 0.5 oz./tree. The dashed line at 1.5% represents the N deficiency threshold for Fraser fir in Michigan as determined by Fisher (1996).

West Michigan Nursery Winter 2002/2003 Plant Damage Survey of 22 growers (From page 22)

Plants-herbaceous perennials		Planting date			Growing systems		Field soil type		Overwintering system		% Damage
Genus	Species/Cultivar	Spring 2002	Summer 2002	2001 or Earlier	Field	Container	Sand	Loam	Polyhouse	Outside	% Total Inventory of This Plant Affected by Winter Damage
<i>Anemone</i>	<i>pamina</i>	X				X			X		80%
<i>Astilbe</i>	<i>arendsii</i>		X		X		X			X	not reported
<i>Gaura</i>	<i>lindheimeri</i>	X				X			X		100%
<i>Hemerocallis</i>			X			X			X		90%
<i>Hemerocallis</i>	'Plum Perfect'		X			X			X		90%
<i>Hemerocallis</i>	'Frankly Scarlet'		X			X			X		90%
<i>Hemerocallis</i>	'Orange Crush'		X			X			X		90%
<i>Hemerocallis</i>	'Pardon Me'		X			X		X			35%
<i>Hemerocallis</i>	many cultivars	X				X			X		98%
<i>Hosta</i>	'Elegans'	X				X			X		90%
<i>Hosta</i>	'June'	X				X			X		50%
<i>Hosta</i>	'Frances Williams'	X				X			X		50%
<i>Iberis</i>	<i>sempervirens</i>		X			X					30%
<i>Iris</i>	<i>germanica</i>		X			X			X		50%
<i>Lavendula</i>	<i>angustifolia</i>	X				X			X		100%
<i>Monarda</i>	'Grosso'			X		X				X	80%
<i>Monarda</i>	'Raspberry Wine'			X		X				X	80%
<i>Monarda</i>	'Blue Stocking'			X		X				X	80%
<i>Monarda</i>	'Snow White'	X				X				X	80%
<i>Papaver</i>	<i>orientale</i>		X			X				X	70%
<i>Platycodon</i>	<i>grandiflorus</i>	X				X		X			100%
<i>Rudbeckia</i>	<i>fulgida</i>	X				X			X		50%P/100%OS*
<i>Scabiosa</i>	<i>caucasica</i>		X			X			X		30%
<i>Sedum</i>	'Vera Jamison'		X		X		X				60%

\*p=polyhouse os=outside

Nursery production and production systems

West Michigan Nursery Winter 2002/2003 Plant Damage Survey of 22 growers (continued)

Plants-woody type		Planting date			Growing systems		Field soil type			Overwintering system		% Damage
		Spring 2002	Summer 2002	Summer 2001 or Earlier	Field	Container	Sand	Loam	Polyhouse	Outside		
Genus	Species/Cultivar											% Total inventory of this plant affected by winter damage
<i>Abies</i>	<i>concolor</i>		X		X		X			X		90%
<i>Abies</i>	<i>fraseri</i>		X		X		X			X		40%
<i>Abies</i>	<i>grandis</i>			X				X		X		75%
<i>Abies</i>	<i>grandis</i>	X			X		X			X		90%
<i>Abies</i>	spp.	X		X	X		X					10%
<i>Acer</i>	<i>rubrum</i>	X			X		X					25%
<i>Acer</i>	<i>palmatum</i>	X										40%
<i>Acer</i>	<i>rubrum</i>		X			X			X			75%
<i>Acer</i>	<i>rubrum</i>			X			X					5%
<i>Rhododendron</i>						X			X			70%
<i>Rhododendron</i>	'Garden State'			X								
<i>Rhododendron</i>	'Bixby'				X							
<i>Berberis</i>						X						
<i>Berberis</i>	'Bonanza Gold'	X				X		X				90%
<i>Betula</i>	<i>papyrifera</i>	X										20%
<i>Buddleia</i>	<i> davidii</i>		X			X		X		X		
<i>Buddleia</i>	<i> davidii</i>											100%
<i>Buddleia</i>	<i> davidii</i>			X		X		X				100%
<i>Buddleia</i>	<i> davidii</i>			X		X		X				100%
<i>Buddleia</i>	<i> davidii</i>			X		X		X				100%
<i>Buddleia</i>	<i> davidii</i>			X		X		X				25%
<i>Buddleia</i>	<i> davidii</i>	X							X			40%
<i>Buddleia</i>	<i> davidii</i>	X										
<i>Buddleia</i>	<i> davidii</i>		X			X				X		21%
<i>Buddleia</i>	<i> davidii</i>					X			X			70%
<i>Buxus</i>	<i> microphylla</i>	X			X					X		50%
<i>Buxus</i>	<i> microphylla</i>	X			X			X		X		25%
<i>Buxus</i>	<i> microphylla</i>		X		X				X			30%

West Michigan Nursery Winter 2002/2003 Plant Damage Survey of 22 growers (continued)

Plants-woody type		Planting date			Growing systems			Field soil type		Overwintering system		% Damage
Genus	Species/Cultivar	Spring 2002	Summer 2002	2001 or Earlier	Field	Container	Sand	Loam	Polyhouse	Outside	% Total inventory of this plant affected by winter damage	
<i>Cercis</i>	<i>canadensis</i>	X		X							75%	
<i>Cercis</i>	<i>canadensis</i>	X		X	X			X			50%	
<i>Cercis</i>	<i>canadensis</i>			X		X			X		100%	
<i>Chamaecyparis</i>	<i>lawsoniana</i>	X			X			X		X	60%	
<i>Cornus</i>	<i>florida</i>	X									75%	
<i>Cornus</i>	<i>anonomum</i>			X							40%	
<i>Cornus</i>	<i>florida</i>			X	X			X			100%	
<i>Cornus</i>	<i>florida</i>			X		X			X		20%	
<i>Euonymus</i>	<i>alatus</i>		X			X			X		50%	
<i>Euonymus</i>	<i>alatus</i>		X			X			X		40%	
Ferns	various		X			X				X	20%	
Forsythia	<i>viridissima</i>	X				X		X			90%	
<i>Hibiscus</i>	<i>syriacus</i>		X			X			X		25%	
<i>Hydrangea</i>	<i>macrophylla</i>	X				X			X		40%	
<i>Hydrangea</i>	<i>macrophylla</i>		X			X			X		40%	
<i>Ilex</i>	<i>meserveae</i>			X		X			X		80%	
<i>Ilex</i>	<i>meserveae</i>	X				X			X		70%	
<i>Juniperus</i>	<i>horizontalis</i>			X		X			X		35%	
<i>Liquidambar</i>	<i>styraciflua</i>	X		X	X			X			50%	
<i>Malus</i>	<i>sargentii</i>			X	X			X		X	100%	
<i>Physocarpus</i>	<i>opulifolia</i>			X							25%	
<i>Picea</i>	<i>pungens</i>		X		X		X			X	70%	
<i>Picea</i>	<i>omorika</i>		X		X		X			X	95%	
<i>Picea</i>	<i>abies</i>		X		X		X			X	40%	
<i>Picea</i>	spp.	X		X	X			X			10%	

## Nursery production and production systems

West Michigan Nursery Winter 2002/2003 Plant Damage Survey of 22 growers (continued)

Plants-woody type		Planting date			Growing systems		Field soil type		Overwintering system		% Damage
Genus	Species/Cultivar	Spring 2002	Summer 2002	2001 or Earlier	Field	Container	Sand	Loam	Polyhouse	Outside	% Total inventory of this plant affected by winter damage
<i>Picea</i>	<i>pungens</i>	X			X			X		X	50%
<i>Picea</i>	<i>abies</i>	X			X		X			X	None
		Fall 02									
<i>Picea</i>	'Kaibab'	X			X		X			X	30%
		Fall 02									
<i>Pieris</i>	'Red Mill'			X		X			X		3.5%
<i>Pinus</i>	<i>nigra</i>		X		X		X			X	99%
<i>Pinus</i>	<i>resinosa</i>		X		X		X			X	55%
<i>Pinus</i>	<i>strobus</i>		X		X		X			X	80%
<i>Pinus</i>	<i>strobus</i>	X		X	X			X			50%
<i>Pinus</i>	<i>nigra</i>			X	X		X			X	95%
<i>Pinus</i>	<i>strobus</i>			X	X			X			10%
<i>Psuedotsuga</i>	<i>menziesii</i>		X		X		X			X	95%
<i>Quercus</i>	<i>rubra</i>			X	X			X		X	100%
<i>Rhododendron</i>	<i>catawbiense</i>			X	X		X				(Flower buds)
<i>Rhododendron</i>	<i>catawbiense</i>			X	X		X				(Flower buds)
	'Janet Blair' 'Pierce's American Beauty'										
<i>Rhododendron</i>	<i>catawbiense</i>			X	X		X				(Flower buds)
<i>Rhododendron</i>	<i>catawbiense</i>			X	X		X				(Flower buds)
<i>Rhododendron</i>	<i>catawbiense</i>			X	X		X				(Flower buds)
<i>Rhododendron</i>	<i>carolinianum</i>			X	X		X				(Flower buds)
<i>Rhododendron</i>	<i>catawbiense</i>			X	X		X				(Flower buds)
<i>Sambucus</i>	<i>canadensis</i>			X							25%
<i>Pinus</i>	<i>omorika</i>	X			X			X		X	85%
<i>Sorbus</i>	<i>aucuparia</i>			X							20%

West Michigan Nursery Winter 2002/2003 Plant Damage Survey of 22 growers (continued)

Plants-woody type		Planting date			Growing systems			Field soil type		Overwintering system		% Damage
		Spring 2002	Summer 2002	Summer 2001 or Earlier	Field	Container	Sand	Loam	Polyhouse	Outside		
Genus	Species/Cultivar											% Total inventory of this plant affected by winter damage
<i>Spirea</i>	<i>japonica</i> White cultivar		X			X			X			99%
<i>Spirea</i>	<i>japonica</i> 'Neon Flash'		X			X			X			90%
<i>Syringa</i>	<i>meyeri</i>		X			X			X			90%
<i>Taxus</i>	<i>media</i> 'Hicksii'		X			X				X		6%
<i>Thuja</i>	<i>occidentalis</i> 'Woodwardii'		X		X	X		X		X		90%
<i>Thuja</i>	<i>occidentalis</i> 'Pyramidalis'		X		X	X		X		X		90%
<i>Thuja</i>	<i>occidentalis</i> 'Dark Green Pyramid'		X		X	X		X		X		90%
<i>Thuja</i>	<i>occidentalis</i> 'Emerald Beauty'		X		X	X		X		X		90%
<i>Thuja</i>	<i>occidentalis</i>		X		X	X		X		X		35%
<i>Thuja</i>	<i>plicata</i>	X			X	X		X				75%
<i>Thuja</i>	<i>occidentalis</i>	X			X	X		X		X		60%
<i>Thuja</i>	<i>occidentalis</i> 'Smaragd'				X	X		X				not reported
<i>Thuja</i>	<i>occidentalis</i> 'Nigra'				X	X		X				
<i>Tsuga</i>	<i>canadensis</i>	X			X	X		X				35%
<i>Thuja</i>	<i>occidentalis</i> 'Golden Globe'	X					X		X			25%
<i>Viburnum</i>	<i>plicatum</i>		X				X		X			30%
<i>Viburnum</i>	<i>plicatum</i> 'Newport'		X				X		X			95%
<i>Viburnum</i>	<i>plicatum</i> 'Shasta'		X				X		X			95%
<i>Viburnum</i>	<i>carlesii</i>		X				X		X			30%
<i>Pinus</i>	<i>strobus</i>	X					X			X		2%
<i>Picea</i>	<i>pungens</i> 'San Juan'	X					X	X		X		50%
		Fall02										

## Seedling type and early growth in scotch pine

### Author

Melvin R. Koelling, MSU Department of Forestry

### Funding

Project GREEN, Michigan Christmas Tree Association

### Significance

In recent years Scotch pine popularity has declined, however, a sizeable market continues to exist. Management practices used by most growers require seven to eight years to produce the typical six- to eight-foot tree preferred by most consumers. If growers could increase the height growth obtained in years one and two, the time period necessary to produce a marketable size and quality tree could be reduced by one to two years.

Aside from the obvious economic benefits (one year less of cultural and management costs) associated with producing a marketable size tree in a shorter time period, it is quite likely that a greater number of salable trees could be harvested per acre. Many growers experience significant losses in the number of harvestable trees as the age of the plantation increases due to degrading insect and/or disease problems. Shortening the rotation by one year would reduce exposure to and damage from these pests and an increase in harvest numbers would result from fewer trees being infested.

### Materials and methods

The purpose of this study was to determine the first, second and third-year annual growth increments of six different size classes of Scotch pine seedlings and to determine annual height growth as a percentage of

seedling size at the beginning of each growing season. All stock was of the same seed source (French Blue) and produced under similar cultural and environmental conditions. The seedling stock size classes were: 18 mm Jiffy pellet; 28 mm Jiffy pellet; 42 mm Jiffy pellet; 160 styroplug; 1-0 seedling; and 2-0 seedling.

In late April and early May of 2000 three replications containing 15 seedlings each were established for each seedling size class at three separate locations. In late April 2001, four additional classes of seedlings (transplants) were out-planted at both the Manton and Sheridan sites. This material was also Scotch pine of the “French Blue” seed source. The classes of planting stock were: 160 styroblock plus 1 transplant; 36 mm plus 1 transplant; 42 mm plus 1 transplant; and 2-1 transplant.

### Results

In early September of 2000, 2001, and 2002 measurements of total height were taken for all seedlings in each category. Total height and percentage height increase each year for seedlings is presented in Table 1.

In Table 2 these same data are arranged to show initial seedling height, amount of height increase after

**Table 2.** Initial height, three-year height increase, three-year total height and average annual percentage height increase for all seedling classes.

Size	Initial Height (in.)	Three-Year Height Increase (in.)	Three-year Total Height (in.)	Average Annual % Height Increase
18mm	1.0	9.02	10.02	117
28mm	1.0	10.13	11.13	129
42mm	2.63	22.63	25.26	122
160 styroplug	1.90	14.81	16.71	97
1-0 seedling	1.69	15.31	17.0	126
2-0 seedling	6.49	24.67	31.16	75

**Table 1.** Annual growth (inches) and height increase (percent) by seedling class and year.

Size	2000			2001			2002		
	Start	Growth	%	Start	Growth	%	Start	Growth	%
18mm	1.0	1.21	121	2.21	3.32	150	5.53	4.49	81
28mm	1.0	1.36	136	2.36	4.31	183	6.67	4.46	69
42mm	2.63	5.25	201	7.28	9.24	118	17.1	8.16	48
160 styroplug	1.90	2.02	109	3.92	6.39	124	10.27	6.44	63
1-0 seedling	1.69	3.45	203	5.14	7.05	137	12.2	4.8	39
2-0 seedling	6.49	5.47	84	1.96	10.91	91	20.85	10.31	49

three growing seasons, total seedling height and average annual percentage height increase.

**Discussion**

The objective of this study was to evaluate the amount of height growth in the first few years following planting for seedlings of different types and sizes. Specifically, is the amount of annual height growth in the first couple of years following planting related to type and size of planting stock? While some of the results appear inconclusive, it is obvious that annual height growth percentages are larger for all Jiffy-type stock (18 mm, 28 mm and 42 mm) as opposed to other classes of seedlings. The one exception was the 1-0 seedling that grew an unexpected amount in the year of planting (Table 1) but declined in the following two growing seasons. The average percentage height increase for the three different sizes of pellet stock was approximately 123 percent.

The decline in annual height growth percentages for years two and three is most likely related to amounts and distribution of rainfall. In contrast to the 2000 growing season, both 2001 and 2002 were characterized by periods of drought. Drought conditions were present during the first part of the 2001 growing season but were particularly severe at both field locations throughout the entire spring and summer in 2002.

Additional height growth can be expected from a pellet-produced seedling as opposed to the conventionally used 2-0 material. This additional increase is particularly significant in the year of planting. While it is not suggested or recommended that smaller sized material (18 mm or 28 mm) be used for field plantings, the 42 mm material can be expected to grow at a rate equal to or superior to 2-0 stock. Over the three-year period of this study this stock (42 mm) increased by 960 percent from its original beginning

height (2.63 to 25.26 inches). For the 2-0 seedling the increase was 480 percent (6.49 to 31.16 inches). The potential for greater height growth in the year of planting is clearly demonstrated.

Demonstration of the increased first-year growth potential of pellet-produced seedling stock leads to some interesting possibilities regarding future seedling production. If a larger diameter pellet were used, e.g. 50 mm, and production conditions could be manipulated to produce a seedling with a greater height, ie. 10 to 12-inches it is highly probable that the rotation length necessary to produce a 7 to 8-foot Scotch pine could be reduced by one year. The economic implications of this reduction in rotation length are obvious as total production costs would be lower. Additionally, exposure to some of the serious insect and disease pests (Zimmerman pine moth, pine gall rust, Diplodia tip blight, etc.) that are common in the latter years of the rotation would be lessened as well. This should result in a significant reduction in pesticide applications as well as an increase in the number of trees harvested per acre.

**Future**

Larger size pellet-produced stock needs to be evaluated with respect to growth increases. Additionally, the influence of type of planting for other species such as Fraser fir should be investigated. It is commonly accepted that seedlings and transplants with larger root systems will perform best when planted in field settings. It seems logical that stock that is planted with minimal root disturbance will also perform better. Most likely this is the factor responsible for greater first-year height growth. Developing a production system that will produce such stock and establishing plantations with planting techniques to minimize root loss could have significant implications for the production of Scotch pine and other Christmas tree species. ☞

**Scotch pine shearing regimes – tree grade relationships**

**Author**

Melvin R. Koelling, MSU Dept of Forestry

**Funding**

Project GREEN, Michigan Christmas Tree Association

**Significance**

Producing the typical 6 to 8-foot Scotch pine Christmas tree requires an average rotation length of

7 to 8 years. Beginning the third year after planting the tree is trimmed annually to develop a characteristic “Christmas tree shape” and to increase foliage density and tree quality.

In the past 20 years Scotch pine has become an increasingly attractive host for a variety of insect and disease pests. Even with regular and timely pesticide applications most growers experience significant loss, resulting in reduced harvest yields of 60 to 70 percent of the initial planting. If rotation length could be reduced by one year significant increases in yield

## Nursery production and production systems

would occur, and reductions in pesticide applications would result. Modification of shearing practices might permit this to occur provided tree height and quality were not adversely affected.

### Objective

To evaluate the effects of five different terminal shoot shearing practices on tree height and tree grade.

### Methods

Five different terminal-length shearing prescriptions were established. These were (1) grower normal, which served as a control, (2) 10-inch terminal, (3) 12-inch terminal, (4) 14-14-12-12-10-inch terminal, and (5) 16-14-14-12-10-inch terminal. The trees were sheared according to the prescriptions for each treatment in late June of 2001, 2002, and 2003 (Photo, color insert, page 3A). In September of each year total tree height and USDA grade was determined for each tree in each treatment.

### Results

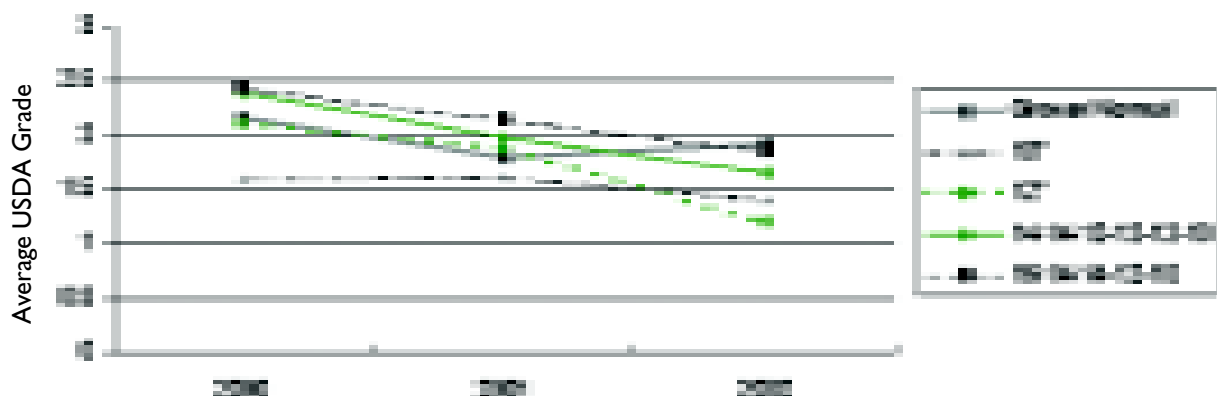
Results by treatment for the years 2000-02 are presented in Table I.

For all regulated shearing treatments the maximum total tree height difference is approximately 12 inches. While this difference might be viewed as sizeable, it is not reason for significant concern if trees are sold in the customary 5-1/2 to 7 foot size class, especially when increases in average grade are considered. For trees in the 12-inch and 14-inch treatments height differences were even less, averaging about 0.7 foot. Of particular significance at the end of the 2002 growing season is the decrease in percentages of No. 3 (cull) trees associated with each treatment. In comparison with the control or grower normal the percentage of treatment trees with

**Table I.** Tree heights, average USDA grade and percent of trees by grade for years 2000, 2001, and 2002.

Treatment	2000	2001	2002
<b>Grower normal (control)</b>			
Av. ht. (ft.)	4.70	5.65	6.66
Av. grade (USDA)	2.17	1.80	1.91
No. 1 (%)	8	20	32
No. 2 (%)	66	80	41
No. 3 (cull) (%)	26	0	27
<b>10-inch terminal</b>			
Av. ht. (ft.)	4.37	5.24	6.12
Av. grade (USDA)	1.60	1.61	1.40
No. 1 (%)	44	45	67
No. 2 (%)	51	49	38
No. 3 (cull) (%)	4	6	5
<b>12-inch terminal</b>			
Av. ht. (ft.)	4.80	5.80	6.83
Av. grade (USDA)	2.10	1.88	1.70
No. 1 (%)	17	19	46
No. 2 (%)	60	73	50
No. 3 (cull) (%)	2	8	4
<b>14-14-12-12-10 terminal</b>			
Av. ht. (ft.)	5.03	6.01	6.87
Av. grade (USDA)	2.40	1.97	1.66
No. 1 (%)	4	13	45
No. 2 (%)	48	77	44
No. 3 (cull) (%)	48	10	11
<b>16-14-14-12-10 terminal</b>			
Av. ht. (ft.)	5.10	6.26	7.09
Av. grade (USDA)	2.43	2.14	1.87
No. 1 (%)	2	17	28
No. 2 (%)	54	79	57
No. 3 (cull) (%)	44	4	15

**Relationship between shearing treatment and average USDA grade by year.**



a No. 3 or cull grade averages 9 percent (all treatments). For all treatments ninety-two percent of all trees are in grades No. 1 and No.2. In contrast the control (grower normal) treatment has an average 27 percent culls. Average percent cull for the prescribed treatments ranges from 4 to 15 percent. From an economic perspective this reduction in cull percentage translates to approximately 109 more trees per acre being available for harvest (9 percent of 1210 trees per acre). If it is assumed all additional trees are only No. 2's with an average wholesale value of \$10.00 each, an additional \$1090.00 per acre would be realized by the grower. For the 10-inch, 12-inch and 14-inch treatments the increase in harvest yield would

be even greater, as would the total increase in revenue if some of the additional trees graded No. 1.

### ***Impacts of research for Scotch pine growers***

Careful attention to regulating terminal shoot length during annual shearing can and does influence tree height and grade. It has been demonstrated that annual shearing following a prescribed shearing regime will result in the production of trees of an acceptable height and with an average higher grade than conventionally followed shearing practices. Furthermore it is possible to reduce the length of a typical 7 to 9-year rotation and still produce trees of a size readily acceptable to the market place. ✂

## Hire, train, and keep a highly motivated workforce: A workshop for green industry managers

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### *Funding*

North Central Risk Management Education Center

### *Significance to industry*

Among the risks agricultural producers face, human resource management risks are possibly the most neglected, but have been identified as a major threat to business survival. Based upon prior published works, five types of labor-related risks have been identified as being pertinent in agriculture and the green industry: (1) not getting essential tasks completed, (2) tasks being done poorly or not in a timely manner, (3) incurring high indirect labor expenses, (4) conflict with employees, (5) incurring fines or having penalties imposed for violation of laws and regulation or the cost of proving compliance with the laws and regulations. Helping managers to better

recognize, deal with, and safeguard against labor related risks reduces employee turnover and increases farm productivity. Measures taken to alleviate labor risks also tend to reduce workplace accident rates and related health problems. In addition, they typically contribute to improved quality of work life for employees.

### *Workshop description*

Based on knowledge gained through focus group discussions with owners and managers of nurseries, landscape businesses, and greenhouses, as well as in-depth interviews with managers, supervisors, and non-supervisory personnel, an educational workshop was developed and conducted. The one-day workshop addressed human resource management practices to mediate labor risks. It was held in Grand Rapids on July 09, 2003. The following topics were included in the workshop program:

1. Recruiting and selecting the best employees
2. Training your employees for high performance
3. Managing with constructive feedback
4. Building relationships with a diverse workforce
5. Chalking the field: the key to satisfied and productive employees

Several speakers were used at the workshop, including project consultants. Evaluations of the workshop have been very positive (7.9 on a 10-point scale). Workshop participants particularly liked the variety of speakers addressing different issues. ☞

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## High-involvement work practices in the Michigan green industries

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### *Funding*

Project GREEN, North Central Risk Management Education Center

### *Acknowledgements*

We also want to thank the participating nursery, landscape and greenhouse business for volunteering both their time and their employees' time and their willingness to openly discuss their human resource practices and strategic human resource management.

### *Significance to industry*

Michigan plant industries face the challenge of attracting and retaining qualified labor. High-involvement work practices have helped other industries develop a proactive approach to human resource management and productivity. These practices have been introduced in innovative Michigan green industry operations but are not yet widespread. Adaptation to industry structure and business strategies is in an early phase. A particular challenge to introducing employee involvement practices in plant production and related services is the seasonality issue. Research on these practices in agriculture is virtually non-existent.

### *Goals and objectives*

1. Identify human resource management practices prevalent in Michigan's nursery and landscape industries.

2. Identify specific human resource management challenges for Michigan's nursery and landscape industries.
3. Compare the human resource management practices in Michigan's nursery and landscape industries to proven practices in other industries.

### ***Project description***

Based upon the findings of focus group discussions with owners and managers of nursery and landscape business (see *Nursery and Landscape Projects and Programs*, 2002) an interview guide was developed to assess human resource management strategies in-depth. Six nurseries, 4 landscapers and 4 greenhouse producers participated in the intensive case studies. A total of 47 separate interviews (e.g., managers, middle managers, and staff) were conducted. Interviews were tape-recorded and transcribed. The data will continue to be analyzed in detail and results will be further refined.

### ***Results and discussion***

Larger and more successful operations are more conscientiously managing their human resources. On one hand, this is borne out of necessity because a small number of employees allows for more informal procedures, individual treatment, and leading by example of the owner. Large operations need more formal procedures to function. Individual treatment needs to be replaced by guidelines and policies. Clearly communicated goals and a vision lead the middle managers, who in turn lead and motivate the lower ranked employees. On the other hand, defined organizational structures and clear human resource guidelines and policies enable sustained growth and profitable operations.

Human resource management practices in successful operations have established retention rates of 80% and above, which include employees returning to the same operation after several months of layoff due to seasonal variation in labor demand. Reducing voluntary turnover is a goal related to cost reduction and quality assurance. While data from other industries suggest turnover costs equal 100% or more of the annual salary of an employee, costs tend to be lower in agriculture depending on recruitment and selection methods and the training needed to adequately perform a task. Since hiring a mostly Hispanic workforce with strong extended family relations and networks has led to employee referral as the preferred recruitment method of non-supervisory employees for a majority of the research participants, recruitment costs have been reduced. Simultaneously, selection has ceased to be a concern for many managers, further reducing turnover costs. However, training has become more difficult with many employees commanding a limited capacity of the English language. Providing a high quality product requires a well-trained and motivated workforce.


Retention plays a paramount role for supervisory and management positions, where significant training investments in employees are and specific know-how and experience are accumulated. In addition, recruitment and selection for supervisory positions are more expensive. Although promotion from within is a strategy common in most operations, it is not always an option and not necessarily less expensive than advertisements and selection procedures, because the employee will require supervisory training to achieve optimum results.

The most common training method is the so-called mentoring or buddy system where the new employee is assigned to an experienced co-worker who is responsible to introduce the new employee to work procedures and the culture of the operation. In very small operations the owner also teaches by example and explanation. In very large operations, the supervisors can have the sole or additional training responsibilities, but the buddy system is most common.

Training also plays a major role in ensuring workplace safety and preventing accidents. While the use of machinery is typically restricted to explicitly trained individuals, eye injuries, slip and fall, and repetitive motion, related health problems are a concern in many operations. In addition, some employees consider exposure to pesticides a health risk.

For many employees hourly wages are a source of dissatisfaction or a reason to consider alternative employment. While respectful treatment and fairness do create loyal employees, a higher wage could lure many experienced employees into other sectors as soon as jobs become available. Few managers are countering this risk by offering productivity bonuses. Several managers are offering seasonal bonuses for employees who stay for the season. The most common retention tool is the yearly merit raise. However, merit raises are often limited by job category and amount of profit available for distribution.

Managers, supervisors, and employees perceive communication as a major challenge. Information sharing with employees is rather limited. Employees hardly ever receive specific financial data. This information is restricted to the upper management or family members and sometimes office personnel. General financial information is shared at formal or informal meetings. Regular meetings are used as tools for sharing information, improving relationships, and generating employee input. However, employee suggestions, particularly from English second language employees, are more likely to come up in individual conversations.

Teamwork is prevalent in the participating operations. Quality and timeliness of production often depend on employees' cooperation and coordination. Yet, formal team based bonuses or other incentive systems to encourage team performance are rare. Employees not working well with their team will be given the opportunity to work with a different team, but coworker pressure is likely to coerce such individuals into looking for alternative employment. 

## Control of downy mildew with fungicides in Lamium “Purple Dragon”

### Author

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### Funding

Michigan Nursery and Landscape Association

### Introduction

Many Oomycetes impact the perennial plant industry. Their occurrence and the fact that they are difficult to control continue to be a problem. The Oomycetes include Pythium, Phytophthora and Peronosporales (downy mildew) species. Since the introduction of metalaxyl/mefenoxam-based fungicides in the early 1980s in Europe, many pathogen populations have been identified that are resistant to or have reduced sensitivity to these products. Resistance to metalaxyl/mefenoxam has not been widely reported or tested in the landscape industry, but it is a common phenomenon in agriculture in part due to the more intensive use of these products. Metalaxyl/mefenoxam resistance has been reported in potatoes (*P. infestans*; late blight, *Pythium ultimum*; *P. erythroseptica*; pink rot); cucurbits and peppers (*P. capsici*) and grapes (*Plasmopara viticola*). Failure of control of some oomycetes has been noted in Michigan e.g., downy mildew in Rudbeckia and Lamium. There has been much research on metalaxyl/mefenoxam resistance; however data are sparse on metalaxyl/mefenoxam

resistance management in perennials.

### Objectives

In the perennial plant industry in Michigan, oomycetes are controlled primarily by cultural practices such as water management or pathogen exclusion on seed stock, but fungicides are the primary protection measure. The objectives of this research are to develop methods to quickly determine the degree of insensitivity of these pathogens to metalaxyl/mefenoxam; especially for downy mildew, which cannot be cultured *in vitro*. In addition, alternative chemical interventions for control of oomycetes are evaluated, such as new fungicides e.g., Cabrio (pyraclostrobin). The methods developed will allow growers to choose an alternative product once the degree of sensitivity of the pathogen to metalaxyl/mefenoxam is determined, and avoid loss of plant material to

**Table 1.** Concentrations of Subdue MAXX and Cygnus 50WG fungicides that inhibited downy mildew in *Lamium maculatum* by 50% relative to the control.

Days after application of fungicide (DAFA)	EC50 value (ppm concentration)	
	Mefenoxam	Kresoxim-methyl
20	0.097	0.47
30	0.096	0.47
40	0.096	1.44
50	13.9	3.47

**Table 2.** Comparison of efficacy of different concentration rates of metalaxyl/mefenoxam (Subdue MAXX) and kresoxim-methyl (Cygnus 50WG) against downy mildew in *Lamium maculatum*.

Concentration of fungicide (ppm <sup>a</sup> )	Downy mildew severity index <sup>b</sup>							
	20 DAFA		30 DAFA		40 DAFA		50 DAFA	
1 Untreated	29.5	a <sup>d</sup>	47.0	a	66.0	a	85.0	a
2 Mefenoxam 0.01	19.0	b	20.5	c	27.0	c	42.0	b
3 Mefenoxam 0.1	0.0	c	0.0	d	0.0	e	18.5	bc
4 Mefenoxam 1.0	0.0	c	0.0	d	0.0	e	17.5	c
5 Mefenoxam 5.0	0.0	c	0.0	d	0.0	e	14.5	c
6 Mefenoxam 10.0	0.0	c	0.0	d	0.0	e	20.0	bc
7 Kresoxim-methyl 1.0	23.5	ab	37.5	b	53.5	b	71.5	a
8 Kresoxim-methyl 5.0	0.0	c	0.0	d	9.0	d	37.0	bc
9 Kresoxim-methyl 10.0	0.0	c	0.0	d	0.0	e	25.0	bc

<sup>a</sup> Fungicide doses of 0, 0.1, 1, 5, and 10 ppm mefenoxam (Subdue MAXX) mixed in water for a final application rate equivalent to 25 gal mixture/acre. Kresoxim-methyl (Cygnus 50WG) applied at 0, 0.1, 1.0 and 5.0 ppm

<sup>b</sup> Indices of 0 - 25 cover the range 0 - 2%; 26 - 50 cover the range 3 - 10%; 50 - 75 cover the range 11 - 50% foliar symptoms and > 75 cover the range 51 - 100% foliar symptoms and plant death.

<sup>c</sup> Days after application of fungicide.

<sup>d</sup> Means followed by the same letter are not significantly different at P = 0.05 (Tukey multiple comparison).

oomycetes. This report covers the efficacy of Subdue MAXX and Cygnus 50WG applied at increasing dose rates in controlled environments.

**Research methodology**

*Lamium maculatum* “Purple Dragon” plants with symptoms of downy mildew were obtained from a Michigan grower. These plants were overwintered outside at Michigan State University Plant Pathology Greenhouse complex (from October 30 to March 30). In early spring, the plants were potted into flats that contained 10 plants, replicated five times for a total of 50 plants per experimental unit. Fungicide doses of 0, 0.1, 1, 5, and 10 ppm mefenoxam (Subdue MAXX) were mixed in water for a final application rate of 25 gal mixture/acre and were applied with a precision fungicide applicator. Additional treatments of kresoxim-methyl (Cygnus 50WG) at rates of 0, 0.1, 1.0 and 5.0 ppm were applied as above. A single application of the fungicide treatments was made on April 4, 2003.

**Data analysis**

A downy mildew index was calculated by counting the number of plants (from each sample of 50 plants in the controlled environment), falling into class 0 = no visible symptoms; 1 = 1 to 2% of leaves with lesions; 2 = 3 to 10% of leaves with lesions; 3 = 11 to 50% of leaves and stems with lesions; 4 = 51% with lesions to 100% defoliation/plant death. The number of plants

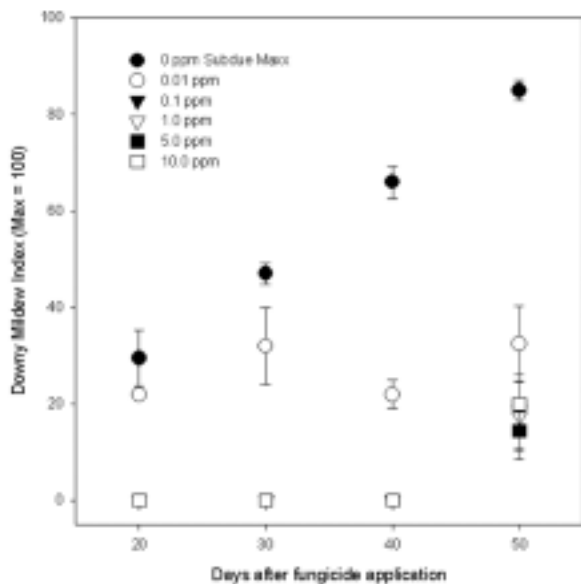
in each class was multiplied by the class number and summed. The sum was multiplied by a constant to express as a percentage. Indices of 0 to 25 cover the range 0 to 2% foliar symptoms; 26 to 50 cover the range 3 to 10% foliar symptoms; 50 to 75 cover the range 11 to 50% foliar symptoms and greater than 75 cover the range 51 to 100% foliar symptoms and plant death.

Downy mildew was evaluated 20, 30, 40 and 50 days after application of fungicides. The average index for each evaluation was expressed as a function of time after planting. In addition, at each evaluation date, the fungicide concentration that inhibited downy mildew by 50% relative to the control (EC50 value) was calculated to determine the duration of efficacy. The EC50 was calculated as percent inhibition of the downy mildew index of the treated plants relative to the untreated control. A regression analysis that expressed percent inhibition as a function of fungicide concentration was calculated and the concentration of the fungicide that inhibited downy mildew by 50% relative to the control was determined.

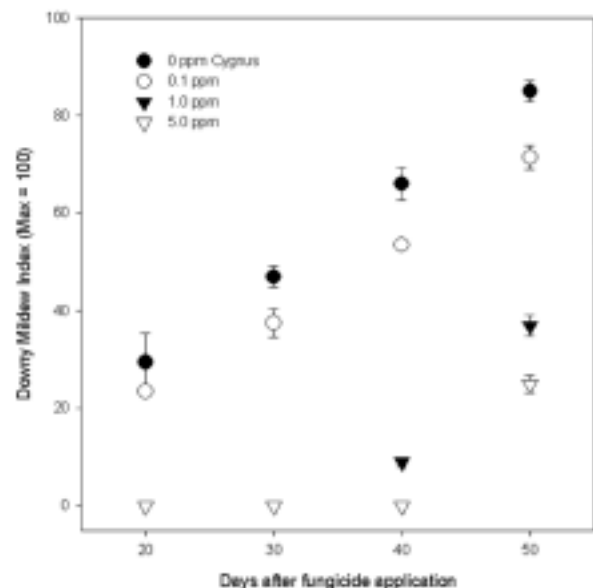
**Results and discussion**

Downy mildew slowly defoliated *Lamium* in the untreated control. By 50 days after application of the fungicides (DAFA) the downy mildew index was greater than 80, indicating that plants were exhibiting

**Figure 1.** Development of downy mildew on *Lamium maculatum*- Influence of time after application on efficacy of mefenoxam (Subdue MAXX) applied at increasing concentrations.



**Figure 2.** Development of downy mildew on *Lamium maculatum*- Influence of time after application on efficacy of kresoxim-methyl (Cygnus 50WG) applied at increasing concentrations.



between 51 and 100% defoliation (Figures 1 and 2). Treatments of 0.1 to 10 ppm mefenoxam (Subdue MAXX) gave effective control of downy mildew up to 40 days after treatment. The EC50 values indicated that both fungicides were effective against downy mildew, but that efficacy decreased with time (Table 1). By 50 days after application, the efficacy of Subdue MAXX at rates effective prior to the final assessment no longer effectively controlled downy mildew. Manufacturer recommended effective field rates (MRR) are between 8 - 16 ppm. The efficacy of Cygnus 50WG was reduced three-fold (MRR between 30 - 60 ppm) by 50 DAFA. Up to 40 days, Subdue MAXX applied at rates greater than 0.1 ppm was more effective than Cygnus 50WG at any rate. The efficacy of Subdue MAXX decreased 50 DAFA and application rates >0.1 ppm were not significantly different from Cygnus 50WG application rates of 5

and 10 ppm.

The occurrence of resistance to metalaxyl/mefenoxam was not noted in this experiment as the downy mildew affected plants responded to applications of Subdue MAXX. Although this was presumably a single isolate of a potentially more diverse population, it should be clear that if plants are observed up to about 40 days after application of Subdue MAXX, control of downy mildew will be obvious. However, as inoculum is rarely eliminated from the environment the re-appearance of downy mildew symptoms may be observed about 50 DAFA. Such a phenomenon should not be confused with resistance but is a normal occurrence as the efficacy of the fungicide is diluted through "weathering". Cygnus 50WG could be applied in rotation with Subdue MAXX to reduce the risk of development of resistance to Subdue MAXX. ☞

## ***Phytophthora* water molds in ponds and recirculated irrigation systems in Michigan nurseries**

### **Authors**

Gerard Adams and Heather Hallen, MSU  
Department of Plant Pathology

### **Funding**

Center for Integrated Plant Systems (CIPS)

### **Background**

*Phytophthora* causes disease on a wide host range of plants. Historically, Michigan nurseries have been relatively free of these highly destructive plant pathogens, except when it arrived on rhododendrons or other stock from other states. In Michigan, introduced *Phytophthora* species often die during the severe winter and native soils seldom contain the pathogen. In contrast, nurseries in western and southeastern states have had continuous problems with infestations of this group of water molds.

Water management in nurseries has recently changed to include the capture of water run-off and the use of re-circulating water stored in ponds. Recently in Michigan, significant losses of lilac and rhododendron nursery stock occurred due to *Phytophthora* cankers and root rot diseases. (Photo, color insert, page 2A.) Preliminary evidence indicated that the source of the infections had been from the nursery's pond water. For example, two years ago a nursery lost over \$300,000 of lilacs from *Phytophthora* canker on the stems. Sprinkler systems had deposited pond water onto the stems during irrigation. The cankers and the pond water

contained the pathogenic water mold *Phytophthora cactorum*. Further sampling of seven ponds that summer yielded *Phytophthora* species.

### **Objectives**

In order to develop a management system to reduce and control *Phytophthora* diseases in the nursery, we needed to know what *Phytophthora* species could survive in the ponds over the winter. Managers would then know if they began each spring with clean ponds or infested ponds. It is remarkable that this type of information has not been determined in any state with a cold winter.

Research in vegetable crops has determined that species of *Phytophthora* forming a thick-walled spore, (Figure 1) can survive winter in soils in Michigan. Species of *Phytophthora* that cannot make these spores, and there are many such species, generally die during winter without the roots of the infected plant present.

Our research objective was to determine which *Phytophthora* species survived the winter in nursery ponds in Michigan; and whether the *Phytophthora* species that survived were species which formed the thick-walled spores or not.

### **Methods**

We sampled 11 ponds and also sampled nursery drains, run-off ditches and rivers used by nurseries for irrigation in eastern and western Michigan. Samples were taken in the fall and in the early spring.

The pathogenic water molds were captured and quantified by floating green pears in samples of the ponds' waters. Plant pathogenic water molds can infect green fruit whereas non-pathogenic species usually cannot. Swimming spores produced by fungal structures formed underwater, (Figure 2) are attracted to the fruit and penetrate the skin causing rot. (Photo, color insert, page 2A)

Pathogenic water molds known as *Pythium* also infect such fruit in high numbers. These pathogens are less important in causing damage of woody plants in the nursery, except during rooting of cuttings and seed germination. So, many *Pythium* species must first be identified and eliminated from the pond assays for accurate information on *Phytophthora* to be determined. We set about the task of separating *Pythium* species and identifying species of *Phytophthora* in the ponds. Identifying *Phytophthora* strains included using DNA sequence analyses to verify the microscope-based identifications. We sampled ponds late in the fall and early in the spring.

In order to verify that a *Phytophthora* strain in a pond in the fall is the same strain found in the early spring, we needed a means of identifying individual strains. We used a new DNA technology to "fingerprint" strains of pathogens, called AFLP analysis (amplified fragment length polymorphism), so that specific spring strains could be compared to specific fall strains. Dr. Kurt Lamour (of MSU plant pathologist Mary Hausbeck's lab) did the DNA fingerprinting AFLP analysis for this research. A picture from our studies of what a portion of an AFLP analysis looks like is shown below. Identical strains will have matching patterns (peaks) on the graph. The graph below (fig. 3) allows comparison of 7 strains of *Phytophthora gonapodyides*.

### Conclusions

Nursery ponds in the spring varied from nearly free of *Phytophthora* species to highly infested. The heavily infested ponds led our research effort to studying nearby rivers. A unique situation was found in Michigan that has never previously been reported in any state: *Phytophthora gonapodyides* was found to be occurring at very high levels in Michigan rivers and some ponds in the earliest spring samples.

There is little literature on this species of *Phytophthora* because it has only been recognized and studied in North America since 1989. Fortunately for the nursery industry, this species that is not pathogenic to plants, except for seedlings of some conifers. It is of no more concern than the many *Pythium* species discarded from the study, so we

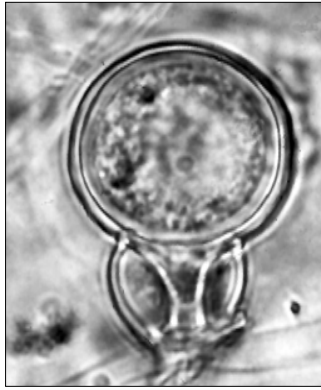
refer to it as "non-pathogenic" in this report. Surprisingly, this species does NOT form the thick-walled "winter" spore, yet it is abundant in rivers and ponds soon after the winter thaw. We discovered that in rare instances species that generally do not form the winter spore could infest our waterways. We speculate the fungus survives in plant debris and roots, or agricultural soils, and then sporulates profusely with early spring rains that drain into the rivers carrying the fungus. Alternatively, the fungus may actually survive in the ice-covered rivers, perhaps in plant debris, aquatic plants, or in roots of riverbank plants.

Unfortunately for our studies, the huge number of this "non-pathogenic" species overwhelms our trapping methods and our assays for the virulent species. The numbers also overwhelm our ability to track an individual strain of a pathogen in a pond in fall into the following spring. In microscopic identifications, *P. gonapodyides* appears identical to two important pathogenic species, *P. drechsleri* and *P. cryptogea*, which means that more expensive DNA methods must be used to separate the pathogenic from the non-pathogenic species. One outcome of our research, was the realization that useful studies of *Phytophthora* in recirculated water systems in Michigan will be much more difficult and costly than originally anticipated.

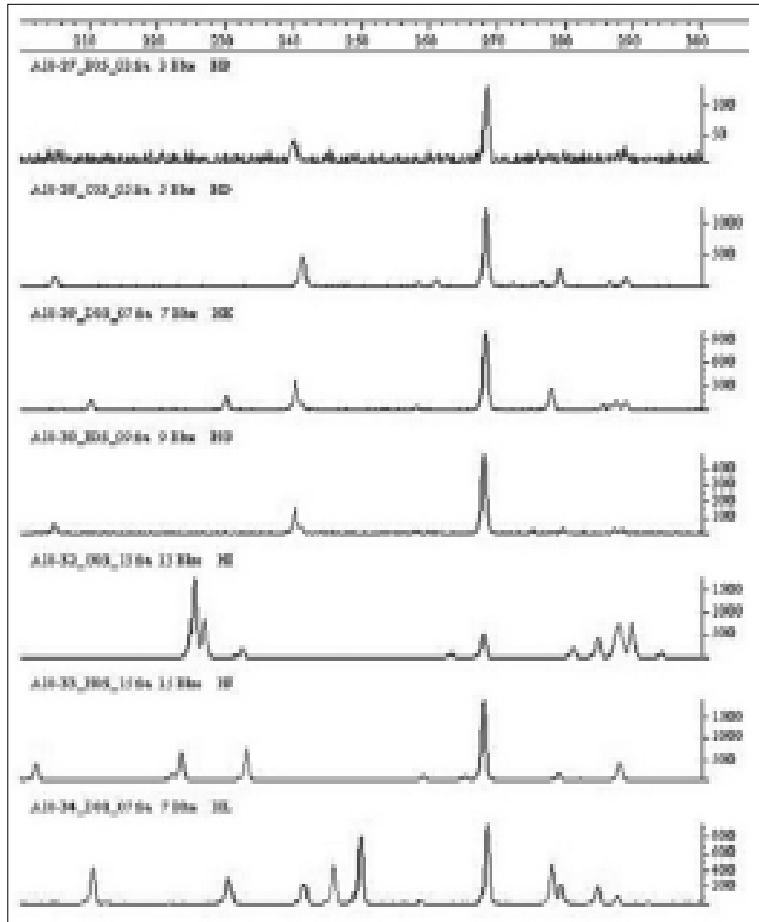
Pathogens found in ponds in early spring were species that formed the "winter" spore, including: *P. cactorum*, *P. citrophthora*, *P. nicotianae*, and a species tentatively identified as *P. humicola*. All of these species were rare and at very low numbers in the ponds in spring. Another pathogenic species, *P. drechsleri*, may have been present. Because we were unable to check these isolates with DNA tests, we remain uncertain. *P. drechsleri* generally would not form the winter spore. If it was present in spring, then it may have been the most abundant and widespread of the pathogenic species in the ponds. More research will be needed to verify this point.

At least one pond was found that had four species of *Phytophthora* present, however, most ponds had only the "non-pathogenic" *P. gonapodyides*. Drains and ditches in nurseries had very high numbers of *Phytophthora* present, but not any higher than rivers. When we compared water from immediately before and immediately after filtration through a diatomaceous earth-based system in a pump house, no discernable difference in numbers of *Phytophthora* were evident, even with moderately high numbers present. Commercial filtration units have been found to be ineffective in reducing *Phytophthora* concentrations in research in other states. ✍

**Figure 1.** Oospore, a thick-walled resting spore of *Phytophthora* sp.



**Figure 2.** Sporangiophores-structures that contain zoospores (swimming spores) of *Phytophthora* sp.



**Figure 3.** A picture from our studies of what a portion of an AFLP analysis looks like. Identical strains will have matching patterns (peaks) on the graph. The graph shows comparison of 7 strains of *Phytophthora gonapodyides*.

## Is a more virulent *Sphaeropsis* shoot blight of pine moving into Michigan forests and killing seedlings?

### Author

Gerard Adams and Mursel Catal, MSU  
Department of Plant Pathology

### Funding

Michigan Department of Natural Resources (DNR)

### Background

In response to urgent requests by some Michigan nurseries, the Michigan DNR funded a cooperative research project with our lab to investigate *Sphaeropsis* shoot blight. The shoot blight is the most damaging disease of pine in the Michigan landscape, especially on Austrian, Ponderosa, Mugo and Scots pines. Most nursery and landscape industry workers know this disease as “Diplodia tip blight.” The pathogenic fungus, *Sphaeropsis sapinea*, also causes “collar rot” on nursery seedlings. The symptom is a

canker at the soil line often followed by death of the seedling. The impetus for this investigation was concern that Michigan conifer seedlings were more frequently infected with this disease than nursery seedlings from neighboring states. There were other concerns in addition to potential loss of sales. For example, several hundreds of acres of forest stands of red and jack pine seedlings had recently died due to the pathogen in Michigan. Were the nursery seedlings the source?

The objectives of our study of nurseries and forests were to determine: 1) whether collar rot was a problem in the nurseries; 2) whether the pathogen was moving from the nursery to newly planted forest stands; and 3) whether a new and more virulent pathogen was moving into the forest stands.

The most important result: the Michigan nurseries examined in our studies had no detectable collar rot! A scientist from University of Wisconsin was brought

in to witness this. He left not only convinced that the examined nurseries were very nearly disease free but also, remarkably, that they were less diseased than those in two other nearby states. The Michigan DNR then took further steps to ensure the disease remains scarce by removing susceptible pines from nursery windbreaks. Enough said. Though, for those who enjoy the more complex stories that arise from research there is much more.

One major objective of the research was to determine whether a more virulent type of the fungus, (known as Type A) was moving into Michigan forests where a less virulent type (known as Type B) appeared to be native. Type A has been the cause of shoot blight in every diseased ornamental pine that I have examined over many years (1987-2002) in Michigan. A general consensus among foresters in the Lake States is that Type A was introduced to the region in the late 1960s and is now responsible for an increasing incidence and severity of the disease.

We examined seed lots, healthy seedlings grown in soil beds and in green houses, windbreak trees, and diseased and healthy forest stands, for presence of *S. sapinea* of Type A and Type B. A number of different methods were used to detect and identify *S. sapinea* in symptomless or diseased pines. The most successful and sensitive method was based on DNA. We were able to detect the DNA of the fungus in extracts of whole plant DNA. Amplification of fungal DNA present in the plants was accomplished using *S. sapinea*-specific primers. The identity of the fungus was verified by sequencing the DNA, and by RFLP (random fragment length polymorphism) analysis. Another method involved detection of fruiting bodies on diseased plant tissues and microscopic identification of the pathogen. Furthermore, *S. sapinea* was detected by isolation and cultivation on agar media and identification of Type A and Type B strains based on colony characteristics and growth rate.

Seeds taken directly from refrigerated nursery lots varied from clean to heavily infested with Type B, Type A and both. The infestation of the seed lots

probably occurred in the forest from which they were sampled because *S. sapinea* is a pathogen of green cones. Variation in climate from year to year can increase or decrease the amount of cone infection by *S. sapinea* in a stand. However, we cannot rule out the possibility of poor handling also increasing the amount of the pathogens. No obvious pattern was discernable in the data although it suggested that in some locations plantation-derived seeds are more infested than natural stand-derived seeds. Table 1 provides the first data on levels of *S. sapinea* in collected seed. It is unknown whether the fungus is on the surface, directly under the seed coat, or among the cells of the embryo. The results may vary from year to year. More precise information on the actual location where seeds were collected in a stand would be useful. These evaluations should be repeated in further studies before they are fully accepted.

Studies revealed that *S. sapinea* was present and latent in healthy green needles of bed-grown seedlings. The presence of the fungus in healthy seedlings confirmed that the fungus survives in pine tissues without causing disease until significant stress occurs to the plant, such as severe drought or hail. Other researchers in South Africa recently discovered the latent nature of the fungus. The fungus is now referred to as an endophyte. Seedlings from the same seed lot, but grown under greenhouse conditions with strict sanitation were found to be entirely free of the endophytic fungus. This discovery is very significant because it informs us that *S. sapinea*-free seedlings can be grown from moderately infested seed. Further research will help clarify the cultivation practices and/or fungicide application practices that encourage production of *S. sapinea*-free seedlings.

Studies of the extensive acreages of jack and red pine seedlings that died or were severely damaged by *S. sapinea* cankers produced unexpected results. The stands in both the lower and upper peninsulas of Michigan had approximately 85% infection (cankers) caused by Type B and 15% by Type A. Healthy

**Table 1.** Pine seed lots and *Sphaeropsis sapinea* infestation- dates in brackets are approximate.

Species	Lot number	Location	Forest	Year	Type A	Type B	Infestation
Red pine	MI0235	Toumee	Natural stand	1975	Yes	No	<u>Moderate</u>
Red pine	9703	Kalkaska Range	Natural stand	1996-7	Trace	No	<u>Clean</u>
Red pine	MI0232	Manistique	Plantation stand, 25 years old	(1997)	Yes	Yes	<u>Heavy</u>
Red pine	MI0233	Manistique	Natural stand	(2001)	No	No	<u>Clean</u>
Red pine	MI0234	Manistee -Osceola	Natural stand	(1999)	Trace	No	<u>Clean</u>
Jack pine	MI0206	Manistique	Natural stand	(2001)	No	Yes	<u>Moderate</u>
Jack pine	MI0208	SE of Gaylord near Mio	Plantation stand	(1996)	No	No	<u>Clean</u>
Jack pine	MI0211	Benzie- Manistee	Natural stand	(2001)	No	Yes	<u>Heavy</u>
Jack pine	MI0218	Brighton- Howell TIC	Plantation stand	1999	Yes	No	<u>Low</u>

foliage had primarily Type B endophytic infections. The general hypothesis was that cankers and death had not been seen when only Type B was present in the forests, therefore, the damage must be due to the introduced Type A. Further research will now be necessary to determine whether seedlings infected with Type A (as endophytes in healthy foliage) keep them after outplanting. Investigations will also be needed to determine whether *S. sapinea*-free seedlings remain so after outplanting. Additionally, seedlings with Type A endophytic infections should be compared with those having Type B endophytes for disease resistance under drought stress.

Significant new information on the *Sphaeropsis* disease in Michigan was rapidly discovered using

DNA detection technologies for fungi, enabling us to provide quick responses to industry concerning questions about collar rot. For example, this is the first report of detection and identification *S. sapinea* Type A and Type B in seed lots and, the first measurement of the level of infestation among lots. Additionally, the DNA-based methods made it possible to compare infestation of seed lots prior to sowing with presence of the fungus after sowing, in needles of healthy seedlings.

Dr. Mursel Catal from our research group joined the MSU Plant Diagnostic Clinic in 2003, and he has integrated this DNA capability into diagnoses of many plant diseases. Dr. Catal has been using the new methods for detection of fungal, bacterial, virus and nematode pathogens. ☞

## Protecting Michigan forests from the introduction of sudden oak death

### Authors

Gerard Adams and Mursel Catal, Department of Plant Pathology, MSU

### Funding

Michigan Department of Agriculture (MDA)

The new and devastating disease of trees and woody ornamentals known as sudden oak death (SOD) has been found in nurseries in California, Oregon, Germany and the Netherlands. The name of the disease comes from the rapid loss of tanoaks in the moist coastal forests of California. The disease is caused by a newly identified pathogen, *Phytophthora ramorum*, first reported in Germany on Rhododendron stock. The pathogen causes oozing cankers on the trunks of the trees and the cankers rapidly girdle the trees, killing them (see photos page 2A). Federal quarantines have been established to protect Michigan and other non-infested states from accidental introduction of this pathogen. However, prudence would warrant a careful watch over nursery stock imported from infested states because the methods for screening shipments of plants are error prone.

The potential impact of introducing *P. ramorum* into Michigan could be a massive devastation of our forestry industry and natural resources. Concern in Michigan is based on the known susceptibility of red oak, *Quercus rubra*. This tree is one of the most valued species in Michigan forestry. The impact could be compounded by loss of other woody plants in the forest ecosystem because the susceptibility of native Michigan plants remains unknown.

Early detection of the pathogen's introduction into Michigan is essential for any plans for eradication to succeed. The MDA began an initial survey of nurseries in 2001-02. They collected samples from

ericaceous plants, such as rhododendron, viburnum, camellia, and blueberry, as they arrived in Michigan from western nurseries. The samples collected included any leaves with necrotic areas and leaf spots. It has been discovered in California that the SOD pathogen causes small harmless infections on leaves of ericaceous plants. These infections cause lesions (see photo, page 2A) in which the pathogen sporulates. The spores are spread by rain. The pathogen is not known to sporulate on the oak trees.

The MDA brought approximately 100 samples to our laboratory to screen for the presence of *P. ramorum* in 2001-02. Screening techniques included incubating the leaves in moist chambers to induce sporulation, culturing of pathogens from the leaf lesions onto selective agar media, and molecular diagnostic tests. The molecular diagnostic tests were developed at the University of California and are based on highly sensitive detection of the pathogen's DNA in leaf tissue. We used molecular techniques and chemical extraction of the DNA of the pathogen sent to us from the California laboratory. The pathogen DNA served as a positive control for verifying that our screening tests were working.

Our screenings of the MDA samples were negative for the SOD pathogen. However, it will be important to continue screening nursery samples in future years and to keep a watchful eye on the health of oak trees near nurseries. Other species of *Phytophthora* were occasionally detected on leaves of the ericaceous plants. Careful analysis was needed to distinguish *P. ramorum* from these other *Phytophthora* species. Experience in California has shown that detection of *P. ramorum* by DNA technology is far more sensitive and precise than older methods based on culturing. ☞

## Phytophthora root rot of Fraser and other true firs in Michigan

### Authors

Dennis W. Fulbright, Sara Stadt, Mursel Catal, and Janette. L. Jacobs, MSU Dept. of Plant Pathology

### Industry partner

Michigan Christmas Tree Association

### Funding

Project GREEN

### Background

Fraser fir is viewed as a premium Christmas tree by the Michigan Christmas tree industry. Phytophthora root rot of Fraser fir, can be caused by several species of *Phytophthora* and is a limiting factor in production if trees are planted in low areas with poor soil drainage. Increased acreage of Fraser fir in Michigan has resulted in more trees being planted in unsuitable soils. In these situations, Phytophthora root rot can cause devastating losses in transplant beds as well as in plantations.

### Project objectives

The purpose of this study was to survey Michigan Christmas tree plantations and nurseries for root rot and identify the species of *Phytophthora* associated with diseased Fraser fir. This knowledge will allow us to institute management plans for Phytophthora root rot in Michigan Christmas tree plantations and to identify fir species resistant to Phytophthora root rot.

### Results

Similar to a results of a survey conducted in 1986, the most common species of *Phytophthora* found associated with Fraser fir plantings in Michigan were *P. citricola* and *P. cactorum*. Although *P. cinnamomi* is highly pathogenic to Fraser fir and is problematic in North Carolina, it was not recovered in Michigan in this or the 1986 survey. It has been suggested that *P. cinnamomi* is poorly adapted to the cooler temperatures of Michigan soils.

Of significance, however, was the finding of another species that has been difficult to characterize. Different aspects of this strain resemble both *P. megasperma* and *P. cryptogea*. Other *P. megasperma* isolates have not been able to cause disease on Fraser fir, but this novel strain is strongly pathogenic to Fraser fir and appears to be new to Michigan farms. Other species of *Phytophthora* including *P. medicaginis*, *P. europa*, *P. gonapodyides* and *P. nicotianae* were also found associated with the roots of dying Fraser fir, but their role in disease, if any, is not well understood.

Using the most pathogenic *Phytophthora* species from our recent survey, we inoculated various fir species in greenhouse tests. In these assays, it appears that Canaan and balsam fir were more tolerant of root rot than Fraser fir.

A unique opportunity to test the results of our greenhouse studies on root rot resistance in Canaan fir appeared during our survey. Both highly pathogenic and weakly pathogenic isolates of *Phytophthora* were present in the soil where a severe root rot epidemic was occurring. It was obvious at the outset that the root rot was associated with contaminated nursery stock from an out-of-state nursery since diseased trees abruptly stopped in the eighth row of a 14-row landing where nursery stock from one nursery was changed to that of another. The next six rows of Fraser fir were from an in-state nursery and no trees in these 6 rows showed symptoms of root rot. (Photo, color insert, page 2A.)

Furthermore, not only did the Fraser fir in this field originate from different nurseries, but the Fraser fir landings at one point were separated by a landing (16 rows) of Canaan fir. Similar to our greenhouse results, the Canaan fir did not develop root rot even though water drained from the diseased trees directly through the Canaan fir landing. Another landing of Fraser fir planted to the far side of the Canaan fir began to develop Phytophthora root rot later in the study.

This disease pattern strongly supports the probability that *Phytophthora* spores were carried by the drainage water through the Canaan fir planting to the Fraser fir landing on the far side. Yet, the passage of *Phytophthora* spores through the Canaan fir did not lead to any root rot of the Canaan fir suggesting some level of field tolerance in Canaan fir. These observations supported our greenhouse inoculation assays that suggested higher levels of resistance to Phytophthora root rot could be found with Canaan fir as with Fraser fir.

### Future directions for research

These results open two directions for future research. First, it may be possible to select balsam or Canaan fir with high levels of root rot resistance with better needle retention than currently available; or, second, it may be possible to graft Fraser fir to fir root stock with high levels of root rot resistance. This at first would appear to be prohibitively expensive. But, using these grafted trees to expand fir acreage into areas where root rot would normally be expected to infect trees could increase premium fir production acreage in Michigan. ☞

## Phytophthora root rot of white pine, a new disease for the state tree

### Authors

Dennis W. Fulbright, Sara Stadt, Janette Jacobs and Mursel Catal, MSU Dept. of Plant Pathology

### Funding Source

Michigan Agriculture Experiment Station

### Background

It is obvious to most travelers of Michigan roads that white pine is struggling along highways. Trees are turning chlorotic and/or red and are dying. It has been suggested that these trees have been stressed from drought, salt spray damage, and a harsh winter that included dehydration where roots could not take up enough water. During these times, it becomes imperative not to assume that all complaints of dying white pine are due to the same stress events throughout the state. One tree farmer in mid-Michigan began to notice dead white pines in his tree planting. These trees were 15 to 20 feet tall, were dying in groups and were not planted near a highway. Only the white pines were affected and dying and the interplanted spruce trees appeared healthy.

### Diagnosis

Several trips were made to the tree farm to determine the cause of the white pine deaths. It was obvious that the affected trees occurred in a pattern (focus) and that a large planting of healthy white pines was less than a hundred yards away. Based on the ground-level stumps, more than 20 dead white pines had been cut down in this particular location in the last two growing seasons. In early June, two more trees were dying and it appeared as if two more trees were candidates with their off-color gray appearing needles. Off-color needles (including gray-green, yellow and red), wilt, bark borers and bark fissures leaking sap were the only common symptoms on trees that had recently died. Roots were black and appeared to be more advanced in decay than the top of the trees. The root collar showed some necrosis and this appeared to be coming up from the roots

rather than down from the stem. Roots on trees beginning to show symptoms of off color needles did not appear to be severely affected.

Samples of the roots were taken back to the laboratory and checked for the presence of *Phytophthora* using a quick immunoassay (ELISA). Some roots appeared positive, however, nonpathogenic *Phytophthora* and other related water molds can confound these assays. Soil samples from around the roots were removed and using rhododendron leaves, *Phytophthora* isolates were baited out of the soil via the rhododendron leaves and cultured on a selective medium.

Using both traditional and new molecular methods, these isolates were characterized and identified as *Phytophthora cryptogea*. When placed in small wounds on the root collar of three-year-old, potted white pine in the greenhouse, death of the stems ensued and trees died within three weeks. This same *Phytophthora* species killed young Fraser fir when inoculated onto young fir in the same greenhouse in a parallel test.

### Significance

This is the first report of *Phytophthora* root rot of Eastern white pine. The trees were planted in a heavy clay soil that was wet in the spring and dry in the summer; the location was slightly lower than the surrounding area. The field had been in field crops prior to planting with conifers. Healthy trees in this disease focus had been dug and shipped, however, the grower indicated that no trees exhibiting symptoms were dug. *Phytophthora cryptogea* is not a new pathogen of conifers and it is possible that the presence of the pathogen, the stressed conditions of the white pine and the heavy, wet soils contributed to the expression of this new disease. In our tests, however, this species of *Phytophthora* appeared very aggressive on white pine and steps to monitor dead and dying white pines throughout the state, especially those trees recently transplanted, should be undertaken. ☞

## Alternatives to ash for Michigan and the Upper Midwest: Planting demonstration and website

### Authors

Robert Schutzki, MSU Dept. of Horticulture and Bert Cregg, Departments of Horticulture and Forestry

### Funding

MSU Project GREEN, Michigan Nursery and Landscape Association J. Frank Schmidt Family Foundation

### Industry partners

J. Frank Schmidt Nursery, Carlton Plants

### Significance

Emerald ash borer has certainly dominated the press over the past year, and unfortunately, it is going to continue until we become better informed and equipped to arrest its spread and begin the road to recovery. A recent survey indicated that ashes comprised up to 25% of the street trees in some Southeast Michigan cities. In all likelihood the emerald ash borer will eventually kill most of these trees. As trees are lost to emerald ash borer, a large-scale replanting effort is underway. To maintain the long-term health and sustainability of our landscapes and urban forests we need to consider and plant a diversity of species and selections. In the March/April 2003 issue of *The Michigan Landscape* we suggested substitute or alternative selections for ash. We looked at a broad spectrum of selection criteria, such as ornamental appeal, adaptability in the urban and suburban environment and availability. The species/ cultivars suggested are already in production, some of which may not be widely known or used in the landscape. The nursery industry has stepped up production on many of these selections to fill the void left by ash, however, it may be a few years before we see find them in plentiful numbers at the upper landscape sizes. Regardless of the time it takes, the introduction of species diversity into our residential and commercial landscapes will

be well worth it.

Thanks to the generosity and assistance of J. Frank Schmidt and Sons Nursery, Carlton Plants, the Michigan Nursery and Landscape Association, and Project GREEN, a demonstration plantation was installed in May at the Michigan State University

Tree Selections Planted at Ash Alternative Arboretum at Michigan State University Tollgate Extension Center, Novi, Michigan

Common Name	Scientific Name
Hedge Maple	<i>Acer campestre</i>
State Street Maple	<i>Acer miabei</i> 'State Street'
Emerald Queen Maple	<i>Acer platanoides</i> 'Emerald Queen'
Superform Maple	<i>Acer platanoides</i> 'Superform'
Tatarian Maple	<i>Acer tataricum</i>
Baumannii Horsechestnut	<i>Aesculus hippocastanum</i> 'Baumannii'
Yellow Buckeye	<i>Aesculus octandra</i>
Red Horsechestnut	<i>Aesculus x carnea</i> 'Ft. McNair'
Pyramidal Hornbeam	<i>Carpinus</i> 'Pyramidal'
European Hornbeam	<i>Carpinus betulus</i>
Hackberry	<i>Celtis occidentalis</i>
Katsura Tree	<i>Cercidiphyllum japonica</i>
Hardy Rubber Tree	<i>Eucommia ulmoides</i>
Royal Purple Ash	<i>Fraxinum americana</i> 'Royal Purple'
Autumn Purple Ash	<i>Fraxinus americana</i> 'Autumn Purple'
Windy City Ash	<i>Fraxinus americana</i> 'Windy City'
Summitt Ash	<i>Fraxinus pennsylvanica</i> 'Summit'
Urbanite Ash	<i>Fraxinus pennsylvanica</i> 'Urbanite'
Autumn Gold Ginkgo	<i>Ginkgo biloba</i> 'Autumn Gold'
Magyar Ginkgo	<i>Ginkgo biloba</i> 'Magyar'
Skyline Honeylocust	<i>Gleditsia triacanthos</i> 'Skyline'
Kentucky Coffetree	<i>Gymnocladus dioicus</i>
Amur Corktree	<i>Maackia amurensis</i>
Dawn Redwood	<i>Metasequoia glyptostroboides</i>
Accolade Cherry	<i>Prunus</i> 'Accolade'
Canadian Red Cherry	<i>Prunus virginiana</i> 'Canadian Red'
Red Spire Pear	<i>Pyrus calleryana</i> 'Red Spire'
Sawtooth Oak	<i>Quercus accutissima</i>
Swamp White Oak	<i>Quercus bicolor</i>
Scarlet Oak	<i>Quercus coccinea</i>
Shingle Oak	<i>Quercus imbricaria</i>
Bur Oak	<i>Quercus macrocarpa</i>
Chinkapin Oak	<i>Quercus muehlenbergii</i>
Japanese Pagodatree	<i>Sophora</i> 'Regent'
Greenspire Linden	<i>Tilia americana</i> 'Greenspire'
Redmond Linden	<i>Tilia americana</i> 'Redmond'
Sentry Linden	<i>Tilia americana</i> 'Sentry'

Tollgate Education Center. The Tollgate Education Center is a full-service conference facility owned and operated by MSU, located on the corner of Meadowbrook and 12 Mile roads within the current EAB quarantine area in Novi, MI. Michigan State University owns 60 acres on the site. The Center has meeting facilities and is open for visitors, which facilitates its use for educational programs. Trees were planted on the southwestern corner of the property and form the basis of a future arboretum. Thirty-seven selections (5 trees of each selection) representing thirty species were planted with additional trees being added in the future as they become available. (Photo, color insert, page 1A.)

Planting day was a comfortable sunny day, one of the few that we had this spring. Thanks to Roy Prentice, Tollgate Farm Manager, and the Tollgate volunteers, we were able to plant all one hundred and eighty-five trees by mid-afternoon. It was an enjoyable day, at times it seemed like a swarm of bees were carrying the trees across the site. After planting, the trees were mulched with a 3-foot ring of wood chips. Personnel from MSU have watered the trees regularly and weed control has been maintained

by a combination of hand weeding and spot treatment with glyphosate. Survival of the trees has been good (approximately 80%) despite below normal rainfall for much of the spring and summer. We will monitor growth and development, ornamental traits and pest resistance and publish it in an annual summary. The plantation will be monitored for a minimum of ten years and serve as an ongoing site for educational workshops.

The arboretum will serve as a centerpiece for our outreach and Extension programming on tree selection for EAB restoration in Southeast Michigan. The press in the area has published at least two large feature articles and the tree planting was featured in *The Michigan Landscape*, the trade magazine of the Michigan Nursery and Landscape Association. We are also grateful to J. Frank Schmidt Nursery for the use of photographic images of the alternative selections, many of which are featured on our new ash alternative website (<http://www.hrt.msu.edu/ash.alt/>). We expect all of our outreach efforts to increase dramatically as the spread of EAB continues and restoration of the effected areas gets into full swing. ☞

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## Identifying Balsam fir Christmas trees with superior needle retention

### *Principal investigator*

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### *Funding*

Washington State University, MSU

### *Significance/importance to industry*

Numerous consumer surveys have shown that needle retention is a major concern associated with the use of real Christmas trees. Although it is possible to reduce needle loss problems with some species of Christmas trees by delaying harvest, this approach is not very effective if there are unusually warm fall temperatures.

Balsam fir (*Abies balsamea*) is an important Christmas tree in the northeastern portion of the U. S. and eastern Canada. Postharvest studies have shown that there is tremendous tree-to-tree variability in needle loss when most true fir Christmas trees,

including balsam fir are displayed dry. Recent work with Nordmann (*A. nordmanniana*) and Canaan (*A. balsamea* var. *phaneroleplsis*) firs has shown that it is possible to identify provenances and/or individual trees with superior needle retention using detached branches. Work with Nordmann fir has also shown that needle retention is under strong genetic control and that there is a highly significant correlation between the needle retention characteristics of maternal trees and their progeny. This research indicates that the Christmas tree industry has the opportunity to significantly reduce the potential for needle loss problems by identifying trees with superior needle retention and then utilize these trees to establish seed orchards.

At Washington State University, a number of projects are underway to identify sources of different species of Christmas trees with superior needle retention. Typically, branches are removed from trees and displayed under controlled conditions for a period of 10 days. As the branches begin to dry, branches from trees with poor needle retention will typically begin to shed green needles within about three to seven days. In an effort to identify balsam fir trees with superior needle retention, a three-year cooperative project involving Washington State University and MSU was initiated in 2002.

### Objective

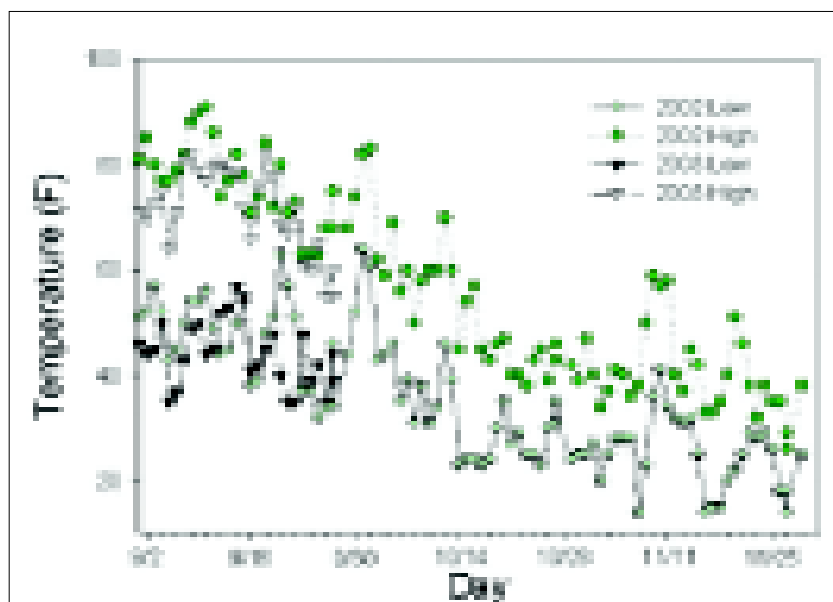
Determine variation in needle retention among a limited number of trees from six sources of balsam fir and one source of Canaan fir.

### Methods

The trees used in this study were planted between 1997 and 1998 at a site near McBain, Michigan. During the fall in 2002 and 2003, a pair of two-year-old branches was harvested from 10 trees from six sources of balsam fir (Bracted, Charlotte, Cook, Granville, Lunenberg, and Rangle) and one unidentified source of Canaan fir. In 2002, the branches were harvested on November 29 and in 2003, they were harvested on September 29. Daily maximum and minimum temperature data from September 1 through the dates of branch harvest in 2002 and 2003 were obtained for Lake City, Michigan, which is located approximately 10 miles from the site where the trees are grown.

The branches were tagged, placed in plastic bags and shipped via overnight mail to Washington State University in Puyallup, Washington. Upon arrival at Puyallup, the branches were removed from the plastic bags and placed in racks on a table in a postharvest display room. A single branch from each tree was randomly placed in each of two display racks. The temperature of the room was maintained at 66°F with about 40-60% relative humidity. The fluorescent lights in the room were left on continuously during the 10-day display period.

To obtain information on rates of moisture loss



**Figure 1.** Daily maximum and minimum temperature from September 1 through the date branches were harvested from trees in 2002 and 2003

during the test, branches from three trees of each source were selected at random in 2002 and small shoots were removed from each branch upon set up and after 3, 7, and 10 days of display to determine changes in their percent moisture content. Moisture content measurements were made on branches from the same trees in 2003. Needles loss from all of the branches was assessed after 3, 7 and 10 days of display by gently rubbing the current season and one-year-old needles on each branch and rating the extent of loss on a 0 to 7 scale, where 0 = none, 1 = <1%, 2 = 1-5%, 3 = 6-15%, 4 = 16-33%, 5 = 34-66%, 6 = 67-90% and 7 = >90%. (Photo, color insert, page 3A.)

### Results

**Temperatures prior to harvest** – Given the much later harvest of branches in 2002, the trees were exposed to colder temperatures prior to branch harvest in 2002 than in 2003 (Figure 1). The lowest temperature in 2002 was 14°F, while the lowest temperature in 2003 was 35°F. In 2002, there were 46 days with low temperatures  $\leq 32^\circ\text{F}$  and 57 days with low temperatures  $\leq 40^\circ\text{F}$ . In 2003, there were no days where the low temperatures were  $\leq 32^\circ\text{F}$  and only 8 days with low temperatures  $\leq 40^\circ\text{F}$ .

**Moisture loss** – In 2002, the initial moisture content of the branches at the time of setup in Puyallup ranged from 117.2 to 130.4%. These decreased to 57 to 78.4% after 10 days display. In 2003, the initial moisture contents for the branches ranged from 129.7 to 146.9%. These decreased to 51.4 to 102.5% by the end of the test. Given the low number of trees sampled from each source and the extent of tree-to-tree variation in moisture loss, it has not been possible to determine if there were significant differences in the rates of moisture loss between the different sources of trees.

**Needle loss** – In 2002, no needle loss was evident on any of the branches after 3 days of display. Branches from five (7.4%) of the 70 trees had needle loss ratings of 1 to 5 by the seventh day. By the day 10, branches from 19 (27.1%) of the trees exhibited some level of needle loss. During the 2003 test, which was conducted two months earlier than the 2002 test, needle loss ratings were much higher (Table 1). Branches from two (2.9%) trees had needle loss ratings of 1 to 5 after 3 days. Branches from 55 (78.6%) of the trees had

ratings of 1 to 7 by day 7. By the tenth day, branches from 66 (94.3%) of the trees had needle loss ratings of 1 to 7.


There was considerable variation in the extent of needle loss among the trees included in this test (Table 1). The percentage of trees from the different sources with needle loss ranged from 10 to 60% during 2002 and 80 to 100% during 2003 (Table 1). In most cases, the needle loss ratings for individual trees were  $\leq 1$  in 2002. Only 6 (8.6%) of the trees had ratings of 2 to 7. In 2003, about two thirds of the trees had needle loss ratings  $\geq 4$  by the end of the test. Even though branches from most of the trees had very high levels of needle loss, 4 (5.7%) of the trees that had no loss and 13 (18.6%) of the 70 trees had needle loss rating  $\leq 1$ .

In 2002 and 2003, individual trees were ranked for potential needle loss based on their current season and one-year-old needle loss ratings. Based on an analysis of these rankings (Spearman Rank Correlation), there was a highly significant correlation in 2002 ( $R=0.975$ ,  $P<0.001$ ) and 2003 ( $R=0.909$ ,  $P<0.001$ ) between rankings based on current season vs. one-year-old needle loss ratings. Even though trees had much higher needle loss ratings in 2003 than 2002, there was also a significant ( $R=0.305$ ,  $P=0.003$ ) correlation between the needle loss rankings of trees in 2002 and 2003 based on an average of their overall current season and one-year-old needle loss ratings.

**Conclusions**

Data collected during the first two years of this study, clearly show the effect of harvest date (exposure to cold temperatures) on the overall extent of needle loss that can occur when balsam and Canaan fir are allowed to dry during display. These data also confirm that even when harvested after exposure to 46 days with low temperatures  $\leq 32^{\circ}\text{F}$ , there was high enough levels of needle loss that would probably not be acceptable to consumers with about 8% of the trees.

Although growers would not normally harvest trees in late September, testing branches harvested at this time of year provides a better opportunity to identify trees that have superior needle retention characteristics than harvesting them later in the fall. About 6% of the trees harvested on September 29, 2003 had no needle loss and about 19% of the tree had needle loss ratings  $\leq 1$ . The correlation between the needle loss rankings in 2002 and 2003, indicate that trees that had high needle loss ratings in 2002 also tended to have high needle loss ratings in 2003.

Additional testing next year will be conducted to confirm the results from these experiments. Although it may not be possible to determine if there are differences in needle retention between the different sources of trees included in this test because of the relatively small number of trees being tested, it should be possible to identify individual balsam fir trees with superior needle retention characteristics. 

**Table 1.** Number of trees with needle loss and average needle loss rating for trees that lost needles after 10-day test

Source	2002 test		2003 test			
	No. with NL <sup>1</sup>	NL rating <sup>2</sup>	No. with NL < 1 <sup>3</sup>	No. with NL	NL rating	No. with NL < 1
Canaan fir	3	1.2	8	8	2.6	3
Bracted balsam fir	6	1.0	8	9	2.6	3
Cook balsam fir	3	0.4	10	9	2.4	2
Charlotte balsam fir	2	3.8	9	10	2.8	2
Rangley balsam fir	2	0.6	10	10	3.4	2
Lunenberg balsam fir	3	0.4	10	10	3.8	1
Granville balsam fir	1	1.8	9	10	3.9	0

<sup>1</sup>Number of trees out of 10 with some needle loss

<sup>2</sup>Average of the current season and one-year-old needle loss ratings for the trees with needle loss.

<sup>3</sup>Number of trees with current season and one-year-old needle loss ratings < 1.

## Resistance to emerald ash borer: Evaluation of Asian and North American ash trees

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### Funding

USDA ARS

### Industry partner

Bailey Nurseries, Inc., St. Paul, Minnesota, Michigan Nursery and Landscape Association

A replicated ash planting was established at the MSU Tollgate Education Center in Novi, Michigan in May 2003 to 1) compare resistance of native and Asian ashes to emerald ash borer, 2) identify mechanisms of resistance and susceptibility by quantifying biochemical and physical responses of phloem to wounding, and 3) determine the effects of drought and other stress on borer susceptibility.

The planting includes white (*Fraxinus americana*) and green ash (*F. pennsylvanica*), Manchurian ash (*F. mandshurica*) with which emerald ash borer shares an evolutionary history in Asia, and 'Northern Treasure' ash (*F. x 'Northern Treasure'*), which is a hybrid between native black ash (*F. nigra*) and

Manchurian ash. The inclusion of this hybrid may provide insight into patterns of inheritance of resistance genes and facilitate their identification. Our prior hypothesis is that the Asian ash is most resistant because of natural defenses resulting from coevolution. Identification of resistant genotypes will be critical for reforestation, as well as maintaining market demand for ash in the nursery industry. Identification of resistance mechanisms and their relationship to whole tree physiology will facilitate screening, selection, and/or breeding of resistant trees, as well as silvicultural management of emerald ash borer in urban natural forests.

Emerald ash borer adult foliage-feeding on July 28, 2003. We observed many adult emerald ash borers and lot of leaf –notching in July. On July 28 we counted the number of leaflets on each tree with at least one leaf notch from emerald ash borer feeding. Only leaves within reach when standing were counted. One leaf from the middle of the lowest branch on the N, S, E, and W side of the tree was observed first. More were counted from the next layer of branches above, if necessary. All the leaflets on each leaf were counted. Counting continued until 50 leaflets were observed.

No data was collected on attacks by emerald ash borer in the first year (2003), because the trunk diameter was too small to attract females for egg laying. One third of the trees of each species will be left untreated in 2004 so we can compare susceptibility/resistance among species. The remaining 2/3 of the trees will be treated with imidacloprid to protect them emerald ash borer in the first year, so they will be available for research the following years. We are going to take advantage of this by putting in a timing study on imidacloprid with the following treatments:

1. Merit soil drench November 7, 2003
2. Merit soil drench April 15, 2004
3. Merit soil drench June 5, 2004
4. Control

In this way we hope to determine when is the best time to apply Merit to the soil for protection against emerald ash borer. We will be sacrificing trees and counting galleries next September or October. ☞

**Experiment I:** Ash grown in containers before planting. Data are mean leaflets (out of 50) with notching from emerald ash borer. Anova F = 11.0, P = 0.0002

Treatment	n	Mean	SD
<i>F. pennsylvanica</i> (Green ash)	20	32.0 a	11.7
<i>F. mandshurica</i> (Mandchurian ash)	20	33.4 a	7.2
<i>F. americana</i> (White ash)	20	44.1 b	5.0

**Experiment II:** Ash trees arrived as bare root trees. Data are mean leaflets (out of 50) with notching from emerald ash borer. Anova F = 12.0, P = 0.0001

Treatment	n	Mean	SD
<i>F. mandshurica</i> X <i>F. nigra</i> 'Northern Treasure'	20	27.9	9.2
<i>F. pennsylvanica</i> (Green ash)	20	35.0	9.6
<i>F. americana</i> (White ash)	20	40.2	8.4

## Which flowering shrubs could retailers market as indoor flowering potted plants?

### Authors

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### Funding and industry partners

Michigan Nursery and Landscape Association, the Fred C. Gloeckner Foundation, FIRST, Spring Meadow Nursery, Inc., the Metro-Detroit Flower Growers Assn., and the Western Michigan Greenhouse Assn.

New or improved products can profitably restart sales of a product in the mature or declining stage of the product life cycle. However, launching new or redesigned products into a market creates challenges relative to existing product choices. Consumers may have preconceived notions that will affect the sale and acceptance of repositioned products. Their experiences with similar or related products may have created expectations and perceptions that need to be addressed along with product changes. As a choice set, consumers perceive some products as similar; these products may be considered substitutes for each other. Products perceived with virtually no substitutes may occupy distinctly unique spaces in consumers' minds. Gaining a better understanding of customers' product perceptions and preferences can help marketers anticipate necessary changes, and may also give marketers pricing and promotional ideas. What new products might be introduced to restart sales of flowering potted plants?

Commercial greenhouse growers now have the capability to program poinsettias, chrysanthemums, and other plants to flower on specific dates, within relatively concise limits. Growth in the wholesale value of flowering potted plants has been mediocre at best. Wholesale value increased from \$210 million in 1980 to \$684 million in 1996 and to \$832 million in 2001, or 3.6% (2.2% when adjusted for inflation) growth annually over the last 21 years, slowing to a mere 1.4% annual growth over the last five years (adjusted for inflation using Consumer Price Index, 2002). The introduction of "new" flowering plants will help improve growth and profitability of this important floriculture segment. We wanted to see if several indoor flowering shrubs could be repositioned as indoor flowering potted plants that could possibly be installed in the garden at a later date.

We chose 15 flowering plants based on their

differences in use (indoor or outdoor), plant habit or form and flower-color. Three plants were traditional flowering potted plants: azalea (*Rhododendron* hybrids), florist hibiscus (*Hibiscus rosa-sinensis*), and florist hydrangea (*Hydrangea macrophylla*). Six plants were herbaceous perennials: campanula 'Cherry Bells' (*Campanula punctata*), delphinium (*Delphinium grandiflorum*), euphorbia (*Euphorbia milii*), geum (*Geum coccineum*), laurentia (*Laurentia axillaris*), and sisyrinchium (*Sisyrinchium tinctorium*). Six plants were flowering shrubs: hibiscus (*Hibiscus syriacus*), hydrangea (*Hydrangea paniculata*), itea (*Itea virginica*), weigela Wine and Roses® (*Weigela florida*), and two lilacs (*Syringa x hyacinthiflora* and *Syringa meyeri*)

Plants were photographed in flower and adjusted with Adobe Photoshop. Adjusting the photographs gave us the ability to show plants in their ideal state. The photographs showed the plants in a green container against a black background. The pictures were shown in a frame on the web page when a link was clicked to elicit a response by comparing two different plants.

We constructed an Internet survey, which was established on the Texas A&M University Horticulture Department Web server. The survey consisted of 36 plant comparison questions, four questions regarding plant preferences, and 15 demographic and gardening questions. Participants were asked to compare two different plants that were shown in a side frame on the web page. (Photo, color insert, page 1A). We asked participants to choose which plants they would most likely use in an outdoor garden bed, which plants they would most likely use for decoration in the home, which flower colors they preferred, and which they would most likely purchase to give as a gift to a friend. The demographic questions included gender, age, education level, income category, number of adults and children in the household, and whether they rented or owned their home.

Survey Sampling, a professional sampling company, randomly selected 5000 e-mail addresses from their ELITE database and invited those individuals to participate in the study. Their ELITE database was collected through a variety of permission-based marketing sources. As a screening question, each potential participant was asked: (a) were they over age 18 and (b) had they purchased a flowering plant to enjoy indoors or to give as a gift in the last year? If they answered yes to both questions, they were invited to participate in the survey. The survey was conducted in June 2002 and 239 responses were obtained for Survey 1 and 282 responses for Survey 2.

Survey 1 participants were mainly women in their

early forties few of whom had some college education with a middle-household income. **Survey 2** participants were composed of women in their mid-thirties who had a college education and middle-household income. The two samples were different in only one of five demographic characteristics (education level), and could be considered comparable. The samples also appear similar to the profile of Americans who participated in flower gardening in 2002 which was described as being 56% female, with 43% between the ages of 35 and 54; 43% were college educated, 24% earned \$50,000 to \$75,000; 58% were married.

All of the participants had purchased indoor flowering potted plants in the past year since this was a screening question to make them eligible to participate in the study. Participants were asked about their plant preferences for indoors and outdoors. Participants were able to make multiple choices per question. **Survey 1** contained three traditional flowering potted plants Azalea (*Rhododendron* hybrids), florist's hibiscus (*Hibiscus rosa-sinensis*), and florist hydrangea (*Hydrangea macrophylla*), three flowering shrubs: hibiscus (*Hibiscus syriacus*), weigela Wine and Roses® (*Weigela florida*), and

syringa (*Syringa meyeri*) and three perennials: Delphinium (*Delphinium grandiflorum*), Euphorbia (*Euphorbia milii*), and Laurentia (*Laurentia axillaries*). Of the participants who expressed a favorite plant(s), the top choices to place solely outdoors were: syringa (72%), hydrangea (66%), and florist's hydrangea (59%). The highest rated plants that participants would use only in their home were Euphorbia (62%), weigela 'Wine and Roses'® (37%), and azalea (33%). Azaleas are typically used both indoors and out, but the weigela 'Wine and Roses'® has been exclusively a landscape plant. This study identifies weigela as one flowering shrub to potentially be repositioned as an indoor flowering potted plant. Some of the participants selected plants to be used indoors and outdoors. The top four plants that were perceived as dual use products were: azalea (28%), weigela (27%), and laurentia and hibiscus (26% each). The participants' favorite two colors were pink (azalea, 28%) and blue (delphinium, 28% and laurentia, 25%). The top three plants that the participant would give as a gift were azalea, florist's hibiscus and weigela 'Wine and Roses'®.

The same three florist's plants were used in **Survey 2** (azalea, florist's hibiscus, and florist's

**Table 1.** Of those who responded to the question, the percentage of Survey 1 respondents who expressed a preference for use location for each plant.

Plant	Use location		
	outdoors	indoors	both places
<i>Rhododendron hybrid</i>	39%	33%	28%
<i>Weigela florida</i> 'Wine and Roses'™	36%	37%	27%
<i>Laurentia axillaries</i>	52%	22%	26%
<i>Hibiscus Rosa-sinensis</i>	44%	31%	26%
<i>Delphinium grandiflorum</i>	49%	28%	23%
<i>Hydrangea macrophylla</i>	59%	24%	18%
<i>Euphorbia milii</i>	21%	62%	18%
<i>Syringa meyeri</i>	72%	13%	15%
<i>Hydrangea paniculata</i>	66%	25%	9%

**Table 2.** Of those who responded to the question, the percentage of Survey 2 respondents who expressed a preference for use location for each plant.

Plant	Use location		
	outdoors	indoors	both places
<i>Rhododendron hybrid</i>	35%	32%	33%
<i>Hydrangea macrophylla</i>	41%	31%	28%
<i>Hibiscus Rosa-sinensis</i>	39%	35%	26%
<i>Campanula carpitaca</i>	46%	30%	25%
<i>Geum coccineum</i>	33%	49%	18%
<i>Itea virginica</i>	44%	38%	18%
<i>Syringa x hyacinthiflora</i>	64%	18%	18%
<i>Hibiscus syriacus</i>	65%	20%	15%
<i>Sisyrinchium tinctorium</i>	60%	26%	14%

hydrangea) to which were added three flowering shrubs (hibiscus, itea, and syringa) and three herbaceous perennials (campanula, geum, and sisyrinchium). Of the participants' favorite plants, the top choices for outdoor use only were hibiscus (65%), syringa (64%), and sisyrinchium (60%). Of their preferred plants for indoor decoration, geum (49%), itea (38%), and florist's hibiscus (35%) were most often chosen. Of those who said they would use it for both in and outdoors, azalea was among the most preferred with 33% of the total participants indicating their preference for its dual use, followed by florist's hydrangea at 28%. Florist's hibiscus was third with a 26% of the participants. Another blue campanula, *Campanula carpatica*, was highly preferred in both indoor and outdoor use in a previous study. A previous study also showed two blue flowering plants as most favorite, followed by a

pink flowered azalea (Moore, 1999). The blue flowering plant that was highly favored in this study was syringa (23%). Pink flowering plants that were highly favored were the campanula (21%) and the azalea (20%). The top three plants that the participant would give as a gift were azalea (43%) and florist's hibiscus (39%). Campanula (42%) was the third favorite choice.

Survey participants were predominately females who had purchased a flowering plant in the year prior to the survey. Consumers may be willing to pay more for the ability to use the former both inside and out over using the latter once indoors. Euphorbia, azalea, and weigela 'Wine and Roses' were the highest rated plants that participants would use in their home.

Azaleas are typically used both indoors and out, but the weigela 'Wine and Roses' is not. This identifies weigela as one flowering shrub to potentially be repositioned as an indoor flowering potted plant. Another plant, which may be repositioned is the lilac. The addition of fragrance from the lilac might be an added value for which some consumers are willing to pay. Although some plants in the survey like sisyrrinchium do not appear to have near substitutes, this could be a marketing advantage (if consumers are willing to pay for the distinction) or it may be a disadvantage (if consumers have no idea how to place the plant in their garden). Results of this research identify some flowering shrubs as better candidates for repositioning than others. ✂

## Evaluation of potential plant species for green roofs

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### Industry partners

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Behrens Systementwicklung, GmbH; Groß Ipener, Germany

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### Significance

In addition to their aesthetic qualities, green roofs provide insulation for buildings, reduce the amount of runoff entering municipal stormwater management systems; and increase the life span of a typical roof by protecting the various roof components from damaging UV rays, extreme temperatures, and rapid temperature fluctuations. However, obtaining these benefits can sometimes be difficult. A rooftop is an extreme environment with strong and variable wind patterns and little or no protection from the sun's intense heat and ultraviolet radiation. Climatic conditions, especially the amount and distribution of rainfall and temperature extremes, will eliminate the use of certain species or will dictate the need for irrigation. Selection of plant material is crucial for success.

### Project goal

Even though green roofs are relatively popular in Germany and the rest of Europe, the concept is just now being introduced in the United States. If we are to realize the benefits they provide, then we must develop a better understanding of what specific species will survive and prosper under harsh rooftop conditions. What works in Germany is not necessarily what is best for Michigan or the rest of the U.S. because of our greater extremes in winter and summer temperatures. Therefore the overall objectives of our research are to evaluate plant species, propagation and establishment methods, substrates, water and nutrient requirements, and water quality and quantity of runoff. The specific objective of this experiment was to evaluate potential plant species for green roof applications.

### Project description

The green roof research program at MSU was initiated in collaboration with Ford Motor Company in an effort to advise them on the installation of a 450,000 square feet green roof that was recently installed on a new assembly plant in Dearborn. Numerous experiments are currently being conducted on 48 model scale roof platforms measuring 8 ft x 8 ft at MSU. The site is equipped with a weather station, thermocouples measuring temperatures at various depths in the growing substrates, and electronic tipping buckets that record the volume and rate of stormwater runoff from the individual platforms. Measurements are taken every five minutes, 24 hours a day, and are recorded on a Campbell Scientific datalogger.

Over the past three years we conducted a study

comparing nine species and cultivars of *Sedum* and 18 taxa of Michigan native plants: *Agastache foeniculum* (lavender hyssop), *Allium cernuum* (nodding wild onion), *Aster laevis* (smooth aster), *Coreopsis lanceolata* (lanceleaf coreopsis), *Fragaria virginiana* (wild strawberry), *Juncus effusus* (spikerush), *Koeleria macrantha* (junegrass), *Liatriis aspera* (rough blazingstar), *Monarda fistulosa* (bergamot), *Monarda punctata* (horsemint), *Opuntia humifosa* (prickly pear), *Petalostemon purpureum* (purple prairie clover), *Potentilla anserina* (silver feather), *Rudbeckia hirta* (black-eyed Susan), *Schizachyrium scoparium* (little bluestem), *Solidago rigida* (stiff goldenrod), *Sporobolus heterolepis* (prairie dropseed), and *Tradescantia ohiensis* (spiderwort). The Michigan natives were planted as plugs and nine species of sedum were planted as either seed or plugs. Criteria for evaluating species included rate of establishment, capability to exclude invasive weeds, heat and cold tolerance, drought tolerance, and survival and persistence.

## Results

All nine species of *Sedum* significantly outperformed the native forbs and grasses in criteria such as rate of establishment, substrate coverage, drought tolerance, and plant mortality. Without irrigation, the native plants either died or went dormant by June, resulting in a brown mass of dead-looking plants that could be a major fire hazard. The natives looked fantastic early in the year, but could not withstand the heat and drought conditions when growing in only four inches of roof substrate. After three years, all natives were dead except for a few plants of *Coreopsis lanceolata*, *Tradescantia ohiensis*, and *Allium cernuum*. These could be potential selections for green roofs depending on the range of conditions present. However, if any of these native plants are to be grown successfully and maintain their aesthetic value, then irrigation must be available or the substrate must be deeper, an impractical solution considering the weight limitations of a green roof installation. In contrast, all of the *Sedum* species survived and thrived under all environmental conditions. ☞

## Genetic improvement of Scotch pine for Christmas tree production in Michigan

### Authors

Paul Bloese and Daniel Keathley, MSU  
Department of Forestry

### Funding source

SAPMA, Michigan Christmas Tree Association

### Industry partners

Michigan Christmas Tree Association, Michigan Seedling Growers Association

### Significance to the industry

Michigan is one of the nation's leading producers of Christmas trees. Each year Michigan growers harvest more than four million trees, producing approximately \$60,000,000 in gross revenue and supplying more than 20 percent of the national market. Although Scotch pine production has decreased over the last decade, it remains an important component of the Christmas tree market. To maintain or increase their share of an increasingly competitive national market, Michigan Scotch pine growers must grow high quality trees. The development of genetically improved Scotch pine planting stock would provide Michigan growers with a solid foundation for producing high quality Scotch pine Christmas trees.

### Objective

The goal of this project is to develop a long-term breeding program for Scotch pine and the eventual production of commercially significant quantities of genetically improved seed.

### Project background

The first step in starting a breeding program is selecting a first generation breeding population, which serves as the foundation of future genetic improvement. In June 1993, over 1,000 acres of ten commercial growers' farms were examined in a search for phenotypically superior Scotch pine Christmas trees. Fifty-seven three- to four-year-old trees exhibiting exceptional branch angle, stem form, crown form, needle length and growth were selected. All selections were free of insect and disease attack when selected. Selected trees were balled and burlapped and transplanted to a breeding arboretum at MSU's Sandhill research area in fall 1993.

To produce significant amounts of seed, the above ground portion of the selected trees had to be genetically duplicated in numbers sufficient to establish a viable seed orchard, which was done by grafting. Nearly 2,000 grafts had been established in seed orchards at Russ Forest and the Tree Research Center by 1997. Both orchards were designed using

“Seed Orchard Management and Design” (SOMAD) software developed by the USDA Forest Service. SOMAD minimizes inbreeding and maximizes outcrossing by optimizing the distances between members of the same clone. At maturity (allowing for culling 30% of the poorer clones), conservative estimates indicate the two orchards will produce over 250 pounds of genetically improved seed annually for use by the Michigan Christmas tree industry.

### *Continuing research*

The next step to improve Scotch pine for Michigan is to progeny test the clones in the orchards. Progeny

testing will evaluate the genetic quality of the clones originally selected based on their phenotype, and provide data critical to the culling of poorer clones. Although most trees in both the Russ and TRC orchards have begun flowering and producing limited amounts of seed, seed production will not accommodate a full-scale progeny test for another year or two. In the interim, seedlings produced from a bulk seedlot collected from the Russ orchard in 2002 will be field planted in fall 2003 and spring 2004. This planting will provide an initial, cursory appraisal of the orchard’s genetic quality and assess the relative merits of fall versus spring planting. ☞

## Provenance testing Noble fir for Christmas tree production in Michigan

### *Authors*

Paul Bloese and Daniel Keathley, MSU Dept of Forestry

### *Funding Source*

Michigan Christmas Tree Association, Dept of Forestry MSU

### *Industry Partners*

Michigan Christmas Tree Association, Michigan Seedling Growers Association

### *Significance to the industry*

Over the past 10 to 15 years, the species produced by Michigan Christmas tree growers has become much more diverse. Although Scotch pine once dominated production, Michigan’s Christmas tree crop is now much more evenly distributed across several species of pine, spruce and fir. True firs in particular have gained importance as their popularity among consumers has risen nationally. In addition to their increasing market share, high quality true firs command premium prices. Although Noble fir is the premier Christmas tree species in the Pacific Northwest, the adaptability of this species to Michigan has not been systematically examined. If high quality Noble fir Christmas trees can be efficiently produced in Michigan, growers could add a high value, high demand species to their production mix.

### *Objective*

Establishing a Noble fir provenance test on several sites will enable the systematic evaluation of this species for Christmas tree production in Michigan.

### *Project background*

Seed from 21 Washington and Oregon Noble fir

provenances was purchased and sown in styroblock containers in MSU Department of Forestry’s greenhouses. Only inland provenances were included in the test because past experience with other Pacific Northwest conifers indicates that coastal provenances are not cold hardy in Michigan. The first crop suffered widespread mortality from fungal root infections (primarily *Fusarium* and *Phytophthora*) when transplanted to the nursery. Consequently, a second crop was sown in January 2003 and a new, more varied fungicide regime has produced, to date, healthier seedlings. Portions of provenances with surplus seedlings were transplanted to the nursery in October 2003. All remaining seedlings will be overwintered in their containers and transplanted to the nursery in spring. Varying the transplant season will provide information on the viability of fall transplanting Noble fir in Michigan, and whether over-wintering Noble fir in containers contributes to root disease (Container stock root systems are assumed to be healthy prior to over-wintering based on the observed health of the fall transplant stock.).

### *Continuing research*

Assuming the 2003 crop survives and grows well in the nursery, planting stock should be available for field planting by Spring 2005. Test plantings will be established at two or more sites in a randomized block design with four-tree linear plots. Because Noble fir seed does not store well, all remaining seed is currently being stratified and will be sown in containers in January 2004. The 2004 crop will be transplanted to the nursery in either Fall 2004 or Spring 2005. The transplant date will be chosen based on the relative vigor of seedlings transplanted October 2003 versus Spring 2004. The 2004 crop should produce field stock for a second set of test plantings in Spring 2006. ☞

## Turfgrass evaluation results (2000-03) at MSU's Northwest Michigan Horticultural Research Station

### *Author*

L. Andrew Norman, District Turfgrass Agent, Northwest Region

### *Cooperators*

Tom Reed, Sr., TriTurf, Inc.; Suleiman Bughrara, Department of Crop and Soil Sciences; James Beard, International Sports Turf Institute; MSU - Northwestern Michigan College (NMC/Traverse City) Applied Plant Science Program students; and the National Turfgrass Evaluation Program (NTEP).

### *Industry partners*

TriTurf Inc., J. R. Simplot Inc., Lebanon Seed Company, Spartan Distributors of Sparta, La Cross Landscaping of Cedar, The GreenMan's Landscape Services of Traverse City and S. White Inc., Robert B. Adams of Overby Farm Lake Leelanau, Northern Michigan Turf Managers Association and Traverse City Golf and Country Club staff.

### *Significance*

Many new turfgrass cultivars are being developed and commercialized each year for use in lawns, athletic fields, golf courses, roadsides, and the like. Claims made about varieties, such as "drought tolerant," "disease resistant" or "lower growing" may not be substantiated by objective research. The National Turfgrass Evaluation Program (NTEP) Commercial/Consumer trials are designed, developed and coordinated for uniform evaluation of turfgrass cultivars in the United States and Canada. (**Editor's note:** For more information about the NTEP program, and for NTEP evaluation results for East Lansing, Michigan, visit the NTEP website at: [http://ntep.org/states/mi1/mi1\\_eastlansing.htm](http://ntep.org/states/mi1/mi1_eastlansing.htm) )

The first turfgrass cultivar plots in Northwest Michigan were planted over 40 years ago. The new turfgrass plot site at the MSU Northwest Michigan Horticultural Research Station (NWMHRS) in Traverse City was developed to provide scientifically based information to the turf and landscape industries and property owners to further their management objectives, while protecting water and natural resources. Throughout the season and at subsequent research station open houses in August 2001, 2002 and 2003, bluegrass plots were shown and explained to interested donors and individuals. This report provides an update of turfgrass research trials that began in 2000.

### *Objectives*

The current plots demonstrate the performance of some commonly used and newly developed cultivars of bluegrass and tall fescue. The parameters for evaluation of the plots at the MSU NWMHRS include density, color, texture, percentage of ground covered, pest problems and environmental stresses.

### *Methods*

The Northwest Michigan trials were developed using NTEP evaluation standards. Each trial area consists of two plot areas with three replications in each plot. Thirty bluegrass cultivars and thirty-two tall fescue cultivars under evaluation were both replicated a total of six times. The NTEP Kentucky bluegrass consumer trial at the NWMHRS was planted during late September and early October of 2000. The tall fescue consumer trial was planted in late September and early October of 2001. This trial consists of a group of commercially available tall fescue cultivars plus several new cultivars that will soon be released to the trade. The two plot areas were fertilized with 10-18-18 starter fertilizer at a pound of phosphorus and potassium per 1000 square feet, covered with a white blanket made of a spun poly material and stapled to the ground for the winter. In the spring, weed control and fertilization programs were developed for the season, to manage the weeds that were present in the plots and to increase density. We started with applying 19-2-9 and Confront, alternating it with 10-18-18 starter fertilizer. Both Kentucky bluegrass plots were irrigated. One tall fescue plot was irrigated; the other was a non-irrigated plot. The bluegrass plots and the (irrigated) tall fescue plot were watered daily for 20 to 25 minutes. Bluegrass plots were mowed at one and three inches, while tall fescue plots were mowed only at three inches.

### *Observations/discussion*

The plots were evaluated on a scale of one to nine (1-9), one being low and nine being high. The bluegrass rankings given here are the averages for both mowing heights of the six replications of each cultivar.

The first evaluation of the bluegrass plots occurred on October 22, 2001. Top ranking cultivars at that time: Serene 7.3; Northstar 7.2; Baronie 7; Boutique 6.9; Unique 6.9; Bartitia 6.7; Brooklawn and Total Eclipse 6.7. There was one cultivar (Cabernet) with significant leaf rust observed in the fall season of

2001. This cultivar did not show any significant leaf rust in fall of 2002 or 2003. From May to October 2001 rainfall was 16.47 inches, while the evapotranspiration was 29.03 inches, giving a moisture deficit of 12.56 inches.

The top-ranked cultivars of the second evaluation on April 8, 2002 were: Baronie 7.75; Serene and Champagne 7.25; Total Eclipse 6.92; Blackstone 6.88; Brooklawn 6.78; and Kenblue 6.75. On August 7, 2002, the top-ranked cultivars were: Northstar 8.67; Alpine 8.33; Total Eclipse 8.25; Serene and Blackstone 8.17; Unique 8.08; Quantum Leap and Boutique 8.0. The top rankings at the September 26, 2002 evaluation (fourth rating) were: Northstar 8.25; Midnight 8.08; Total Eclipse 8.0; Absolute, Blackstone and Odyssey 7.92. The May to October 2002 rainfall was 15.55 inches, while the evapotranspiration was 30.76 inches giving a moisture deficit of 15.21 inches.

The first rating in 2003 was on April 30. The top-rated cultivars were: Champagne and Rita at 6.58; Cabernet 6.42; Brooklawn 6.0; Kenblue 5.83; Baronie 5.75; and Odyssey 5.58.

On July 31st, top-rated cultivars were: Northstar at 8.75; Absolute 8.17; Alpine, Blackstone, Rugby II and Serene all at 8.08. Top rankings on October 2nd were: Alpine and Serene 7.92; Blackstone; Midnight and Moonlight 7.83; and Bartitia 7.75. From May to October 2003 rainfall was 13.85 inches, while the evapotranspiration was 28.46 inches giving a moisture deficit of 14.61 inches.

There has been very little general, visual difference in the irrigated tall fescue cultivars with the exception of the standard Kentucky 31, which was not as dark, dense or attractive as the remaining cultivars in the trial. The top-ranking cultivars on June 13, 2003 were: Pure Gold and JT-8 at 7.0; Tar Heel 6.83; Bonsai and KO1-WAF 6.67; and Matador, Olympic Gold, KO1-8015 and KO1-8007 at 6.5. Observations suggest that KO1-8007 was the finest textured cultivar. The non-irrigated plot experienced two growing seasons of drought and has not filled in to date.

The brief summary of information presented here is only an introduction and not the entire story. The majority of the data have yet to be consolidated and analyzed. There appeared to be bluegrass cultivars that performed better, for example, in the early spring as compared to the summer months. The above ratings are a combination of the data at both the mowing heights (1" and 3") for the bluegrass plots. However, some of the bluegrass cultivars tended to rank higher when mowed at one cutting height (1" or 3"). Both tall fescue plots were mowed at a three-inch height. Thanks to Dr. Suleiman Bughrara, for assistance with developing the trials, and to Tom Reed, Sr. and MSU -NMC Applied Plant Science students, who helped in grading and seeding the plots both years and additionally with the installation of the irrigation in 2000. J. R. Simplot Inc. and Lebanon Seed donated some of their new cultivars and the balance was supplied by NTEP (USDA- Beltsville, MD). ☞

## 2003 Grand Rapids summer turf and landscape field day

### *Author*

Rebecca Finneran, Kent MSU Extension  
Horticulture Educator

### *Industry partner*

Association of Grand Rapids Landscape Professionals

### *Significance*

The annual summer field day provides hands-on training that addresses basic landscape management issues. The program follows an intensive winter lecture series and often times, the summer topics allow for hands-on follow-up to winter lectures. These programs are held yearly; topics change based upon current issues affecting the green industry.

### *2003 Program description*

#### **I. Good Nutrients Gone Bad-When Does Phosphorous Become a Problem?**

Phosphorous loading has become a significant issue in most watershed environments of West Michigan. Tom Smith, executive director of the Michigan Turfgrass Foundation, shared the basics of phosphorous movement in urban landscape management, the influence of local legislation in this issue and the efforts of the MTF and MSU to be proactively engaged.

#### **II. Professional Etiquette on Your Customer's Home Front**

How does your workforce represent the standards

and values of your company in public? All too often, employees are sending messages about quality to your customer with unwritten signals. Rob McCartney, director of horticulture at the Frederik Meijer Gardens and Sculpture Park, discussed his many years of customer service experience at a major theme park during this presentation. Participants came away with positive ways to be in tune with what the client thinks is important.


#### **III. Take the Guesswork out of Liquid Calibration!**

Calibrating hand held sprayers can be tricky and poorly calibrated equipment can lead to over or under applying pesticides. Reading the label, understanding how to mix products, and handling equipment properly to take the guesswork out of calibration were presented by Tony VanDorp, sales consultant for BLESCO, and Dirk Bakhuyzen of PROCARE.

#### **IV. Small Engine Trouble Shooting**

Is your lawn mower smokin'? Is your tailpipe draggin' you down? Eric Ozolins, service manager for Kubota of West Michigan led participants through some on-the-spot trouble shooting tips to save time and headaches with equipment on the job.

#### **V. Walk on the Wild Side**

Calvin College's campus was the location for discussion of current turf problems while exploring solutions that were environmentally sound and cost effective. Participants shared their experiences with workshop leaders, Kevin Timmer of Tender Lawn Care and Jim Zylstra of Tuff Turf-MoleBusters. 

## Emerald ash borer volunteer education

### *Team members*


Colleen Boyer<sup>1</sup>, Bob Bricault<sup>1</sup>, Rebecca Finneran<sup>1</sup>, Gary Heilig<sup>1</sup>, Terry McLean<sup>1</sup>, George Silva<sup>1</sup>, Dave Smitley<sup>1,2</sup>, Diane Brown Rytlewski<sup>1,2</sup>, Mary Wilson<sup>1</sup>  
<sup>1</sup> MSU Extension; <sup>2</sup> MSU Department of Entomology

### *Michigan Department of Agriculture staff*

Kendra Anderson, John Bedford

On October 2 more than 100 Master Gardeners and staff from Clinton, Eaton, Genesee, Ingham, Kent, Muskegon, Shiawassee, Oakland and Ottawa counties participated in a bus tour and emerald ash borer (EAB) identification training in Oakland County. Following a presentation by Dr. David Smitley on EAB biology, pest distribution, and research efforts and an update of regulatory efforts by MDA staff, Master Gardeners received "hands on" experience in

searching for EAB infestation of park trees. Participants eagerly dug out many larvae for their collection bottles. The samples will be very useful for programs and public displays on EAB. (Photo, color insert, page 1A.)

The purpose of training sessions like this one is to prepare Master Gardeners to assist their local agents with activities related to EAB outreach efforts such as staffing hotlines, door to door delivery of information and to answer homeowner questions with the most up-to-date information available, write newsletter articles, and assist with educational programs and projects. They will also watch for suspected new infestations as they work in their respective communities on various volunteer projects. Each participant received a packet containing a variety of bulletins on the subject and a chisel to use for peeling off ash bark, to look for larvae. 

# Ornamental plant industries education in Southeast Michigan

### *Organizer*

Mary A. Wilson, Genesee County Horticulture Agent

### *Funding*

Program registrations

### *Significance*

Solving landscape ornamental and turfgrass problems is paramount to business success within the ornamental plant industries. However, the amount of knowledge to be “mastered” is extensive plus the landscape is a dynamic ecosystem. The environment, plants, pests and management techniques are constantly changing. Businesses must stay up-to-date to remain competitive.

The industry is also challenged by the lack of trained pesticide applicators due to high employee turnover rate within the industry.

### *Program goals*

1. Provide identification and environmentally sound management information on turfgrass and ornamental plant pests to industry professionals.
2. Train industry professionals to become certified pesticide applicators.
3. Provide certified pesticide applicators with CEUs on current issues relating to environmental protection, personal safety, regulations and pest management.

### *Programs*

**Pest Management** – The annual, one-day “Pest Management in the Landscape: Turf and Ornamentals” seminar was held in Flint on February 4, 2003. Collaborators were Dr. David Smitley, MSU Entomology Specialist; David Gilstrap, MSU Turfgrass Specialist; Dr. David Roberts, MSUE District Horticulture Agent; and Diane Brown-Rytlewski, MSU IPM Program, Entomology. There were 144 industry professionals in attendance, and 110 pesticide applicators obtained four recertification credits for 3b (ornamentals), 3a (turfgrass), or core.

**Turfgrass Education** – A one-day “Turfgrass Short Course” in early March focused on the dirty truth of soils, grub wars and other turf battles, weedy matters and the fate of phosphorus. Collaborators were Dr. James Crum and Ron Calhoun, MSU Turfgrass Specialists; Terry Davis, MSU Entomology Research Assistant; and Greg Lyman, MSU Turfgrass Environmental Stewardship Program Manager. There were 145 industry professionals

trained at this short course, and 97 pesticide applicators were granted four recertification credits in category 3a (turfgrass).

**Pesticide Applicator Training** – A three-day training series was held in March in Flint for ornamental plant industry professionals. Resource people were Bob Bricault, Washtenaw County MSUE Horticulture Agent; Darren Bagley, Genesee County MSUE Natural Resources Agent; and Mary Wilson, Genesee County MSUE Horticulture Agent. There were 73 professionals trained during this program, and 54 participants took the Michigan Department of Agriculture pesticide applicator exams following the training sessions. Also, 19 currently certified pesticide applicators were granted 2 recertification credits for each session they attended.

### *Impacts*

**Pest Management in the Landscape** – A formal evaluation was distributed with 73 completed forms returned. The program impacts were: 97% gained knowledge that will improve profitability, 91% plan to change pest management practices, 97% gained knowledge to help control or explain new pest problems and 100% gained knowledge on pesticide selection for both pest control and environmental concerns. Participants were also surveyed for their experience level. Of the participants, 58% have been in the industry 10 years or less with 26% for less than 5 years.

**Turfgrass Short Course** – A formal evaluation with 48 responses indicated: 98% plan to change cultural practices to improve turfgrass health, 100% gained knowledge to improve turfgrass health and maintain/improve environmental quality, 98% indicated they can now implement strategies that will reduce insect problems and hard-to-control weeds, 92% of the athletic field managers can now implement or modify cultural or pest management practices that will improve plant and reduce injuries and liability. When asked specifically about soil testing and fertilizer options, 59% of those not offering soil testing for the clientele, will now offer, or consider offering, soil testing. Of those persons not offering low or no phosphorus fertilizer for their clientele, 12% will offer this option and 86% will now consider offering this option.

**Pesticide Applicator Training** – Based on information from Michigan Department of Agriculture, 54 (100%) of the program participants not currently certified passed their pesticide applicator exams with high scores. ☞

## Plants of distinction 2003

### *Program organizers*

Rebecca Finneran, Kent County Horticulture Agent; Mary Wilson, Genesee County Horticulture Agent

### *Funding*

Program registrations

### *Significance*

A growing number of landscape customers have become more discriminating about the plants in their landscape. They no longer want “cookie-cutter” landscapes. Consequently, there is a need to increase industry awareness of new and underutilized plants as well as new uses for current plants in the Michigan landscape. Coupled with this is the need to diversify plantings and seek pest resistance. By selecting the proper plant material, not only will customer satisfaction (and profit) improve, but there will also be fewer pesticides and fertilizers added to the environment.

### *Program goals:*

1. Increase awareness of new and underutilized plant material for the Michigan landscape.
2. Communicate information about plant evaluations and trials to professionals and plant enthusiasts.
3. Increase profitability for ornamental plant businesses by exposing them to new and proven plant material that is more marketable to their customers.
4. Expose professionals and plant enthusiasts to landscape plant material with fewer pest problems and nutrient requirements.
5. Increase consumer demand and satisfaction through education of improved plant performance.
6. Encourage use of diverse plant material in the Michigan landscape.

### *Program*

Two hundred and seventy-seven industry professionals and plant enthusiasts attended “Plants of Distinction” programs in Grand Rapids and Flint in February 2003. Horticultural experts from universities, public and private gardens, and businesses are brought in to provide their perspectives on a number of plant related topics that change

yearly. The portfolio of speakers and topics for this year’s programs included Dr. Edward Hasselkus (Emeritus, University of Wisconsin-Madison) who shared his extensive knowledge of conifers for the backbone of the garden. In addition to being a professor of horticulture for many years, Dr. Hasselkus is the curator of Longenecker Gardens, a 50-acre collection of ornamental trees and shrubs within the UW Madison Arboretum, which includes a large number of conifers.

Jeff Epping, manager of horticulture at Olbrich Botanical Gardens, in Madison, Wisconsin delivered an information-packed talk about plants to use for special effects in the landscape. Tom Kimmel, owner of Twixwood Nursery in Berrien Springs entertained the audience with his quirky sense of humor and discussion about how to make landscapes soar through the use of vines. Tim Wood, of Spring Meadow Nursery in Grand Haven, covered the merits of landscape specimens for the most challenging growing conditions and Nancy Lindley of Great Lakes Roses in Belleville shared new and innovative ways to use roses in the landscape. Two pesticide applicator recertification credits were offered for ornamentals (3b).

### *Results*

Through formal surveys conducted after both seminars, participants indicated the following impacts: 100% plan to apply information from this session in their business; 98% gained knowledge of plants that have fewer pest problems and/or lower maintenance requirements; 100% gained knowledge about plants that will solve clients’ needs and site-related problems; and 100% gained knowledge that will improve customer satisfaction and business profitability.

The Nursery / Landscape AoE focus on “Plants of Distinction” has been an initiative since 1998. Local growers have modified the assortment of plants that they are now growing. Also, the impacts on customer purchasing decisions at area garden centers are now apparent. Past participants return repeatedly for continually emerging plant information. This issue continues to be a priority identified by local advisory boards, the Nursery/Landscape AoE and Michigan Nursery and Landscape Plant Promotion Committee. ☞

### West Michigan Nursery Growers Summer Tour

#### *Program organizer*

Thomas A. Dudek, District Extension Horticulture and Marketing Agent, West Central Region

#### *Sponsors*

Zelenka Nursery, Greenstone Farm Credit Services

#### *Industry partners*

Zelenka Nursery, Vans Pines Nursery, Northland Farms, Inc., Michigan Evergreen Nursery, Sawyer Nursery

#### *Program presenters*

David Smitley, Diane Brown-Rytlewski, George Bird, MSU Dept of Entomology; Tom Fernandez, Rob Richardson, MSU Dept of Horticulture; Bud Hart, Dept of Forestry; Lee Jacobs, MSU Dept of Crop and Soil Sciences

Zelenka Nursery was host for the 2003 West Michigan nursery growers summer tour. The first program of the day was by David Smitley, who presented results of phytotoxicity testing of Flagship 25 WG, (a neonicotinoid insecticide) and Dinetofuran 20 SG (a nitroguanidine insecticide) on container stock, and showed a demonstration plot of 26 taxa of both woody and herbaceous plants treated with the compounds. Rates used included controls with no insecticide applied, and rates of 1x, 2x and 4x the recommended rates. Results of the tests, sponsored by the IR-4 program, which provides for testing and registration of pesticides for minor-use crops, can be found on page 7 of this report. He also gave updates on current European chafer and emerald ash borer research.

Zelenka Nursery was also the site for a research project related to managing water quality in landscape nurseries. The project, in its final year, was designed to look at the effects of several different fertilization regimes on levels of nitrate leaching into groundwater. Several slow-release fertilizers were evaluated this year. Bud Hart presented the research results.

The next tour stop was Vans Pines, the site of research on weed control for deciduous tree and shrubs seedlings including green ash, pin oak,

highbush cranberry, autumn olive, rugosa rose and white oak. Rob Richardson led the tour through the trials of several promising new herbicides.

While at Vans Pines, Tom Fernandez discussed the implications of the new groundwater protection bill (Senate Bill 289) and their potential impacts on nurseries with tour participants. If the bill becomes law, annual reporting of water usage will be required.

At Northland Farms, the topic for discussion by David Smitley and Jim Oros (of Northland Farms) was the nursery's experience with biological control of Fletcher scale on Taxus. Natural enemies kept scale populations in check without the use of insecticides. Also at Northland Farms, Rob Richardson showed results of trials with Flumioxazin (Sureguard) and other herbicides in field-grown liners of Taxus and Arborvitae. Sureguard is expected to receive registration "for outdoor use on and around conifers and deciduous trees" in Michigan in fall of 2003.

An interesting presentation about using cheese biosolids as a nutrient source for nursery fields followed at Michigan Evergreen Nurseries. Lee Jacobs, with the department of crops and soil science at MSU spoke about this practical and innovative approach for putting a waste product to good use as fertilizer. The cheese by-product provides a good source of nitrogen and phosphorus.

Research into methyl bromide alternatives for field production of herbaceous perennials was shown at Sawyer Nursery, the site for trial plots of alternative fumigants including: idomethane; metham sodium; Basamid; TeloneII; Telone C-35 and chloropicrin in various combinations and rates of application (mostly under tarp) compared to two standard methyl bromide plus chloropicrin treatments and a tarped and untarped control. (Photo, color insert, page 1A.) George Bird explained the project and pointed out results of treatments, several of which appeared especially promising. The final item on the tour was a summary of planned research in methyl bromide alternatives that will be conducted over the next three years, presented by Diane Brown-Rytlewski. A USDA grant for over \$370,000 was recently awarded for this new project. ☞

## Winter protection 2003-04

### *Overall program organizer*

Thomas A. Dudek, District Extension Horticulture and Marketing Agent, West Central Region

### *Organizer for east Michigan location*

Mary Wilson, Horticultural Agent, Genesee County

### *Program sponsors*


Harrell's, The Scotts Company, and Genesee Area Landscape and Nursery Association

### *Program presenters*

Bert Cregg, Tom Fernandez, Rob Richardson, Department of Horticulture; Willie Kirk, Department of Plant Pathology; Tom Dudek, District Extension and Marketing Agent, West Central Region; Mary Wilson, Horticultural Agent, Genesee County; Al Nietring, Zelenka Nursery; Paul Pilon, Sawyer's Nursery; Andrew Austin, Austin's Nursery; Bryan Purkey, Purkey's Nursery and Landscaping; Tom Kluck, Kluck Nursery; and Bob Kuzmaul, D&B Plants.

In response to record amounts of winter damage that occurred on a wide range of herbaceous and woody nursery stock, a day-long educational program was organized to provide information for nursery growers about conditions that trigger winter injury and an update of the latest techniques for winter protection of ornamentals in nursery settings. To give growers from more locations in the state an opportunity to attend, the program was held in Grand Haven on September 24, 2003 and repeated in Flint on October 29.

Explanations of cold hardiness, conditions that trigger acclimation, deacclimation and dormancy release by Tom Fernandez and Bert Cregg set the stage for later talks about winter protection strategies. Topics covered by Bert Cregg included pros and cons of decreasing fall irrigation to force dormancy, the effects of nutrition on winter hardiness and the use of antitranspirants. Tom Fernandez gave an overview of root hardiness, watering container plants before storage in hoopouses, pot spacing, thermal blankets, hoopouse design considerations, pot-in-pot systems and short term frost protection.

Willie Kirk spoke about preparing herbaceous perennials for winter from a disease prevention viewpoint. Tom Dudek addressed protection for plants from rodents and deer at the program held in Grand Haven, while Mary Wilson presented rodent protection at the program held in Flint. Rob Richardson discussed recent herbicide research on major problem weeds in nurseries and mentioned several different backpack sprayer types to use for herbicide application, and a constant flow valve that can be used to improve the accuracy of spray output, an important consideration when using herbicides. The final portion of the program was a panel discussion by growers who talked about overwintering strategies used in their nurseries, results they had seen with various types of protection; what worked; what didn't work. Throughout the day, a number of good questions were asked, which furthered discussion between the presenters and the audience. A related article about winter injury is on page 22. 

## Impacts and spread of beech bark disease in Michigan

### *Principal investigators*

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### *Cooperators*

John Witter, Dept. of Natural Resources, University of Michigan; Frank Sapio, Michigan Department of Natural Resources

### *Funding*

Michigan Department of Natural Resources

### *The beech resource*

American beech (*Fagus grandifolia*) is a major component of northern hardwood forests throughout much of eastern North America. In Michigan, there are almost 140 million beech trees growing on more than 7 million acres of forested land. Beech lumber can be used for a number of products, but beech is especially valuable for wildlife. Beech nuts, produced by mature trees (40 years and older), are utilized as food by many mammal and bird species, especially in northern regions such as the Upper Peninsula, where oaks and hickories are rare. Beech trees are attractive to perching raptors, and used for nesting, roosting or insect foraging by a variety of birds. Small mammals frequently use cavities in beech trees for shelter or dens. Beech trees are also aesthetically unique and are often especially valued by private property owners for their appearance.

### *Introduction and spread of beech bark disease*

Beech bark disease has profoundly affected American beech throughout much of its range in eastern North America. Beech scale, the precursor to beech bark disease, was introduced into Nova Scotia around 1890 on ornamental nursery trees shipped from Europe. By the early 1930's, beech scale had spread into Maine and most of New England, New York; areas of Pennsylvania were affected by the 1970's. A major infestation of beech scale was discovered in West Virginia in 1981 and beech bark disease has been recently found in localized areas of Ontario, Virginia and Ohio. Beech scale infestations were discovered in northwestern Lower Michigan and the eastern Upper Peninsula in 2000, although records and data collected from affected stands indicate that the scale was present in specific areas as early as 1991. Only a few stands in the eastern Upper Peninsula and northwestern Lower Peninsula

currently have full-fledged beech bark disease.

### *Beech scale and Nectria fungi*

Beech bark disease refers to a complex consisting of an exotic (non-native) sap-feeding scale insect (*Cryptococcus fagisuga* Lind.) and cambium-killing *Nectria* spp. fungi. Beech scales are tiny insects (0.5 to 1.0 mm) with a single generation each year. The mobile, immature stage known as crawlers typically becomes established on the trunk or main branches of large beech trees where the bark is rough. Crawlers, present from late summer through fall, are likely dispersed by wind, birds and people transporting infested firewood or logs. Once crawlers insert their mouthparts and begin to feed on sap from the inner bark, they molt and remain immobile for the rest of their lives. Feeding scales secrete white wax; heavily infested trees appear to be covered by white wool. (Photo, color insert, page 4A.) Minute wounds caused by beech scale eventually enable *Nectria* fungi to invade the tree. *Nectria* fungi kill areas of the inner bark, typically causing the trunk or major branches of the tree to die.

### *Impacts of beech bark disease*

During the first wave of beech bark disease, roughly 50% of mature beech trees are expected to die and in some areas, 70 to 80% of beech trees have been killed. In Michigan, an estimated 7.5 million large beech trees (= 10 inches dbh) are expected to die during the first wave of beech bark disease. This amounts to roughly 800 million board feet of sawtimber. During windy conditions, infected trees may break off at cankered areas, a condition known as beech snap. This can be an important problem in recreation areas, campgrounds or when affected trees are near homes or vehicles. Some areas affected by beech bark disease are characterized by dense thickets of beech saplings, which limit regeneration of other species.

### *Goals and methods*

Our major goals are to quantify and predict the long-term impact of beech bark disease on overstory species composition, productivity, and wildlife-related variables in Michigan forests. In 2002, we cooperated with the University of Michigan and the MI DNR to establish 40 permanent plots stratified by geography (upper and lower peninsulas), beech density (low, moderate and high) and level of beech scale infestation/beech bark disease (zero, light and heavy). An additional 22 plots were established in 2003.

Within each of the 62 stands, we selected 12 mature beech trees in three cardinal directions from the center of the stand using the following criteria. Height, diameter at breast height, dominance class and canopy dieback were measured on all of the selected beech and non-host trees. Increment cores were extracted at breast height from each beech and non-host tree within all 62 stands to assess radial growth. Beech scale density was estimated on two aspects of each beech tree. To assess potential overstory species composition, we established regeneration plots to quantify number and species of seedlings, saplings and recruits. Litter traps were placed in each stand to quantify beech nut production and leaf biomass by species. Volume and species of coarse woody debris and abundance of snags and cavities were measured along two transects in each stand.

### **Preliminary results**

Analysis of data from the 22 plots established in 2003 is in progress. Preliminary results from the 40 stands sampled in 2002 indicate that 23 stands had no beech scale, 9 stands had light beech scale infestation, two stands had moderate infestations and eight stands had heavy beech scale infestation. Trees with greater than 30% canopy dieback occurred most commonly in stands with heavy beech scale infestation, regardless of beech density. High levels of dieback did not occur in any of the stands where beech scale was absent, and only a few trees in uninfested stands exhibited moderate dieback. No

apparent patterns in canopy dieback occurred in relation to beech density.

**Wildlife habitat:** Volume of coarse woody debris was greatest in stands with heavy beech scale and in stands with moderate beech density. Snag and cavity density did not significantly differ among stands with varying beech density or beech scale infestation. Quantification of beech nut mass is in progress.

**Understory species composition:** Beech regeneration did not significantly differ among stands with varying beech and beech scale densities. In most regeneration plots, beech and sugar maple were the most abundant species, but red maple (*Acer rubrum*) and black cherry (*Prunus serotina*) were also common. There were no significant differences in sugar maple regeneration or understory species richness related to beech scale infestation or beech density.

### **Continuing work**

Analysis of data collected in 2003 and radial growth rates is in progress. We expect to re-visit these sites at roughly 5-year intervals to quantify beech decline, wildlife habitat and changes in species composition as beech bark disease advances through the state. Results will be used to prioritize areas for public outreach efforts, pest surveys and silvicultural activities. Data from 2002 and 2003 will also be used in a related study to model the dynamics of beech scale dispersal and the rate of spread of beech scale and beech bark disease. ☞

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## **Tracking the emergence of emerald ash borer adults**

### **Authors**

Diane Brown-Rytlewski, MSU Dept of Entomology,  
Mary Wilson, Genesee County Horticulture Agent

### **Funding**

Project GREEN

### **Cooperators**

St. Joseph's Hospital, Ann Arbor, Mich.;  
Applewood Garden, Flint, Mich.; Tollgate Center,  
Novi, Mich.; Master Gardeners of Genesee and  
Oakland Counties

### **Significance**

Predicting the occurrence of vulnerable stages of Emerald Ash Borer (EAB) is needed to enable homeowners and professionals to accurately time management strategies and improve their efficacy. Since this is a new pest in North America, there are

no indicators or any data established to correlate treatments with. Information about the emergence of adult EAB as related to degree-day accumulation and bloom time of common landscape plants would be an extremely useful tool for determining timing when treatments should be applied, or to determine when infested wood can or cannot be safely transported out of the quarantined area.

### **Background**

Phenology is a science that looks at the relationship between climate and periodic biological phenomena. Using plant phenological events (i.e. flowering, first leaf) to determine when a pest insect is at a stage vulnerable to treatment has been used for several landscape and nursery pests for many years. It provides a more accurate means of tracking insect development and determining appropriate timing for control measures than the calendar, due to weather changes from year to year and within different

localities within a state. The weather plays a major role in determining the rate of plant growth and development and influences development of insect life cycles. Soil and air temperatures, rainfall and humidity are all contributing factors. Obtaining plant phenological information, along with growing degree-day accumulations, that coincide with EAB adult emergence could help provide the accurate predictors required for successful pest management. Although the precise base temperature to use as a threshold for calculating adult emergence of emerald ash borer has not been determined, 50°F is a standard threshold commonly used, and a good starting point. Adjustments can be made with existing degree-day information by substituting in the appropriate threshold once it has been determined.

### Methodology

Twenty green ash trees (*Fraxinus pennsylvanica*) of approximately the same age were used in the study; eleven were planted in parking lot islands mulched with stone and nine were planted in grassed lawn areas. Emergence of adult emerald ash borers was monitored at one site in Ann Arbor from the first week in May through the end of August. All D-shaped emergence holes on individual trees were counted and marked in sections located between 4'-6' and 10'-12' from the base of the trunk. Surface areas of trunk sections (high/low) were measured and divided by 4 to get surface area for each direction-NE, NW, SE, SW. Since trunk sections varied in size, the number of emergence holes for each area was divided by the amount of area in square centimeters to arrive at the number of emergence holes/cm<sup>2</sup> of trunk. Each tree was a whole plot; while high/low on the trunk and direction (NE, NW, SE and SW) were recorded as within tree measurements.

Bloom times of common landscape plants and weather data were recorded at four locations (Tollgate Center in Novi, Applewood Garden in Flint, St. Joseph's Hospital in Ann Arbor, and the campus of Michigan State University in East Lansing) during the same time period. (Figure 1)

The modified sine wave method was used with hourly temperature readings to calculate degree-days, using a base temperature of 50°F.

### Results and conclusions

Out of 387 emergence holes counted, 151 were on the southwest side, 102 on the southeast side, 82 on the northwest side, and 52 on the northeast side. There were statistically significant differences in the number of emergence holes relative to their location on the trunk as measured by the factor 'direction' ( $P= .0009$ ). [Note: P values or probability values are a

measure of the strength of evidence to support a hypothesis. Values of  $p \geq 0.10$  are not significant;  $p < 0.05-0.01$ , are moderately significant; and  $p \leq 0.001$  strongly significant.] Earliest emergence occurred on the southwest and southeast sides of the trees (Figure 2), on trees planted in the parking lots and mulched with stone. The interaction of height and mulch was also significant ( $P= .0355$ ). There was greater emergence of EAB adults high on the trunk than low for trees planted in grass. Most of the trees planted in grass had shaded lower trunks, and more sunlight on the trunks at the 10' height, which would have resulted in warmer temperatures on the high sections of the trunks compared to the lower sections. Insect development is strongly correlated to temperature. Our observations support this; greater emergence of adults occurred on the sunniest exposures of the trees, and earlier on trees mulched with stone and planted in parking lots.

The bloom times and corresponding degree-day accumulations for a number of flowering trees, shrubs and herbaceous perennials were observed during the May-August time period. Information for four sites was collected and is being compiled. The selection of plants tracked at each location varied, as not all of the same taxa were planted at each location. Not all plants selected for evaluation as potential indicators turned out to be good choices. Some had bloom periods that were too long or too indistinct to be useful. Plants in bloom at the Ann Arbor site during key periods, and corresponding degree-days are listed below.

#### Ann Arbor - June 5, 2003 - 471.4 DD B50

Week preceding first observed emergence holes for EAB adults

Black locust- full bloom

Dame's rocket full bloom

Vanhoutte spirea- late bloom

#### Ann Arbor - June 13, 2003 - 584.0 dd B50

First adult EAB emergence holes observed on site

Doublefile viburnum, *Viburnum plicatum*

*tomentosum* 'Maresii'-ending bloom

Black locust, *Robinia pseudoacacia*- late bloom

Dame's rocket, *Hesperis matronalis* - full-late bloom

#### Ann Arbor - August 16, 2003

2123.2 dd B50

Last date of observed emergence holes

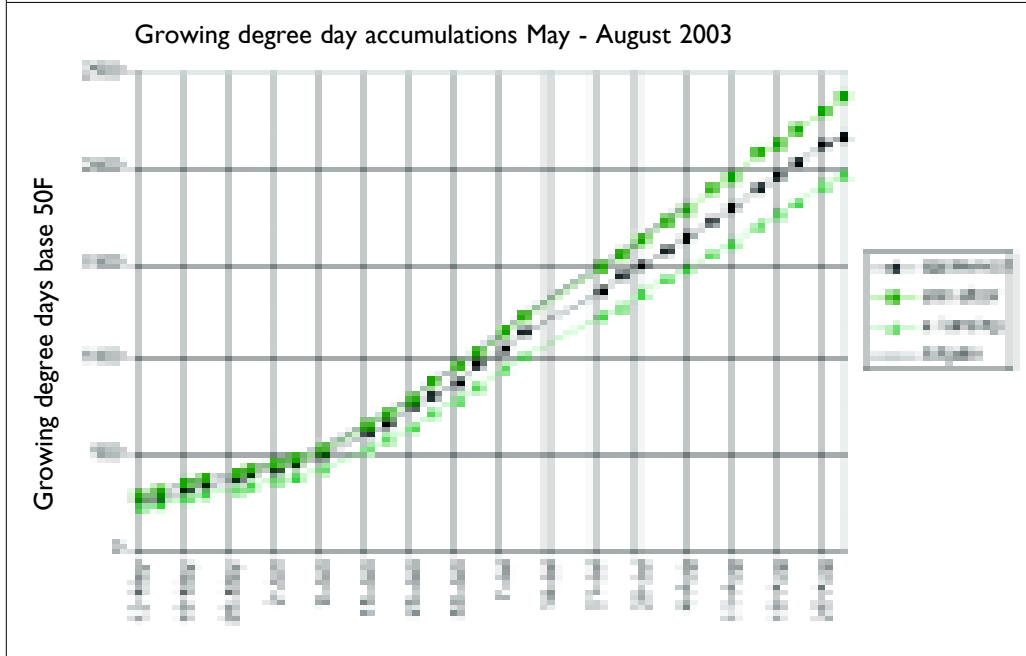
Joe Pye weed, *Eupatorium purpureum* -full bloom

Purple coneflower, *Echinacea purpurea* - late bloom

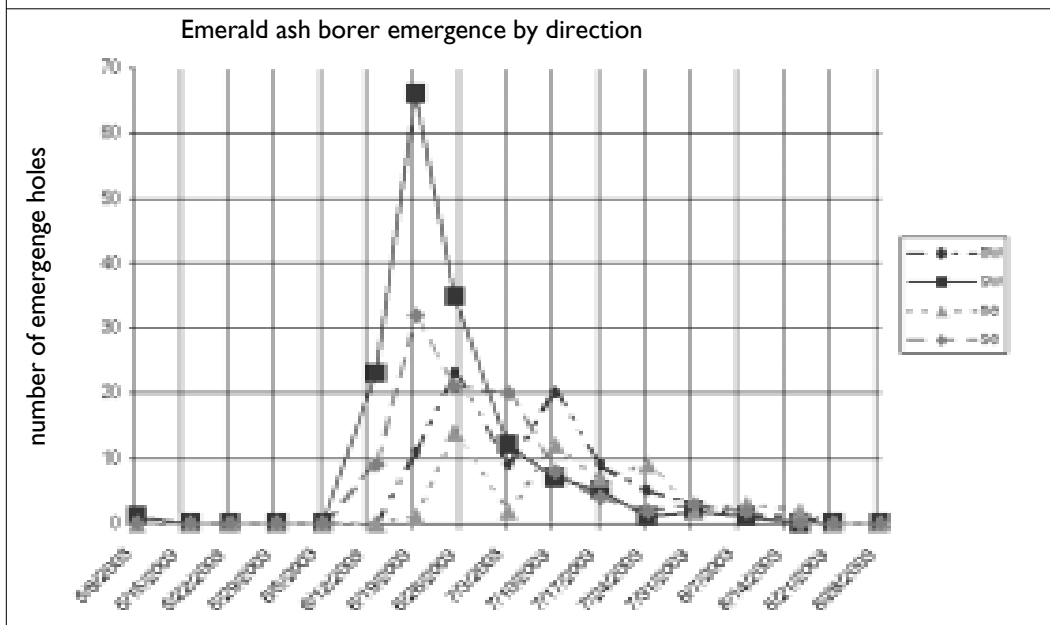
Blazing star, *Liatris spicata*- late bloom

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**Figure 1.** Cumulative degree-days recorded from March 1-August 28, 2003 for Flint (Applewood); Ann Arbor; East Lansing and Novi (Tollgate). Degree day accumulations for the Novi and Ann Arbor Locations were higher than those for Flint and East Lansing.



**Figure 2.** A comparison of EAB adult emergence holes as related to direction on the trunk, and the date they were observed. Emergence peaks are earlier for adults emerging on the southwest and southeast sides.



## Biology, ecology and control of the emerald ash borer

### *Principal investigators*

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### *Funding*

USDA Forest Service; USDA APHIS; Michigan Dept. of Agriculture; MSU Project GREEN, USDA ARS and Michigan Nursery and Landscape Association

### *Background*

The emerald ash borer (*Agrilus planipennis* Fairmaire) was identified in July 2002 as the cause of mortality of an estimated 5.5 million ash (*Fraxinus* spp.) trees in southeastern Michigan and Windsor, Ontario. This Asian pest was probably introduced into the Detroit area on wood packing material arriving in cargo ships or airplanes at least 10 years ago. Larvae feed in the cambium and phloem area of the trunk and branches. The galleries excavated by the feeding larvae disrupt translocation of nutrients and water through the tree. Even relatively healthy trees succumb after 2-4 years of heavy infestation. (Photos of adult, larva and infested ash tree, color insert, page 4A) Ongoing surveys suggest that an estimated 3000 square miles in southeastern Michigan are now infested. Localized populations were found in 2003 in several additional areas of lower Michigan and Ohio. These relatively new infestations originated from infested ash nursery trees, firewood or logs that were transported before the beetle was discovered.

### *Significance*

In Michigan alone, at least 700 million ash trees in forest and urban forests are at risk. Moreover, spread of this exotic pest threatens ash species throughout North America. Given the potential impacts of emerald ash borer, regulatory officials and scientists agreed in October 2002 to attempt a long-term program to contain the current infestation, reduce beetle density and ultimately eradicate emerald ash borer from North America.

Very little information about the biology, impact or control of emerald ash borer is available from Asian

countries where the insect is native. We initiated several studies in 2003, in cooperation with USDA Forest Service and USDA APHIS scientists to begin acquiring critical information. Results from these studies are needed to advise residents, property owners, foresters and other affected groups about their options for dealing with this tree-killing pest. Our results are also urgently needed by federal and state regulatory officials charged with implementation of the eradication program. The general goals and objectives of some of these studies are briefly summarized here.

### *Host range study*

Currently, emerald ash borer is known to infest only ash (*Fraxinus* spp.) trees. Reports from Asia, however, indicate that this or a closely related beetle, have been collected from Asian species of elm, walnut and *Pterocarya* sp. (wingnut). The ability of emerald ash borer to utilize alternative hosts would obviously have major implications for survey activities and the overall success of the eradication effort.

In addition, we have observed that North American ash species may differ in their susceptibility to emerald ash borer or in their vulnerability once infested. Green ash (*F. pennsylvanica*) trees, for example, appear to be colonized at higher densities or decline more rapidly than white ash (*F. americana*) trees, even when trees are growing in the same area and subject to similar infestation pressure.

The role that tree stress plays in attracting ovipositing beetles or in the ability of the tree to defend itself from larval feeding is an important question. In the Core of the infestation in southeastern Michigan, even healthy trees have been heavily colonized and killed. In contrast, native *Agrilus* beetles such as bronze birch borer and two-lined chestnut borer attack only severely stressed trees. It is not yet clear whether emerald ash borer is simply more aggressive than native *Agrilus* species or if population densities are simply so high that all trees are likely to be killed.

Our objectives are to evaluate species of concern (American elm, black walnut, privet, hackberry, and shagbark hickory) to determine whether they are acceptable as alternate hosts for ovipositing adult beetles and whether they are suitable for larval development. We are also comparing attack rates and damage between green and white ash trees and assessing whether stressed trees are more attractive to beetles than vigorous trees. We conducted a laboratory test and found that female beetles will oviposit on cut sections of the alternate species. First

stage larvae fed readily on all three ash species, and several larvae appeared to successfully feed on privet, a relative of ash. Only a few larvae tried to feed on the other species and their galleries were generally malformed. We also conducted several field trials and found that females will lay eggs on cut logs of alternate species, as well as cut ash logs. In another test, larvae were inserted into live elm, green ash and walnut trees and cut logs. Dissection of these trees, along with over 200 logs to quantify larval feeding is in progress.

### ***Insecticides for control of adults and larvae***

Virtually no information is available from Asia regarding the ability of insecticide products and application methods to protect ash trees from emerald ash borer. Objective evaluations of registered insecticide products and application methods are needed to identify control options for high value shade trees. Insecticides may also be useful for treating ash trees in outlying populations targeted for eradication.

### ***Objectives***

Our objectives were to (1) evaluate registered insecticide products and application methods for adult and larval control; (2) identify optimal timing for soil, trunk and spray applications; (3) monitor persistence of insecticides over time; and (4) identify factors such as tree age or previous injury that could affect insecticide efficacy.

### ***Methods***

In 2003, we set up insecticide studies at eight different sites with relatively light emerald ash borer densities. Trees at each site ranged from 2 to 22 inches in diameter and appeared relatively healthy. Different combinations of insecticide treatments, along with untreated controls, were evaluated at each site. There were at least six trees per treatment per site.

Treatments that we evaluated included:

- A. Soil injected imidacloprid (Merit 75 WP) applied with either a Kiortiz injector or as a high pressure soil injection in mid-April.
- B. Trunk injections in mid to late May of imidacloprid using either Mauget capsules (Imicide) or a Wedge (Pointer).
- C. Trunk injections of bidrin using Mauget capsules (Injecticide-B) in early June, mid July or early September;
- D. Bark and foliage cover sprays (Orthene, Sevin, Tempo, Onyx) applied in late May and again in early July.

Xylem sap from shoots in the upper and lower crown of trees treated with imidacloprid (high pressure Merit, Imicide, Pointer) at one site were collected at roughly 2 week intervals from 3 June to 31 July. Samples were submitted to cooperating USDA APHIS scientists for ELISA analysis to assess imidacloprid concentration over time.

We conducted bioassays to evaluate effectiveness of insecticide applications for adult beetle control. In these bioassays, 5 adult beetles were caged on a leaf from treated or control trees for 8 days. Beetle survival and foliage consumption were monitored.

In early September, we began removal of bark to quantify larval density in treated and control trees. On each tree, we carefully sampled bark windows, each roughly 600 cm<sup>2</sup> (90 in<sup>2</sup>), on two aspects of the trunk, lower and upper canopy. At least 14 bark windows were sampled on each tree.

### ***Results***

Data from insecticide studies are currently being analyzed. Results will be provided to landscapers, arborists and foresters at upcoming meetings and in trade publications. Results and guidelines for emerald ash borer control will also be distributed to MSU-Extension offices, officials involved with state and federal eradication programs, and residents of Michigan via published materials and the multi-agency web site at <http://www.emeraldashborer.info/>.

### ***Beetle dispersal study***

Dispersal of adult emerald ash borers is a critical issue for regulatory officials involved in survey activities and eradication of newly established outlier populations. We had a unique opportunity to assess dispersal of one generation of emerald ash borer adults in a rural area near Tipton, Lenawee County, Michigan. This area was well beyond the Core infestation, when a Michigan Dept. of Agriculture inspector discovered adult beetles ovipositing on small ash trees in 2002. Discussions with the property owner showed that the infestation originated from a load of infested ash firewood brought in from southeastern Michigan in spring of 2002. The infested firewood, which effectively served as the point source of the infestation, had been piled along the side of a drainage ditch. A mixture of green ash, soft maple, black walnut and other hardwoods grew along the sides of the drainage ditch, generally from about 65 to 425 feet (20 to 125 m) out from the ditch. We were confident that any emerald ash borer galleries on trees in this area were the result of adults that had emerged from the firewood pile in 2002.

In February and March 2003, we marked and

recorded location and diameter of the roughly 235 ash trees growing along both sides of the ditch, out to 1300 feet (400 m) away from the firewood pile. We randomly selected small, medium and large ash trees for sampling within each 50 m contour interval around the firewood pile. Trees were felled and a section of bark, at least 600 cm<sup>2</sup> (roughly 90 in<sup>2</sup>), was removed from the trunk, lower, mid and upper canopy of each tree (minimum of 4 samples per tree).

Preliminary results showed that more than 70% of the emerald ash borer galleries occurred on trees growing within about 325 feet (100 m) of the firewood pile. Gallery density decreased substantially with increasing distance, but a gallery was discovered in one tree that was 0.47 miles (750 m) from the firewood pile. Beetles appeared to exhibit directional dispersal and followed the corridor provided by the drainage ditch. No galleries were found on trees growing in the woodlot across the cornfield. There were no significant effects of tree size. Galleries were most often found on medium-sized trees (about 6 to 8 inches dbh) but trees ranging from about 4 to 10+ inches dbh had one or more galleries. Galleries were more likely to be found in the mid and upper

canopy of trees than on the trunk or lower canopy as distance from the firewood pile increased. Analysis of data is continuing. All ash trees within a half-mile (800 m) radius of the infested firewood pile were destroyed by the Michigan Dept. of Agriculture later in the spring, before the new generation of beetles could emerge.

### ***Additional emerald ash borer studies that are underway include:***

1. Phenology of emerald ash borer life stages;
2. Survival of larvae and prepupae following grinding and chipping;
3. Use of sticky bands on ash trap logs, girdled trees and herbicide-treated trees for survey and detection;
4. Identification of ash volatiles that are attractive to adult beetles and development of effective lures and trap designs for survey, detection and monitoring activities;
5. Distribution of larval galleries in relation to age of infestation, tree age and tree size;
6. Effects of woodpeckers and insect predators on survival of larvae and prepupae. ✍

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## **Factors affecting the success of the gypsy moth biological control agent *Entomophaga maimaiga* in the North Central United States**

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### ***Principal investigators***

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### ***Funding and support***

USDA Forest Service; Michigan Dept. of Agriculture and USDA APHIS

### ***Introduction***

Gypsy moth (*Lymantria dispar* L.) is a notorious defoliator of oaks, aspen and many other species of forest trees. Populations of this exotic pest continue to expand throughout the North Central region and

have recently become established in areas of Wisconsin, Illinois, Indiana, Ohio and some southeastern states. Managing gypsy moth populations is expensive; costs of suppressing gypsy moth in Michigan alone amounted to more than \$17 million from 1986-1995. There is much interest in the North Central region in identifying effective biological controls that may help reduce the duration and magnitude of gypsy moth outbreaks or increase the interval between outbreaks.

Use of the fungal pathogen *Entomophaga maimaiga* (Figure 1) as a biological control agent is an attractive option because it has few impacts on non-target organisms and is compatible with other pathogens and natural enemies. It has been responsible for dramatic declines in gypsy moth populations in northeastern states since 1989 (see related photo, color insert, page 4A), resulting in substantially lower costs for suppression programs. *E. maimaiga*, however, is highly sensitive to variations in temperature and moisture, which may affect its success in regulating gypsy moth populations. In Michigan, for instance, the pattern of *E. maimaiga* epizootics has been inconsistent since

its introduction in 1991. Although it is established throughout Michigan, high-density gypsy moth populations and severe defoliation have continued to occur.

Forest health managers and pest specialists have expressed interest in incorporating this fungal pathogen into integrated management strategies, especially in newly infested areas. Thorough evaluation of climatic factors, however, is necessary for the establishment and success of the gypsy moth biological control agent *E. maimaiga* in the North Central United States.

### Primary objectives

1. Evaluate the suitability of weather conditions in Michigan for *E. maimaiga*; compare weather in Michigan and the North Central region with weather in northeastern states where the pathogen has been important in gypsy moth regulation.
2. Identify climatic factors that affect the establishment, persistence or infection rate of *E. maimaiga* in gypsy moth populations in Michigan forests.
3. Develop methods to produce larval cadavers containing *E. maimaiga* resting spores for introduction or inoculation in areas with established gypsy moth populations.

### Notable results

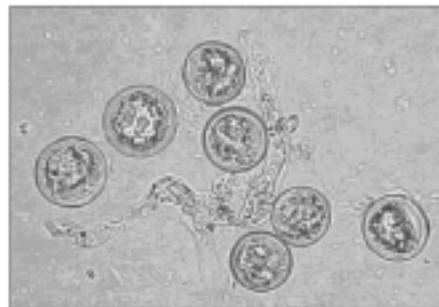
- Climate-matching analyses suggest that *E. maimaiga* should be successful in much of the Midwest and Northeast. *Entomophaga maimaiga* could, however, be limited by cold temperatures in areas of northern Michigan, Minnesota and Wisconsin. Variations in climate (e.g. cold temperatures to the North, warm temperatures to the South, and lack of sufficient precipitation in the West) may limit the long-term effectiveness of this pathogen beyond the Midwest and Northeast regions. Annual climatic variability will be important in the development of *E. maimaiga* epizootics year to year throughout much of the North Central region.
- Bioassays were conducted for 3 years using live larvae placed on the soil at the base of 12 oak trees in each of 33 oak forests in Michigan. Approximately 50% of the larvae in field bioassays died from pathogens (fungal and/or

viral). Fungal infection rates were lower on southern and western aspects of trees than on northern and eastern aspects.

- Bioassays were also conducted under optimal conditions (for the fungus) in the laboratory by placing live caterpillars on soil from each of the 33 oak stands. Infection rates were inversely proportional to field infection rates (i.e. when field infection rates were high, laboratory infection rates were low).
- Bioassay results and on-site climate monitoring suggest that greater than normal June rainfall increased *E. maimaiga* infection rates in Michigan. Without adequate rainfall, fungal spores do not germinate in the soil and few larvae are infected.
- Intensive analysis of microclimate on 3 sites showed that *E. maimaiga* infection rates fluctuate substantially, but generally increase following rain. Little infection appeared to occur when air temperatures exceeded 30°C.
- Technology for production of *E. maimaiga* resting spores in live caterpillars has been developed. *In vivo* production results in  $3.1 \times 10^5 \pm 1.0 \times 10^5$  spores per cadaver. This technology will make it possible to produce high numbers of infected gypsy moth cadavers that can be used to introduce *E. maimaiga* into areas with new gypsy moth infestations.

### Contributions

Results from this research will enable us to: (1) help resource managers predict the potential long-term effectiveness of *E. maimaiga* in their respective region; (2) identify site and weather conditions associated with high rates of *E. maimaiga* infection; and (3) provide methods for providing gypsy moth cadavers with *E. maimaiga* resting spores for introductions or augmentations. ☞



**Figure 1.** Overwintering spores of the gypsy moth fungal pathogen *Entomophaga maimaiga*.

## Jack pine budworm ecology, impacts and management in Michigan forests

### *Principal investigators*

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### *Funding*

USDA Forest Service

### *Background*

Jack pine (*Pinus banksiana*) ecosystems are ecologically and economically important in northern Michigan and much of the Lake States region of the U.S. Stands dominated by jack pine occur on nearly 1.2 million acres in Michigan and Wisconsin. Jack pine is capable of rapid growth on sandy, low nutrient soils. Regeneration of this shade intolerant, fire-adapted species typically occurs after wildfire or clearcutting. More than 270,000 cords of jack pine are harvested each year in Michigan and Wisconsin alone, amounting to a stumpage value of nearly \$10.1 million. Jack pine forests also provide important habitat for wildlife, including the endangered Kirtland's Warbler in Michigan. Many people enjoy berry picking, hunting, snowmobiling, hiking and other recreational activities in jack pine forests.

Jack pine budworm (*Choristoneura pinus pinus* Free.) is a native defoliator of jack pine and arguably the most important pest in the jack pine ecosystem (photo, color insert, page 3A). Budworm outbreaks occur at 6-12 year intervals and generally persist for 3-4 years before populations collapse. Moderate to heavy defoliation during outbreaks reduces radial growth and can affect reproduction. Defoliation is often concentrated in the tops of trees, leading to death of several feet of the leader, a condition called topkill. Tree mortality can also occur when defoliation is heavy, leading to loss of merchantable volume. Dead and topkilled trees and coarse woody debris accumulate over time as stands experience periodic outbreaks. This can lead to high fuel loads and increase wildfire risk, but can also provide habitat for wildlife species.

Previous studies we have conducted have focused on the ecology and population dynamics of jack pine budworm and the effects of one outbreak on jack pine radial growth, mortality and volume loss in the Raco Plains region of the eastern Upper Peninsula. Results of the impact study were incorporated into a GIS-based Decision Support System (DSS). This DSS uses standard inventory variables and a growth-

and-yield model to predict impacts of future budworm outbreaks. Forest managers can identify and map stands that are most vulnerable to mortality and volume loss following defoliation. Forest planners and silviculturists in other regions of Michigan are interested in using the Decision Support System, but relationships between stand characteristics and budworm impact have not been measured beyond the Raco Plains area.

### *Objectives of current study*

1. Establish a network of plots in jack pine stands in six regions of northern Michigan and a selected area of Wisconsin to document the current status of the jack pine resource. Plots will be re-measured over time to calculate long-term impacts of jack pine budworm outbreaks on tree growth, mortality and volume, and on coarse woody debris accumulation.
2. Identify characteristics of stands most likely to sustain the highest levels of damage from jack pine budworm outbreaks. These high hazard stands can then be prioritized for harvest, salvage or pest survey activities.
3. Incorporate results into an expanded Decision Support System that can be used throughout northern Michigan and areas of Wisconsin.

### *Methods*

Plot establishment and measurement of tree and stand variables began in 2001 and was completed in 2003. Stands in six regions of northern Michigan and one area in west central Wisconsin were selected using a stratified random sampling system based on inventory variables routinely collected by land managers. Stands were statistically grouped on the basis of stand age, site index (a measure of site quality), and basal area (a measure of tree density and size). A circular, fixed-radius plot (1/40 ac) was established in each stand and size; crown class and condition of jack pine trees (live, dead, topkilled) in each plot were determined. Increment cores were extracted from live trees and annual radial growth was determined. Coarse woody debris volume and decay level were recorded along two transects within each plot. (Editor's note: a transect is a sample area in a long, continuous strip.)

During the past three years, plots were established in a total of 356 stands and 4471 jack pine trees were assessed in six regions of Michigan and one region of

Wisconsin. Data have been summarized by region, but analysis of impact and growth data is still in progress.

### Results

Preliminary results indicate that live jack pine volume ranged from 2069 to 3508 ft<sup>3</sup>/ac in six regions, but was significantly higher in the western Upper Peninsula, where volume averaged 6407 ft<sup>3</sup>/ac. This likely reflects better soil and growing conditions in this region. Median site index in this region, for example, averaged 60 ft compared to median site index values of 49-55 in other regions.

On average, 10% of trees in the Raco Plains region had been topkilled, but less than 5.5% of trees in the other regions had dead tops. Our previous research has shown that topkill generally results in little volume loss, but may predispose trees to mortality during the next budworm outbreak.

Percentage of jack pine trees that were dead averaged roughly 15% in two regions (Raco Plains and state land in the northern Lower Peninsula). Percentage mortality, however, averaged over 25% in the Ottawa National Forest in the western Upper Peninsula and in the Wisconsin forest. Most of the dead trees were suppressed trees growing in the understory; dominant trees accounted for only 2-11% of the mortality in any region. This suggests that jack pine budworm acts as a natural thinning agent,

weeding out the less competitive trees and freeing up resources for the dominant/co-dominant trees.

Dead jack pine volume ranged from 214 to 464 ft<sup>3</sup>/ac in four regions, but dead volume averaged 894 ft<sup>3</sup>/ac in the Ottawa National Forest and 977 ft<sup>3</sup>/ac on state land in the western Upper Peninsula. Ratios of live to dead volume in the Ottawa National Forest, where site quality is high, were roughly 6 to 1 compared with a 3 to 1 ratio of live:dead volume on state land in the western Upper Peninsula.

Analysis of relationships between stand inventory variables and jack pine mortality and volume loss are continuing. Preliminary results, however, show that younger stands (e.g. < 50 years old) consistently have lower mortality and volume loss than older stands. Surprisingly, site index seemed to have little effect on mortality or volume loss. Mortality was greater on the higher quality sites in all regions, but differences were significant only in the Raco Plains area. Mortality and volume losses were generally lowest in understocked stands and greater in stands with at least 70 ft<sup>2</sup>/ac of basal area.

Work is in progress to assess accumulation of coarse woody debris and to evaluate radial growth of jack pine trees in relation to stand inventory variables. Final results of all analyses will be used to modify and expand the existing Decision Support System to ensure that predictive relationships are accurate for specific areas. ☞

## Introduction of two pathogens to leading edge infestations of Japanese beetle pathogens in Michigan

### Authors

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### Industry partner

Michigan Turfgrass Foundation

### Problem statement

Japanese beetle (*Popillia japonica* Newman) is a costly pest for the nursery, landscape, turf, blueberry and grape industries in Michigan. For landscapers and golf course superintendents, adult Japanese beetles may be the most serious tree and shrub pest in southern Michigan, frequently defoliating lindens, sycamores, Japanese maple, birch, chestnut, sassafras, hibiscus, crabapple, ornamental cherries, roses, mountain ash, and Virginia creeper. In heavily

infested areas, insecticide applications must be repeated frequently to maintain foliage on these plants. Japanese beetle larvae are also the most damaging pests of golf courses in Michigan. Adults are attracted to moist turf where they prefer to lay their eggs. The larvae feed on turf roots, sometimes causing extensive damage. Costly insecticides are applied to prevent turf injury. Recreational turf, industrial turf, home lawns and sod farms also may be damaged from Japanese beetle larvae.

Currently, exotic white grubs are just developing as pests in the Saginaw Valley region. Catches of Adult Japanese beetles indicate they are present, but at far lower levels than in the well-established range further south. European chafer is also present, but has not been recorded at the epidemic levels seen in Lansing and Ann Arbor. Thus we are presented with the opportunity to document the process of Japanese beetle range expansion, and to introduce *Ovavesicula popilliae* and the Eugregarine pathogen, *Stictospora*

## Insect biology and management

*villani* before populations reach damaging levels throughout the region.

### Objectives

1. Provide early information on population trends of Japanese beetle in areas of the state where it is now spreading into, and assist turf and nursery managers, extension staff, and the general public in making proactive management decisions.
2. Reduce the pest status of Japanese beetle through the introduction of *Ovavesicula popilliae* and *Stictospora villani*

### Research results 2002-03

- *Stictospora* and *Ovavesicula* were introduced to 5 plots at 3 different golf courses in 2002. Neither pathogen was found in the region prior to

pathogen introduction, except a low incidence of *Stictospora* at Brookwood (Table 1).

- Grubs were collected from research plots in October, 2002. *Stictospora* was found in 5/5 plots where it was introduced and 1/5 in control plots (Table 3).
- *Ovavesicula* was found in 1/5 plots where it was introduced and 0/5 control plots.

### Conclusions

- *Stictospora villani* is easily introduced and highly contagious.
- It is not yet possible to determine impact of *Stictospora* introductions on populations of Japanese beetle. More sampling is needed in 2004 from plots and from area around introduction plots to evaluate impact. ☞

**Table 1.** Sites in the Saginaw Valley Region where Japanese beetle larvae were collected and examined for infection by pathogens, May 16 to June 13, 2002

Pair	County	Irrigation	Location	n	% Gregarines	% <i>Ovavesicula</i>
1	Bay	Yes	Bay County G.C.	0	-	-
		No	Bay Landscaping	0	-	-
2	Bay	Yes	Maple Leaf G.C.	0	-	-
		No	Maple Leaf G.C.	0	-	-
3	Genesee	Yes	Brookwood G.C.	122	12.6	0
		No	Brookwood G.C.	78	0	0
4	Genesee	Yes	Captain's Club G.C.	0	-	-
		No	Captain's Club G.C.	0	-	-
5	Midland	Yes	Currie Mun. G.C.	68	0	0
		No	Currie Mun. G.C.	8	0	0
6	Midland	Yes	Dow Gardens	0	-	-
		No	Dow Gardens	0	-	-
7	Midland	Yes	Sanford Lake Park	0	-	-
		No	Veteran's Mem. Park	0	-	-
8	Saginaw	Yes	Crooked Creek G.C.	56	0	0
		No	Crooked Creek G.C.	118	0	0
9	Saginaw	Yes	Fortress G.C.	0	-	-
		No	Fortress G.C.	0	-	-
10	Saginaw	Yes	Saginaw Cntry Club	1	0	0
		No	Saginaw Cntry Club	0	-	-
11	Saginaw	Yes	Swan Valley G.C.	0	-	-
		No	Kluck's Nursery	0	-	-

**Table 2.** Density of Japanese beetle larvae in paired plots where infected larvae were introduced to one plot (introduction plot) and not to the other (control plot). Data are from samples collected in spring and fall of 2002. Infected larvae were introduced immediately after larvae were sampled on May 13 – 15, 2002.

Golf course	Treatment	Japanese beetle larvae per 0.1 m <sup>2</sup>			
		5-14-02	10-25-02	5-13-03	10-17-03
Currie Mun. G.C. #2	Introduction	8.9	5.1	13.0	4.0
	Control	7.8	8.7	12.0	6.0
Currie Mun. G.C. #5	Introduction	5.2	6.8	11.0	5.5
	Control	8.1	6.0	13.0	8.0
Currie Mun. G.C.#8	Introduction	7.7	2.8	2.5	0.5
	Control	19.4	3.5	2.5	4.5
Brookwood G.C.	Introduction	13.2	2.2	0.0	1.0
	Control	15.3	2.9	11.5	2.0
Crooked Creek G.C.	Introduction	33.1	5.3	7.0	2.5
	Control	29.2	7.6	6.0	1.5

**Table 3.** Incidence of Stictospora at 5 pairs of sites where Japanese beetle larvae infected with Stictospora, Ovavesicula and milky disease were introduced to one of the paired plots (introduction) and not to the other (control). Data are from samples collected in spring and fall of 2002. Infected larvae were introduced immediately after larvae were sampled on May 13 - 15.

Golf course	Treatment	May 13-15		October 2	
		No. larvae dissected	% Stictospora infected	No. larvae dissected	% Stictospora infected
Currie Mun. G.C. #2	Introduction	10	0	30	27
	Control	28	0	30	0
Currie Mun. G.C. #5	Introduction	10	0	27	11
	Control	28	0	30	3
Currie Mun. G.C. #8	Introduction	10	0	18	22
	Control	28	0	20	0
Brookwood G.C.	Introduction	10	10	19	58
	Control	10	10	23	30
Crooked Creek G.C.	Introduction	10	0	30	53
	Control	10	0	25	0

## Host preference, phenology and potential impacts of the pine shoot beetle (*Tomicus piniperda*) in Michigan

### Principal investigators

Deborah McCullough, MSU Dept. of Entomology and Dept. of Forestry; Nathan W. Siebert, MSU Dept. of Entomology

### Funding

USDA Forest Service; McIntire-Stennis Cooperative Forestry Research Program; Michigan Department. of Natural Resources and Michigan Christmas Tree Association.

### Introduction

Established populations of the exotic pine shoot beetle, *Tomicus piniperda* L. (related photos, color insert, page 4A), a Eurasian pest of pine forests, were discovered in North America in 1992 near Cleveland, Ohio. As of May 2003, pine shoot beetle had been found in at least 390 counties in 13 north central and eastern U.S. states, and the Canadian provinces of Ontario and Quebec. Federal and provincial quarantines regulate movement of pine logs, bark and trees from infested to uninfested areas.

Pine shoot beetle larvae develop in phloem of recently cut, killed or severely stressed pines. Adult beetles colonize suitable pine brood material in early spring, usually 2 to 6 weeks before most native bark beetles in the North Central region of the U.S. become active. Most progeny adults emerge from brood material in June in the Great Lakes region and fly to live pine trees where they feed inside 2 to 6 current-year shoots over the course of the summer.

The quarantines, along with the discovery of damaging populations of pine shoot beetle in pine stands in New York and Ontario, have generated concern about the potential impacts of this exotic beetle in the Great Lakes and other regions. Host preference and suitability, distribution, and associated interactions and phenology in relation to native insects have posed key research needs for the successful management of pine shoot beetle in the Great Lakes region. In addition, Christmas tree growers needed an integrated pest management and compliance program to be developed in order to effectively control pine shoot beetle year-round to aid in reducing the risk of spread of this pest.

### Primary objectives

1. Assess pine shoot beetle attack densities in pine logs that were placed in Scotch, red and jack pine stands in southwestern, central and northern lower Michigan.
2. Determine if pine shoot beetle adults preferentially colonized Scotch pine logs when presented with jack, red and Scotch pine logs in pine stands in a large-scale field experiment.
3. Determine if pine shoot beetle adults preferentially colonized Scots pine logs and current-year shoots when presented with jack, red and Scotch pine logs and current-year shoots in laboratory wind-tunnel experiments.
4. Survey Scotch, red and jack pine forest plantations in lower Michigan to determine the extent and frequency of shoot-damage attributable to pine shoot beetle versus other shoot-feeding insects and non-insect factors.
5. Determine if the presence of pine shoot beetle adversely affects the development of native bark beetles.
6. Monitor the phenology of pine shoot beetle in relation to native insects in red pine plantations.
7. Examine the suitability of Scotch, red and jack pine hosts with respect to the survivorship of pine shoot beetle larvae and subsequent brood production.
8. Develop and evaluate an integrated management and compliance program for Christmas tree growers.

### Summary of results

- Pine shoot beetle colonized 80-90% of the pine logs in southwestern Michigan pine stands, 2-19% of logs in central Michigan pine stands and no logs in northern Michigan pine stands.
- In southwestern pine stands, pine shoot beetle attack densities were significantly greater on Scotch pine than on jack and red pine logs, regardless of stand species.
- In southwestern pine stands, pine shoot beetle killed significantly more shoots in Scotch pine stands than in red or jack pine stands, and injured more shoots in Scotch pine stands than all other insects combined.
- With the exception of the southwestern Scotch pine stands, most of the shoot damage was attributable to squirrels or abiotic factors such as wind, ice or snow.
- Parent adult beetles colonized Scotch pine significantly more often when given a choice of Scotch pine and either red or jack pine logs, but did not show a preference when presented with red and jack pine logs.
- Shoot-feeding adult progeny initiated tunnels in

jack pine shoots significantly more often than Scotch and red pine shoots, and preferred Scotch pine shoots over red pine shoots.

- The phenology of pine shoot beetle was monitored; two species of phloem feeders and four species of predators were active as early in the spring as pine shoot beetle.
- Native bark beetle attack density and brood production were significantly reduced in the presence of pine shoot beetle in field and laboratory experiments.
- An integrated management and compliance program was developed for effective control of pine shoot beetle in Christmas tree plantations that

could be incorporated into standard Christmas tree production practices.

### *Contributions*

Results from this research have been presented at numerous national and regional scientific meetings. More than six manuscripts have been published in peer-reviewed scientific journals, with at least three others in progress. Methods and recommendations have been developed from this research and have played an integral role in the effective control and management of this exotic forest pest in Michigan and the Great Lakes region. ✍

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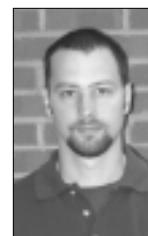
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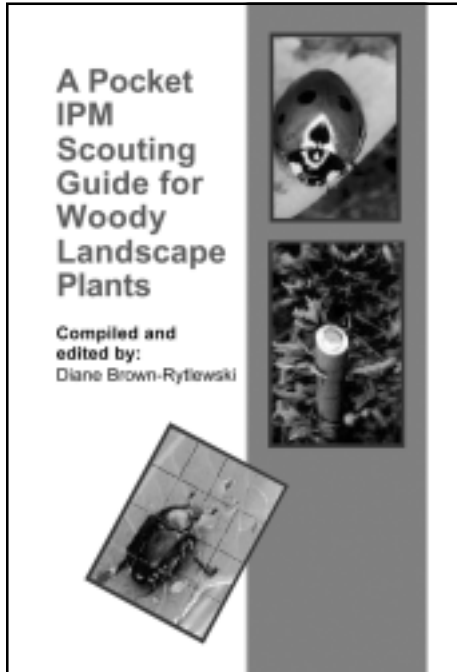


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**Michigan State University's  
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by Diane Brown-Rytlewski

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- ♦ The emergence of emerald ash borer and control of multicolored Asian ladybeetle.
- ♦ Optimum timing for fertilizing turfgrass.
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