Forest Pest Management Cooperative

Report on

Research Accomplishments in 2009

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Table of Contents

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Executive Summary

The Forest Pest Management Cooperative (FPMC) made significant strides in 2009. A brief summary of FPMC activities is given below. Three primary research projects (systemic injection studies, tip moth impact/hazard/control, and leaf-cutting ant control) were continued from 2008. We also revisited weevil control and expanded into imported fire ant and exotic pest control. These projects contained 18 smaller studies that were initiated, continued and/or completed. Separate detailed reports for each study are attached. The purpose of this report is to provide executive committee members with an update on research findings and a basis for evaluating the merits of the attached 2010 Project Proposals.

No major changes occurred in the membership of the FPMC in 2009. Given the hard times everyone has experienced, **thank you all for your continued support!**

William Upton, our staff forester, continued to manage the systemic insecticide injection and leaf-cutting ant trials, while Billi Kavanagh, research specialist, is managing the tip moth and weevil projects. Seasonal technician Nikolas Battise is still with us and Staff Assistant Larry Spivey was hired to provide assistance with field and lab studies. Southern Pine Beetle Prevention Foresters Mike Murphrey and Aleksandar Dozic provided assistance with cone evaluations and GPS/GIS work. We also greatly appreciate the time and effort provided by member representatives on the various projects. They are acknowledged in each report.

Service to members is always an important part of the FPMC. To this end, four issues of the *PEST* newsletter were prepared and distributed. Also, 7 presentations, 5 meeting requests, 7 training sessions, and 61 phone/e-mail requests were addressed relating to the following topics: leaf-cutting ants, pine tip moths, reproduction weevils, cone and seed insects, bark beetles (*Ips* engravers and mountain pine beetle), fall webworm, scales and aphids.

In 2009, rainfall generally was above normal in most of East Texas. Lufkin, which normally receives 46+ inches per year in rainfall, finished the year a little more than 9 inches above average. Similarly, AR, AL and GA had large surpluses (Table 1). In contrast, other areas (LA, NC and FL) had a relatively short period of drought in August and September resulting in moderate deficits. Thankfully, no significant hurricanes were reported in 2009.

Table 1: Total rainfall (inches) at locations across the South compared to annual average: 2005 - 2009. (Black is surplus and red is a deficit)

Location	2005	2006	2007	2008	2009	Average	09 to Avg Difference
Lufkin, TX	27.26	41.08	50.49	40.63	55.19	46.02	9.17
Monticello, AR	26.96	---	37.61	51.58	68.21	55.33	12.88
Alexandria, LA	33.45	53.62	47.92	57.02	55.53	61.44	-5.91
Jackson, MS	---	41.92	32.63	54.55	58.79	58.64	0.15
Birmingham, AL	49.27	56.55	28.86	55.64	71.66	52.16	19.50
Macon, GA	47.54	34.45	39.85	48.14	61.63	45.00	16.63
Raleigh, NC	37.56	53.69	35.81	50.22	40.43	46.55	-6.12
Columbia, SC	39.44	38.95	30.19	46.38	49.15	50.14	-0.99
Tallahassee, FL	68.36	49.34	44.52	60.28	57.91	63.21	-5.30

Since the phase out of Volcano in 2003, efforts have been made to evaluate alternative baits (Blitz®, Amdro® and Advion®) for control of Texas leaf-cutting ants. Unfortunately, the small market for leaf-cutting ant baits and primary focus of insecticide producers on fire ant baits have made it difficult to find and register an effective product. Yet, the significant impact of leaf-cutting ants on forest industry and private lands in Texas and Louisiana demands that an effective control option is found. Some progress was made in 2009 to develop two options, PTM™ soil injection (BASF) and a modified (larger) Amdro® bait (Central Garden & Pet). Efficacy trials demonstrated that both treatments were significantly more effective in completely halting ant activity compared to the standard Amdro® Ant Block treatment after 16 weeks. EPA approved the addition of leaf-cutting ants to the PTM™ Insecticide label in December 2009. A few additional modifications and tests are needed for the new Amdro® LCA bait in 2010, but we expect that this product will be registered for use by fall 2010.

Populations and damage caused by several defoliators, including forest tent caterpillar, oak leaf roller and walnut caterpillars, were moderate and localized in several areas of the Western Gulf Region. Pine tip moth damage levels declined somewhat on second-year trees from 48% of shoots infested to 43%; no locations averaged 100% infested shoots by mid-summer. Coneworm and seed bug pressure were generally stable at moderate levels in 2009 compared to 2008 in several Western Gulf seed orchards. On the positive side, no infestations of the southern pine beetle were reported in Texas, Arkansas, Oklahoma or Mississippi in 2009 (Table 2). Southern pine beetle populations continued to decline on state and national forests in Alabama, Georgia, and Mississippi, and fell markedly in the Carolinas. SPB infestations were generally stable at low levels in all other southern states. The latest overall trend appears to be generally lower SPB activity. With the return of more normal rainfall, *Ips* engraver beetle populations declined in Georgia and South Carolina compared to 2008. In contrast, drought conditions on top of root damage caused by Hurricane Ike in some areas of east Texas led to a dramatic increase in *Ips* populations during late summer and resulting in considerable tree mortality.

Table 2: Southern pine beetle infestations by state, 2001 - 2009 and latest trend.

State	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	Latest Trend
OK	0	0	0	0	0	0	0	0	0	0	Stable
AR	0	0	0	0	0	0	0	0	0	0	Stable
TX	0	0	0	0	0	0	0	0	0	0	Stable
LA	0	0	0	0	0	0	0	5	1	1	Stable
MS	809	143	689	65	158	92	50	208	31	0	Down
AL	26,407	11,849	4,991	206	1,434	1,791	1,286	765	222	9	Down
GA	2,682	4,938	9,070	333	73	0	0	2,077	115	24	Down
TN	9,883	12,746	6,394	1,294	257	5	14	39	1	0	Stable
KY	1,664	3,456	NA	NA	0	0	0	0	0	1	Stable
VA	1,946	763	274	50	10	0	0	64	33	25	Stable
FL	1,172	2,892	650	2	10	7	3	43	22	15	Stable
SC	13,124	22,270	67,127	9,514	4,324	2,388	2,267	734	990	142	Down
NC	2,199	3,871	4,028	181	10	24	49	15	131	5	Down
Total	59,886	62,928	93,223	11,645	6,276	4,307	3,669	3,950	1,546	222	Down

Progress continues on the evaluation and development of systemic insecticides and injection systems. With the discovery that emamectin benzoate and fipronil were effective against bark beetles in 2004 and confirmation in 2005, a trial was established in Texas in 2006 to evaluate the effects of treatment timing and dosage rate on chemical efficacy and duration. Other chemicals, including imidacloprid, nemadectin and cyfluthrin, also were tested. The 2006 results again indicate that emamectin benzoate was highly effective against bark beetles and wood borers and fipronil and nemadectin were moderately effective. Emamectin benzoate, fipronil and nemadectin continued to be effective in 2007 and 2008, particularly at higher rates.

We also are interested in determining if these chemicals are effective against more aggressive *Dendroctonus* species. Trials established in 2005, 2006 and 2007 in Mississippi and Alabama for southern pine beetle on loblolly pine, in California for western pine beetle on ponderosa pine, in Utah for spruce beetle on Englemann spruce, and in Idaho, British Columbia and Colorado for mountain pine beetle on lodgepole pine have been completed. Data from Mississippi, California and Alabama trials indicate that emamectin benzoate is highly effective in reducing tree mortality by bark beetles. Fipronil showed some activity at these sites as well. In contrast, results for mountain pine beetle from Idaho and British Columbia and spruce beetle from Utah were relatively poor for both chemicals most likely due to short growing seasons and cold temperatures. A manuscript presenting the results of the *Dendroctonus* trials in Mississippi and Alabama was published in the Journal of Economic Entomology. Two other manuscripts based on results of trials in California, Idaho and Utah are in press. Two new trials (AL and UT) were established in 2009 to evaluate the potential of combining emamectin benzoate with a fungicide mix to improve tree survival. In the Alabama trial, the combination treatment was no better than emamectin benzoate alone for protecting trees against southern pine beetle.

A trial established in a Florida pine seed orchard in fall 2008 evaluated emamectin benzoate, abamectin and imidacloprid and their effects against coneworms and seed bugs. The 2009 data indicated that emamectin benzoate had excellent activity against coneworms, but no treatment affected seed bug damage levels. A second trial in a Texas oak orchard showed that emamectin benzoate reduced the incidence and damage caused by leaf beetles, borers, tussock moth caterpillars, leaf-rolling weevils, and oakworm caterpillars on cherrybark and burr oaks compared to untreated checks. Tissue analysis showed that a moderate level (150 ppb) of emamectin benzoate was present in leaves that had dropped to the ground in the fall. Surprisingly, no chemical was detected in the acorns from the same trees. It suggests a new potential market for use of emamectin benzoate against insect pests on edible nut crops (pecan, walnut etc.). Two small trials were established in 2009 to determine the efficacy of emamectin benzoate against a chalcid wasp attacking Afghan pine near El Paso and the soapberry borer attacking western soapberry near Dallas and Houston. Emamectin benzoate was highly effective in preventing additional chalcid wasp colonization of host. Results were inconclusive for the soapberry borer.

Syngenta submitted a registration package to EPA for emamectin benzoate in January 2008. The standard registration process takes 18 months. EPA approved the registration for use on ash for emerald ash borer in July 2009. However, approval for use in conifers for several forest pests (seed and cone insects, bark beetles, etc.) has been delayed. We are hoping for EPA approval in 2010.

The pine tip moth project, established in 2001, to evaluate the true impact of this insect pest on the growth of loblolly pine and to identify site characteristics that influence the occurrence and severity of pine tip moth infestations, was further expanded in 2009. One hundred and six (106) impact plots on 74 sites are now established in the Western Gulf Region. An additional three hazard-rating plots were established in 2008, bringing the total to 138. The analysis of impact data indicates that protected trees continue to grow at an accelerated rated through the fifth year after establishment. The threshold at which tip moth damage significantly impacts growth was calculated to be an average of 11% or greater of the shoots infested over the first two growing seasons. Unfortunately, little progress was made on the hazard-rating model or cost benefit analysis in 2009. The FPMC has arranged to have a graduate student, Mr. Trevor Walker, work on model development as part of a Master's in Forestry degree with the guidance of Dr. Dean Coble, Stephen F. Austin & State University. Mr. Walker also will conduct a cost/benefit analysis for tip moth control.

Systemic insecticide trials revealed that single applications of fipronil continued to be effective against pine tip moth using different application techniques and for extended periods of time. Trials were established in 2007 to assess operational applications of fipronil by hand or machine planter, respectively. Hand application after planting is marginally effective, whereas applications of fipronil while machine planting continue to significantly reduce tip moth damage and improve tree growth during the second growing season in 2008. An additional trial was established in 2008 to assess the efficacy of fipronil applied at different depths to one-year old pine. Shallow (4") fipronil applications provided slightly better protection compared to deeper (8") applications. The trial established in 2007 on two sites to test the efficacy of fipronil applied to containerized seedlings prior to planting was continued in 2008. The effects were still very good, although not as outstanding as 2007. Because EPA is considering several other fipronil uses, BASF has postponed a request to modify the PTM™ label to include use on containerized seedlings.

After the registration of SilvaShield™ Forestry tablet (imidacloprid plus fertilizer) in 2006, trials were established on six sites in 2007 to further evaluate application techniques. Tablets applied in plant holes continued to work well in 2008 to reduce tip moth damage and improve tree growth. Tablets applied next to seedlings after planting were less effective. New trials were established in 2008 to refine application techniques, evaluate different rates, and develop operational procedures. One, two and three tablets were equally effective when applied shallow (4") or deep (8") at planting. Post-plant treatments were more effective against tip moth at higher rates, but inconsistent in their effect on pine growth. Operational treatments were more effective against tip moth when applied just after planting compared to application at the beginning of the second growing season. However, both applications significantly improved growth parameters.

TEXAS LEAF-CUTTING ANT

Control Option Development and Evaluation - East Texas

Highlights:

- An efficacy trial was conducted in winter, spring, summer and fall 2009 to evaluate the efficacy of modified Amdro® Ant Block and soil injections of PTM™ (fipronil) against the Texas leaf-cutting ant.
- Modified Amdro® treatments using larger pellets were consistently more effective than Amdro® Ant Block and quickly reduced ant activity after 2 weeks. Treatments applied in winter and spring and at higher rates ($\geq$10g per m2) were most effective. After 16 weeks, >67% of the treated colonies were still inactive.
- PTM™ soil injection treatments also quickly reduced ant activity after 2 weeks. Treatments applied in winter and spring and at higher rates ($\geq$40ml per hole) were most effective. After 16 weeks, >91% of the treated colonies were still inactive.

Justification: Currently, there is no safe and effective control option available for control of Texas leaf-cutting ants. Volcano™ (sulfluramid/citrus pulp bait) and methyl bromide were phased out in 2003 and 2005, respectively. In 2003, Grant Laboratories, CA, began marketing their Grant's Total Ant Killer™ bait. Trials conducted by the FPMC early in 2004, found that a single application only halted the activity of 25% of the treated colonies – about equal to the efficacy of the old Amdro® bait used in the mid-1990s. In late 2004, Central Garden and Pet (formerly Ambrands and American Cyanamid) began marketing a new Amdro® Ant Block bait. Additional trials conducted in early spring 2005 and later in 2006 found that a single application of this bait did not halt the activity of most treated colonies, but did reduce all colonies by 60% compared to untreated colonies. Grosman hypothesized that the poor efficacy of Amdro® is at least in part due to the small particle size of the bait. He proposed that modifying the bait to increase the pellet size may improve performance. The goal of the proposed research is to evaluate the potential of a modified (larger) Amdro® Ant Block bait as an effective alternative to methyl bromide fumigation and unmodified Amdro® Ant Block for control of the Texas leaf-cutting ant in forestry applications. As bait efficacy tends to change with season (Grosman, personal observation), there is a need to determine to what extent the optimal application rate varies with season.

PTM™ Insecticide (fipronil) was recently registered with EPA for soil injection use for protection of pine seedlings from pine tip moth. Fipronil is also a well-known insecticide for control of termites (Termidor®) and ants (Over and Out®). Upon contact with fipronil in the soil, these social insects will pass this active ingredient throughout the colony. A trial was conducted to determine the efficacy of PTM™ (fipronil) applied at different volumes to colony entrance holes for halting ant activity in treated colonies.

Objective: Evaluate the efficacy of a new bait modified from Amdro® Ant Block as well as PTM™ soil injection for reducing activity in Texas leaf-cutting ant colonies and determine if efficacy changes with season.

Cooperators:

Dr. Harry Quicke	BASF Corporation, Auburn, AL
Ms Kimberley Dickinson	Central Garden and Pet, N. Richland Hills, TX
Mr. Regan Bounds	Hancock Forest Management, Silsbee, TX
Mr. Bill Stansfield	Campbell Group, Diboll, TX
Mr. Doug Long	Rayonier
Mr. Rick Gay	Land Manager, Pine Island Club

Study Sites: Active colonies (195) were located in East Texas on lands owned by Campbell Group, Hancock Forest Management, Rayonier and private landowners.

Insecticides:

Hydramethylnon – undetectable, slow-acting poison

Amdro® Ant Block bait - concentration (0.88% a.i.); defatted corn grit carrier with soybean oil; packing (tight); color (yellow); size modified from 2 mm dia. to 2.5 mm X 7 mm length).

Fipronil – undetectable, slow-acting poison in liquid formulation

PTM™ Insecticide - concentration (2 % a.i. v/v).

Research Approach:

Amdro® Ant Block bait was run through a laboratory pellet mill to create larger pellets [2.8 mm (3/32") dia. X 7 mm (1/4") length] for the winter, spring and summer trials. In addition, Central Garden and Pets arranged to have Schirm USA run Amdro® Ant Block through its pellet mill to create larger pellets [3.3 mm (7/64") dia. X 8 mm length (Schirm 1) or 3.3 mm length (Schirm 2)] for the summer (3) and fall (4) trials.

Experiments were conducted in East Texas, within 75 miles of Lufkin. In this area, Texas leaf-cutting ant colonies were selected depending on the season. Those colonies larger than 30 m by 30 m, smaller than 3m by 3 m, adjacent to each other (within 100 m), and/or lacking a distinct central nest area were excluded from this study. Treatments were randomly assigned to the selected ant nests with 3-11 replicates per treatment.

The central nest area (CNA) is defined as the above-ground portion of the nest, characterized by a concentration of entrance/exit mounds, surrounded by loose soil excavated by the ants (Cameron 1989). Scattered, peripheral entrance/exit and foraging mounds are not included in the central nest area. Application rates were based on label rates and/or the area (length X width) of the central nest. Four trials were conducted in 2009; the treatments included:

Trial 1:

1) Large TFS Amdro® - bait was spread uniformly over CNA at 2 lbs per colony.
2) Large TFS Amdro®- bait was spread uniformly over CNA at 3/4 lb per colony.
3) Small Amdro® Ant Block - bait was spread uniformly over CNA at 3/4 lb per colony.
4) PTM™ SC Insecticide – soil injection into entrance holes within CNA at 1 gallon per 300 sq ft.
5) Untreated colony (Check)

Trial 2:

1) Large TFS Amdro® bait - bait was spread uniformly over CNA at 2.5 g/m^2.
2) Large TFS Amdro® bait - bait was spread uniformly over CNA at 5.0 g/m^2.
3) Large TFS Amdro® bait - bait was spread uniformly over CNA at 10.0 g/m^2.
4) Large TFS Amdro® bait - bait was spread uniformly over CNA at 20.0 g/m^2.
5) Small Amdro® Ant Block - bait was spread uniformly over CNA at 3/4 lb per colony.
6) PTM™ Insecticide – soil injection within CNA at 10.0 ml/entrance hole.
7) PTM™ Insecticide – soil injection within CNA at 20.0 ml/entrance hole.
8) PTM™ Insecticide – soil injection within CNA at 40.0 ml/entrance hole.
9) PTM™ Insecticide – soil injection within CNA at 80.0 ml/entrance hole.
10) Untreated colony (Check)

Trial 3:

1) Large Schirm 1 Amdro® bait - bait was spread uniformly over CNA at 5.0 g/m^2.
2) Large Schirm 1 Amdro® bait - bait was spread uniformly over CNA at 10.0 g/m^2.
3) Large TFS Amdro® bait - bait was spread uniformly over CNA at 5.0 g/m^2.
4) Large TFS Amdro® bait - bait was spread uniformly over CNA at 10.0 g/m^2.
5) Large TFS Amdro® bait - bait was spread uniformly over CNA at 20.0 g/m^2.
6) Small Amdro® Ant Block - bait was spread uniformly over CNA at 3/4 lb per colony.
7) PTM™ Insecticide – soil injection within CNA at 10.0 ml/entrance hole.
8) PTM™ Insecticide – soil injection within CNA at 20.0 ml/entrance hole.
9) PTM™ Insecticide – soil injection within CNA at 40.0 ml/entrance hole.
10) PTM™ Insecticide – soil injection within CNA at 40.0 ml/entrance hole to ¼ of all holes.
11) Untreated colony (Check)

Trial 4:

1) Large Schirm 2 Amdro® bait - bait was spread uniformly over CNA at 10.0 g/m^2.
2) Large Schirm 2 Amdro® bait - bait applied in 22g piles over CNA at 10.0 g/m^2.
3) Large TFS Amdro® bait - bait was spread uniformly over CNA at 10.0 g/m^2.
4) Small Amdro® Ant Block - bait was spread uniformly over CNA at 3/4 lb per colony.
5) PTM™ Insecticide – soil injection within CNA at 40.0 ml/entrance hole.
6) PTM™ Insecticide – soil injection within CNA at 40.0 ml/entrance hole to ¼ of all holes.
7) Untreated colony (Check)

Bait treatments were applied with a cyclone spreader to evenly spread amounts over the CNA. PTM™ solutions were applied using the PTM Injection Probe™ (Enviroquip). The lance was inserted into each entrance hole so that the tip was 3 inches below ground.

Data Collection: Procedures used to evaluate the effect of treatments on Texas leaf-cutting ant colonies followed those described by Cameron (1990). The number of active entrance/exit mounds was counted prior to treatment and periodically following treatment at 1, 2, 4, 8, and 16 weeks. Six to eight untreated colonies were included as checks and monitored to account for possible seasonal changes in ant activity. For each colony, the percent of initial activity was calculated as the current number of active mounds at each post-treatment check (X 100) divided by the initial number of active mounds.

Results:

In the winter trial, 16 and 11 colonies were treated with the modified Amdro® or PTM™, respectively, in January and early February 2009. Both modified Amdro® and PTM™ treatments quickly reduced ant activity (>99%) on treated colonies compared to initial activity within 2 weeks after treatment (Table 1). At this time (2 weeks), 82% to 100% of the treatment colonies were completely inactive. A few of the Amdro® colonies had renewed activity 16 weeks post-treatment. In contrast, more PTM™ -treated colonies were inactive at 16 weeks. Of the colonies that were still active after 16 weeks, all had reduced activity compared to initial activity. This suggests that the bait was effective in killing some, but not all, of the queens in each colony.

In the spring trial, 28 and 36 colonies were treated with the modified Amdro® or PTM™, respectively, in late February and March 2009. All modified Amdro® treatments completely halted ant activity (100%) on treated colonies compared to initial activity within 2 weeks after treatment (Table 2). Similarly, most PTM™ treatments halted ant activity at 2 weeks. A few of the modified Amdro® colonies renewed activity by the 16-week post-treatment, but all PTM™-treated colonies were inactive at 16 weeks. The regular Amdro® Ant Block-treated colonies had significantly higher activity than the other treated colonies.

In the summer trial, 33 and 26 colonies were treated with the modified Amdro® (TFS and Schirm 1) or PTM™, respectively, in June and July 2009. It was observed that worker ants tended to have some difficulty grabbing and/or picking up the Schirm 1 bait. As before, both modified Amdro® and PTM™ treatments quickly reduced ant activity (>90%) on treated colonies compared to initial activity within 2 weeks after treatment (Table 3). At this time (2 weeks), 50% to 100% of the treatment colonies were completely inactive. Several of the Amdro® and PTM™ colonies renewed activity by 16 weeks post-treatment. Only TFS Amdro® 10g and 20g and PTM™ 40ml were more than 40% effective in completely halting activity after 16 weeks. Of the colonies that were still active after 16 weeks, all had reduced activity compared to initial activity. This suggests that these baits were effective in killing some, but not all, of the queens in each colony.

Based on observations made on the retrieval of the Schirm 1 bait, the length of the bait particle was reduced by about 50% to create the Schirm 2 bait. In the fall trial, 29 and 13 colonies were treated with the modified Amdro® (TFS and Schirm 2) or PTM™, respectively, in late November and early December 2009. The retrieval of the Schirm 2 bait was a little better compared to the Schirm 1 bait, but the ants still had some difficulty grabbing the bait. The two Schirm treatments completely halted ant activity on $\geq$50% treated colonies compared to initial activity within 2 weeks after treatment (Table 4). The PTM™ treatments were initially less effective than the modified Schirm baits, but additional PTM™ colonies went inactive at 4 weeks post-treatment. Only Schirm Amdro® 10g and PTM™ 40ml were $\geq$ 70% effective in completely halting activity after 16 weeks.

Based on field observation and trial results and comparisons of modified Amdro® baits to other effective baits (Volcano and Blitz), the ideal leaf-cutting ant bait particle is likely to be 2.3 mm (5/64”) in diameter, about 7-9 mm (1/4 – 1/3”) long and weigh about 0.04 g (25 particles per gram) (Table 5).

Conclusions:

The efficacy trials showed that the PTM™ soil injection treatment (particularly at the rate of 40ml per hole) was very effective in halting ant activity within >70% of the treated colonies during the fall, winter and spring months (November – February). The shifting of colonies from sun to shade may have reduced treatment efficacy in the summer months.

The modified (larger) bait was found to be more effective in halting ant activity in all seasons compared to the standard Amdro® Ant Block. Future work in 2010 should focus on: 1) evaluating the optimal bait size for efficacy, and 2) use of bait stations as an application tool. Once the optimal bait dimensions have been identified and efficacy proven, Central Garden and Pets is willing to submit a request to register the modified bait with EPA. As the bait shape is being modified, not the chemical formulation, the registration process should be short (4 months). If all goes well, a new leaf-cutting bait may be registered and available by fall 2010.

Acknowledgements: We thank The Campbell Group, Hancock Forest Management, Rayonier and several private landowners for providing access to ant colonies. We appreciate the donation of Amdro® formulation from Central Garden and Pet and PTM™ from BASF for the trials.

Table 3. Efficacy of PTM soil injection and Amdro Ant Block applied to control the Texas leaf-cutting ant, *Atta texana* , in East Texas (Jan. - May 2009).

Treatment	No. of colonies treated	Mean central nest area (ft^2)	Mean # mounds at Trt	Mean % of initial activity[a] (% of colonies inactive after): 2 weeks		4 weeks		8 weeks		16 weeks	
Large Amdro (2.0 lb / colony = 12g/m^2)	9	802	226	0.2 **a**	(89)	0.4 **a**	(89)	0.8 **a**	(78)	8.6 **a**	(67)
Large Amdro (0.75 lb / colony = 6g/m^2)	7	621	183	0.0 **a**	(100)	0.2 **a**	(86)	0.5 **a**	(86)	0.6 **a**	(86)
Amdro Ant Block (0.75 lb / colony = 7g/m^2)	6	520	182	0.3 **a**	(50)	1.0 **a**	(83)	1.9 **a**	(75)	3.7 **a**	(67)
PTM Soil Injection (1 gal / 300 ft2 = 55ml/hole	11	539	134	0.7 **a**	(82)	1.0 **a**	(91)	3.4 **a**	(91)	1.7 **a**	(91)
Check (no treatment)	8	1061	199	74.5 **b**	(0)	80.0 **b**	(0)	104.1 **b**	(0)	99.0 **b**	(0)
	41	710	182								

[a] Means followed by the same letter within each column are not significantly different at the 5% level (Fisher's Protected LSD).

Table 4. Efficacy of modified (large) Amdro bait and Amdro Ant Block applied to control the Texas leaf-cutting ant, *Atta texana* , in East Texas (March - June 2009).

Treatment	No. of colonies treated	Mean central nest area (ft^2)	Mean # mounds at Trt	Mean % of initial activity[a] (% of colonies inactive after): 2 weeks		4 weeks		8 weeks		16 weeks	
Large TFS Amdro ($2.5 g/m^2$)	7	859	185	0.0 **a**	(100)	0.0 **a**	(100)	0.1 **a**	(86)	3.1 **a**	(86)
Large TFS Amdro ($5.0 g/m^2$)	7	830	214	0.0 **a**	(100)	0.1 **a**	(86)	3.4 **a**	(71)	3.5 **a**	(71)
Large TFS Amdro ($10.0 g/m^2$)	7	743	238	0.0 **a**	(100)	0.0 **a**	(100)	0.0 **a**	(100)	0.5 **a**	(86)
Large TFS Amdro ($20.0 g/m^2$)	7	702	196	0.0 **a**	(100)	0.0 **a**	(100)	0.0 **a**	(100)	0.0 **a**	(100)
Amdro Ant Block (0.75 lb / colony = $6 g/m^2$)	8	643	174	6.6 **a**	(25)	13.1 **a**	(50)	22.2 **a**	(38)	21.6 **a**	(38)
PTM Soil Injection (10ml / hole)	10	550	164	1.0 **a**	(90)	0.0 **a**	(100)	0.0 **a**	(100)	0.0 **a**	(100)
PTM Soil Injection (20ml / hole)	9	498	181	1.3 **a**	(78)	1.0 **a**	(89)	0.0 **a**	(100)	0.0 **a**	(100)
PTM Soil Injection (40ml / hole)	10	605	164	0.1 **a**	(90)	0.0 **a**	(100)	0.0 **a**	(100)	0.0 **a**	(100)
PTM Soil Injection (80ml / hole)	7	481	128	0.0 **a**	(100)	0.0 **a**	(100)	0.0 **a**	(100)	0.0 **a**	(100)
Check (no treatment)	7	565	222	96.3 **b**	(0)	93.4 **b**	(0)	97.6 **b**	(0)	86.3 **b**	(0)
	79	638	185								

[a] Means followed by the same letter within each column are not significantly different at the 5% level (Fisher's Protected LSD).

Table 5. Efficacy of modified (large) Amdro bait, Amdro Ant Block, and PTM soil injections applied to control the Texas leaf-cutting ant, *Atta texana* , in East Texas (June - November 2009).

Treatment	No. of colonies treated	Mean central nest area (ft^2)	Mean # mounds at Trt	Mean % of initial activity[a] (% of colonies inactive after): 2 weeks	4 weeks	8 weeks	16 weeks
Large TFS Amdro (5.0g/m^2)	8	649	171	0.5 **a** (75)	0.4 **a** (75)	5.9 **ab** (13)	25.9 **a** (13)
Large TFS Amdro (10.0g/m^2)	9	527	160	0.6 **a** (89)	1.2 **a** (89)	4.8 **ab** (67)	8.3 **a** (67)
Large TFS Amdro (20.0g/m^2)	7	616	172	0.3 **a** (71)	0.0 **a** (100)	3.6 **ab** (71)	17.8 **a** (43)
Schirm (1) Amdro (5.0g/m^2)	3	612	37	3.3 **ab** (67)	0.0 **a** (100)	2.2 **a** (67)	42.2 **ab** (33)
Schirm (1) Amdro (10.0g/m^2)	6	594	98	10.4 **b** (83)	4.2 **a** (83)	6.5 **ab** (67)	87.5 **bc** (33)
Amdro Ant Block (0.75 lb / colony = 7g/m^2)	8	588	159	1.3 **a** (63)	0.1 **a** (88)	13.9 **ab** (25)	36.9 **a** (13)
PTM Soil Injection (10ml / hole)	7	843	146	1.3 **a** (71)	3.6 **a** (57)	16.5 **b** (43)	29.2 **a** (14)
PTM Soil Injection (20ml / hole)	7	430	124	2.2 **ab** (71)	2.2 **a** (71)	11.1 **ab** (43)	33.9 **a** (14)
PTM Soil Injection (40ml / hole to all holes)	6	551	158	0.0 **a** (100)	0.0 **a** (100)	2.5 **a** (50)	13.0 **a** (50)
PTM Soil Injection (40ml / hole to 25% holes)	6	983	177	3.4 **ab** (50)	2.2 **a** (67)	8.1 **ab** (33)	46.1 **ab** (0)
Check (no treatment)	7	772	209	92.4 **c** (0)	80.8 **b** (0)	78.0 **c** (0)	99.7 **c** (0)
Total/Mean	74	647	153				

[a] Means followed by the same letter within each column are not significantly different at the 5% level (Fisher's Protected LSD).

Table 6. Efficacy of modified (large) Amdro bait, Amdro Ant Block, and PTM soil injections applied to control the Texas leaf-cutting ant, *Atta texana* , in East Texas (November 2009 - March 2010).

Treatment	No. of colonies treated	Mean central nest area (ft^2)	Mean # mounds at Trt	Mean % of initial activity[a] (% of colonies inactive after): 2 weeks	4 weeks	8 weeks	16 weeks
Schirm (2) Amdro (10.0g/m^2) even spread	10	452	138	3.7 **a** (50)	4.6 **a** (40)	4.0 **a** (70)	6.7 **ab** (70)
Schirm (2) Amdro (10.0g/m^2) in piles	8	354	110	14.1 **ab** (75)	11.0 **a** (50)	12.4 **ab** (25)	15.5 **abc** (50)
Large TFS Amdro (10.0g/m^2) even spread	11	430	58	21.5 **b** (18)	29.9 **b** (18)	30.3 **c** (27)	33.9 **c** (55)
Amdro Ant Block (0.75-1.5 lb / colony = 9g/m^2)	7	795	189	11.0 **ab** (14)	18.6 **ab** (0)	25.2 **bc** (0)	31.8 **bc** (0)
PTM Soil Injection (40ml / hole to all holes)	7	473	141	2.4 **a** (43)	0.7 **a** (71)	2.1 **a** (71)	2.6 **a** (71)
PTM Soil Injection (40ml / hole to 25% holes)	6	369	165	13.1 **ab** (0)	7.8 **a** (17)	7.1 **ab** (17)	10.7 **abc** (0)
Check (no treatment)	6	745	191	79.0 **c** (0)	70.5 **c** (0)	98.8 **d** (0)	104.4 **d** (0)
Total/Mean	55	502	133				

[a] Means followed by the same letter within each column are not significantly different at the 5% level (Fisher's Protected LSD).

Table 7: Comparison of different leaf-cutting ant baits.

Bait Formulation	Diameter (mm)	Length (mm) [Range]	Weight (g) per particle	Bait Matrix	Bait Efficacy
Amdro Ant Block	1.8	2.6 (0.8 - 4.2)	0.003	Corn Grit	Fair
TFS Amdro	2.8	6.8 (5.2 - 8.3)	0.040	Corn Grit	Good
Shirm1	3.3	8.4 (7.7 - 11.7)	0.076	Corn Grit	Good
Shirm2	3.3	3.3 (4.0 - 6.0)	0.035	Corn Grit	Good
Blitz	2.3	7.3 (5.3 - 9.2)	0.037	Orange pulp	Excellent
Volcano	2.2	8.9 (6.7 - 12.2)	0.024	Citrus pulp	Excellent
Recommended for new Shirm 3	**2.3**	**7 (5 - 9)**	**0.040**	**Corn Grit**	

Figure 1. Comparison of different ant baits.

IMPORTED FIRE ANT

Control Option Evaluation - East Texas and Louisiana

Highlights:

- An efficacy trial was conducted in winter 2009 to evaluate the efficacy of soil injections of PTM™ (fipronil) against the imported fire ant. All PTM™ treatments quickly reduced ant activity after 2 weeks. After 12 weeks ≥90% of the colonies receiving a shallow treatment were inactive.

Justification: Red imported fire ants, *Solenopsis invicta* Buren, cause billion of dollars per year in various costs across the southern United States. Individual mound treatments play an important role in fire ant management. Mound treatments are selective and often faster-acting than broadcast insecticide treatments (Merchant and Drees, 2000). One desirable characteristic of fire ant mound treatments is low toxicity. This test evaluates a relatively new, lower toxicity treatment: PTM™ Insecticide (9.1% fipronil) applied using a backpack soil injection probe to single fire ant mounds that have been established in a loblolly pine seed orchard next to orchard trees. The trial was designed to observe the effectiveness of PTM™ applied using different techniques in reducing fire ant activity over a 12-week period.

Objective: Evaluate the efficacy of PTM™ soil injection for reducing activity in imported fire ant colonies.

Cooperators:

Dr. Harry Quicke	BASF Corporation, Auburn, AL
Mr. Shannon Stewart	ArborGen, Livingston, TX

Study Sites: Active colonies (240) were located in ArborGen's Woodville Seed Orchard.

Insecticide:

Fipronil (PTM™ Insecticide, BASF) – undetectable, slow-acting poison in liquid formulation

Research Approach:

Experiments were/will be conducted in east Texas and Louisiana; within 100 miles of Lufkin. In this area, 240 imported fire ant colonies were/will be selected each season (winter and spring). Study colonies were/will be at least 7m (23 ft) apart, 8 inches or more in diameter and with newly excavated soil. Mounds less than 12 inches apart were considered a single colony. No other observable IFA colonies can occur within 2m (6 ft) of a study colony. Treatments were/will then be randomly assigned to the selected ant nests with 40 replicates per treatment.

Treatments:

A) PTM™ solution 2% ai, 1.5 oz (40 ml) total injected 3 inches below soil surface using Enviroquip's PTM Injection Probe.
B) PTM™ solution 2% ai, 1.5 oz (40 ml) total injected at colony base (12-18" deep)
C) PTM™ solution 2% ai, 3.0 oz (80 ml) total injected- 1.5 oz 3 inches below soil surface and 1.5 oz at the base of colony
D) Check1 – water only injected at 3" depth
E) Check2 – water only injected at colony base (12-18" deep)
F) Check3 – untreated

Data Collection: Procedures used to evaluate the effect of treatments on fire ant colonies followed those described by Nester (2001a & b). Study colonies were marked with a pin flag (see definition of central nest area above). Treatments were applied on December 9, 2009. At 0, 7, 14, 49, 87 and 117 days after treatment (DAT) each mound was checked for presence or absence of fire ant activity and amount of recent soil excavation. First, a small diameter stick was inserted into the mound. If no fire ants appear after 15 seconds, the mound was considered inactive (0). If fire ants were present within the allotted time period the mound activity was assigned a 1 (< 10 fire ants or freshly worked soil), 2 (10-50 fire ants, not aggressive), or 3 (>50 aggressive fire ants). Second, amount of fresh excavation was determined. Mounds with no fresh excavation are considered inactive (0). Mounds with some level of fresh excavation were assigned a 1 (<1/4 of surface area), 2 (1/4 – 2/3 of surface area), or 3 (>2/3 of surface area). On day 117, the presence of "satellite" mounds, defined as small freshly-produced ant mounds within a foot of the treated mound, was noted. At least ten untreated colonies were included as checks and monitored to account for possible seasonal changes in ant activity. Results were analyzed using Analysis of Variance (ANOVA) at $P < 0.05$ for active ant mound assessment data, with means separated using Tukey's Studentized Range test.

Results:

In the winter trial, 120 colonies were treated with PTM™ in early December 2009. The treatments had relatively little effect on ant activity during the first week after treatment (Table 6). Shallow (3”) PTM™ applications (A and C) had the greatest effect after 2 weeks. Daytime temperatures during the following 4 weeks rarely went above 50^{o}F, thus the ants were inactive due to the cold temperatures. Subsequent evaluations were delayed until temperatures rose above 60^{o}F for three or more consecutive days. After 49, 87 and 117 days, most colonies treated with PTM™ were inactive. Again, the best efficacy occurred with shallow PTM™ applications.

Conclusions:

The efficacy trial showed that the PTM™ soil injection treatment (particularly those with shallow applications) were very effective in halting ant activity within $\geq$90% of the treated colonies during the winter months (December – February). However, it is apparent that the ants need to be actively excavation soil in order to come in contact with the fipronil chemical. Future work in 2010 should focus on: 1) evaluating the efficacy of different volumes of PTM™ applied per colony; 2) evaluating effect of season on treatment efficacy. Assuming that the PTM™ treatment is proven effective against imported fire ants, BASF is willing to submit an amendment request to EPA to include imported fire ants on the label.

Acknowledgements: Thanks go to ArborGen for provided access to ant colonies. We appreciate the donation of PTM™ from BASF for the trials.

Table 8. Efficacy of PTM™ soil injection applied to control the imported fire ant, *Solenopsis invicta*, in East Texas (December 2009 - March 2010).

Treatment	No. of colonies treated	Mean nest dia. (in)	Mean ant activity ranking[a b] (% of colonies inactive after): 0 Days		7 Days		14 Days		49 Days		87 Days		117 Days	
PTM Soil Injection (45 ml @ 3" below mound surface)	40	15.8	3.0 **a**	(0)	1.2 **a**	(0)	1.3 **a**	(20)	0.3 **a**	(73)	0.2 **a**	(90)	0.2 **a**	(93)
PTM Soil Injection (45 ml @ colony base)	40	14.5	3.0 **a**	(0)	2.1 **b**	(5)	2.3 **b**	(8)	0.6 **b**	(53)	1.3 **b**	(50)	1.0 **b**	(65)
PTM Soil Injection (45 ml each @ 3" and base)	40	16.2	3.0 **a**	(0)	1.4 **a**	(5)	1.3 **a**	(20)	0.2 **a**	(80)	0.2 **a**	(93)	0.2 **a**	(93)
Check (water only or no treatment)	120	14.4	2.9 **a**	(0)	2.8 **c**	(1)	2.7 **c**	(3)	2.5 **c**	(4)	2.8 **c**	(5)	2.4 **c**	(17)

[a] Colonies were ranked on number of ants after distubance and amount of recent soil excavation.

[b] Means followed by the same letter within each column are not significantly different at the 5% level (Fisher's Protected LSD).

Summary and Registration Status of Leaf-cutting Ant and Fire Ant Control Options

Based on our previous experience with leaf-cutting ant baits, marginally-effective baits (including the "old" Amdro® and Grant's baits) can significantly reduce worker ant populations and activity for 4 to 12 weeks after treatment. However, if the active ingredient is not passed to all the queen ants, the surviving queens will ultimately repopulate the colony. The data collected during the 2005 and 2006 Amdro® trial indicate that ant activity in most colonies had not recovered to the initial level. This suggests that the Amdro® Ant Block bait was somewhat effective in reducing the number of queens in each treated colony and preventing the colony's population from recovering fully. However, communications with several forest industries, TIMOs and private landowners continue to indicate that this bait is rarely effective in completely halting ant activity with several applications, let alone a single application.

Two alternative options were evaluated in 2009. One was to modify the Amdro® Ant Block™ bait into larger pellets. Central Garden and Pets (CGP) provided bait for modification. Several trials showed that larger modified bait provided significantly better control in all seasons compared to the original Ant Block bait. Plans for 2010 include refinement of the bait particle size to maximize bait efficacy. The indication from CGP is that registration of the modified bait would be simple since the active and inert ingredients are already registered for other species of ants (fire ants). If all goes well, a new leaf-cutting ant bait could be registered and available by fall 2010.

The other option tested soil injection of PTM™ Insecticide (fipronil) solution into entrance holes within the central nest area. This treatment was highly effective during most seasons. As a result of these trials, EPA approved the addition of leaf-cutting ants to the PTM™ label as of December 2009. Additional trials are planned for 2010 if PTM™ applications to imported fire ant colonies are similarly effective. If so, fire ants could be added to the PTM™ label as well.

A B

Figure 2. Soil injection systems: A) Enviroquip's PTM™ Injection Probe and B) PTM™ Spot Gun

SYSTEMIC PESTICIDE INJECTION TRIALS

Potential Insecticides for Cone and Seed Insect Control in Pine Seed Orchards - Florida

Highlights:

- Tree IV injections of emamectin benzoate (EB), imidacloprid or abamectin did not reduce seed bug damage on first- and second-year cones during the first year after injection.
- Tree IV injections of EB reduced coneworm damage by 90 - 100%. Imidacloprid and abamectin did not significantly reduced coneworm damage compared to checks.

Justification: Trials conducted from 1998 – 2006 at Texas, Louisiana, Alabama and Florida seed orchards showed that both emamectin benzoate and fipronil were very effective in reducing damage caused by coneworms, but to a lesser extent damage caused by seed bugs. New formulations of imidacloprid and abamectin recently have been developed and a trial was established to evaluate their efficacy against cone and seed insect pests.

Objectives: 1) Continue evaluating the potential efficacy of new formulations of imidacloprid and dinotefuran against seed bugs in pine seed orchards and 2) determine the duration of treatment efficacy.

Cooperators:

Mr. Early McCall	Rayonier, Fernandina Beach, FL
Dr. Tom Byram	Western Gulf Tree Improvement Program
Mr. Joseph Doccola	Arborjet, Inc., Worchester, MA
Ms. Marianne Waindle	Mauget Inc., Arcadia, CA

Study Site

Rayonier's Yulee orchard containing loblolly pine near Yulee, FL (Nassau Co.)

Insecticides:

Emamectin benzoate (TREE-äge™, Arborjet, Inc.) -- avermectin derivative
Abamectin (Abacide™2, Mauget) – a mix of avermectins ((B1a and B1b)
Imidacloprid (Ima-jet®, Arborjet, Inc.) – neonicotinoid insecticide with reported activity against sucking insects.

Research Approach:

Randomized complete block with clones as blocks. 7 treatments X 7 clones = 49 ramets used per study site. The treatments included:

1) Imidacloprid (Ima-jet®, Arborjet) (0.4 g AI per inch DBH) injection + 5X foliar spray
2) Abamectin (Abacide™ 2, Mauget) (0.4 g AI per inch DBH) injection + 5X foliar spray
3) Emamectin benzoate (TREE-äge™, Arborjet) (0.4 g AI per inch DBH) injection + 5X foliar spray.
4) Imidacloprid + Abamectin (Arborjet) (0.2 g AI each per inch DBH) injection + 5X foliar spray
5) Imidacloprid + Abamectin (Dutrex, Mauget) injection + 5X foliar spray
6) Imidacloprid + Emamectin benzoate (each at 0.2 g AI per inch DBH) injection + 5X foliar spray
7) Check (5X foliar spray only)

In November 2008 (FL), at least four holes, 0.95 cm (3/8 in) in diameter and 5-8 cm (2-3 in) deep, were drilled about 30 cm above ground at cardinal points on the tree bole. Arborplugs™ were installed in each hole. The Arborjet™ Tree IV system was used to inject a predetermined amount of product into each hole. The length of time to inject each tree varied from 5-30 min and was dependent on tree, species, location and weather.

Foliar spray treatments (Fanfare®, Asana® XL, and Confirm®) were aerially applied 5X to the orchard block (Yulee) every 6 weeks starting in April.

Data Collection:

Seed Bug Damage to Conelets - 10 healthy first-year cones were picked "at random" from each tree in October; conelets were pealed to expose seed ova; seeds were categorized as healthy or damaged.

***Dioryctria* Attacks** -- All cones that could be reached by bucket truck were picked in September; cones were categorized as small dead, large dead, green infested, with other insect or disease damage, or healthy.

Seed Bug Damage to Cones -- 10 healthy second-year cones were picked "at random" from all healthy cones collected from each ramet; seeds were extracted and radiographed (X-ray); seeds were categorized as full seed, empty, seed bug-damaged, 2nd year abort, seedworm-damaged, and other damage.

Results:

None of the study trees exhibited phytotoxic symptoms in 2008.

The study orchard block has been sprayed for several years suggesting that pressure from coneworms and seed bugs (in particular) would likely be low. This was confirmed for coneworm by 15% damage on check cones (Table 9). In 2009, few leaffooted and shieldbacked pine seed bugs were observed in the study trees (Early McCall, personal communication). This was confirmed for seed bugs by 17% damage on check cones (Table 10).

Treatment Effect on Coneworm Damage: Both injection treatments containing emamectin benzoate significantly reduced early and late coneworm damage compared to the checks (Table 9). Overall, the emamectin benzoate treatments provided the greatest reductions in total coneworm damage (90 - 100%) compared to the check. None of the treatments improved the percentage of healthy cones.

Treatment Effect on Seed Bug Damage to First-Year Conelets: In 2009, evaluation of conelet ovules from Yulee Seed Orchard showed none of the injection treatments improved the percentage of good ovules in conelets compare to checks (standard spray) (Table 10).

Treatment Effect on Seed Bug Damage to Second-Year Cones: Analysis of seed lots from Yulee Seed Orchard indicated that none of the injection treatments reduced seed bug damage compared to checks (standard spray treatment) (Table 10).

Conclusions:

Surprisingly, imidacloprid alone or combined with other chemicals did not significantly improve protection against seed bug damage compared to checks (standard spray).

As in past trials, emamectin benzoate was highly effective against coneworms in 2009. The fall 2008 application allowed emamectin benzoate to completely circulate in treated trees through the winter, thus trees were completely protected from the start of the next season. Neither imidacloprid nor abamectin, alone or combined, had any appreciable effect on coneworms.

Based on little or no protection against seed bug in 2009, we may wish to discontinue this trial. However, if Rayonier is interested, we may wish to continue to monitor treatments for duration of treatment efficacy against coneworms.

Acknowledgements: We appreciate the assistance provide by Early McCall, Rayonier. We thank Arborjet, Inc., Mauget and Syngenta for the financial support, chemical donations, and/or injection equipment loans.

Table 9. Mean percentages (+ SE) of cones killed early and late by coneworms, other-damaged cones, and healthy cones on loblolly pine protected with systemic injections of imidacloprid, abamectin, emamectin benzoate (EB) or combinations, Yulee, FL, 2009 & 2010.

			Mean Coneworm Damage (%)				
Year	Treatment	N	Early (small dead)	Late (large dead and infested)	Total	Mean Other Damage (%) *	Mean Healthy (%)
2009	Imidacloprid	6	1.1 ± 0.3 *†	15.5 ± 5.2	16.7 ± 5.3	16.9 ± 5.3	66.4 ± 9.7
	Abamectin	6	0.2 ± 0.1 *	11.6 ± 3.9	11.8 ± 3.9	19.4 ± 5.2	68.8 ± 8.2
	Emamectin benzoate	6	0.0 ± 0.0 *	0.0 ± 0.0 *	0.0 ± 0.0 *	16.4 ± 3.8	83.6 ± 3.8
	Imidacloprid + Abamectin (AJ))	6	1.1 ± 0.5 *	10.7 ± 3.5	11.8 ± 3.6	24.0 ± 6.2	64.2 ± 9.7
	Imidacloprid + Abamectin (M)	6	0.6 ± 0.3 *	9.7 ± 4.1	10.3 ± 4.3	15.5 ± 2.2	74.2 ± 5.6
	Imidacloprid + Emamectin benzoate	6	0.0 ± 0.0 *	1.5 ± 1.0 *	1.5 ± 1.0 *	29.5 ± 14.0 *	69.0 ± 13.9
	Check	6	2.9 ± 0.9	11.8 ± 3.8	14.7 ± 4.3	14.7 ± 3.3	70.7 ± 5.9
2010	Imidacloprid	6					
	Abamectin	6					
	Emamectin benzoate	6					
	Imidacloprid + Abamectin (AJ))	6					
	Imidacloprid + Abamectin (M)	6					
	Imidacloprid + Emamectin benzoate	6					
	Check	6					

Table 10. Seed bug damage, seed extracted, and seed quality (Mean + SE) from first- and second-year cones of loblolly pine and slash pine protected with systemic injections of Imidacloprid, dinotefuran, emamectin benzoate and combinations, Yulee, FL, 2009 & 2010.

			Mean Seed Bug Damage (%) to:				
			First-year Conelet Ovules	Second-year Cone Seed			Mean No.
				Early			Filled Seed
Year	Treatment	N	Late (Oct.)	(2nd Yr Abort)	Late	Total	per Cone
2009	Imidacloprid	7	1.74 ± 1.29 †	0.3 ± 0.1	17.3 ± 5.1	17.6 ± 5.2	112.7 ± 8.3
	Abamectin	7	0.04 ± 0.04	0.4 ± 0.1	19.9 ± 6.6	20.3 ± 6.6	107.2 ± 12.7
	Emamectin benzoate	7	0.19 ± 0.19	0.5 ± 0.2	17.2 ± 5.6	17.8 ± 5.7	103.4 ± 7.9
	Imidacloprid + Abamectin (AJ)	7	1.24 ± 1.24	0.3 ± 0.1	14.3 ± 3.4	14.6 ± 3.5	112.4 ± 7.2
	Imidacloprid + Abamectin (M)	7	1.46 ± 1.08	0.3 ± 0.1	14.3 ± 3.3	14.6 ± 3.3	105.9 ± 11.6
	Imidacloprid + Emamectin benzoate	7	0.33 ± 0.29	0.3 ± 0.1	19.0 ± 4.3	19.3 ± 4.4	108.8 ± 9.1
	Check	7	3.83 ± 2.87	0.2 ± 0.1	17.0 ± 5.7	17.2 ± 5.8	107.0 ± 11.2
2010	Imidacloprid	7					
	Abamectin	7					
	Emamectin benzoate	7					
	Imidacloprid + Abamectin (AJ)	7					
	Imidacloprid + Abamectin (M)	7					
	Imidacloprid + Emamectin benzoate	7					
	Check	7					

† Means followed by an asteriks in each column of the same site are significantly different from the checks at the 5% level based on Fisher's Protected LSD.

SYSTEMIC PESTICIDE INJECTION TRIALS

Evaluation of Emamectin Benzoate (TREE-age™) for Protection of Oaks Against Insect Pests

Highlights:

- Tree IV injections of emamectin benzoate (EB) significantly reduce occurrence/damage caused by leaf beetles, borers, tussock moth caterpillars, leaf-rolling weevils, and oakworm caterpillars on cherrybark and burr oaks compared to untreated checks.
- EB treatments did not reduce level of weevil damage in cherrybark acorns. Laboratory analysis detected EB in leaf tissue but not in acorn nut meat.
- Tree IV injections of EB significantly reduced the number of live cerambycid larvae and level of feeding in water oak logs 4 and 8 months after treatment.

Justification: Injection trials conducted by the Forest Pest Management Cooperative, Arborjet Inc. (Woburn, MA) and others from 1999 – 2008 have shown that emamectin benzoate (Tree-age), injected into conifers and hardwoods, are highly effective against coneworm, bark beetles, wood borers, forest tent caterpillar and winter moth. Syngenta submitted TREE-äge™ for registration by EPA in January 2008. Syngenta is interested in generating additional data in support of TREE-age against foliar, bud and stem pests of hardwood.

Objective: Evaluate the potential for systemic injections of TREE-age (emamectin benzoate) in reducing foliar, bud and stem insect pest damage on bur oak, cherrybark oak and water oak.

Cooperators:

Mr. Joe Hernandez	Western Gulf Tree Improvement Program, College Station, TX
Mr. Marvin Lopez	Western Gulf Tree Improvement Program, College Station, TX
Dr. Tom Byram	Western Gulf Tree Improvement Program, College Station, TX
Dr. Jackie Driver	Syngenta, Waco, TX
Dr. David Cox	Syngenta, Modesta, CA
Mr. Joseph Doccola	Arborjet, Inc., Worchester, MA

Study Site: Three acre orchard block containing 10 - 20 year-old water oak (*Quercus nigra)*, cherrybark oak (*Q. pagoda*), and bur oak (*Q. macrocarp)* -- Texas Forest Service Hudson Hardwood Seed Orchard, Angelina Co., TX.

Insecticides:

Emamectin benzoate (Tree-äge) -- avermectin derivative that has shown systemic activity against Coleoptera and Lepidoptera

Research Approach:

Bur Oak - randomized complete block with clones as blocks. 2 treatments X 7 clones X 2 ramets per clone = 28 ramets used for study.

Cherrybark Oak - randomized complete block with clones as blocks. 2 treatments X 7 clones X 2 ramets per clone = 28 ramets used for study.

Water Oak – 2 X 2 X 3 factorial design. 2 treatments X 2 felling dates X 3 evaluation periods X 10 replicates = 120 replicates used for study

The treatments include:

Bur Oak Trial

1) Emamectin benzoate (TREE-age®, 4% ai) applied undiluted at 10 ml of product per inch tree diameter at breast height (DBH) (0.4g active per inch DBH) (N = 14)
2) Check (untreated) (N = 14)

Cherrybark Oak Trial

1) Emamectin benzoate (TREE-age®, 4% ai) applied undiluted at 10 ml of product per inch tree diameter at breast height (DBH) (0.4g active per inch DBH) (N = 14)
2) Check (untreated) (N = 14)

Water Oak Trial

1) Emamectin benzoate (TREE-age®, 4% ai) applied undiluted at 10 ml of product per inch tree diameter at breast height (DBH) (0.4g active per inch DBH) (N = 20)
2) Check (untreated) (N = 10)

In late April 2009, study trees were selected and measured for DBH to determine volume of insecticide to be injected. Eight (8) holes, 0.95 cm (3/8 in) diameter and 4 cm (1.5 in) deep, were drilled into the root flare of the tree bole (5 cm above ground). Arborplugs were installed in each hole. The Arborjet™ QUIK-jet system was used to inject an equal amount of product into each injection point.

Data Collection:

Bur and Cherrybark Oak Trials

All study trees were visibly inspected for insect damage at the time of treatment and at one or two month intervals thereafter (May 21, June 22, August 4, and September 30). Damage levels were ranked on a scale of 0 to 5 (0 = absent, 1 = isolated, 2 = light, 3 = moderate, 4 = heavy, or 5 = extensive) and recorded. If damage was occurring to foliage, a sample was collected for proper identification of the causal agent.

In the fall (October), 25-100 acorns from branch samples were collected from several (11) cherrybark oaks (most cherrybark and all burr oaks did not have any acorn crop). All collected acorns were dried for 24 hrs, counted and stored temporarily in refrigerators or coolers. Some (15-40) collected acorns were split in half. The interior of each half was evaluated for the presence of weevil larvae and/or feeding damage in excess of 5% of the acorn meat.

Later in the fall (November and early December), a tarp was laid out under each of 13 cherrybark oaks. The trees were shaken and 50 fallen leaves collected. These leaves, as well as 25 acorns from the same trees, were shipped to Syngenta's laboratory in Greensboro, NC for analysis of emamectin benzoate concentrations.

Water Oak Trial

The injected trees were/will be allowed 2 (June 2009) and 12 (April 2010) months to translocate product. In June, a series of 10 trees per treatment were felled and 1.5 m bolts taken from the 3, 4.5 and 6 m heights. The bolts were randomly placed 1 m from other bolts on discarded, hardwood bolts to maximize surface area available for colonization as well as to discourage predation by ground and litter-inhabiting organisms. To facilitate timely insect colonization, an amber bottle with wick, containing ethanol, was attached to 1 m stakes evenly spaced in the study area.

A series of bolts (10 for each treatment) were/will be retrieved 8 (August), 25 (December) and ~42 (March 2010) weeks after deployment. In the laboratory, the length and diameter of each bolt was measured. The bark was/will be removed from each bolt. The following measurements were/will be recorded from each bark sample:

1) Number of cerambycid egg niches on bark surface.
2) Number of live and dead cerambycid larvae
2) Percent of bark sample with cerambycid activity, estimated by overlaying a 100 cm^2 grid on the underside of each bark strip and counting the number of squares where cerambycid larvae had fed.
4) Number of ambrosia beetle entry holes

Treatment efficacy was determined by comparing the number of cerambycid and/or ambrosia beetle attacks and the area of cerambycid feeding for each treatment and felling date. Data was transformed by $\log_{10}(x+1)$ if necessary to satisfy criteria for normality and homoscedasticity (Zar 1984) and analyzed by GLM and the Fisher's Protected LSD test using the Statview® statistical program (SAS Institute Inc.).

Results:

A hard frost in early April 2009 caused considerable damage to young leaves and flowers, particularly on the burr oaks. Many trees had to put out new shoots. Early season damage due to insects was difficult to see.

Observations indicated that several insect species attack oaks through the year: most common were a chrysomelid beetle (May and June), trunk borer (family and species unknown, June), and tussock moth caterpillars (June) on cherrybark oaks, and a leaf-rolling weevil (Coleoptera: Attelabidae**,** June) and oakworm caterpillars (September) on burr oaks (Table 11 and Pictures). The emamectin benzoate treatment significantly reduced damage levels of pests on one or both tree species. Another common pest, acorn weevil (Coleoptera Curculionidae) appeared to be unaffected by the emamectin benzoate treatment (Table 12). No chemical was detected in acorns from treated trees (Table 13). Other pests observed in very low numbers included branch gall insects, aphids, walking sticks, fall webworm and twig girdler.

Logs from emamectin benzoate-treated water oaks had significantly fewer cerambycid egg niches, live larvae and less feeding area compared to untreated checks (Table 14). There was no difference between treatments in the number of dead cerambycid larvae or ambrosia beetle holes penetrating into xylem tissue.

Conclusions:

Moderate concentration of emamectin benzoate in treated trees can protect hardwoods against several defoliators and can suppress damage from leaf beetles and weevils. Based on these results, the duration of emamectin benzoate efficacy will be evaluated in 2010. No emamectin benzoate was detected in the nutmeat of acorns from cherrybark oak. This likely explains the lack of protection against acorn weevils. However, this discovery may open the possibility that EB could be used to protect foliage, branches and trunks edible nut crop trees (pecan, walnut, etc.) against several important pests yet safe for consumption (no protection from nut-inhabiting insects (acorn weevil).

Acknowledgements:

We appreciate the assistance provide by Todd Nightingale, Joe Hernandez and Marvin Lopez. We thank Arborjet, Inc., Mauget and Syngenta for the financial support, chemical donations, and/or injection equipment loans.

Figure 4. A) Leaf beetle (Coleoptera: Chrysomelidae) and B) skeletonized leaves of burr oak.

Figure 5. Leaf-rolling weevil, *Homoeolabus analis* (Coleoptera: Curculionidae), and damage.

Figure 6: Banded tussock moth caterpillar, *Halysidota tessellaris* (Lepidotera: Arctiidae).

Figure 7. Borer damage on cherrybark oak trunk.

Figure 8. Spiny oakworm caterpillar, *Anisota stigma* (Lepidoptera: Saturnidae) and pink-striped caterpillar, *A. virginiensis*.

Figure 9. Acorn weevil and damage

Table 11: Occurrence/severity of insect damage on bur and cherrybark oak treated with emamectin benzoate, Hudson, TX; 2009

			Insect Family or Species				
Tree Species	Treatment*	N	Chrysomilid leaf skeletinizer	Borer	Tussock moth caterpillar	Leaf-rolling weevil	Oakworm caterpillar
Burr Oak	Emamectin benzoate	14	1.29 ± 0.19 *†	0.00 ± 0.00	0.00 ± 0.00	0.14 ± 0.10 *	0.00 ± 0.00 *
	Check	14	2.07 ± 0.17	0.14 ± 0.10	0.14 ± 0.10	0.64 ± 0.20	0.57 ± 0.25
Cherrybark Oak	Emamectin benzoate	14	1.57 + 0.20 *	0.00 + 0.00 *	0.00 + 0.00 *	-------	0.00 + 0.00
	Check	14	2.29 + 0.16	0.50 + 0.14	0.64 + 0.22	-------	0.43 + 0.20

Damage Ranking: 0=absent, 1=isolated, 2=light, 3=moderate, 4=heavy, or 5=extensive

† Means followed by an asteriks in each column of the same tree species are significantly different from the checks at the 5% level based on Fisher's Protected LSD.

Table 12: Acorn weevil damage to cherrybark oak acorns; Hudson, TX; 2009

		1-Oct-09		5-Dec-09	
Treatment*	N	Weevil Damaged	Healthy	Weevil Damaged	Healthy
Emamectin benzoate (2005)	3	6.5 ± 3.9 †	90.5 ± 6.8	21.7 ± 15.8	78.3 ± 15.8
Emamectin benzoate (2009)	3	32.5 ± 6.7	55.6 ± 10.7	46.2 ± 6.9	53.8 ± 6.9
Check	5	20.9 ± 5.3	72.1 ± 6.1	37.0 ± 10.7	63.0 ± 10.7

† Means followed by an asteriks in each column of the same tree species are significantly different from the checks at the 5% level based on Fisher's Protected LSD.

Table 13: Emamectin benzoate concentratuion (ppb) in cherrybark oak leaves and acorns; Hudson, TX; 2009

Treatment*	N	Leaves (fallen)	N	Acorn nutmeat
Emamectin benzoate (2005)	4	0.8 + 0.8 †	3	< 1.0
Emamectin benzoate (2009)	4	151.5 ± 49.4 *	3	< 1.0
Check	5	0.6 ± 0.6	5	< 1.0

† Means followed by an asteriks in each column are significantly different from the checks at the 5% level based on Fisher's Protected LSD.

Table 14: Level of insect damage on logs from water oaks treated with emamectin benzoate, Hudson, TX; 2009

			Insect Activity				
Date	Treatment*	N	Cerambycid Egg Niches	Live Cerambycid Larvae	Dead Cerambycid Larvae	Feeding Area (cm^2)	Ambrosia Beetle holes
24-Aug	Emamectin benzoate	9	5.1 ± 1.1 *†	1.2 ± 0.5 *	1.6 ± 0.6	43.2 ± 12.9 *	20.8 ± 3.5
	Check	10	13.1 + 1.3	15.5 + 1.8	0.8 + 0.4	194.8 + 26.1	22.5 + 4.5
17-Dec	Emamectin benzoate	12	2.0 ± 0.3 *	10.3 ± 2.2 *	1.3 ± 0.5	164.7 ± 37.3 *	20.3 ± 6.9
	Check	9	7.3 ± 1.2	47.2 ± 13.2	1.6 ± 0.5	689.7 ± 77.2	17.3 ± 5.1

† Means followed by an asteriks in each column of the same tree species are significantly different from the checks at the 5% level based on Fisher's Protected LSD.

SYSTEMIC PESTICIDE INJECTION TRIALS

Systemic Insecticide Timing, Dose Rate and Volume for Single Tree Protection from Southern *Ips* Engraver Beetles – Zavalla and Rusk, TX

Highlights:

- Tissue analyses for emamectin benzoate concentration was completed and aligned with efficacy data against *Ips* engraver beetles and wood borers.
- The FPMC continued to evaluate the efficacy of a formulation of abamectin and fipronil, for preventing attacks and brood production of *Ips* engraver beetles and wood borers on bolt sections of loblolly pine in East Texas.
- Two rates (0.4 and 0.8 g AI/inch DBH) of abamectin applied in the spring and fall and fipronil in the fall were highly effective against *Ips* engraver beetles and wood borers 10 - 16 months after injection.

Justification: In 2004 and 2005, the FPMC conducted injection trials in East Texas to evaluate the potential efficacy of the systemic insecticide emamectin benzoate (EB) for protection of loblolly pine against *Ips* engraver beetles (Coleoptera: Curculionidae). The results showed that EB was highly effective in preventing both the successful colonization of treated bolts by engraver beetles and wood borers (Coleoptera: Cerambycidae) and the mortality of standing trees (see 2004 and 2005 Accomplishment Report). Additional trials were needed to determine the best timing, dosage rate, and duration of emamectin benzoate treatments. It is of interest to determine the concentration of EB in different tissues relative to different application rates. An additional chemical product, abamectin (Mauget), is now available and should be tested for efficacy against bark beetles and wood borers.

Objectives: 1) Evaluate the efficacy of systemic injections of emamectin benzoate, fipronil, and abamectin in reducing colonization success of pine engraver beetles and wood borers on loblolly pine; 2) evaluate the chemicals applied at different timings and dosage rates using Arborjet's Tree IV™ pressurized injection system; and 3) determine the duration of treatment efficacy.

Cooperators:

Mr. Jason Ellis	Texas Forest Service, Jacksonville, TX
Mr. Doug Long	Rayonier, Lufkin, TX
Dr. David Cox	Syngenta, Madera, CA
Ms. Marianne Waindle	Mauget, Arcadia, CA
Mr. Joseph Doccola	Arborjet, Inc., Worchester, MA

Study Sites: Two 20-year-old, recently-thinned loblolly pine plantations were selected on the Fairchild State Forest (Rusk Co.) about 12 miles west of Rusk, TX and on land owned by Rayonier in Polk County. Selected trees were injected for use in a bolt study. A staging area was set up in a nearby plantation (Anderson Co., about 10 miles east of Palestine, TX) where bolts were exposed to bark beetles and wood borers.

Insecticides:

Emamectin benzoate (Arborjet Inc.) – an avermectin derivative

Fipronil (experimental BASF BAS 350 PW) -- a phenyl pyrazole insecticide that has shown systemic activity against other Coleoptera (bark beetles)

Abamectin (Abacide™ 2, Mauget) – a mixture of avermectin B1a and B1b; fermentation products from soil bacterium *Streptomyces avermitilis*.

Research Approach:

The treatments by trial included:

Trial 1: Established October 2005 and May 2006

Trt #	Chemical	Formulation	Application Timing	Rate (g ai/inch dbh)	No. of Trees Treated	Felling Dates
1	Emamectin benzoate	Avajet	Oct-05	0.016	30	Jul '06, '07 & '08
2	Emamectin benzoate	Avajet	Oct-05	0.08	30	Jul '06, '07 & '08
3	Emamectin benzoate	Avajet	Oct-05	0.4	30	Jul '06, '07 & '08
7	Emamectin benzoate	Avajet	May-06	0.016	30	Jul '06, '07 & '08
8	Emamectin benzoate	Avajet	May-06	0.08	30	Jul '06, '07 & '08
9	Emamectin benzoate	Avajet	May-06	0.4	30	Jul '06, '07 & '08
13	Untreated				30	Jul '06, '07 & '08
14	Untreated	Plug only	May-06		30	Jul '06, '07 & '08

Trial 2: Established April 2008

Trt #	Chemical	Formulation	Application Timing	Rate (g ai/inch dbh)	No. of Trees Treated	Felling Dates
1	Abamectin	Abacide	Apr-08	0.4	40	Sept '08, July '09, '10 & '11
2	Abamectin	Abacide	Apr-08	0.8	40	Sept '08, July '09, '10 & '11
3	Abamectin	Abacide	Oct-08	0.4	30	Jul '09, '10 & '11
4	Abamectin	Abacide	Oct-08	0.8	30	Jul '09, '10 & '11
5	Fipronil	BAS 350 PW	Oct-08	0.4	30	Jul '09, '10 & '11
6	Fipronil	BAS 350 PW	Oct-08	0.8	30	Jul '09, '10 & '11
7	Untreated				40	Sept '08, July '09, '10 & '11

Trial 1: Loblolly pine trees (450), 15 – 20 cm diameter at breast height (DBH), were selected in September 2005. Thirty trees were each injected with emamectin benzoate (October 2005 and May 2006). Each injection treatment (1-3 & 7-9) consisted of a single insecticide formulation injected into four cardinal points about 0.3 m above the ground on each tree in April using the Arborjet Tree IV™.

After 2 (July '06), 14 (July '07) and 26 (July '08) months post-injection, 10 trees of each emamectin benzoate treatment were felled and one 1.5 m-long bolts were removed from the 3 m height of the bole.

At the time of tree felling in 2006, smaller bolts (46 cm) also were cut from the 5 m (= 16 ft) and 11 m (= 36 ft) height of the bole of each emamectin benzoate and fipronil tree. In addition, foliage (100 needles) and cone (5) samples were collected from the crown of each emamectin benzoate tree. All samples were brought back to the laboratory. Phloem tissue (50 g) was collected from each emamectin benzoate- and fipronil-treated bolt. Xylem tissue (50 g) was also collected from the emamectin benzoate-treated bolts. All samples were temporarily placed in a freezer before being sent in dry ice to the Syngenta laboratory (Greensboro, NC.). In 2007 and 2008, a second and third series, respectively, of plant tissues (phloem and xylem from 5m and 1st and 2nd year foliage) were collected from each emamectin benzoate tree. All samples were sent to Syngenta's laboratory in Greensboro, NC, for analysis of chemical concentrations (ppb = parts per billion).

Trial 2: Loblolly pine trees (240), 15 – 20 cm DBH, were selected in April 2008. Thirty - forty trees were each injected with one of two treatments: abamectin (April and October 2008), or fipronil (October 2008) at two different rates (0.4g or 0.8g per 1 inch of tree diameter). Each injection treatment (1 - 6) consisted of a single insecticide formulation injected into four cardinal points about 0.3 m above the ground on each tree using the Arborjet Tree IV™.

After 5 (September '08), 15 (July '09), 27 (July '10), or 39 (July '11) months post-injection, 10 trees of each abamectin and fipronil treatment were/will be felled and one 1.5 m-long bolts were/will be removed from the 3 m height of the bole.

For each trial, 1.5 m bolts were transported to another plantation that was recently thinned and contained fresh slash material. Each bolt was placed about 1 m from other bolts on discarded, dry pine bolts to maximize surface area available for colonization as well as to discourage predation by ground and litter-inhabiting organisms. To facilitate timely bark beetle colonization, packets of *Ips* pheromones (racemic ipsdienol and cis-verbenol; Synergy Semiochemicals, Delta, BC, Canada) were attached separately to three 1 m stakes evenly spaced in the study area.

Each series of bolts was retrieved about 3 weeks after deployment, after we observed many cerambycid egg niches on the bark surface of most bolts. In the laboratory, two 10 cm X 50 cm samples (total = 1000 cm^2) of bark were removed from each bolt. The following measurements were recorded from each bark sample:

1) Number of unsuccessful attacks - penetration to phloem, but no egg galleries.
2) Number of successful attacks - construction of nuptial chamber and at least one egg gallery extending from it.
3) Number and lengths of egg galleries with larval galleries radiating from them.
4) Number and lengths of egg galleries without larval galleries.
5) Percent of bark sample with cerambycid activity, estimated by overlaying a 100 cm^2 grid on the underside of each bark strip and counting the number of squares where cerambycid larvae had fed.

In 2008, data was also collected for:

6) Number of bark beetle emergence holes on the bark surface.
7) Percent of bark sample with bark beetle activity, estimated by overlaying a 100 cm^2 grid on the underside of each bark strip and counting the number of squares where bark beetle adult and larvae had fed.
8) Number ambrosia beetle entrance hole in the xylem.

Treatment efficacy was determined by comparing *Ips* beetle attacks, *Ips* egg gallery length and cerambycid feeding for each treatment. The data were transformed by $\log_{10}(x+1)$ to satisfy criteria for normality and homoscedasticity (Zar 1984) and analyzed by GLM and the Fishers Protected LSD test using the Statview statistical program.

Results:

Trial 1: Timing, Rate & Concentration of EB in Tissue:

Ips Attack Success – In 2007, after more than a year (14 – 20 months), the total number of attacks (nuptial chambers constructed) by male *Ips* engraver beetles did not differ among the treatments (Table 15). Most (90%) of the nuptial chambers were successfully constructed on untreated bolts - with at least one egg gallery radiating from each nuptial chamber. In contrast, all emamectin-benzoate-treated bolts (both seasons and all rates) had significantly fewer nuptial chambers with egg galleries (Tables 11). Nearly all treatments reduced the total number and length of egg galleries compared to check trees (Tables 16 & 17).

In 2008, after more than two years (28 – 34 months), the total number of attacks (nuptial chambers constructed) by male *Ips* engraver beetles did not differ among the treatments (Table 15). In this third series, less than half (47%) of the nuptial chambers were successfully constructed on untreated bolts - with at least one egg gallery radiating from each nuptial chamber. As a result, none of the treatments had significantly fewer nuptial chambers with egg galleries (Tables 15). All emamectin benzoate treatments reduced the total number and length of egg galleries compared to check trees (Tables 16 & 17).

Cerambycid Larval Feeding – In 2007, the attack level of wood borers (egg niches) on logs from injected trees was often significantly greater than that on check logs (Table 19). Relatively little cerambycid feeding (20%) occurred on untreated bolts during the 3 weeks period between tree felling and bolt evaluation (Table 19). All emamectin benzoate treatments significantly reduced the amount of larval feeding and development compared to the check.

In 2008, the attack level of wood borers (egg niches) on logs from injected trees did not differ from that on check logs (Table 19). Relatively little cerambycid feeding (14%) occurred on untreated bolts during the 3-week period between tree felling and bolt evaluation (Table 19). All emamectin benzoate treatments significantly reduced the amount of larval feeding and development compared to the check.

Concentration in Tissue: - Plant tissue samples were collected from emamectin benzoate trees in 2006, 2007 & 2008. EB concentrations were highest in xylem tissue followed by 2nd year foliage, 1st year foliage and phloem tissue and 2nd year cones (Table 18). Concentrations were positively correlated with dosage rate for most tissue types.

Trial 2: Abamectin and Fipronil formulation:

Ips Attack Success – In 2008, the total number of attacks (nuptial chambers constructed) by male *Ips* engraver beetles did not differ among the abamectin treatments (Table 20). Most (87%) of the nuptial chambers were successfully constructed on untreated bolts - with at least one egg gallery radiating from each nuptial chamber. In contrast, both abamectin treatments had significantly fewer nuptial chambers with egg galleries (Tables 20). Both treatments completely prevented brood development compared to check trees (Tables 21 & 22).

In 2009, the total number of attacks by male *Ips* engraver beetles did not differ among the abamectin and fipronil treatments (Table 20 & 24). Most (81%) of the nuptial chambers were successfully constructed on untreated bolts - with at least one egg gallery radiating from each nuptial chamber. In contrast, all abamectin and fipronil treatments had significantly fewer nuptial chambers with egg galleries (Tables 21 & 25). All treatments completely prevented brood development compared to check trees (Tables 22 & 26).

<u>Cerambycid Larval Feeding</u> – In 2008, the attack level of wood borers (egg niches) on logs from injected trees did not differ from that on check logs (Table 23). Relatively little cerambycid feeding (10%) occurred on untreated bolts during the 3 weeks period between tree felling and bolt evaluation (Table 23). Both abamectin treatments reduced the amount of larval feeding and development compared to the check.

In 2009, the attack level of wood borers (egg niches) on logs from most injected trees did not differ from that on check logs (Table 23 & 27). Relatively little cerambycid feeding (8%) occurred on untreated bolts during the 3 weeks period between tree felling and bolt evaluation (Table 23). All abamectin and fipronil treatments reduced the amount of larval feeding and development compared to the check.

Conclusions:

Trial 1 showed that emamectin benzoate is highly effective in preventing successful attacks by *Ips* bark beetles and cerambycids 28 and 34 months after injection. The adults showed some limited success in constructing extended (> 1") egg galleries. However, the treatments still were able to prevent bark beetle brood and cerambycid larval development (Table 12 & 13).

Emamectin benzoate concentrations were highest in xylem tissue, moderate in foliage and phloem tissue and fairly low in cones. Concentrations were still significantly higher than checks 34 months after injection.

Trial 2 revealed that abamectin and fipronil were highly effective against bark beetles and wood borers. No significant difference in the efficacy of abamectin or fipronil at the two rates was observed 10 months after injection. The trial will be continued through 2011.

Acknowledgements: Many thanks go to Jason Ellis, TFS-Jacksonville, and Doug Long, Rayonier, for providing thinned stands for the project. We appreciate the chemical donations and injection equipment loans made by Arborjet, Inc, BASF, Syngenta, Fort Dodge Animal Health and Mauget.

Table 15: Attack success and gallery construction of *Ips* engravers beetles on loblolly pine bolts cut 2 - 30 months after fall (Oct.) and spring (May) trunk injections with different rates of emamectin benzoate; Lufkin, TX, 2006, 2007 & 2008.

Evaluation period	Season/Yr. Injected	Treatment	Mean # of nuptial chambers without egg galleries		Mean # of nuptial chambers with egg galleries		Mean total # of nuptial chambers
			No.	% of total	No.	% of total	
2 Months Post-Injection (Jul. '06)	Spring 2006	EB 0.016g	3.9	69.6	1.7 *	30.4	5.6
		EB 0.08g	2.6	96.3	0.1 *	3.7	2.7 *
		EB 0.4g	3.7	97.4	0.1 *	2.6	3.8
8 Months Post-Injection (Jul. '06)	Fall 2005	EB 0.016g	6.6 *	91.7	0.6 *	8.3	7.2
		EB 0.08g	5.3 *	85.5	0.9 *	14.5	6.2
		EB 0.4g	4.4 *	97.8	0.1 *	2.2	4.5
		Check	2.6	36.1	4.6	63.9	7.2
14 Months Post-Injection (Jul. '07)	Spring 2006	EB 0.016g	7.5 *	85.2	1.3 *	14.8	8.8
		EB 0.08g	5.0 *	92.6	0.4 *	7.4	5.4
		EB 0.4g	4.8 *	98.0	0.1 *	2.0	4.9 *
20 Months Post-Injection (Jul. '07)	Fall 2005	EB 0.016g	6.1 *	77.2	1.8 *	22.8	7.9
		EB 0.08g	4.8 *	87.3	0.7 *	12.7	5.5
		EB 0.4g	5.6 *	84.8	1.0 *	15.2	6.6
		Check	0.9	10.3	7.8	89.7	8.7
28 Months Post-Injection (Sept. '08)	Spring 2006	EB 0.016g	7.4 *	78.7	2.0	21.3	9.4
		EB 0.08g	4.2	92.7	0.3	7.3	4.6
		EB 0.4g	6.0	98.4	0.1 *	1.6	6.1
34 Months Post-Injection (Sept. '08)	Fall 2005	EB 0.016g	7.6	81.0	1.8	19.1	9.3
		EB 0.08g	7.9 *	94.0	0.5	6.0	8.4
		EB 0.4g	9.0 *	67.7	4.3	32.3	13.3
		Check	2.0	53.3	1.8	46.7	3.8

* Means followed by an asteriks in each column are significantly different from the check at the 5% level based on Fisher's Protected LSD.

Table 16: Mean number of egg galleries constructed by *Ips* engravers beetles in loblolly pine bolts cut 2 - 30 months after fall (Oct.) and spring (May) trunk injections with different rates of emamectin benzoate; Lufkin, TX, 2006, 2007 & 2008.

Evaluation period	Season/Yr. Injected	Treatment	Number of egg galleries: Without larvae No.	Without larvae % of total	With larvae No.	With larvae % of Total	Total #
2 Months Post-Injection (Jul. '06)	Spring 2006	EB 0.016g	1.0 *	37.0	1.7 *	63.0	2.7 *
		EB 0.08g	0.2 *	100.0	0.0 *	0.0	0.2 *
		EB 0.4g	0.1 *	100.0	0.0 *	0.0	0.1 *
8 Months Post-Injection (Jul. '06)	Fall 2005	EB 0.016g	1.1 *	84.6	0.2 *	15.4	1.3 *
		EB 0.08g	1.4 *	100.0	0.0 *	0.0	1.4 *
		EB 0.4g	0.1 *	100.0	0.0 *	0.0	0.1 *
		Check	3.1	29.0	7.6	71.0	10.7
14 Months Post-Injection (Jul. '07)	Spring 2006	EB 0.016g	2.5	100.0	0.0 *	0.0	2.5 *
		EB 0.08g	0.6 *	100.0	0.0 *	0.0	0.6 *
		EB 0.4g	0.2 *	100.0	0.0 *	0.0	0.2 *
20 Months Post-Injection (Jul. '07)	Fall 2005	EB 0.016g	4.2	95.5	0.2 *	4.5	4.4 *
		EB 0.08g	1.3 *	100.0	0.0 *	0.0	1.3 *
		EB 0.4g	2.6 *	100.0	0.0 *	0.0	2.6 *
		Check	5.7	24.4	17.7	75.6	23.4
28 Months Post-Injection (Sept. '08)	Spring 2006	EB 0.016g	2.5	95.2	0.1 *	4.8	2.6
		EB 0.08g	0.3	100.0	0.0 *	0.0	0.3
		EB 0.4g	0.1	100.0	0.0 *	0.0	0.1 *
34 Months Post-Injection (Sept. '08)	Fall 2005	EB 0.016g	3.2	96.7	0.1 *	3.3	3.3
		EB 0.08g	0.8	72.7	0.3 *	27.3	1.1
		EB 0.4g	4.7	97.9	0.1 *	2.1	4.8
		Check	0.5	16.7	2.5	83.3	3.0

* Means followed by an asteriks in each column are significantly different from the check at the 5% level based on Fisher's Protected LSD.

Table 17: Mean length of egg galleries constructed by *Ips* engravers beetles in loblolly pine bolts cut 2 - 30 months after fall (Oct.) and spring (May) trunk injections with different rates of emamectin benzoate; Lufkin, TX, 2006, 2007 & 2008.

				Length of egg galleries				
				Without larvae		With larvae		
Evaluation period	Season/Yr. Injected	Treatment	N	cm	% of Total	cm	% of Total	Total length
2 Months Post-Injection (Jul. '06)	Spring 2006	EB 0.016g		3.7 *	36.6	6.4 *	63.4	10.1 *
		EB 0.08g		0.7 *	100.0	0.0 *	0.0	0.7 *
		EB 0.4g		0.5 *	100.0	0.0 *	0.0	0.5 *
8 Months Post-Injection (Jul. '06)	Fall 2005	EB 0.016g		5.6 *	80.0	1.4 *	20.0	7.0 *
		EB 0.08g		4.8 *	100.0	0.0 *	0.0	4.8 *
		EB 0.4g		0.9 *	100.0	0.0 *	0.0	0.9 *
		Check		23.9	26.6	65.9	73.4	89.8
14 Months Post-Injection (Jul. '07)	Spring 2006	EB 0.016g		7.4 *	100.0	0.0 *	0.0	7.4 *
		EB 0.08g		2.3 *	100.0	0.0 *	0.0	2.3 *
		EB 0.4g		0.9 *	100.0	0.0 *	0.0	0.9 *
20 Months Post-Injection (Jul. '07)	Fall 2005	EB 0.016g		19.7	87.2	2.9 *	12.8	22.6 *
		EB 0.08g		2.9 *	100.0	0.0 *	0.0	2.9 *
		EB 0.4g		6.5 *	100.0	0.0 *	0.0	6.5 *
		Check		39.9	22.6	136.7	77.4	176.6
28 Months Post-Injection (Sept. '08)	Spring 2006	EB 0.016g		7.9	95.5	0.4 *	4.5	8.3 *
		EB 0.08g		1.3	100.2	0.0 *	0.0	1.3 *
		EB 0.4g		0.4	100.0	0.0 *	0.0	0.4 *
34 Months Post-Injection (Sept. '08)	Fall 2005	EB 0.016g		7.4	93.1	0.6 *	7.0	8.0 *
		EB 0.08g		4.3	81.1	1.0 *	18.9	5.3 *
		EB 0.4g		11.8	95.9	0.5 *	4.1	12.3 *
		Check		6.5	23.6	21.0	76.4	27.5

* Means followed by an asteriks in each column are significantly different from the check at the 5% level based on Fisher's Protected LSD.

Table 18: Mean cnoncentration (ppb) of emamectin benzoate in loblolly pine tissue collected 2 - 34 months after fall (Oct.) and spring (May) trunk injections with different rates of emamectin benzoate; Lufkin, TX, 2006, 2007 & 2008.

			EB Concentrations (ppb)				
					Foliage		
Evaluation period	Season/Yr. Injected	Treatment	Phloem	Xylem	1st Yr	2nd Yr	Cones
2 Months Post-Injection (Jul. '06)	Spring 2006	EB 0.016g	2.2 *	58.2 *	4.6 *		0.7
		EB 0.08g	6.7 *	576.2 *	32.9 *		11.7 *
		EB 0.4g	61.9 *	6162.3 *	426.6 *		60.6 *
8 Months Post-Injection (Jul. '06)	Fall 2005	EB 0.016g	3.3 *	101.2 *	4.9 *		0.8
		EB 0.08g	11.8 *	260.8 *	11.8 *		5.2
		EB 0.4g	26.7 *	207.0 *	23.6 *		12.7 *
		Check	0.9	0.2	0.4		0.1
14 Months Post-Injection (Jul. '07)	Spring 2006	EB 0.016g	4.7 *	125.9 *	3.3 *	43.2 *	
		EB 0.08g	8.2 *	1864.4 *	85.3 *	62.6 *	
		EB 0.4g	41.5 *	7833.8 *	51.8 *	504.8 *	
20 Months Post-Injection (Jul. '07)	Fall 2005	EB 0.016g	2.0	28.5 *	2.3 *	14.2 *	
		EB 0.08g	6.5 *	103.8 *	11.0 *	153.8 *	
		EB 0.4g	65.9 *	930.0 *	32.1 *	308.3 *	
		Check	0.6	0.5	0.3	0.4	
28 Months Post-Injection (Sept. '08)	Spring 2006	EB 0.016g	NA	NA		NA	
		EB 0.08g	12.5 *	182.4 *		71.8 *	
		EB 0.4g	9.1 *	3353.8 *		169.0 *	
34 Months Post-Injection (Sept. '08)	Fall 2005	EB 0.016g	NA	NA		NA	
		EB 0.08g	5.8	168.6 *		49.8 *	
		EB 0.4g	12.6 *	455.3 *		118.9 *	
		Check	0.8	0.3		0.2	

* Means followed by an asteriks in each column are significantly different from the check at the 5% level based on Fisher's Protected LSD.

Table 19: Extent of feeding by cerambycid larvae in loblolly pine bolts cut 2 - 30 months after fall (Oct.) and spring (May) trunk injections with different rates of emamectin benzoate; Lufkin, TX, 2006, 2007 & 2008.

Evaluation period	Season/Yr. Injected	Treatment	No. of egg niches on bark	% phloem area consumed by larvae	No. of bark beetle emergence holes on bark	% phloem area colonized by bark beetles	No. of ambrosia beetle entrance holes in xylem
2 Months Post-Injection (Jul. '06)	Spring 2006	EB 0.016g	4.5	0.2 *			
		EB 0.08g	5.5	0.2 *			
		EB 0.4g	4.2	0.0 *			
8 Months Post-Injection (Jul. '06)	Fall 2005	EB 0.016g	7.9	0.0 *			
		EB 0.08g	7.0	0.0 *			
		EB 0.4g	6.0	0.0 *			
		Check	6.6	8.1			
14 Months Post-Injection (Jul. '07)	Spring 2006	EB 0.016g	9.4	0.8 *			
		EB 0.08g	12.2 *	0.0 *			
		EB 0.4g	11.0	0.0 *			
20 Months Post-Injection (Jul. '07)	Fall 2005	EB 0.016g	11.5	0.1 *			
		EB 0.08g	14.0 *	1.3 *			
		EB 0.4g	11.3 *	0.0 *			
		Check	7.1	19.6			
28 Months Post-Injection (Sept. '08)	Spring 2006	EB 0.016g	6.1	1.6 *	9.7 *	9.5 *	2.0
		EB 0.08g	6.9	0.0 *	0.0 *	0.1 *	0.6
		EB 0.4g	7.1	0.4 *	0.0 *	0.1 *	0.6
34 Months Post-Injection (Sept. '08)	Fall 2005	EB 0.016g	5.9	1.0 *	2.3 *	8.0 *	3.2
		EB 0.08g	6.7	1.6 *	0.1 *	0.1 *	1.6
		EB 0.4g	6.4	1.1 *	1.2 *	3.2 *	3.6
		Check	5.7	14.1	65.9	30.1	1.7

* Means followed by an asteriks in each column are significantly different from the check at the 5% level based on Fisher's Protected LSD.

Table 20: Attack success and gallery construction of *Ips* engravers beetles on loblolly pine bolts cut 5 to 16 months after trunk injection with abamectin using the Tree IV injection system; Lufkin, Texas - 2008 & 2009.

Evaluation period	Season/Yr. Injected	Treatment	N	Mean # of nuptial chambers without egg galleries: No.	Mean # of nuptial chambers without egg galleries: % of total	Mean # of nuptial chambers with egg galleries: No.	Mean # of nuptial chambers with egg galleries: % of total	Mean total # of nuptial chambers
5 month post-injection (Sept '08)	Spring 2008	Aba 0.8 g AI	11	4.2 *	94	0.3 *	6	4.5
		Aba 0.4 g AI	9	3.3 *	79	0.9 *	21	4.2
		Check	11	0.6	13	4.2	87	4.8
10 month post-injection (Aug. '09)	Fall 2008	Aba 0.8 g AI	9	4.0 *	100	0.0 *	0	4.0
		Aba 0.4 g AI	8	3.9 *	100	0.0 *	0	3.9
16 month post-injection (Aug. '09)	Spring 2008	Aba 0.8 g AI	10	4.6 *	100	0.0 *	0	4.6
		Aba 0.4 g AI	10	4.5 *	100	0.0 *	0	4.5
		Check	10	0.8	19	3.2	81	4.0

* Means followed by an asterisk are not significantly different from the check at the 5% level based on Fisher's Protected LSD.

Table 21: Mean number and length of egg galleries constructed by *Ips* engravers beetles (per 1000 cm^2) in loblolly pine bolts cut 5 to 16 months after trunk injection with abamectin using the Tree IV injection system; Lufkin, Texas - 2008.

				Number of egg galleries				
				Without larvae		With larvae		
Evaluation period	Season/Yr. Injected	Treatment	N	No.	% of total	No.	% of Total	Total #
5 month post-injection (Sept '08)	Spring 2008	Aba 0.8 g AI	11	0.2 *	100	0.0 *	0	0.2 *
		Aba 0.4 g AI	9	1.2	100	0.0 *	0	1.2 *
		Check	11	1.5	18	6.6	82	8.1
10 month post-injection (Aug. '09)	Fall 2008	Aba 0.8 g AI	9	0.0	####	0.0 *	####	0.0 *
		Aba 0.4 g AI	8	0.0	####	0.0 *	####	0.0 *
16 month post-injection (Aug. '09)	Spring 2008	Aba 0.8 g AI	10	0.0	####	0.0 *	####	0.0 *
		Aba 0.4 g AI	10	0.0	####	0.0 *	####	0.0 *
		Check	10	0.0	0	9.4	100	9.4

* Means followed by an asterisk are not significantly different from the check at the 5% level based on Fisher's Protected LSD.

Table 22: Mean number and length of egg galleries constructed by *Ips* engravers beetles (per 1000 cm^2) in loblolly pine bolts cut 5 to 16 months after trunk injection with abamectin using the Tree IV injection system; Lufkin, Texas - 2008.

				Length of egg galleries				
				Without larvae		With larvae		
Evaluation period	Season/Yr. Injected	Treatment	N	cm	% of Total	cm	% of Total	Total length
5 month post-injection (Sept '08)	Spring 2008	Aba 0.8 g AI	11	0.5 *	100	0.0 *	0	0.5 *
		Aba 0.4 g AI	9	3.9	100	0.0 *	0	3.9 *
		Check	11	8.5	10	74.0	90	82.5
10 month post-injection (Aug. '09)	Fall 2008	Aba 0.8 g AI	9	0.0	####	0.0 *	####	0.0 *
		Aba 0.4 g AI	8	0.0	####	0.0 *	####	0.0 *
16 month post-injection (Aug. '09)	Spring 2008	Aba 0.8 g AI	10	0.0	####	0.0 *	####	0.0 *
		Aba 0.4 g AI	10	0.0	####	0.0 *	####	0.0 *
		Check	10	0.0	0	94.9	100	94.9

* Means followed by an asterisk are not significantly different from the check at the 5% level based on Fisher's Protected LSD.

Table 23: Extent of feeding by cerambycid larvae (per 1000 cm^2) in loblolly pine bolts cut 5 to 16 months after trunk injection with abamectin using the Tree IV injection systems; Lufkin, Texas - 2008 & 2009.

Evaluation period	Season/Yr. Injected	Treatment	N	No. of cerambycid egg niches on bark	Percent phloem area consumed by larvae
5 month post-injection (Sept '08)	Spring 2008	Aba 0.8 g AI	11	4.3	0.1 *
		Aba 0.4 g AI	9	6.3	1.3 *
		Check	11	7.9	10.1
10 month post-injection (Aug. '09)	Fall 2008	Aba 0.8 g AI	9	1.7	0.0 *
		Aba 0.4 g AI	8	1.9	0.0 *
16 month post-injection (Aug. '09)	Spring 2008	Aba 0.8 g AI	10	0.9 *	0.0 *
		Aba 0.4 g AI	10	3.6	0.0 *
		Check	10	4.4	7.7

* Means followed by an asterisk are not significantly different from the check at the 5% level based on Fisher's Protected LSD.

Table 24: Attack success and gallery construction of *Ips* engravers beetles on loblolly pine bolts cut 10 months after trunk injection with fipronil using the Tree IV injection system; Lufkin, Texas - 2009.

Evaluation period	Season/Yr. Injected	Treatment	N	Mean # of nuptial chambers without egg galleries: No.	Mean # of nuptial chambers without egg galleries: % of total	Mean # of nuptial chambers with egg galleries: No.	Mean # of nuptial chambers with egg galleries: % of total	Mean total # of nuptial chambers
10 month post-injection (Aug. '09)	Fall 2008	Fip 0.8 g AI	9	6.0 *	100	0.0 *	0	6.0
		Fip 0.4 g AI	10	4.4 *	96	0.2 *	4	4.6
		Check	10	0.8	19	3.2	81	4.0

* Means followed by an asterisk are not significantly different from the check at the 5% level based on Fisher's Protected LSD.

Table 25: Mean number and length of egg galleries constructed by *Ips* engravers beetles (per 1000 cm^2) in loblolly pine bolts cut 10 months after trunk injection with fipronil using the Tree IV injection system; Lufkin, Texas - 2008.

Evaluation period	Season/Yr. Injected	Treatment	N	Number of egg galleries: Without larvae: No.	Without larvae: % of total	With larvae: No.	With larvae: % of Total	Total #
10 month post-injection (Aug. '09)	Fall 2008	Fip 0.8 g AI	9	0.0	####	0.0 *	####	0.0 *
		Fip 0.4 g AI	10	0.2	100	0.0 *	0	0.2 *
		Check	10	0.0	0	9.4	100	9.4

* Means followed by an asterisk are not significantly different from the check at the 5% level based on Fisher's Protected LSD.

Table 26: Mean number and length of egg galleries constructed by *Ips* engravers beetles (per 1000 cm^2) in loblolly pine bolts cut 10 months after trunk injection with fipronil using the Tree IV injection system; Lufkin, Texas - 2008.

Evaluation period	Season/Yr. Injected	Treatment	N	Length of egg galleries: Without larvae cm	Without larvae % of Total	With larvae cm	With larvae % of Total	Total length
10 month post-injection (Aug. '09)	Fall 2008	Fip 0.8 g AI	9	0.0	####	0.0 *	####	0.0 *
		Fip 0.4 g AI	10	0.8	100	0.0 *	0	0.8 *
		Check	10	0.0	0	94.9	100	94.9

* Means followed by an asterisk are not significantly different from the check at the 5% level based on Fisher's Protected LSD.

Table 27: Extent of feeding by cerambycid larvae (per 1000 cm^2) in loblolly pine bolts cut 10 months after trunk injection with fipronil using the Tree IV injection systems; Lufkin,

Evaluation period	Season/Yr. Injected	Treatment	N	No. of cerambycid egg niches on bark	Percent phloem area consumed by larvae
10 month post-injection (Aug. '09)	Fall 2008	Fip 0.8 g AI	9	6.2	0.0 *
		Fip 0.4 g AI	10	4.7	0.0 *
		Check	10	4.4	7.7

* Means followed by an asterisk are not significantly different from the check at the 5% level based on Fisher's Protected LSD.

SYSTEMIC PESTICIDE INJECTION TRIALS

Emamectin Benzoate and Fipronil for Protection of High-Value Southern and Western Conifers from Bark Beetles – Alabama, Colorado and Utah

Highlights:

- The FPMC continued to evaluate the efficacy of fipronil and emamectin benzoate for preventing mortality of conifers by *Dendroctonus* beetles (Coleoptera: Curculionidae, Scolytinae) in Colorado in 2009, as well as established new trials in Alabama and Utah.
- Emamectin benzoate (EB) treatment applied in the fall (9 months prior to beetle attack) was most effective in preventing mountain pine beetle from successfully attacking lodgepole pine trees over a 2-year period in Colorado.
- Initial results indicate that tree injections that included emamectin benzoate were effective in reducing/preventing tree mortality by southern pine beetle in the first year after treatment. The addition of a propiconazole/thiabendazole mix did not improve tree survival.
- A new injection trial was established in Utah for prevention of mountain beetle attacking lodgepole pine. Efficacy of EB, EB + fungicide, abamectin and abamectin + fungicide as preventative treatments will be determined in 2010.

Justification: Bark beetles (Coleoptera: Curculionidae, Scolytinae) such as the southern pine beetle (SPB), *Dendroctonus frontalis* Zimmermann, and mountain pine beetle (MPB), *D. ponderosae* Hopkins, are responsible for extensive conifer mortality throughout North America. These species do not just affect the timber industry; they also have a significant impact on recreation, water, and wildlife resources as well as residential property values.

In 2004, the FPMC conducted an injection trial in East Texas to evaluate the potential efficacy of several reported systemic insecticides, including emamectin benzoate, fipronil, imidacloprid and dinotefuran, for protection of loblolly pine against *Ips* engraver beetles. Emamectin benzoate injections had been found to be highly effective (4+ years) against both pinewood nematode, *Bursaphelenchus xylophilis*, and coneworms, *Dioryctria* spp. The results from the 2004 trials with *Ips* bark beetles showed that emamectin benzoate was highly effective in preventing both the successful colonization of treated bolts 3 and 5 months after tree injection and the mortality of standing trees (see 2004 Accomplishment Report, Grosman et al., 2006). Similarly, abamectin was found to be effective against *Ips* spp. in a 2008 trial. Trials are needed to confirm efficacy against SPB and MPB and other bark beetle species as well as to determine duration of treatment efficacy.

Objectives: 1) Evaluate the efficacy of systemic injections of emamectin benzoate alone or combined with fungicide or abamectin for preventing mortality of conifers found in the southeastern and western regions of the United States by *Dendroctonus* bark beetles and blue stain fungi; 2) evaluate affect of injection timing on treatment efficacy, and 3) determine the duration of treatment efficacy.

Cooperators:

Dr. Steve Clarke	USDA Forest Service – FHP R8, Lufkin, Texas
Dr. Christopher Fettig	USDA Forest Service – PSW Research Station, Davis, CA
Dr. Steve Munson	USDA Forest Service – FHP R4, Ogden, Utah
Ms. Meg Halford	Colorado State Forest Service, Walden, CO
Dr. David Cox	Syngenta, Modesta, CA
Ms. Marianne Waindle	Mauget, Arcadia, CA
Mr. Joseph Doccola	Arborjet, Inc., Worchester, MA

Study Sites: The study has/is being conducted at 3 sites:

1) State Forest State Park in Jackson Co., Colorado with MPB attacking lodgepole pine,
2) Talladega National Forest, Oakmulgee Ranger District in Bibbs and Perry Co., Alabama with SPB attacking loblolly pine,
3) Uinta-Wasatch-Cache National Forest, Mountain View-Evanston Ranger District, Utah, with mountain pine beetle (MPB) attacking lodgepole pine.

Insecticides:

Emamectin benzoate (TREE-äge™, Arborjet Inc.) – an avermectin derivative
Abamectin (Abacide® 2, JJ Mauget) – a mixture of avermectin B1a and B1b; fermentation products from soil bacterium *Streptomyces avermitilis*.
Thiabendazole - a systemic benzimidazole fungicide
Propiconazole – a systemic triazole fungicide
Tebuconazole (Tebuject™ 16, Mauget Inc.) – another triazole fungicide

Research Approach:

The treatments by trial included:

Trial 1

1) Emamectin benzoate (0.4g AI per inch) injection at 10 ml per inch DBH in September 2006,
2) Emamectin benzoate (0.4g AI per inch) injection at 10 ml per inch DBH in May 2007,
3) Emamectin benzoate (0.2g AI per inch) injection at 5 ml per inch DBH in May 2007,
4) Untreated (control) - used to assess beetle pressure during each summer (2007 - 2008)

Trial 2

1) Emamectin benzoate (0.4g AI per inch) injection at 10 ml per inch DBH in April 2009,
2) Thiabendazole (13%) + Propiconazole (7%) (1:1) injection at 10 ml per inch DBH,
3) Emamectin benzoate + Thiabendazole + Propiconazole (2:1:1) injection at 20 ml per inch DBH,
4) Untreated (control) - used to assess beetle pressure during each summer (2009 - 2010)

Trial 3

1) Emamectin benzoate (0.4g AI per inch) injection at 10 ml per inch DBH in June 2009,
2) Emamectin benzoate (0.4g AI per inch) injection at 10 ml per inch DBH in September 2009,
3) Emamectin benzoate + Propiconazole injection at 20 ml per inch DBH in June 2009,
4) Emamectin benzoate + Propiconazole injection at 20 ml per inch DBH in September 2009,
5) Abamectin (0.4g AI per inch) injection at 20 ml per inch DBH in September 2009,
6) Abamectin (0.4g AI per inch) injection at 20 ml per inch DBH + Tebuconazole (0.4g AI per inch) injection at 6 ml per inch DBH in September 2009,
7) Untreated (control) - used to assess beetle pressure during each summer (2009 - 2010)

Table 28. Scheduled injection, baiting and evaluation dates for three *Dendroctonus* bark beetle trials.

	MPB (CO)	SPB (AL)	MPB (UT)
Project Leader(s)	Doccola	Grosman & Clarke	Fettig
Injection Dates	Sep-06 May-07	Apr-09	Apr-09 Sep-09
Baiting Period	------	May - Jun 2009 Apr - Jun 2010	Jul - Aug 2009 Jul - Aug 2010
Prelim Evaluation	Nov 2007 Nov 2008	Jun - Nov 2009 May - Nov 2010	Oct 2009 Oct 2010
Final Evaluation	Aug 2009	Dec. 2009 Dec. 2010	Jun 2010 Jun 2010

SPB = Southern pine beetle; MPB = Mountain pine beetle

Each insecticide (injection or spray) treatment was applied to 15-35 randomly-assigned trees. A similar number of trees was used for each set of untreated checks (2 sets (by year) total). Test trees were located in areas with recent beetle activity, spaced >100m apart, were 23 to 52 cm dbh, and were within 75m of an access road to facilitate treatment.

Each systemic insecticide treatment was injected with Arborjet Tree IV™ microinfusion system (Arborjet, Inc. Woburn, MA) into 4-8 points 0.3 m above the ground. The injected trees were generally allowed 1-2 months (depending on water availability) to translocate chemicals prior to being challenged by the application of synthetic pheromone baits. Due to the short season because elevation, the trees in Utah were not baited until 2006 (Table 28). One group of trees in Colorado was injected in the fall of 2006. A second set of trees also was injected in the spring of 2007. In Utah, two sets were injected in June 2009 and two other sets were injected in September 2009

All test trees and the first set of untreated check trees in AL and UT were be baited with appropriate species-specific lures (Phero Tech Inc., Delta, BC or Synergy Semiochemical, Delta, BC) for 2 to 4 weeks in 2009. The surviving treated trees in each treatment (if there are no more than 6 killed by the bark beetle challenge), and the second set of check trees was/will be baited again for the same length of time in 2010.

The only criterion used to determine the effectiveness of the insecticide treatment was/will be whether or not individual trees succumb to attack by bark beetles. Tree mortality was/will be assessed in August for multiple, consecutive years until efficacy is diminished. The period between pheromone removal and mortality assessment was/will be sufficient for trees to "fade," an irreversible symptom of pending mortality. Presence of species-specific galleries will be verified in each tree classified as dead or dying.

Treatments were/will be considered to have sufficient beetle pressure if ≥60% of the untreated control trees dies from beetle attack during each year. Insecticide treatments were/will be considered efficacious if <7 treated trees die as a result of bark beetle attacks. These criteria were established based on a sample size of 30 to 35 trees/treatment and the test of the null hypothesis, Ho:S (survival ≥ 90%). These parameters provide a conservative binomial test (α = 0.05) to reject Ho when more than six trees die (Shea et al., 1984).

Results:

Mountain pine beetle on lodgepole pine (CO) – Trial 1

2007 - 2008 in State Forest - One set of trees was treated in fall 2006. A second set was treated in May 2007. Most trees were heavily attacked during the 2007 flight period (June – August). The final assessment was made in June 2008. Beetle pressure was sufficient to kill 70% (21 of 30) of the untreated trees (Figure 11). In contrast, all EB treatments significantly reduced tree mortality. The fall treatment proved most effective with only 20% (6 of 30%) tree mortality.

2009 – Only a few tees were attacked during the 2008 flight period (June – August). The final assessment was made in June 2009. Beetle pressure was sufficient to only kill 11% (1 of 9) of the untreated trees (Figure 11). In contrast, only the high rate spring treatment was able to prevent additional tree mortality.

Southern pine beetle on loblolly pine (AL) – Trial 2

2009 at Oakmulgee NF - The study trees were baited with the three-component bait (frontalin, turpentine and endo-brevicomin) from the start (May). The results showed nearly 41% (12 of 29) of the check trees exhibited fading crowns by December 2009 (Figure 12). In contrast, 3% each of the EB and EB plus fungicide-treated trees had faded. The tree mortality (46%) for fungicide only treatment did not differ substantially from mortality among check trees. All dead trees were cut down to determine the cause of tree mortality. As in the past, mortality of check trees was caused by a combination of SPB activity and blue-stain fungal infection (Table 29). SPB was not successful in trees injected with EB. Although other treatment trees also had blue stain fungi, the cross sectional area covered by fungi was somewhat reduced compared to checks.

Mountain pine beetle on lodgepole pine (UT) – Trial 3

Nearly all baited trees were heavily attacked by MPB within 3 weeks. A preliminary assessment of tree mortality will be conducted in June 2010. Final assessment is planned for summer 2011.

Conclusions:

The results of trials presented above indicate that emamectin benzoate injection treatments can provide good protection against southern pine beetle, but is marginal for mountain pine beetle. It appears that the addition of a fungicide may reduce the success of blue stain fungi colonization. It is not apparent, if the combination treatment improved protection compared to EB alone.

The AL and UT trials will be monitored in 2010 to evaluate the potential efficacy of combination treatments of emamectin benzoate and fungicide.

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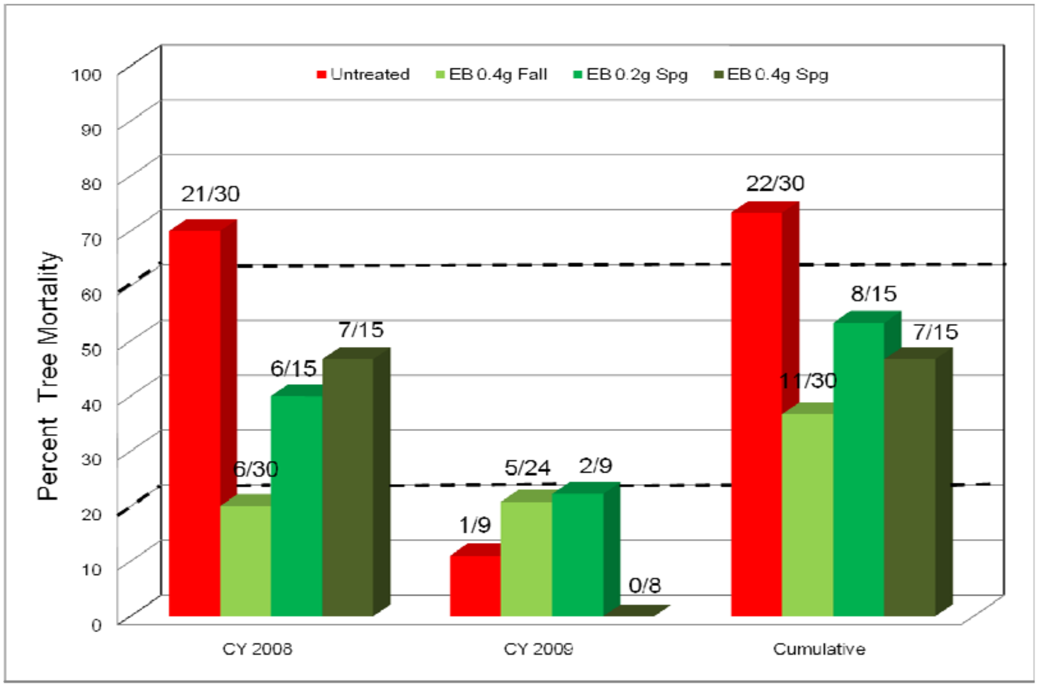

Figure 11. Effects of emamectin benzoate injection treatments on lodgepole pine mortality caused by mountain pine beetle (so far in 2008), The State Forest, CO. The dashed line at 60% cumulative mortality is the level of control tree mortality necessary for a valid test; the dashed line at 20% cumulative mortality is the maximum allowable mortality of treatments to be considered efficacious.

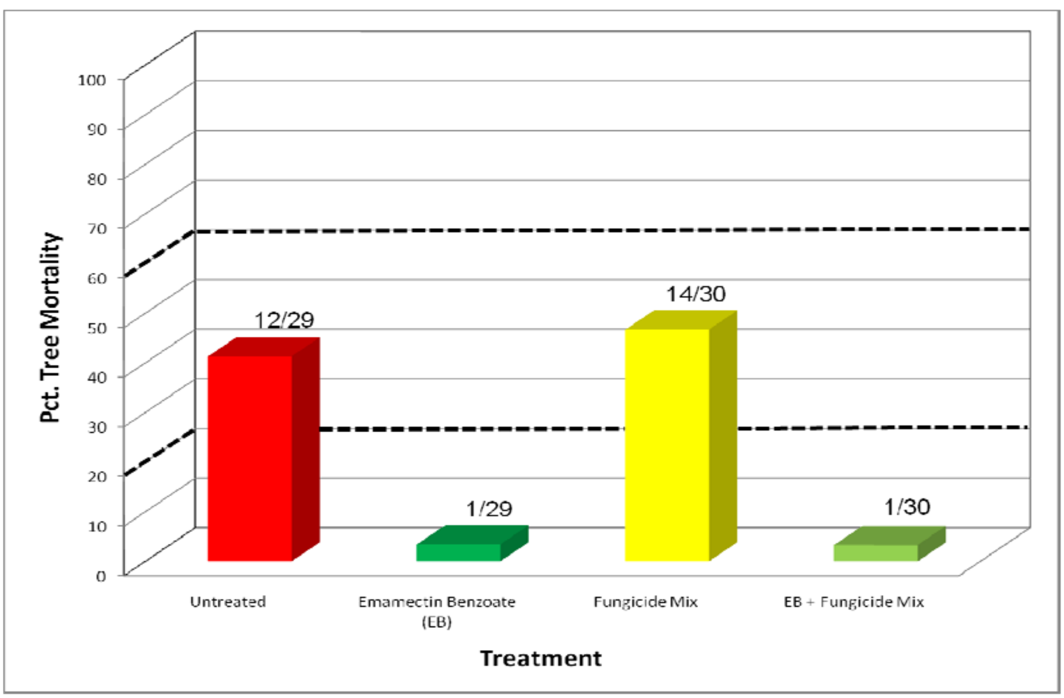

Figure 12. Effects of emamectin benzoate injection treatments on loblolly pine mortality caused by southern pine beetle (so far in 2009), Talladega Nat. For., AL The dashed line at 60% cumulative mortality is the level of control tree mortality necessary for a valid test; the dashed line at 20% cumulative mortality is the maximum allowable mortality of treatments to be considered efficacious.

Table 29 - Effects of Emamectin Benzoate and Fungicide Injection Treatments on Mean (+ SE) of Success of Bark Beetle, Cerambycids and Blue Stain Colonization.

Treatment	N	Length (cm) of Bark Beetle Galleries	Cerambycid Feeding Area (cm^2)	Percent cross section covered with Blue stain Fungi
Emamectin benzoate (EB)	1	0.0 **a**	0.0 **a**	55.0 **ab**
Fungicide	12	42.8 **b**	26.6 **b**	51.4 **a**
EB + Fungicide	1	0.0 **a**	0.0 **a**	57.0 **ab**
Check	14	56.3 **b**	39.4 **b**	87.0 **b**

† Means followed by the same letter in each column of the same site are not significantly different at the 5% level based on Fisher's Protected LSD.

SYSTEMIC PESTICIDE INJECTION TRIALS

Effects of Insecticide and Fungicide on Fungal Growth in Amended Media and Lesion Formation in Longleaf Pine

Highlights:

- A fungicide mix (propiconazole/ thiabendazole; PT)) was highly effective in inhibiting growth of five *Leptographium* spp. in laboratory media. Emamectin benzoate (EB) had limited effects against three *Leptographium* species.
- A preliminary field trial indicates that none of the tree injection treatments ((EB, PT or EB + PT) affected the growth of *Leptographium* spp. in longleaf pine roots and stems.

Justification: Injection trials conducted by the Forest Pest Management Cooperative, Arborjet Inc. (Woburn, MA), and others from 2004 – 2008 have shown that emamectin benzoate (EB, TREE-age™), injected into conifers, is highly effective against bark beetles (*Ips* and *Dendroctonus* spp.) and significantly reduces tree mortality. However, one trial indicates that although EB prevented the successful colonization of loblolly pine by southern pine beetle, a number of trees were apparently killed as the result blue stain fungi, introduced by the attacking bark beetles. Bark beetles carry with them different fungal species, *Ceratocystiopsis* spp. in specialized structures (mycangia), or *Ophiostoma minus* and *Leptographium* spp, carried externally on the exoskeleton, which aid them in overcoming the defenses and colonizing the host. Trials were initiated in 2009 to evaluate a combination treatment of EB plus a fungicide mix (propiconazole + thiobendazole) against southern pine beetle and mountain pine beetle as way of improving tree survival over that of EB alone.

Pine decline is associated with loblolly and longleaf pines in the southern United States, particularly in Alabama and Georgia. *Leptographium* spp. have been associated with pine decline and mortality, primarily as associates of root-colonizing bark beetles (*Hylastes* spp.) and weevils (*Hylobius pales* and *Pachylobius picivorus*) that attack living trees.

It is of interest to know if EB, propiconazole/thiobendazole mix or a combination have any effect on the growth of *Leptographium* spp. in the laboratory in amended media or in the field in a tree host (e.g. longleaf pine).

Objectives: To determine 1) the effect of emamectin benzoate, fungicide mix or combination on the growth of *Leptographium* species in the laboratory; 2) the effect of insecticide/fungicide rate on fungal growth and 3) the effect of emamectin benzoate, fungicide mix or combination trunk injection into longleaf pine on the growth of introduced *Leptographium* species.

Cooperators

Dr. Lori Eckhardt	Forest Health Cooperative, Auburn, AL
Mr. Joseph Doccola	Arborjet, Inc., Worchester, MA

Study Site: The field trial was conducted:

1) Fort Benning, GA with longleaf pine, *Pinus palustris;* age: 15 years

Research Approach:

The treatments included:

1) Emamectin benzoate (EB, 0.4g AI per inch; TREE-äge, Arborjet Inc.) injection at 10 ml per inch DBH in April 2009,
2) Propiconazole (7%) + Thiabendazole (13%) (PT, 1:1) injection at 10 ml per inch DBH,
3) Emamectin benzoate + Propiconazole + Thiabendazole (EB + PT, 2:1:1) injection at 20 ml per inch DBH,
4) Untreated (control)

Laboratory Trial: At the Forest Health Cooperative laboratory, 20ml of 3% Potato-Dextrose Agar (PDA) amended with PT, EB, and EB+PT was poured into glass petri plates (100 x 15 mm). Each fungal species (*Leptographium procerum, L. profanum, L. terebrantis, L. serpens L. huntii*) was grown on PDA for 10-14 days at 25C. A disk (4 mm dia) was cut using a cork borer from the actively-growing margin of the source fungus and transferred to the center of each study plate. Six plates were prepared for each combination of fungus and chemical as well as a control (unamended PDA). Colony diameters were traced at 3, 5, and 7 days after inoculation and area calculated using a planimeter. Mean area and percent growth of the control were calculated and were analyzed using protected least square means procedure and contrasts in ANOVA in SAS.

Field test: Longleaf pine trees (8), 15 – 20 cm diameter at breast height (DBH), were selected 12 August 2009. Two trees were each injected with emamectin benzoate, propiconazole/ thiobendazole mix or combination (EB + PT). Each injection treatment consisted of a single insecticide formulation injected into four cardinal points about 0.3 m above the ground on each tree using the Arborjet Tree IV™.

The trees were inoculated with *L. terebrantis* and *L. huntii* on the stem and a lateral root on 12 October 2009. Trees were harvested and lesion measurements taken on 12 February 2010. Due to sample size a t-test was used to determine differences.

Results:

Laboratory Trial: All fungi tested were inhibited the most by PT only, moderately by EB+PT, and minimally by EB. When fungal growth was compared to the percent area of the controls, *L. terebrantis, L. procerum and L. profanum* had between a 3- 5% decrease in growth in the presence of EB, while *L. huntii* and *L. serpens* were not inhibited at all (Fig. 13). Growth of fungi was less when grown in the presence of PT with complete inhibition at 50ppm and 25ppm (Fig. 14). At 10ppm inhibition ranged from 95-98% and at 5ppm inhibition ranged from 84-98% (Fig. 14). At 1ppm, *L. huntii* was only inhibited 32%, while the other fungi were inhibited 77-94% (Fig. 2). When fungi were grown in the presence of EB+PT, there was complete inhibition at 50ppm for *L. procerum, L. profanum and L. serpens* and at 25ppm for *L. procerum* (Fig. 15). *Leptographium huntii* was affected the least with inhibition decreasing from 71% at 10ppm to 4% at 1ppm (Fig. 3). *Leptographium terebrantis* only had 39% inhibition at 1ppm (Fig. 15).

Field test: Root inoculations with *L. terebrantis* after tree injections were not different from controls. Lesion area in trees injected with EB and EB+PT and then inoculated with *L. huntii* appeared to be larger than in roots injected with PT alone and controls (Fig. 16). Mean lesion area in trees treated with stem inoculations with *L. huntii* after tree injections were not different from those in controls. Lesion area in trees injected with PT, EB+PT and no chemical and then inoculated with *L. terebrantis* tended to be larger than in trees injected with EB alone (Fig. 17).

Conclusions:

The lab trial indicates that EB has only marginal effects against three root-infecting blue-stain fungi species (*L. terebrantis*, *L. procerum* and *L. profanum*). In contrast, the fungicide mix has good to excellent activity on all fungi species. There was no additive effect with the combination treatment.

It is difficult to make determinations from the field trial results due to small sample size and variation among trees. These results do not show any fungal growth reduction due to the chemical being present. A larger study needs to be completed before conclusions can be reached.

Acknowledgements: Many thanks go to cooperators: Lori Eckhardt, and her graduate students for their efforts on the projects. We appreciate the chemical donations and injection equipment loans made by Arborjet, Inc, and Syngenta. These trials were supported by funds from the FPMC and Forest Health Cooperative.

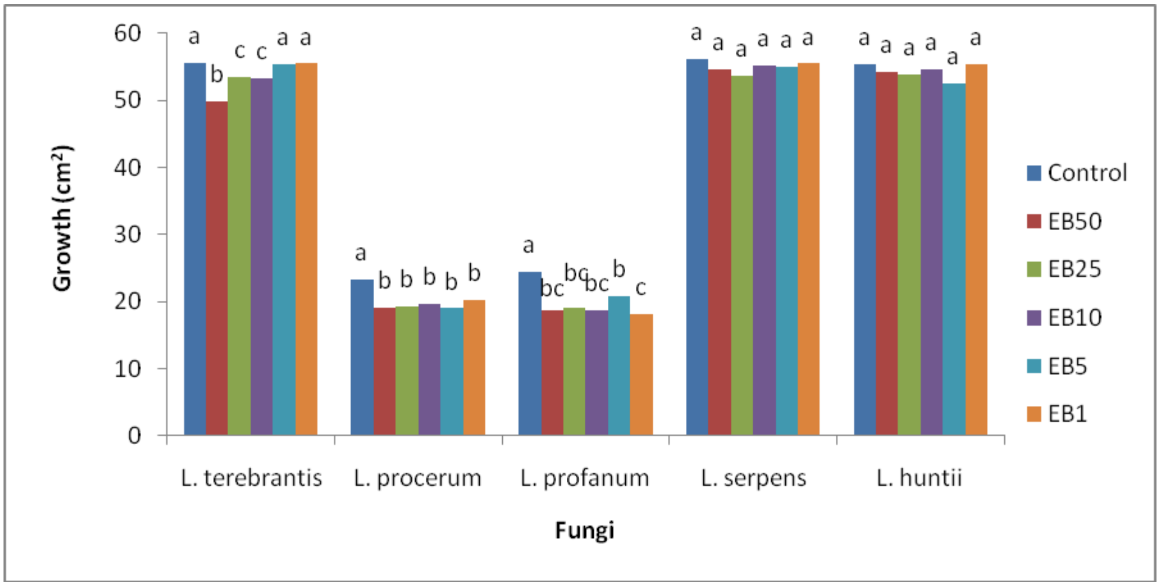

Figure 13. Effects of EB at 5 concentration levels on fungal growth in the laboratory. Mean area (cm^2) of colony growth of five fungi associated with root disease grown on 3% Potato-Dextrose Agar amended with EB for 7 days.

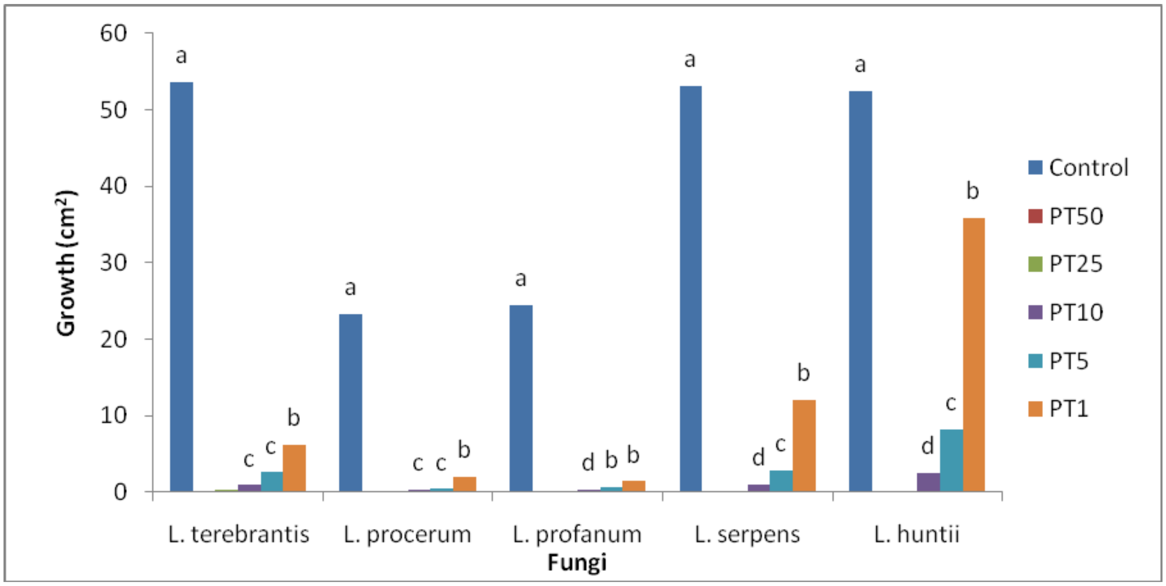

Figure 14. Effects of PT at 5 concentration levels on fungal growth in the laboratory. Mean area (cm^2) of colony growth of five fungi associated with root disease grown on 3% Potato-Dextrose Agar amended with EB for 7 days.

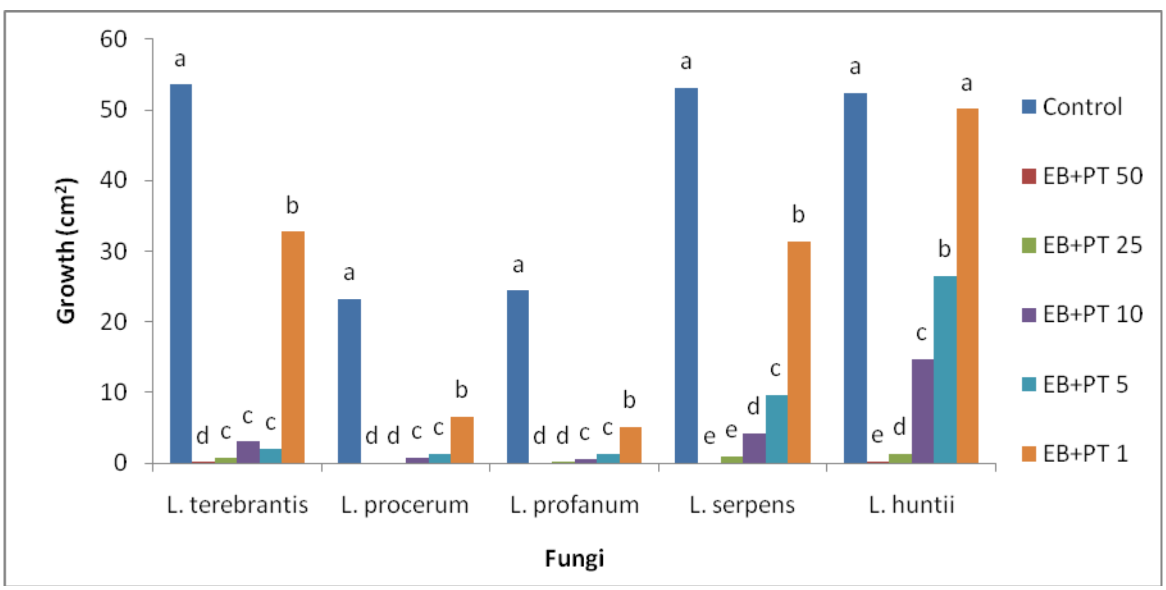

Figure 15. Effects of EB+PT at 5 concentration levels on fungal growth in the laboratory. Mean area (cm^2) of colony growth of five fungi associated with root disease grown on 3% Potato-Dextrose amended with EB+PT for 7 levels.

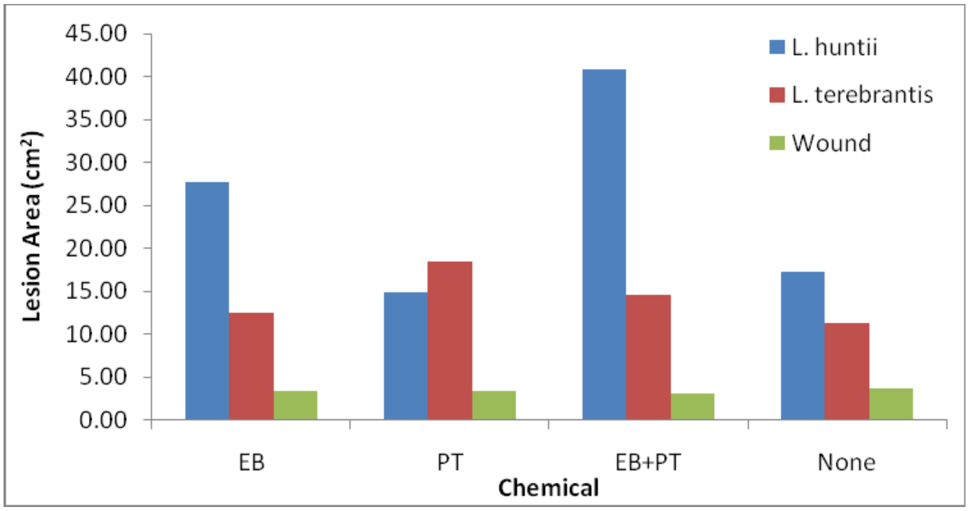

Figure 16. Effects of injection chemicals on lesion formation in *Pinus palustris* roots. Mean area (cm^2) of lesions produced by two fungi and wound control following injection by EB, PT or EB+PT.

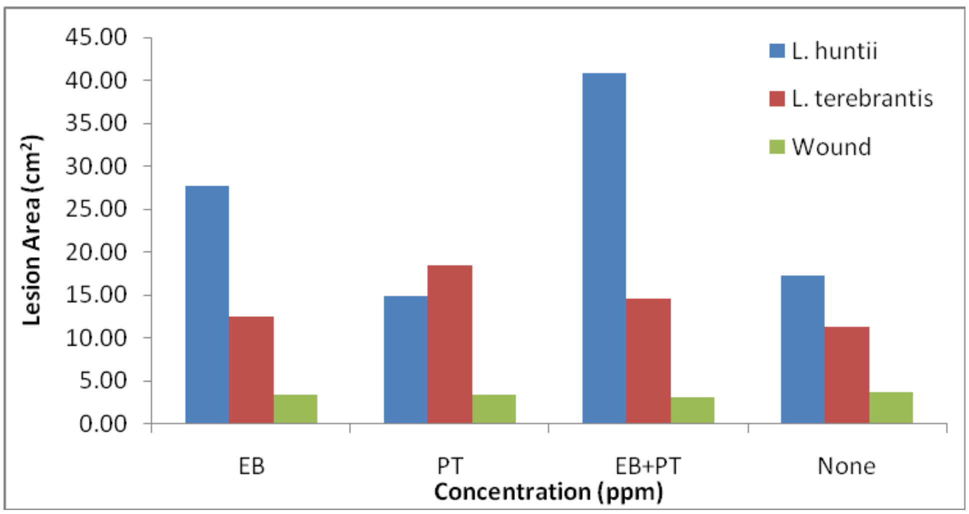

Figure 17. Effects of injection chemicals on lesion formation in *Pinus palustris* stems. Mean area (cm^2) of lesions produced by two fungi and wound control following injection by EB, PT or EB+PT.

SYSTEMIC PESTICIDE INJECTION TRIALS

Evaluation of Emamectin Benzoate (TREE-age™) for Protection of Trees Against Invasive Insect Pests

Highlights:

- The emamectin benzoate treatment significantly reduced the success of chalcid wasps in Afghan pines during the first year.
- Preliminary data suggests that EB-treated western soapberry trees infested with the invasive soapberry borer, *Agrilus prionurus* (Coleoptera: Buprestidae) may be somewhat healthier compared to checks by the end of 2009.

Justification: Injection trials conducted by the Forest Pest Management Cooperative, Arborjet Inc. (Woburn, MA) and others from 1999 – 2008 have shown that emamectin benzoate (EB, TREE-äge™), injected into conifers and hardwoods, is highly effective against coneworm, bark beetles, wood borers, forest tent caterpillar and winter moth. Syngenta submitted TREE-äge for registration by EPA in January 2008. Partial approval has been granted for use on ash against emerald ash borer (EAB). It is of interest to know if the Tree-age™ formulation is effective in preventing/reducing damage by new pests, such as an unnamed chalcid wasp and the soapberry borer, a close relative of EAB.

Objectives: 1) To determine the efficacy of TREE-age™ for protecting individual afghan pines and western soapberry trees from damage and/or mortality attributed to different invasive insect pests; and 2) To determine the duration of protection provided by TREE-age™ against invasive insect pests.

Cooperators

Mr. Oscar Mestas	Urban Forester, Texas Forest Service, El Paso, TX
Mr. Randy Myers	Urban Forester, Midland, TX
Mr. Tom French	Private landowner, Rosharon, TX
Ms. Dennis Moore	City Forester, Allen, TX
Mr. Chad Krajca	District Park Supervisor, Mesquite, TX
Dr. David Cox	Syngenta, Modesta, CA
Mr. Joseph Doccola	Arborjet, Inc., Worchester, MA

Study Sites: The trials are being conducted at 5 sites:

1) Skyline Park, El Paso, TX with chalcid wasps attacking Afghan pine,
2) Municipal property, Midland, TX with chalcid wasps attacking Afghan pine,
3) Private property, Rosharon, TX with soapberry borer (SBB) attacking western soapberry,
4) Municipal property, Allen, TX with soapberry borer (SBB) attacking western soapberry.
5) Parschall Park, Mesquite, TX with soapberry borer (SBB) attacking western soapberry.

Research Approach:

Treatments by trial included:

Trial 1 (Chalcid)

1) Emamectin benzoate (0.4g AI per inch; TREE-äge™, Arborjet Inc.) trunk injection at 10 ml per inch DBH in March 2009,
2) Imidacloprid (8.7g AI tree; Merit 75 WSP, Bayer.) soil injection at 74 gal mix in 4-8 holes around drip line of tree,
3) Untreated (control)

Trial 2 (Soapberry Borer)

1) Emamectin benzoate (0.4g AI per inch; TREE-äge™, Arborjet Inc.) trunk injection at 10 ml per inch DBH in June 2009,
2) Untreated (control)

Trial 1: This study is being conducted in an El Paso and Midland, TX. A number of afghan pine (age and size unknown) at each location have been under attack by insect (chacid wasp?) pests for several years. Test trees (10 - 15) were selected in early December 2008 in El Paso and in early March in Midland. Five (5) were injected with a standard rate (10 ml per inch diameter) of TREE-age™ in the spring (late March) in each location. Five (5) trees were treated with imidacloprid via soil injection in El Paso only. Five trees serve as untreated controls at each location.

The imidacloprid application was performed (Dec. 2008 – Jan. 2009) by injecting the dilution about 12 inches into the ground with 45 lbs. PSI using a grid of 4-8 holes around the drip line in a zig-zag pattern. Prior to the injection of chemical the area around the tree was irrigated for several days and again after the irrigation process.

The TREE-äge™ treatment was injected with Arborjet Tree IV™ microinfusion system (Arborjet, Inc. Woburn, MA) into 4 cardinal points 0.3 m above the ground. First, a 3/8" diameter hole is drilled horizontally at each point. An Arbor –plug is installed into each hole. The Tree IV needle is inserted into the plug. Under pressure (60 psi), the TREE-age™ product was pumped into the chamber behind the plug and then out into the xylem tissue. The injected trees were allowed five months to translocate chemicals prior to being evaluated for efficacy.

In April (just after treatment) and late September, 3-4' long branches were collected from three heights (low, middle and top crown) on each study tree. In the laboratory, 2-3 inch sections were clipped off from each branch (12 inch total per branch). The diameter at each section was measured. The bark was pealed and the number of live and dead larvae, live and dead adults, current and last year's adult emergence holes were recorded. Calculated number of chalcids (larvae or adult) per 100 cm^2 of branch.

Trial 2: This study is being conducted at three locations in Texas (Rosharon,TX, near Houston and Allen and Mesquite, TX near Dallas). Several (8 – 17) western soapberry (2 – 18" DBH) were selected in each location. Four to eight trees were injected with a standard rate (10 ml per inch diameter) of TREE-äge™ in the summer (late June and early July) using a QUIK-jet injection system (Arborjet, Inc. Woburn, MA). The trunk injection procedure was generally the same as that described for the previous trial. A similar number of trees serve as untreated controls at each location.

All study trees were evaluated in September and November, 2009 for relative health. Additional evaluations are planned for summer and fall 2010 and 2011.

Results:

Trial 1: Chalcid infestation levels were significantly higher in the upper crown of untreated Afghan pines compared to lower crown levels (Figure 18).
Emamectin benzoate significantly reduced the number of live chalcid larvae in branches at both sites compared to their checks (Figures 19 & 20). Imidacloprid did not affect chalcid levels compared to checks in El Paso.

Trial 2: Efficacy of EB treatment on SBB damage was difficult to evaluate, even after 5 months post treatment as no tree mortality occurred at any sites as of December. Some cursory observations indicate that SBB attacks (larval galleries) on several EB-treated trees appear to be healing. Also, EB-treated trees tended to have more leaves at the end of the growing season compared to untreated checks.

Conclusions:

The EB treatment significantly reduced the success of chalcid wasps in Afghan pines during the first year. Preliminary data suggests that EB-treated western soapberry may be somewhat healthier compared to checks. The duration of treatment efficacy will be evaluated in 2010.

Acknowledgements: Many thanks go to our cooperators: Oscar Mestas, Randy Myers, Tom French, Dennis Moore, and Chad Krajca for their efforts on the projects. We appreciate the chemical donations and injection equipment loans made by Arborjet, Inc and Syngenta and field laboratory assistance of Bill Upton and Billi Kavanagh. These trials were supported by funds from the FPMC.

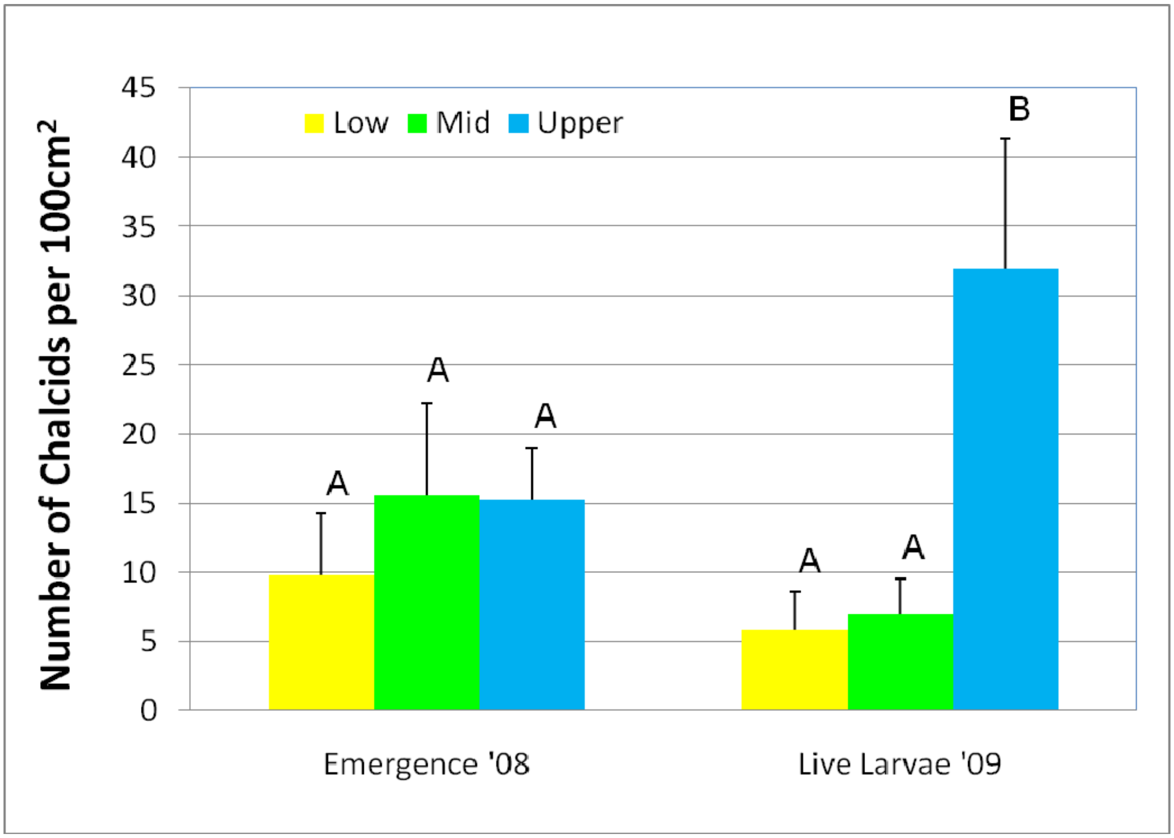

Figure 18. Effects of crown level on number of chalcid adults emerging in 2008 and live larvae found in branches in 2009.

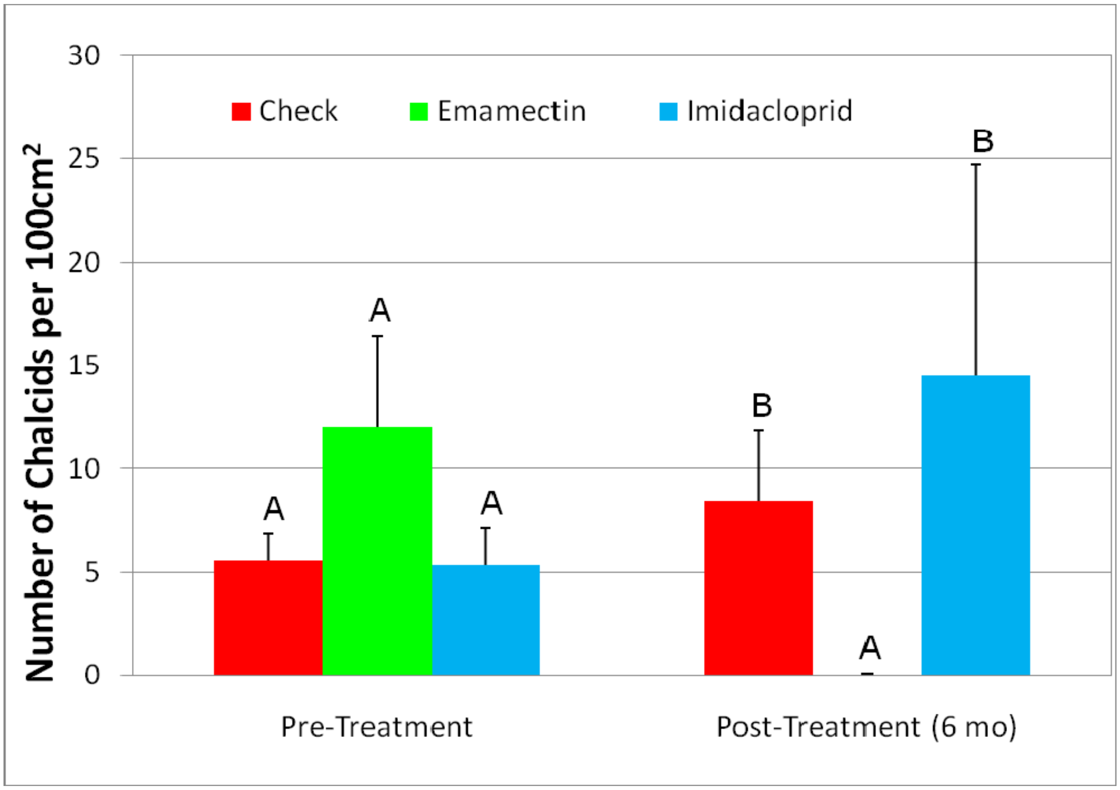

Figure 19. Effects of treatment on number of chalcid larvae present in Afghan pine branches from El Paso, TX, 2009.

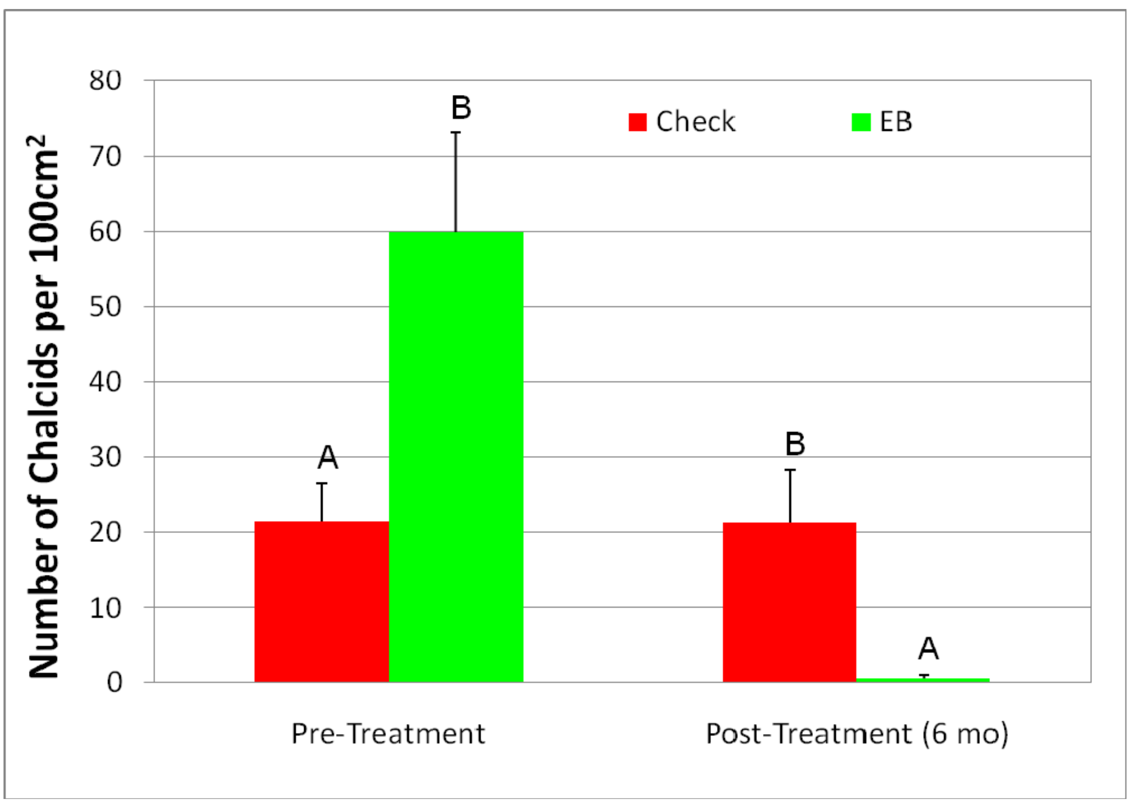

Figure 20. Effects of treatment on number of chalcid larvae present in Afghan pine branches from Midland, TX, 2009.

SYSTEMIC PESTICIDE INJECTION TRIALS

Evaluation of Injection Systems for Application of Emamectin Benzoate in Loblolly Pine

Highlights:

- Seven injection systems were evaluated based on their potential to effectively and efficiently inject emamectin benzoate (EB) into pine trees; four systems were found capable of injecting product. The Tree IV system ranked best overall, followed by Quick-jet, Portle and Sidewinder (backpack).
- EB treatments made by these four systems were evaluated for their ability to protect logs against *Ips* engraver beetles and wood borers 1, 13 and 25 months after injection. Treatments made using all four systems were highly and equally effective against both insect groups.

Justification: Injection trials conducted by the Forest Pest Management Cooperative from 1999 – 2005 have shown that different formulations of emamectin benzoate (EB) such as Shot Wan™, Denim™ & "Ava-jet™" when injected into loblolly pine, are highly effective against several forest insects including coneworms and/or bark beetles. Arborjet, Inc (Woburn, MA) in cooperation with Syngenta has developed a new EB formulation (Ava-jet™) that will be submitted for registration by EPA in the near future. Applications of emamectin benzoate have been made almost exclusively through the use of Arborjet's Tree IV system. Syngenta, the manufacturer of EB, was interested in knowing if the EB formulation can be applied to pine trees using other available injection/infusion systems and whether these applications are effective in preventing/reducing insect damage.

Objectives: 1) Evaluate the ability of various available injection systems to inject EB formulation based on time to prepare/load, install and treat each tree and safety; 2) Evaluate speed of uptake based on control 30 days after injection, and then yearly for 2 more years.

Cooperators

Mr. Jason Ellis	Texas Forest Service, Jacksonville, TX
Dr. David Cox	Syngenta, Modesta, CA
Mr. Joseph Doccola	Arborjet, Inc., Worchester, MA

Research Approach: Seven injection/infusion systems were evaluated. These included:

<u>Mauget</u> System (Mauget; contact: Marianne Waindle) low volume (4 ml/inj pt); low pressure (10 psi)

<u>M3</u>™ System (Rainbow Treecare Scientific Advancements; contact: Shawn Bernick); moderate volume (30 ml/inj pt); low pressure (20 - 30 psi)

<u>Portle</u>™ (prototype) System (ArborSystems; contact: Chip Doolittle) – moderate volume (10 – 20+ ml/inj pt); high pressure (500+ psi)

<u>Quick-jet</u>™ (prototype) System (Arborjet, Inc.; contact: Joe Doccola) – moderate volume (5 – 20+ ml/inj pt); moderate pressure (50+ psi)

<u>Sidewinder</u>™ Systems – <u>backpack and Bug Buster</u>™ - (Sidewinder; contact: Geoff Eldridge) high volume (50+ ml/inj pt); high pressure (500+ psi)

<u>Tree IV</u>™ System (Arborjet, Inc.; contact: Joe Doccola) – high volume (125+ ml/inj pt); moderate pressure (60 psi)

Information about the systems was requested from each manufacturer. In particular, information was requested on the recommended procedures for installation and injection of trees. Each system was ranked on the following criteria with potential points in parentheses:

1) System cost (10 pts)
2) Need for peripheral parts (plugs, needles, battery chargers) (5 pts)
3) System capacity (volume of product) (3 pts)
4) Is system disposable or reusable? (2 pts)
5) Does chemical come prepackaged; can product be injected undiluted or is it necessary to dilute with water? (5 pts)
6) Time and ease to fill system with chemical product (5 pts)
7) Time and ease to install system on tree (5 pts)
8) Number of injection points required per tree (5 pts)
9) Can system be left alone on tree or does the applicator need to manually operate system continuously? (5 pts)
10) Time and ease to inject X amount of product. (10 pts)
11) Cumulative time applicator spends at each tree. (10 pts)
12) Potential for chemical exposure. (10 pts)
13) Time and ease to clean system. (10 pts)
14) Weather restrictions (moisture, temperature) (5 pts)
15) Effectiveness of treatment 1 month after treatment (10 pts)

<u>Treatment Methods and Evaluation:</u>
This study was conducted in a loblolly pine plantation (about 20 years old) that had been recently thinned in Fairchild State Forest, Rusk Co.,Texas. Test trees (135), ranging from 15 to 23cm dbh, were selected. Fifteen (15) trees were each injected with the same AI concentration (0.2g/ inch diameter of tree) but at one of two volume rates (low = 5ml/in dia. or high = 10ml/in dia) of EB (Arborjet, Inc.) using each system in late March and early April 2007 (Table 30). Fifteen trees served as untreated controls. The application procedure used to inject the EB formulation was based on the recommendations of each system manufacturer. The injected trees were allowed at least 1 month to translocate chemicals prior to being challenged by bark beetles.

Groups of five (5) trees for each treatment were felled at 1, 13 and 25 months after injections. One 1.5 m-long bolt was removed from the 5 m height of the bole of each injected tree. The bolts were transported to a nearby plantation that had been recently thinned and contained fresh slash material. Bolts were randomly placed 1 m from other bolts on discarded, dry pine bolts to maximize surface area available for colonization as well as to discourage predation by ground- and litter-inhabiting organisms. To facilitate timely bark beetle colonization, packets of *Ips* pheromones (racemic ipsdienol and cis-verbenol; Synergy Semiochemical, Delta, BC, Canada) were attached to 1 m stakes evenly spaced in the study area.

Table 30. Volume (ml) of Emamectin benzoate formulation injected per tree diameter class.

Tree Diameter		Low Volume 1 EB (0.2 g/" dia) undilute				High Volume 1 EB (0.2 g/" dia): 1 Water			
Inches	cm	EB ml	Water ml	Total ml	mls/ Inj Pt	EB ml	Water ml	Total ml	mls/ Inj Pt
1	2.5	5	0	5	1	5	5	10	3
2	5.1	10	0	10	3	10	10	20	5
3	7.6	15	0	15	4	15	15	30	8
4	10.2	20	0	20	5	20	20	40	10
5	12.7	25	0	25	6	25	25	50	13
6	15.2	30	0	30	8	30	30	60	15
7	17.8	35	0	35	9	35	35	70	18
8	20.3	40	0	40	10	40	40	80	20
9	22.9	45	0	45	11	45	45	90	23
10	25.4	50	0	50	13	50	50	100	25
11	27.9	55	0	55	14	55	55	110	28
12	30.5	60	0	60	15	60	60	120	30

Each series of bolts was retrieved about 3 weeks after deployment, after many cerambycid egg niches were found on the bark surface of most bolts. In the laboratory, two 10 cm X 50 cm samples (total = 1000 cm^2) of bark were removed from each bolt. The following measurements were recorded from each bark sample:

1) Number of bark beetle pitch tubes and cerambycid egg niches on bark surface.
2) Number of unsuccessful attacks – penetration to phloem, but no egg galleries.
3) Number of successful attacks – construction of nuptial chamber and at least one egg gallery extending from it.
4) Number and lengths of egg galleries with larval galleries radiating from them.
5) Number and lengths of egg galleries without larval galleries.
6) Percent of bark sample with cerambycid activity, estimated by overlaying a 100 cm^2 grid on the underside of each bark strip and counting the number of squares where cerambycid larvae had fed.

Treatment efficacy was determined by comparing the number of *Ips* beetle attacks, the number and total length of *Ips* egg galleries and the area of cerambycid feeding for each treatment and application timing. Data were transformed by $\log_{10}(x+1)$ if necessary to satisfy criteria for normality and homoscedasticity (Zar 1984) and analyzed by GLM and the Fisher's Protected LSD test using the Statview® statistical program (SAS Institute Inc.).

Results:

Field evaluations of systems were performed between March 30 and April 5, 2007. Four (Portle, Quick-jet, Tree IV and Sidewinder - backpack) of the seven systems were found to be capable of injecting the desired amount of emamectin benzoate into a study tree (Table 31). Of the remaining systems, two (Mauget and M3) had insufficient pressure to allow the chemical to overcome the tree's resin pressure and the third system (Sidewinder – Bug Buster) malfunctioned and could not be repaired.

Based on the time needed to inject product, it was determined it was quicker to inject an undiluted (low volume) with the Quick-jet, Portle and Sidewinder then to inject a dilute (high volume) solution. In contrast, it was quicker to inject a diluted (high volume mix) with the Tree IV compared to an undiluted product. Although the average injection rate for the Sidewinder (6.6 ml/minute) was 29% or more faster compared to that of the Quick-jet (4.7 ml/min), Tree IV™ (4.6 ml/minute), and Portle (4.1 ml/min), the cumulative time spent at a given tree with the Tree IV was 1.5 – 3.9 minutes less than that required by the other systems.

Table 32 compares the seven tested injection systems relative to fifteen criteria (cost, peripheral parts, capacity, reusablity, can it be left alone, prepackaged or mix, weather restrictions, ease/time to fill system, number of injection points, ease/time to install system, ability of system to inject product, cumulative time spent at tree, ease/time to clean system, potential for chemical exposure, effectiveness of treatment). Each criterion had a value ranging from 2 to 10 points.

The Tree IV system (Arborjet) garnered the greatest number of points (81) based on the fact that it was very consistent in its ability to inject emamectin benzoate into conifers, it can be installed and left alone on a tree, and there is very little chance of applicator exposure to the chemical. Other attractive features include that it is a fairly inexpensive system that is reusable, it has a large chemical capacity (1000 ml), require few injection points to treat the tree, and is not limited to any great extent by weather conditions. Some important limitations include a need to install plugs and manage spaghetti-like tubing, the need to mix product with water prior to injection, and the need to measure product and fill the system for each tree

The Quick-jet system (Arborjet), with 79 points, performed nearly as well as the Tree IV system. It has several attractive features including that the emamectin benzoate product can be effectively applied undiluted under most conditions, it also has a large volume capacity, one load can be used to treat several trees, it requires few injection points to treat the tree, and is reusable and easy to clean. Some limitations include the fact that the applicator has to remain with the system during the injection, there is some potential for chemical exposure and plugs need to be installed in each tree.

The Portle System (ArborSystem) ranked third with 71 points. Its attractive features are that the system has a large product capacity (1000 ml), the product would be prepackaged, and the system is reusable and easy to install on the tree. Some important limitations include the need for additional injection points compared to other systems (more time and effort), that the applicator has to remain with the system during the injection, there is some potential for chemical exposure and the system is fairly costly.

The Sidewinder™ backpack system was fourth with 68 points. The system has a large product capacity (1000 ml), can be installed quickly and easily, and the product is quickly injected into the tree under most conditions. However, the equipment cost is high, there is a need to change and recharge batteries, the model tested had a tendency to leak around injection points, and there is a tendency for chemical to get on the surfaces of the drill and pump handle. Thus, the potential for applicator exposure to the chemical is fairly high and cleaning the system takes longer than other systems.

All four of the above systems were effective in injecting the desired amount of product into each of 15 trees. The evaluation of the first series of logs taken one month after injection revealed that all treatments were highly effective in protecting logs from bark beetle and wood borer attacks regardless of the system used (Tables 33 – 36).

The other systems (Mauget, M3 and Sidewinder - Bug Buster) each have some attractive features. However, the EB product could not be effectively and consistently injected with any of these systems because either the system pressure was too low (Mauget & M3) or the system malfunctioned (Sidewinder – Bug Buster).

Further assessments of treatment duration showed that EB treatments applied with the Tree IV, Quick-jet and Sidewinder were still highly effective 13 months after application (Tables 33 – 36). The treatment applied by the Portle was noticeably less effective. In contrast, all four treatments (systems) were highly and equally effective against both insect groups 25 months after treatment (Tables 33 – 36).

Conclusions:

Four injection systems (Tree IV, Quick-jet, Portle and Sidewinder) were found to be operationally effective in the injection of emamectin benzoate into loblolly pine. However, the seed orchard manager or arborist needs to consider several factors (cost, convenience, injection rate, safety, etc.) before selecting a system to use.

The development of new and/or improved injection systems is anticipated in the near future with the realization that protection of trees and crops with systemic chemicals is an economically- viable option. Arborjet™ continues to upgrade its Tree IV system and has just released the new Quick-jet system. Also, upgrades of the Sidewinder™ system will reduce chemical leaks and exposure and the system can be connected to a compressed air injector pump on a tractor or any other suitable mobile power source to improve treatment efficiency. Lastly, a new Eco-ject system (not tested) is being developed by BioForest Technologies based on Dr. Blair Helson's STIT concept.

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Table 31: Comparison of four injection system characteristics during operational use in March/April 2007.

System Evaluated:	Tree IV		Quick-jet		Portle		Sidewinder (backpack)	
Volume Category	Low	High	Low	High	Low	High	Low	High
No. Trees Injected	5	15	15	5	15	5	15	5
Mean DBH	6.3	6.8	6.6	6.6	6.4	6.4	6.6	6.8
Mean Volume Injected	32	68	33	70	32.5	64	33	70
No. Units used at a time:	3	3	1	1	1	1	1	1
Time (min) needed to fill system unit with chemical product:	1.0	1.1	0.2	0.2	NA	NA	0.2	0.2
Number of injection points required:	4	4	4	6.6	6.8	10.8	3.9	4.6
Time (min) needed to install system on tree:	4.7	4.2	1.5	2.8	1.2	2.8	1.4	1.6
Time (min) required to inject/infuse X-amount of product:	25.8	14.6	7.0	8.6	7.9	14.7	5.0	7.0
Cumulative time at tree (min):	5.7	5.2	8.7	11.5	9.1	17.5	6.6	8.8
Time (min) needed to clean system units	13.5	13.5	2.2	2.2	6.8	6.8	7.3	7.3

NA = Not applicable

Table 32: Comparison of characteristics of several injection systems that may be compatible with emamectin benzoate.

Characteristics (Potential Points)	System: Mauget		M3		Tree IV		Quick-jet		Portle		Sidewinder (Backpack)		Sidewinder (Bug Buster)	
Manufacturer	Mauget		Rainbow TreeCare		Arborjet		Arborjet		ArborSystems		Sidewinder		Sidewinder	
Retail Cost (10)	$6.20/ unit @ 8 per 10" tree	10	$299/ kit @ up to 16 per tree	8	$300/ unit @ 1 per tree	8	$359/ unit @ 1 per tree	7	$884/ unit @ 1 per tree	5	$1562/ unit @ 1 per tree	3	~$2000/ unit @ 1 per tree	2
Need for Peripheral Parts (5)	No	5	No	5	Yes: Plugs: $0.65 ea	3	Yes: Plugs: $0.65 ea	3	Yes: Needles: $6.25 ea	4	Yes: Plugs, Battery charger	3	Yes: Plugs, Battery charger	2
Sysem Capacity (3)	4 ml	1	30 ml	3	1000 ml	4	1000 ml	5	1000 ml	5	1000 ml	5	1000 ml	5
System Reusable? (2)	No	1	Yes	2	Yes	2	Yes	2	Yes	2	Yes	2	Yes	2
Can System be Left Alone on Tree? (5)	Yes	4	Yes	4	Yes	4	No	3	No	3	No	3	No	3
Chemical Prepackaged, Undilute, or Mixed (5)	prepackaged	5	undilute	3	mixed w/ water	2	undilute	3	prepackaged	5	mixed w/ water	2	mixed w/ water	2
Weather restriction(s) (5)	cold and dry	2	cold and dry	2	cold and dry	4	cold and dry	3	cold and dry	4	cold and dry	4	cold and dry	4
Ease/time to fill system with chemical product (5)	prepackaged	5	each unit needs to be filled separately as it is installed on tree	2	need to fill system for each tree	3	single system fill for several trees	4	if prepackaged	5	single system fill for several trees	4	single system fill for several trees	4
No. of injection points required per tree (5)	8 points	2	4 points	5	4 points	5	4 points	5	7 points	3	5 points	4	5 points	4
Ease/time of system installation on tree (5)	generally easy	4	generally easy, but several steps involved	3	installation of plugs, sphagetti	3	installation of plugs	4	generally easy, but needle often bends	4	easy	5	easy	5
Ability to push product into tree (10)	generally unable under most conditions	1	generally unable under most conditions	1	effectively applied almost always	9	effectively applied under most conditions	8	effectively applied under most conditions	7	effectively applied under most conditions	7	system malfunctioned	2
Cumulative time spent at each tree (10)	considerable	3	considerable	3	present at tree only to install and remove	9	fast, but must remain at tree	7	moderately fast, but must remain at tree	6	quick, but must remain at tree	8	quick, but must remain at tree	8
Ease/time to clean system (10)	disposable	8	need to clean several units	6	need to clean several units	7	easy to clean unit	9	should be easy flush, but chemical was also on outer surface	5	should be easy flush, but chemical was also on outer surface of drill and pump handle	4	fairly easy to clean	8
Potential for chemical exposure (10)	very little exposure potential	9	little potential for exposure	8	very little exposure potential	9	some potential exposure	6	frequent leaks from and around needles	3	several leaks around injection point or chemical on or dripping from	4	few leaks around injection point; little chemical on or dripping from	6
Effectiveness of treatment 1 month after injection (10)	NA	0	NA	0	very good	9	excellent	10	excellent	10	excellent	10	NA	0
Total Score (out of 100 possible points)	**60**		**55**		**81**		**79**		**71**		**68**		**57**	

NA = Not Applicable or Available

Excellent Good Fair Poor Bad

Scored 80% or higher

Table 33: Attack success and gallery construction of *Ips* engraver beetles on loblolly pine bolts cut 1, 13 and 25 months after trunk injection with emamectic benzoate using different injection systems; Lufkin, Texas: 2007-2009.

Injection season / Evaluation period	System	Rate	N	Mean # of nuptial chambers without egg galleries: No.	Mean # of nuptial chambers without egg galleries: % of total	Mean # of nuptial chambers with egg galleries: No.	Mean # of nuptial chambers with egg galleries: % of total	Mean total # of nuptial chambers
Spring (May) / 1 month post-injection (June 2007)	Tree IV	Low (5ml / "dbh)	5	5.8	81	1.4	19	7.2
	AJ Micro		5	2.6	100	0.0 *	0	2.6 *
	Portal		5	6.6 *	100	0.0 *	0	6.6
	Sidewinder		5	4.8	96	0.2 *	4	5.0
	Tree IV	High (10ml / "dbh)	5	9.4 *	96	0.4 *	4	9.8
	AJ Micro		5	5.0	100	0.0 *	0	5.0
	Portal		5	4.4	100	0.0 *	0	4.4
	Sidewinder		5	5.6	93	0.4 *	7	6.0
	Check		5	3.4	44	4.4	56	7.8
Spring (May)/ 13 months post-injection (June 2008)	Tree IV	High (10ml / "dbh)	5	3.4 *	100	0.0 *	0	3.4
	AJ Micro	Low (5ml / "dbh)	5	2.4 *	100	0.0 *	0	2.4
	Portal	Low (5ml / "dbh)	5	1.0	36	1.8	64	2.8
	Sidewinder	High (10ml / "dbh)	5	2.6 *	100	0.0 *	0	2.6
	Check		5	1.0	26	2.8	74	3.8
Spring (May)/ 25 months post-injection (June 2009)	Tree IV	High (10ml / "dbh)	5	2.0 *	100	0.0 *	0	2.0
	AJ Micro	Low (5ml / "dbh)	5	2.0 *	100	0.0 *	0	2.0
	Portal	Low (5ml / "dbh)	5	2.4 *	100	0.0 *	0	2.4
	Sidewinder	High (10ml / "dbh)	5	2.2 *	100	0.0 *	0	2.2
	Check		5	0.2	9	2.0	91	2.2

* Means followed by an asterisk are not significantly different from the check at the 5% level based on Fisher's Protected LSD.

Table 34: Mean number of egg galleries constructed by *Ips* engraver beetles (per 1000 cm^2) in loblolly pine bolts cut 1, 13 and 25 months after trunk injection with emamectin benzoate using different injection systems; Lufkin, Texas: 2007-2009.

Injection season / Evaluation period	System	Rate	N	Number of egg galleries: Without larvae No.	Without larvae % of total	With larvae No.	With larvae % of Total	Total #
Spring (May) / 1 month post-injection (June 2007)	Tree IV	Low (5ml / "dbh)	5	2.0	77	0.6 *	23	2.6 *
	AJ Micro	Low (5ml / "dbh)	5	0.0 *	#####	0.0 *	#####	0.0 *
	Portal	Low (5ml / "dbh)	5	0.0 *	#####	0.0 *	#####	0.0 *
	Sidewinder	Low (5ml / "dbh)	5	0.2 *	100	0.0 *	0	0.2 *
	Tree IV	High (10ml / "dbh)	5	0.8	80	0.2 *	20	1.0 *
	AJ Micro	High (10ml / "dbh)	5	0.0 *	#####	0.0 *	#####	0.0 *
	Portal	High (10ml / "dbh)	5	0.0 *	#####	0.0 *	#####	0.0 *
	Sidewinder	High (10ml / "dbh)	5	0.4 *	100	0.0 *	0	0.4 *
	Check		5	4.2	27	11.2	73	15.4
Spring (May)/ 13 months post-injection (June 2008)	Tree IV	High (10ml / "dbh)	5	0.0	#####	0.0 *	#####	0.0 *
	AJ Micro	Low (5ml / "dbh)	5	0.0	#####	0.0 *	#####	0.0 *
	Portal	Low (5ml / "dbh)	5	1.4	35	2.6 *	65	4.0 *
	Sidewinder	High (10ml / "dbh)	5	0.0	#####	0.0 *	#####	0.0 *
	Check		5	0.4	5	7.4	95	7.8
Spring (May)/ 25 months post-injection (June 2009)	Tree IV	High (10ml / "dbh)	5	0.0 *	#####	0.0 *	#####	0.0 *
	AJ Micro	Low (5ml / "dbh)	5	0.0 *	#####	0.0 *	#####	0.0 *
	Portal	Low (5ml / "dbh)	5	0.0 *	#####	0.0 *	#####	0.0 *
	Sidewinder	High (10ml / "dbh)	5	0.0 *	#####	0.0 *	#####	0.0 *
	Check		5	0.8	11	6.2	89	7.0

* Means followed by an asterisk are not significantly different from the check at the 5% level based on Fisher's Protected LSD.

Table 35: Mean length of egg galleries constructed by *Ips* engraver beetles (per 1000 cm^2) in loblolly pine bolts cut 1, 13 and 25 months after trunk injection with emamectin benzoate using different injection systems; Lufkin, Texas: 2007-2009.

				Length of egg galleries				
				Without larvae		With larvae		
Evaluation period	System	Rate	N	cm	% of Total	cm	% of Total	Total length
Spring (May) / 1 month post-injection (June 2007)	Tree IV	Low (5ml / "dbh)	5	7.6	56	6.0 *	44	13.6 *
	AJ Micro	Low (5ml / "dbh)	5	0.0 *	#####	0.0 *	#####	0.0 *
	Portal	Low (5ml / "dbh)	5	0.0 *	#####	0.0 *	#####	0.0 *
	Sidewinder	Low (5ml / "dbh)	5	1.0 *	100	0.0 *	0	1.0 *
	Tree IV	High (10ml / "dbh)	5	4.6	70	2.0 *	30	6.6 *
	AJ Micro	High (10ml / "dbh)	5	0.0 *	#####	0.0 *	#####	0.0 *
	Portal	High (10ml / "dbh)	5	0.0 *	#####	0.0 *	#####	0.0 *
	Sidewinder	High (10ml / "dbh)	5	1.8	100	0.0 *	0	1.8 *
	Check		5	15.2	13	98.8	87	114.0
Spring (May)/ 13 months post-injection (June 2008)	Tree IV	High (10ml / "dbh)	5	0.0	#####	0.0 *	#####	0.0 *
	AJ Micro	Low (5ml / "dbh)	5	0.0	#####	0.0 *	#####	0.0 *
	Portal	Low (5ml / "dbh)	5	3.8	3	123.6 *	97	127.4 *
	Sidewinder	High (10ml / "dbh)	5	0.0	#####	0.0 *	#####	0.0 *
	Check		5	2.0	2	81.4	98	83.4
Spring (May)/ 25 months post-injection (June 2009)	Tree IV	High (10ml / "dbh)	5	0.0 *	#####	0.0 *	#####	0.0 *
	AJ Micro	Low (5ml / "dbh)	5	0.0 *	#####	0.0 *	#####	0.0 *
	Portal	Low (5ml / "dbh)	5	0.0 *	#####	0.0 *	#####	0.0 *
	Sidewinder	High (10ml / "dbh)	5	0.0 *	#####	0.0 *	#####	0.0 *
	Check		5	6.0	6	100.0	94	106.0

* Means followed by an asterisk are not significantly different from the check at the 5% level based on Fisher's Protected LSD.

Table 36: Extent of feeding by cerambycid larvae (per 1000 cm2) in loblolly pine bolts cut 1, 13 and 25 months after trunk injection with emamectin benzoate using different injection systems; Lufkin, Texas: 2007-2009.

	System	Rate	N	No of cerambycid egg niches on bark	Percent phloem area consumed by larvae
Spring (May) / 1 month post-injection (June 2007)	Tree IV	Low (5ml / "dbh)	5	11.6	0.0 *
	AJ Micro	Low (5ml / "dbh)	5	18.2	0.0 *
	Portal	Low (5ml / "dbh)	5	10.4	0.0 *
	Sidewinder	Low (5ml / "dbh)	5	18.4	0.0 *
	Tree IV	High (10ml / "dbh)	5	20.0	0.0 *
	AJ Micro	High (10ml / "dbh)	5	11.4	0.0 *
	Portal	High (10ml / "dbh)	5	16.2	0.0 *
	Sidewinder	High (10ml / "dbh)	5	13.4	0.0 *
	Check		5	11.4	6.8
Spring (May)/ 13 months post-injection (June 2008)	Tree IV	High (10ml / "dbh)	5	15.8	1.2 *
	AJ Micro	Low (5ml / "dbh)	5	12.8	0.0 *
	Portal	Low (5ml / "dbh)	5	11.2	9.4 *
	Sidewinder	High (10ml / "dbh)	5	16.6	0.4 *
	Check		5	17.4	63.4
Spring (May)/ 25 months post-injection (June 2009)	Tree IV	High (10ml / "dbh)	5	6.4	0.0 *
	AJ Micro	Low (5ml / "dbh)	5	4.4	0.0 *
	Portal	Low (5ml / "dbh)	5	4.8	2.4
	Sidewinder	High (10ml / "dbh)	5	7.0	0.0 *
	Check		5	8.6	2.6

* Means followed by an asterisk are not significantly different from the check at the 5% level based on Fisher's Protected LSD.

SYSTEMIC PESTICIDE INJECTION TRIALS

Summary and Registration Status of Tested Systemic Insecticides and Fungicides

One of the initial goals of the Forest Pest Management Cooperative was to develop alternative control options for cone and seed insects in light of the potential loss of registered foliar pesticides (e.g. Guthion®). Individual tree injections in seed orchards offer several advantages. Control efforts can be allocated to clones on the basis of inherent susceptibility to insect attacks, genetic worth, and high potential for seed production. With these criteria, only 10 – 25% of the ramets in an orchard might need to be protected with insecticides. In turn, the pesticide load (amount of pesticide per acre) produced by conventional application techniques could be substantially reduced. Potential environmental concerns from insecticides in runoff water could be virtually eliminated because insecticides would be contained within the tree. Specific situations where systemic injections may be particularly useful include protecting seeds on trees with control pollinated crosses, protecting selected ramets of genetically-valued clones in early-generation orchards after emphasis shifts to newer orchards, and providing insect control in orchards located in environmentally-sensitive sites where conventional air and ground sprays may be hazardous or prohibited.

Protection of individual trees from bark beetles has historically involved insecticide applications to the tree bole using hydraulic sprayers. However, this control option can be expensive, time-consuming, of high risk for worker exposure and drift, and detrimental to natural enemies. The use of a newly developed injection technology to deliver systemic insecticides could reduce or eliminate many of the limitations associated with hydraulic spray applications.

<u>Insecticides</u>

Emamectin Benzoate (EB) - Over a 6-year period, emamectin benzoate (Arise SL®), injected as part of the initial Seed Orchard Duration trial, exhibited excellent protection in pine seed orchards against coneworms, with a mean reduction in damage of 80% compared to checks. The data suggest that a single injection of EB can protect trees against coneworms for 72 months or longer. A second injection is not necessary during the second growing season to improve efficacy. EB has not been as effective against seed bugs. Single injections are capable of significantly reducing seed bug damage, but only for about 18 months. The work by the FPMC has proven that EB is highly effective in protecting cone crops. Unfortunately, because seed orchard use constitutes a very small market (only ~10,000 acres in the South), the primary chemical manufacturer, Syngenta, had been reluctant to support an injection use registration in the U.S. for seed orchards alone.

Since 2002, an attempt had being made to expand the potential forestry market for EB through trials with other tree and pest species. In 2004, injected EB (Denim®) was tested for efficacy against southern pine engraver beetles. EB was found to be highly effective in preventing the colonization and mortality of stressed loblolly pine by southern pine engraver beetles (see 2004 Annual Report, Grosman et al. 2006).

In light of the large potential market for EB, particularly as it relates to protection of high-value trees from bark beetles, Syngenta has shown considerably more interest in pursuing registration of this chemical for injection use. Unfortunately, the Denim® formulation had several negative characteristics that limited its potential use as an injectable formulation. Syngenta reached an agreement with Arborjet, Inc. during the winter of 2004/2005 to develop a new injectable formulation of EB. Arborjet created a non-toxic, low viscosity formulation for injection use (Joe Doccola, Arborjet™, personal communication).

Several additional FPMC trials were established in 2005 - 2008 with some ongoing in 2009, to evaluate the new formulation of EB for 1) efficacy against cone and seed insects in loblolly pine, slash pine, and Douglas-fir seed orchards, 2) efficacy of different rates and duration against *Ips* engraver beetles, 3) efficacy against aggressive *Dendroctonus* bark beetles in the South (southern pine beetle) and the West (mountain pine beetle, western pine beetle and spruce beetle); 4) efficacy against different pests oak; and 3) efficacy against two invasive insect pests in Texas. All trials showed that the new EB formulation could be quickly injected into trees, was non-toxic, and, where results were available, effective against different species of coneworms, bark beetles, hardwood pests, and a chalcid wasp; in some cases, for two or more consecutive years. Arborjet also has ongoing trials to test the new formulation for control of emerald ash borer, Asian longhorned beetle, forest tent caterpillar, gypsy moth, winter moth, hemlock wooly adelgid and red gum lerp psyllid. In light of these successes, Syngenta and Arborjet conducted the required toxicology tests and submitted a request to EPA in January 2008 for full label registration. The product is called "**TREE-äge**." In the mean time, requests were made and approved in 2008 for 24C (Special Local Need) registration for use against emerald ash borer in IL, IN, MD, MI, MN, MO, OH, PA, VA, WI & WV. EPA did approve the Section 3 use of TREE-äge in ash for protection against EAB in July 2008, but requested additional data to support use in other sites (i.e., seed orchards and conifers). As of April 2010, the new data is still under review. Syngenta has decided not to support requests for 24C registration of EB for use in seed orchards until EPA has ruled on the full registration.

Fipronil – In light of the discovery that fipronil had systemic activity in loblolly pine against pine tip moth in 2002 (see 2003 Annual Report), an experimental emulsifiable concentrate (EC) formulation of fipronil was injected into trees as part of a seed orchard trial (2003) and a bark beetle trial (2004). The EC formulation reduced overall coneworm damage by 80% and was highly effective in preventing the colonization and mortality of stressed loblolly pine by southern pine engraver beetles (*Ips* spp.) (see 2004 Annual Report). Although this formulation had not been found to cause stem necrosis in injected trees, BASF elected to develop and test several new formulations of fipronil for injection use. These were available for comparison with the new formulation of EB in the three 2005 FPMC trials mentioned above. Although fipronil tends to require more time to move throughout the tree, it proved nearly as effective as EB in most trials.

The BAS 350 UB formulation of fipronil, developed by BASF in 2005, requires the addition of methanol to improve uptake of the chemical by trees. This would be undesirable when sold for commercial use. Thus, BASF developed three new formulations (PW, PS and UK) that already contain a solvent and is injection ready. These formulations were tested in 2007 and found highly and equally effective against *Ips* bark beetles. Additional trials were established in the West to test against western and mountain pine beetles. Unfortunately, the results were less effective than expected. Again timing and temperatures appeared to play a role in the reduced activity. BASF decided not to submit an application to EPA for registration of fipronil for use as a tree injection treatment. Mauget is now interested in this chemical and is working with the FPMC to conduct additional tests. Initial results show again that fipronil is highly effective in preventing the successful colonization of pine by *Ips* engraver beetles.

Imidacloprid – Imidacloprid is another neonictinoid chemical tested by the FPMC in our seed orchard trials at low (2ml, Pointer® w/ Wedgle Tip injector in 1997) and high (30 ml, Admire® w/ STIT injector in 1999-2000) volumes. Generally, low volume injections were ineffective against coneworms and seed bugs. High volume injections of imidacloprid did significantly reduce coneworm damage (45%), but were not nearly as effective as EB (94%) in the first year after injection. In contrast, imidacloprid was more effective against seed bugs (82% reduction) than was EB (34% reduction). However, there was considerable variability in the efficacy against both groups of pests. As observed with thiamethoxam, imidacloprid efficacy against both coneworms and seed bugs declined markedly in the second year.

Protection against seed bugs, but not coneworms, improved significantly with a second injection of imidacloprid in 2000 (see 2000 Annual Report). This suggests that yearly injections of imidacloprid are needed for optimal protection against seed bugs. Again, the cost (manpower and excessive tree wounding) makes yearly injections unattractive. In addition, imidacloprid has a low solubility in water (0.4g/L). Thus, mixing currently-registered products (Merit® and Admire®) in water to create an injectable solution at an effective concentration is difficult. For these reasons, we elected to discontinue our evaluation of imidacloprid after 2000. Recently, Arborjet has developed a new formulation of 5% injectable imidacloprid (Ima-jet™). Trials have been established in 2007 - 2009 to evaluate this formulation alone or combined with their new formulation of EB or abamectin. Ima-jet™ can significantly reduce seed bug damage but had no significant effect against coneworm and efficacy was not enhanced by EB. The effects declined markedly in second year after injection.

Dinotefuran - Dinotefuran (Valent) is a "3rd generation" neonicotinoid insecticide with primary activity against sucking insects as well as Coleoptera (beetles). Although dinotefuran (0.2g/inch DBH) was not found to be active against bark beetles in our 2004 trial, it was found by Arborjet (at 0.4g/inch DBH) to be as effective as imidacloprid against emerald ash borer (Joe Doccola, Arborjet, personnel communication). One advantage dinotefuran has over imidacloprid is that it is 100X more water soluble (40g/L vs 0.4g/L). Thus, higher concentrations can be developed that translocate more quickly compared to imidacloprid. Arborjet, working in cooperation with Valent, developed a formulation of dinotefuran that may be combined with EB for seed orchard use. The trial in 2007 and 2008 showed that this chemical can reduce seed bug damage but had little effect against coneworms.

Nemadectin - Nemadectin (Fort Dodge Animal Health) is a fermentation product of *Streptomyces cyanogriseus noncyanogenus* and closely related to EB. A preliminary trial was conducted in 2005 to determine if nemadectin has similar efficacy against bark beetles. The results suggest some activity, but treatment and evaluation earlier in the year should provide more conclusive evidence. Additional tests initiated in 2006 confirmed that nemadectin has moderate activity against *Ips* engraver beetles. The trial was continued through 2008 and showed that nemadectin at the highest rate (0.4 g AI / inch DBH.) had very good efficacy against *Ips* engravers and wood borers 28 months after injection. Fort Dodge Animal Health indicated they planned to sell the use rights to another company who would then submit for EPA registration. No progress has been made on this registration since 2008.

Abamectin – Abamectin (Syngenta) is an avermectin derivative and closely related to EB. A preliminary trial was initiated in 2008 in cooperation with Mauget Co. to determine if abamectin has similar efficacy against bark beetles. The results indicate that abamectin is very active against

Ips engraver beetles and wood borers. The trial will be extended through 2011. An additional trial was initiated in the fall 2008 at the Rayonier seed orchard near Fernandino Beach, FL, but results indicate no initial activity against coneworms and/or seed bugs.

Fungicides

Propiconazole - Propiconazole is a systemic triazole fungicide with a broad range of activity - used agriculturally on grasses grown for seed, mushrooms, corn, wild rice, peanuts, almonds, sorghum, oats, pecans, apricots, peaches, nectarines, plums and prunes, as well as used to protect oaks against oak wilt disease. Propiconazole is considered to be fungistatic or growth inhibiting rather than fungicidal or killing.

Thiabendazole - Thiabendazole is a systemic benzimidazole fungicide used to control fruit and vegetable diseases such as mold, rot, blight and stain, as well as a prophylactic treatment for Dutch Elm disease. Thiabendazole has both fungistatic and fungicidal properties.

A trial was initiated in 2009 in cooperation with Arborjet to determine if the combination of an EB plus propiconazole + thiabendazole (below) mix treatment would improve survival of baited pine after SPB attack compared to EB alone. The results suggest that addition of the fungicide mix does not improve survival of pines. The trial will be extended through 2011. An additional trial was initiated in the fall 2009 in cooperation with Dr. Lori Eckhardt, Auburn University, to determine to what extent the fungicide mix would affect growth of *Leptographium* species on media in the laboratory or in the host in the field. The results indicate that the fungicide mix was highly effective in inhibiting growth of five *Leptographium* spp. in laboratory media but did not affect growth of *Leptographium* spp. in longleaf pine roots and stems.

Another trial was initiated in 2009 in Utah to determine if EB combined with propiconazole only would improve survival of baited pine after MPB attack. Results are pending.

Tebuconazole – Tebuconazole is another triazole fungicide used agriculturally to treat a wide range of plant pathogenic fungi thanks to its broad spectrum. In the same Utah trial (mentioned above), abamectin was combined with tebuconazole. Again, results are pending.

REGENERATION WEEVILS

Evaluation of Arctic™ and OnyxPro™ for Protection of Pine Seedlings Against Pine Regeneration Weevils

Highlights:

- Two insecticides products, Arctic™ and OnyxPro™, were evaluated for their ability to protect pine seedlings against regeneration weevils for 16 weeks post treatment.
- Arctic™ (permethrin) with and without a spreader sticker was highly effective in causing weevil mortality and/or reducing feeding by weevils for the full 16 weeks.
- OnyxPro™ caused limited weevil mortality during the first 5 weeks after seedling treatment, but did significantly reduce weevil feeding compared to checks for 16 weeks.

Justification: The pales weevil, *Hylobius pales*, and pitch-eating weevil, *Pachylobius picivorus*, are two of the most serious insect pests of pine seedlings in the eastern United States. Adult weevils of both species are attracted to freshly-harvested pine sites where they breed in logging slash, stumps and old root systems. Seedlings planted in freshly-logged areas are injured or killed by adult weevils that feed on the stem bark. It is not uncommon to have 30 to 60 percent weevil-caused mortality among first-year seedlings in the South, and mortality of 90 percent or more has been recorded.

One strategy to reduce losses caused by reproduction weevils is the use of seedling protective treatments. Pounce® 3.2EC (permethrin, FMC) had been used extensively through the 1990s. The longevity of Pounce on treated seedlings was evaluated in the Texas Forest Service Forest Pest Management laboratory in 1998. Overall, the chemical caused better than 50% weevil mortality even after exposure to seedlings treated nearly four months earlier. It is clear that when seedlings are thoroughly covered with Pounce®, they can be protected from weevils for as long as six months post-treatment. In addition, measurement of feeding areas on treated and untreated seedling sections showed that Pounce® is capable of significantly reducing the amount of feeding damage for eight months or longer.

FMC discontinued production of the EC formulation of Pounce® in 2005. Waylay™ and Arctic™ (permethrin, Winfield Solutions) were registered in 2006 to replaced Pounce®. Both of these new products contained similar concentrations of the active ingredient, but differ somewhat in their inert ingredients. Unfortunately, applicators had/have indicated that the Waylay™ or Arctic™ treatments have not been performing (repellency/duration) as well as Pounce® (Note: Waylay™ was discontinued in 2008). We were interested to know if the addition of a spreader/sticker to an Arctic™ solution would improve duration of protection of seedlings against weevils. Additionally, another product, OnyxPro™ (bifenthrin, FMC) is already registered for use in nurseries but has not been tested for effectiveness and duration of protection when applied to pine seedlings in nursery beds.

Objectives:

1) Determine the efficacy of Arctic™ (permethrin) alone or combined with a spreader/sticker and OnyxPro™ (bifenthrin) in reducing weevil-caused seedling mortality.
2) Determine the longevity of Arctic™ and OnyxPro™ residuals on treated pine seedlings.

Cooperators:

Mr. Shannon Stewart	ArborGen, Livingston, TX
Mr. Robert Cossar	Winfield Solutions, Crossett, AR
Mr. Brian Mount	FMC, Warren, AR

Insecticide:

Arctic™ 3.2 EC (permethrin) – pyrethroid insecticide
OnyxPro™ (bifenthrin) – pyrethroid insecticide.
Complex™ – self-emulsifiable spreader sticker and non-ionic surfactant

Research Approach:

The treatments included:

1) Arctic™ applied once to pine seedlings at 2 quarts / 100,000 seedlings just prior to lifting.
2) Arctic™ + Complex™ (spreader/sticker) applied once to pine seedlings at 2 quarts. / 100,000 seedlings just prior to lifting.
3) OnyxPro™ applied once to pine seedlings at 0.32 oz. / 1000 sq ft just prior to lifting.
4) Check

A laboratory colony, consisting of pales weevils only, was established during the winter of 2009. Weevils, from the field, were collected once a week using pit traps baited with a 5:1 mix of ethanol and turpentine and set up in recently harvested tracts. In the laboratory, collected weevils were maintained in clear plastic containers containing a layer of vermiculite, split bolts, and foliage. The plant material and vermiculite will be changed every two weeks.

Two hundred seedlings (50 Arctic™-treated, 50 Arctic™ + Complex™-treated, 50 OnyxPro™-treated, and 50 untreated) were obtained from the ArborGen's Livingston Nursery in mid-October, 2009. Seedlings (other than checks) were treated prior to lifting with Arctic™ 3.2 EC per label recommendations (2 qt / 100,000 seedlings) or OnyxPro™ (13.9 oz / acre). All seedlings were planted in 3 gal pots (8 seedlings per pot; treatments separated) and placed outside for exposure to the elements. The soil was a 3:1 mix of plantation soil and potting soil. The seedlings were watered as needed.

At two week intervals for the first 2 months and once a month thereafter for 4 additional months, 20 seedlings (5 Arctic™ -treated, 5 Artic™ + Complex™-untreated, 5 OnyxPro™ -treated, and 5 untreated) were/will be pulled and the above-ground stem of each seedling clipped into 5 cm twig segments. Each twig was/will be placed in an individual moistened paper sleeve and placed separately in a petri dish. One weevil, starved for 24 hours, was/will be placed in each dish. All dishes were/will be placed in a dark room (temperature: ~70 ^{o}F) for 48 h. Paper towels sleeves were/will be remoistened after 24 h. The number of dead weevils and an estimate of weevil feeding on cambial tissue were/will be made after 24, 48 and 72 h for each twig. The amount of feeding was/will be measured with a transparent grid of 2 mm^2 squares transposed over the feeding sites on the twigs. Each treatment was/will be replicated 10 times for both male and females, on each of at least nine separate testing periods.

Results:

Preliminary laboratory experiments showed no significant differences between the weevil species or sexes in the amount of feeding per 24 hours or susceptibility to Arctic™ and OnyxPro™. Therefore, species and sex data were pooled. Subsequent evaluations of Arctic™ and OnyxPro™ longevity on treated seedlings in the laboratory showed that, overall, treatments containing Arctic™ caused better than 67% weevil mortality even after exposure to seedlings treated 16 weeks earlier (Table 37). Onyx Pro™ caused no mortality after 5weeks post treatment. Measurement of feeding areas on treated and untreated seedlings showed that Arctic® and OnyxPro™ significantly reduced the amount of feeding damage by weevils for at least 16 weeks (Table 38).

Conclusions:

This trial confirmed that Arctic™ (permethrin) provides excellent, extended protection of pine seedlings against regeneration weevils. The addition of a spreader/sticker does not enhance protection. It is important that applicators take care to completely cover seedlings with the chemical to ensure maximum protection. The FPMC recommends the use of a bar in front of the sprayer heads to bend the seedling to expose the stems to spray in the nursery. Two passes along the seedling bed (one in each direction) should be made for maximum insecticide coverage.

Acknowledgements: We thank Shannon Stewart for providing seedlings for the project. We appreciate the chemical donations and injection equipment loans made by FMC and Winfield Solutions.

Table 37. Mortality of pales weevils after exposure to Arctic™ and OnyxPro™-treated pine seedlings from Arborgen's Livingston Nursery [a]

	Percent Mortality after:			
Treatment	1 week	5 weeks	8 weeks	16 weeks
Arctic™	100 c†	100 c	88 b	83 b
Arctic™ + Complex™	100 c	100 c	100 b	67 b
Onyx Pro™	19 b	25 b	0 a	0 a
Check	0 a	6 a	6 a	0 a

[a] Pine seedlings were treated on November 3, 2009 using backpack sprayers.

† Means followed by the same letter in each column of the same site are not significantly different at the 5% level based on Fisher's Protected LSD.

Table 38. Feeding area by pales weevils after exposure to Arctic™ and OnyxPro™-treated pine seedlings from Arborgen's Livingston Nursery [a].

Treatment	Mean Feeding Area (mm^2) per 24 hrs: 1 week	5 weeks	8 weeks	16 weeks
Arctic™	1.00 a†	0.29 a	0.67 a	0.56 a
Arctic™ + Complex™	0.75 a	0.46 a	0.48 a	0.72 a
OnyxPro™	8.85 b	4.02 ab	3.71 b	5.69 b
Check	25.38 c	15.90 b	10.08 c	9.03 c

[a] Pine seedlings were treated on November 3, 2009 using backpack sprayers.

† Means followed by the same letter in each column of the same site are not significantly different at the 5% level based on Fisher's Protected LSD.

PINE TIP MOTH TRIALS

Impact Study – Western Gulf Region

Highlights:

- Three new Nantucket pine tip moth impact plots were established in 2009, bringing the total to 106 plots established since 2001.
- Tip moth damage levels on first-year check trees declined slightly to 21% in 2009. Damage levels on second-year check trees, established in 2008, declined to moderate levels (25%).
- Periodic applications of Mimic® to second-year trees in 2009 provided good protection against tip moth on most sites. This resulted in overall damage reductions of 69%, compared to untreated checks. The use of PTM™ on first year trees provided excellent protection; damage was reduced by 97%.
- Protected trees experienced significantly improved tree growth compared to check trees at all tip moth damage levels. Growth differences between protected and checks trees increased as damage levels on check trees increased; trees protected from high damage levels (>20% shoots infested) had 62% greater volume than unprotected trees.
- Mimic®-treated trees in most age groups (1-5 years old) continued to show improved differences in growth measurements compared to untreated checks. Fifth-year trees, previously treated with Mimic®, were on average 28 cm (1 ft) taller, had 0.45 cm greater diameter and 6,607 cm^3 (0.25 ft^3) greater volume compared to check trees.

Objectives: 1) Evaluate the impact of Nantucket pine tip moth infestation on height, diameter, volume growth and form of loblolly pine in the Western Gulf Region and 2) identify a pine tip moth infestation threshold that justifies control treatment.

Cooperators:

Mr. Conner Fristoe	Plum Creek Timber Co., Crossett, AR
Dr. Nick Chappell	Potlatch Forest Holdings, Warren, AR
Mr. Peter Birks	Weyerhaeuser Co., Columbus, MS
Mr. Bill Stansfield	The Campbell Group, Diboll, TX
Mr. Jeff Hall	Forest Investment Associates, Jackson, MS
Mr. Trevor Walker	Stephen F. Austin State University, Nacogdoches, TX
Dr. Dean Coble	Stephen F. Austin State University, Nacogdoches, TX

Study Sites: Several FPMC members have established 10 or more impact study sites by 2009. In most plantation sites, one to two areas were selected and divided into 2 plots each – with each plot containing 126 trees (9 rows X 14 trees). Tip moth populations were monitored on TFS sites in East Texas.

Insecticide:

Mimic® 2F (tebufenozide) - molting stimulant specific to Lepidoptera.
PTM™ Insecticide (fipronil) -

Design: 74 sites X 1-2 plots X 2 treatments X 50 trees = 9,900 monitored trees.

Treatments:

1) Mimic® 2F applied once per generation at 0.08 oz. / gal. on second-year sites, or PTM™ dilution applied just after planting (60 ml per seedling) on first–year sites.
2) Check

Application Methods: Treatments were randomly assigned to each plot pair at the establishment of each site. Pesticides were applied by backpack sprayer or spray bottle (Mimic®) or soil injector applicator (PTM™) to all 126 trees within the designated treatment area on second- and first-year sites, respectively. Mimic® application dates were based on optimal spray period predictions for locations near each study site (Fettig et al. 2003), generally every 7-8 weeks starting in late February and ending in late September. PTM™ treatments consisted of a single application at or just after planting.

Tip Moth Damage Survey: Tip moth infestation levels were determined by surveying the internal 50 trees within each plot during the pupal stage of each tip moth generation for the first two years after establishment. Each tree was ranked according to the extent of tip moth damage including: 1) tree identified as infested or not, 2) if infested, the proportion of tips infested on the top whorl and terminal was calculated, and 3) separately, the terminal was identified as infested or not. Trees also were surveyed a final time in November or December. At this time, data also were collected on tree height and diameter at 15 cm (6 in) above the ground. Tree height, diameter at breast height (DBH) and form data were collected on third-year and fifth-year sites. Tree form was evaluated based on number of forks occurring on each tree: 0 = no forks, 1 = one fork, 2 = two to four forks and 3 = five or more forks. A fork is defined by the presence of a lateral branch that is more than half the diameter of the main stem at its base.

Data Analysis: Trevor Walker, graduate student at SFASU, has provided the following outline for data analysis:

A) Dominant height equation modifier:
- Relate tree growth impact to infestation level (Hedden paper):
  - Predictor variables - Years since treatment, identify others in Hazard-rating part of study

B) Economic simulation:
- Determine *willingness to pay* (Asaro 2006) for treatment:
- Assume:
  - Real price increase and consumer price index
  - Fluctuate levels of, or numerically solve - price per unit of forest product, alternative rate of return.

Results: Figure 21 shows the mean number of pine tip moths captured in traps per day at several one- to three-year-old sites surrounding Lufkin, TX from 2001- 2007. The optimal spray periods in East Texas (near Lufkin) for the first four generations were predicted to be March 22-26, May 21-25, July 10-14, and Aug 19-23 (Fettig et al. 2003). Based on previous years trap data (Figure 21), a fifth spray period was calculated to be September 29 to October 3. In contrast, optimal spray periods for southern Arkansas sites (near Crossett) should be April 6-10, June 5-9, July 30-August 3, and Sept. 13-17. The distribution and use of new Confirm® (Mimic®) and surfactant resulted in much improved protection on both first- and second-year sites in 2008 and 2009 (Table 39).

Three new impact plots were established in 2009, bringing the total number of plots established since 2001 to 106. The use of PTM™ on these sites resulted in even better protection (Table 39). Figure 22 shows the distribution of the 106 first- through nine-year impact study sites in the Western Gulf Region.

Group 1 - Ninth-year sites (12):
Trees on these sites were not measured in 2009.

Group 2 - Eighth-year sites (4 new):
Trees on these sites were not measured in 2009.

Group 3 - Seventh-year sites (8 new; 24 total):
Trees on these sites were not measured in 2009.

Group 4 - Sixth-year sites (2 new; 26 total):
Trees on these sites were not measured in 2009.

Group 5 - Fifth-year sites (6 new; 40 total):
Three years after the last Mimic® spray the difference in growth (height, diameter and volume) between Group 5 Mimic®-treated and untreated trees have expanded considerably. When combined with Group 1, 2, 3 & 4 sites, five-year old Mimic®-treated trees are on average 27 cm (0.9 ft) taller, had 0.45 cm greater diameter at breast height and 6,608 cm^3 (0.23 ft^3) greater volume compared to check trees (Table 40 and Figures 23 25 & 27). This is generally stable compared to the 29 cm (1.0 ft) greater height, 0.43 cm greater diameter at breast height and 6,293 cm^3 (0.22 ft^3) greater volume compared to check trees calculated for the Group 1-4 sites alone. **Note:** The top 30% of the Mimic®-treated trees were on average 28 cm (0.9 ft) taller, had 0.5 cm greater diameter at breast height and 9,343 cm^3 (0.28 ft^3) greater volume compared to check trees (Figures 27).

Group 6 - Fourth-year sites (22 new; 64 total):
Trees on these sites were not measured in 2009. Their next measurements are scheduled for 2010.

Group 7 - Third-year sites (13 new; 88 total):
As with fifth-year sites, the difference in growth (height, diameter and volume) between Mimic®-treated and untreated trees continued to expand even after Mimic sprays were halted. On this group of sites, Mimic-treated trees averaging 39 cm (1.3 ft) taller, had 0.62 cm greater diameter at breast height, and 1,367 cm^3 (0.04 ft^3) greater volume compared to check trees. These "moderate" differences in growth, after only 3 years, are likely the result of better protection against tip moth both in the first and second years (Table 38). Overall (88 sites), Mimic-treated trees were on average 26 cm (0.9 ft) taller, had 0.5 cm greater diameter at breast height and 1,266 cm^3 (0.037 ft^3) greater volume compared to check trees (Table 39, Figures 23-26).
Note: The top 30% of the Mimic-treated trees were on average 47 cm (1.6 ft) taller, had 0.7 cm greater diameter at breast height and 2264 cm^3 (0.07 ft^3) greater volume compared to check trees (Figure 26).

Group 8 - Second-year sites (15 new; 103 total):

Tip moth infestation levels on untreated second-year trees were considerably lower (25% of shoots infested) in 2009 compared to similar aged trees in 2008 (48% of shoots infested) (Table 39). Overall protection of second-year trees was better, but not great, with Mimic® reducing damage to shoots by only 69%. Combined, these factors have resulted in smaller than expected gains in the height (10%), diameter (9%) and volume (24%) of Mimic®-treated trees compared to check trees (Table 40, Figures 23-25).

Group 9 - First-year sites (3 new; 106 total):
Overall, tip moth infestation levels on untreated first-year seedlings was similar (21% of shoots infested) in 2009 compared to 2008 levels (24% of shoots infested) (Table 39). PTM™ protection was considerably better in 2009 compared to previous results with Mimic®. Overall, the soil injection treatments reduced damage by 97%; reductions in damage were above 75% on all three sites. PTM™-treated trees on each site showed significant gains in height, diameter, and volume compared to untreated check trees. Overall, protected (Mimic®/ PTM™) seedlings saw gains in height, diameter and volume of only 9%, 8% and 29%, respectively, compared to check trees (Table 40, Figures 23-25).

To determine if there is a threshold of tip moth damage that significantly impacts tree growth, the 76 sites were divide into three groups based on level of mean shoots infested over the first two years (i.e., ≤ 10%, 11 – 20%, and > 20%). By the end of year 3, the Mimic® treatment had significantly improved 3rd year growth at all tip moth pressures; by 17% at low (≤ 10%) levels, by 40% at moderate (11 – 20% shoots infested) levels, and by 62% at high (>20%) levels (Figure 26, Table 42). If analysis is restricted to crop tree (top 30% or 15 trees by volume, there is a similar trend in growth gains from low to high tip moth pressures. By the end of year 5, the Mimic® treatment significantly improved growth at low pressures by 17%, at moderate pressures by 19%, and at high pressures by 13% (Figure 27, Table 41).

Conclusions: Overall, tip moth populations and damage levels remained high in 2009 compared to 2008. Although close to average rainfall was received in 2007, the extensive drought conditions that occurred in the Western Gulf Region through 2005, most of 2006, and periodically since then may have allowed tip moth populations to build. Multiple applications of Mimic® were able to significantly reduce tip moth infestation levels on most two-year-old sites in 2009. Whereas, Mimic® treatments did significantly improve tree growth on first-year sites in 2001, 2003, 2005 & 2006 and second-year sites in 2002, 2005 & 2006, they did not improve tree growth on first-year sites in 2002 or second-year sites in 2003. One reason may be that tip moth populations were too low (below some threshold) to impact the growth of untreated trees on first and second-year sites in 2002 and 2003, respectively. In contrast, tip moth populations were apparently high enough on second-year sites to significantly impact growth of unprotected trees. Analysis of data from 76 sites 3 years of age or older showed that two-year mean tip moth damage levels (percent shoots infested) of less than 10% can still significantly impact tree growth in a given year.

The question remains, at what damage level does protection treatments become cost effective in forest plantations? Data presented below is currently being evaluated by Mr. Trevor Walker, biometrician graduate student, to answer this question.

Given the disparity in tip moth population levels over the past three years, it is suggested that additional impact sites be established in 2010. If additional impact sites are to be installed, we recommend that PTM™ Insecticide be used and applied at planting to protect trees for 2+ years. Also, it is important to monitor tip moth damage and impact on third- and fifth-year sites in 2010.

Acknowledgments: We greatly appreciate the efforts of Peter Burk (Weyerhaeuser), Al Cook (independent contractor for International Paper and Plum Creek), Nick Chappell (Potlatch), Conner Fristoe (Plum Creek), Bill Stansfield (Campbell Group), and Jimmy Murphy and Rodney Schroeder (American Forest Management, contractor for Forest Investment Associates), for establishing, spraying and monitoring the impact plots. Many thanks go to Andy Burrows, Potlatch, for volunteering his time to assist us in the analysis of the impact data.

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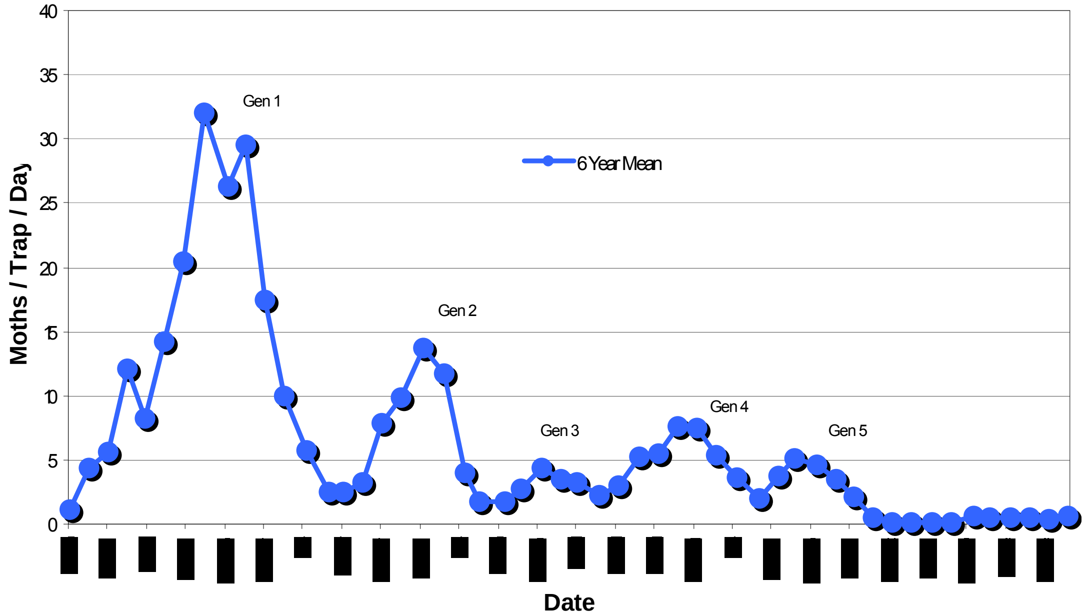


Figure 21. Mean number of pine tip moth adults captured per trap per day in the Lufkin, TX area (2001 - 2007).

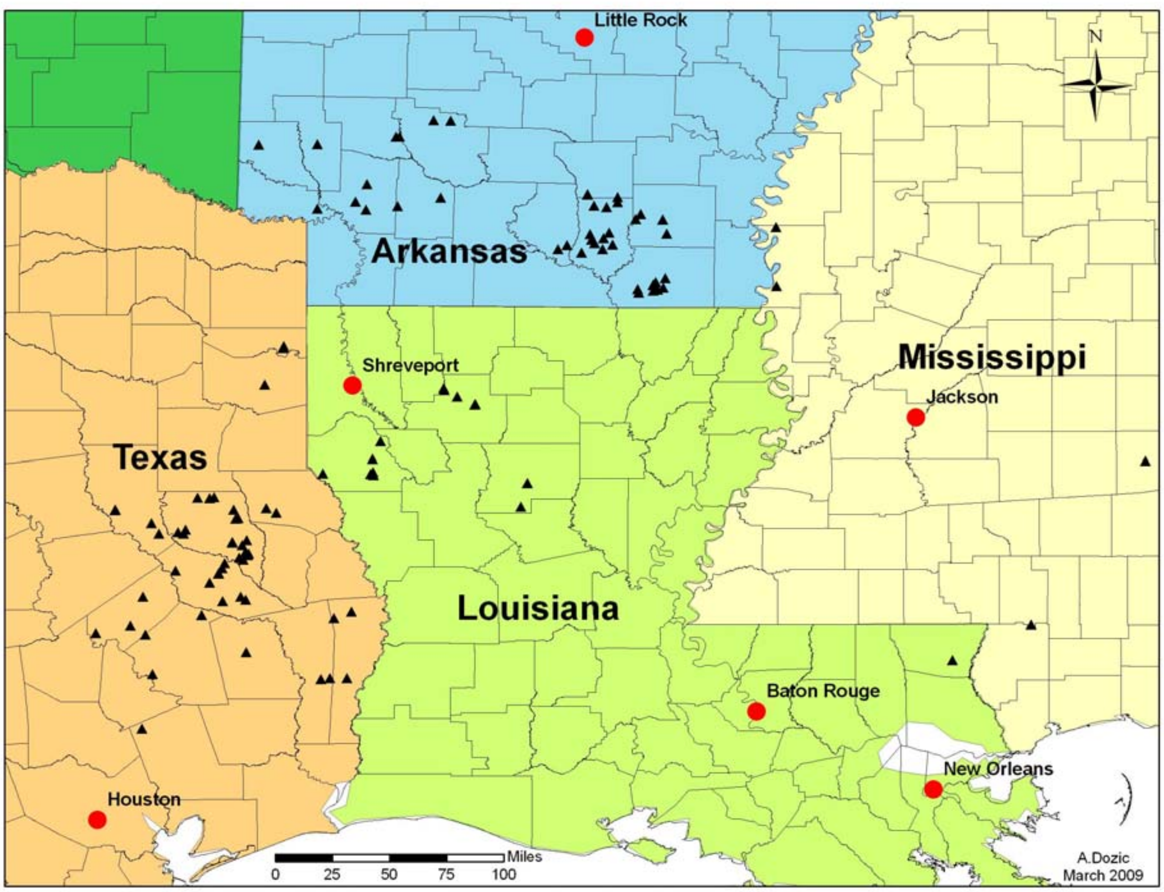


Figure 22. Distribution of 106 one- to five-year old impact sites (▲) from 2001 – 2009 in the Western Gulf Region.

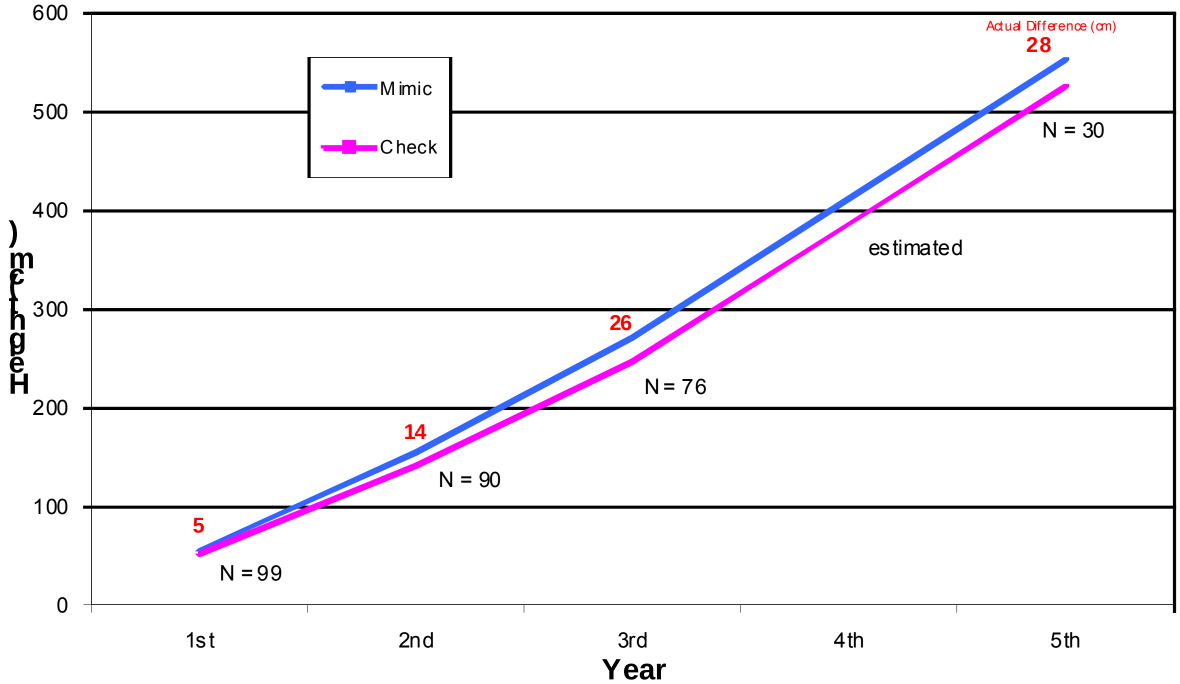


Figure 23. Mean height (cm) of one- to five-year old loblolly pine treated with Mimic® compared to untreated trees on all Western Gulf sites: 2001 – 2009.

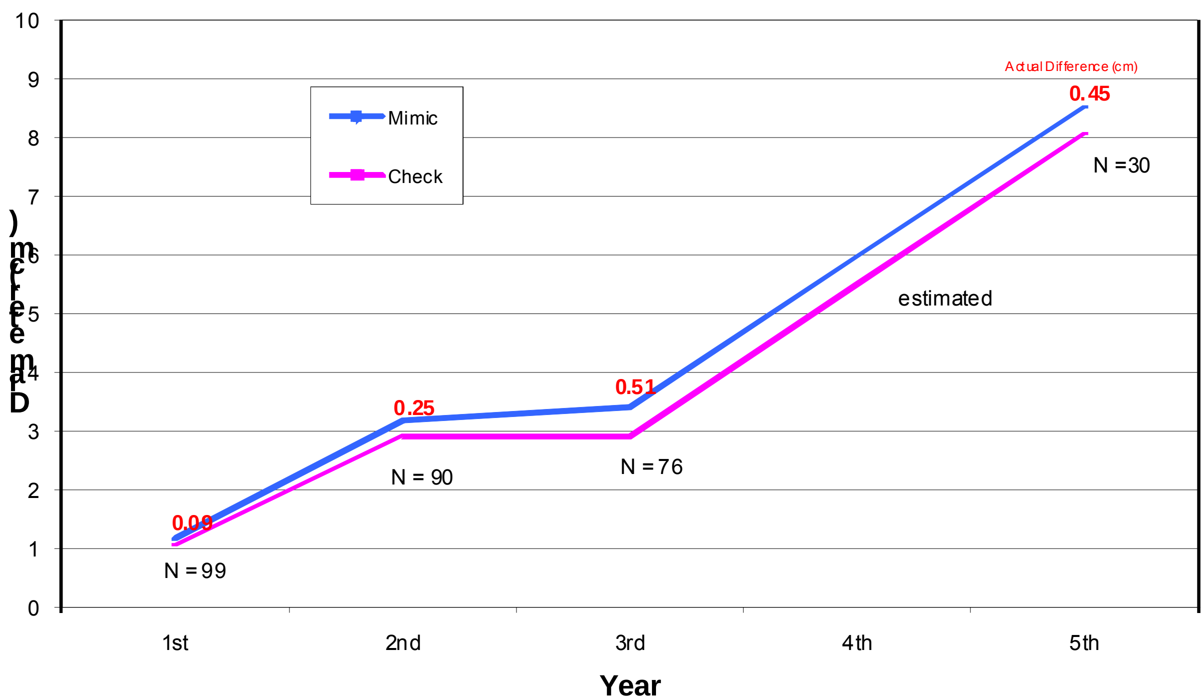


Figure 24. Mean diameter (cm) of one- to five-year old loblolly pine treated with Mimic® compared to untreated trees on all Western Gulf sites: 2001 – 2009.

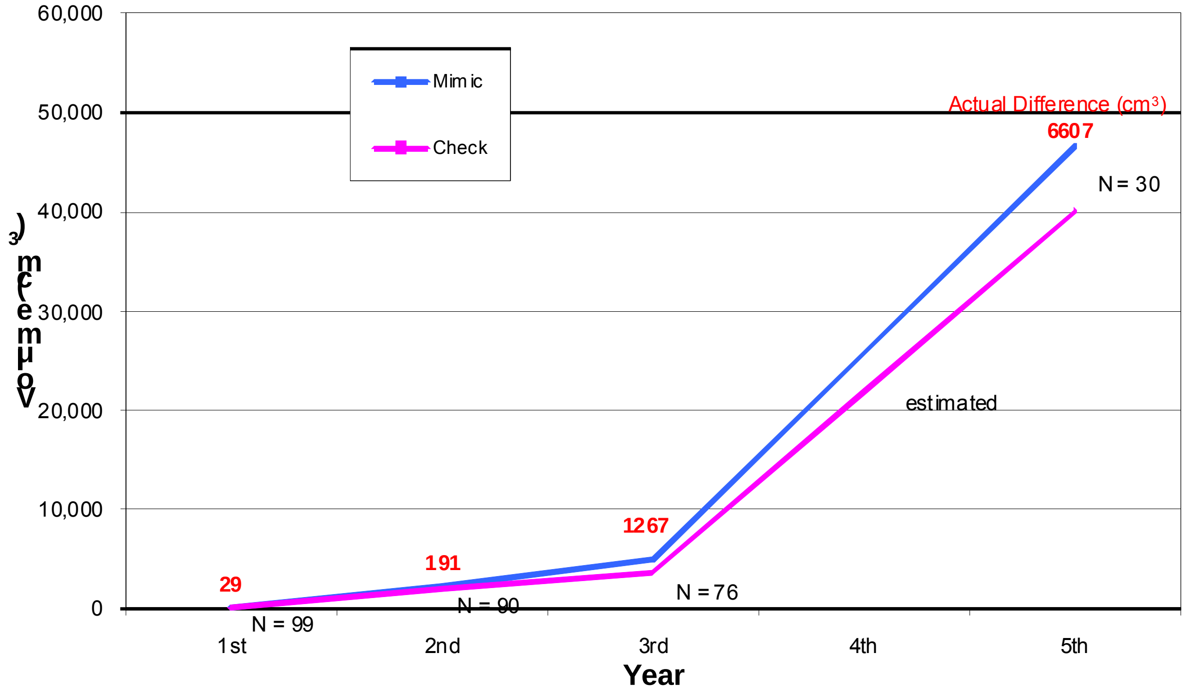


Figure 25. Mean volume index (cm^3) of one- to five-year old loblolly pine treated with Mimic® compared to untreated trees on all Western Gulf sites: 2001 – 2009.

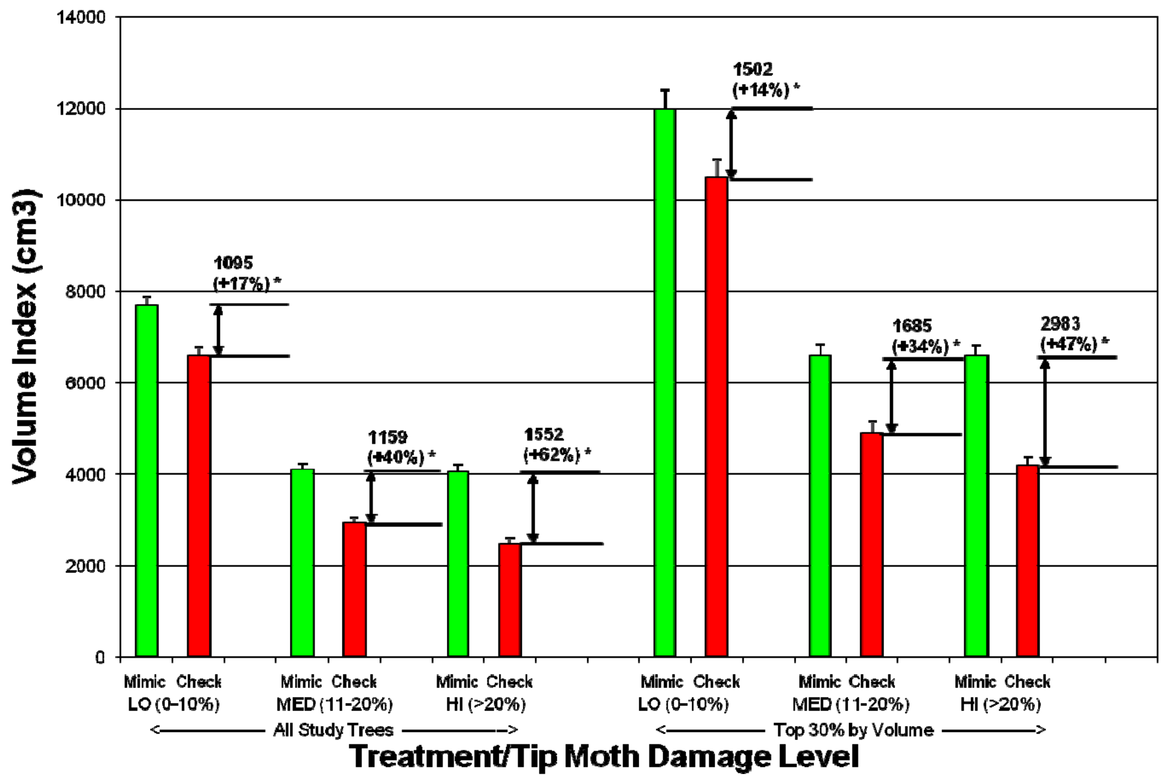


Figure 26. Differences in 3rd-year volume index (cm^3) of protected and unprotected loblolly pine exposed to different tip moth pressures.

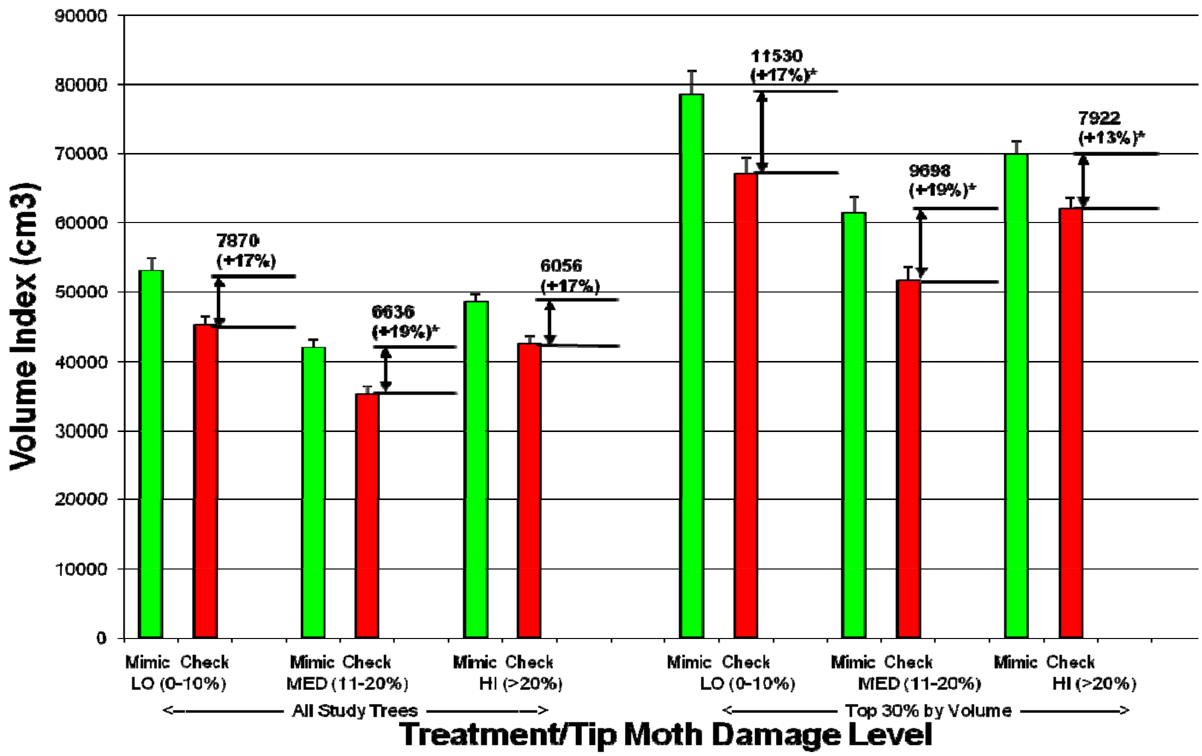


Figure 27. Differences in 5th-year volume index (cm^3) of protected and unprotected loblolly pine exposed to different tip moth pressures

Table 39: Mean percent of pine shoots (in top whorl) infested by Nantucket pine tip moth on one- and two-year old loblolly pine trees following treatment with Mimic® after each generation in Year 1 and 2, or PTM™ in Year 1 (2009); Arkansas, Lousiana, Mississippi and Texas sites, 2001 - 2009.

	Planted 2001 (N =16)		Planted 2002 (N=7) (N=4)		Planted 2003 (N=10) (N=9)		Planted 2004 (N= 8) (N= 5)		Planted 2005 (N= 6)	
Treatment	Yr 1	Yr 2	Yr 1	Yr 2	Yr 1	Yr 2	Yr 1	Yr 2	Yr 1	Yr 2
Mimic®	1.8	3.8	1.5	3.8	1.2	1.2	1.4	1.8	3.0	7.2
Check	23.0	21.9	7.5	15.5	12.2	12.0	10.3	15.6	13.2	15.7
% Reduction	92	83	80	75	90	90	87	88	78	54

	Planted 2006 (N=29) (N=22)		Planted 2007 (N= 13)		Planted 2008 (N=15)		Planted 2009 (N= 3)		Mean Year 1	Mean Year 2
Treatment	Yr 1	Yr 2	Yr 1	Yr 2	Yr 1	Yr 2	Yr 1	Yr 2	(N=106)	(N=91)
Mimic®	5.0	13.2	15.5	17.1	4.4	7.7	0.6		3.8	7.0
Check	14.0	26.0	24.0	47.9	24.0	25.0	20.6		16.6	22.4
% Reduction	65	49	35	64	82	69	97		**77**	**69**

Table 40: Mean tree height, diameter and volume index and percent growth gain and actual difference in growth of one-, two-, three- and five-year old loblolly pine following treatment with Mimic® after each generation in Year 1 and 2; Arkansas, Lousiana, Mississippi and Texas, 2001 - 2009.

Treatment	Mean			
	Year 1 (N= 9153 trees on 101 sites)	Year 2 (N= 8367 trees on 89 sites)	Year 3 (N= 7177 trees on 76 sites)	Year 5 (N= 2853 trees on 30 sites)
	Height (cm)			
Mimic®	56.2	155	272	553
Check	51.6	141	246	526
Actual Diff. In Growth (cm)	5	14	26	27
Pct. Gain Compared to Check	**9**	**10**	**10**	**5**
	Diameter (cm)			
	at 6"	at 6"	at DBH	at DBH
Mimic®	1.16	3.18	3.42	8.53
Check	1.07	2.93	2.91	8.08
Actual Diff. In Growth (cm)	0.09	0.25	0.51	0.45
Pct. Gain Compared to Check	**8**	**9**	**18**	**6**
	Volume Index (cm^3)			
Mimic®	130	2412	5557	46674
Check	101	1951	4966	40066
Actual Diff. In Growth (cm)	29	461	591	6608
Pct. Gain Compared to Check	**29**	**24**	**12**	**16**

Volume Index = Height X $Diameter^2$

Table 41. Differences in fifth-year height, diameter and volume of protected (Mimic-sprayed) and unprotected loblolly pine exposed to different tip moth pressures.

Tip Moth Pressure on Checks	Treatment §	# Sites at Year 5	N Trees	Mean End of Year 5 Loblolly Pine Seeding Growth Measurements (**Growth Difference (cm/tree, cm³/tree or ft³/acre) Compared to Check**) Height (cm)			Diameter (cm)			Volur		
Low	Mimic	8	378	573.2	**22.7**		8.49	**0.37**		53084		
(0-10%)	Check		393	550.5			8.12			42536		
Med	Mimic	12	629	523.6	**29.7**		8.23	**0.67**		41958.6	**6636.3**	
(11-20%)	Check		673	493.9			7.56			35322.3		
3 High	Mimic	8	391	585.8	**33.0**	*	8.78	**0.55**	*	48593.2	**6056.4**	*
(>20%)	Check		389	552.8			8.23			42536.8		

4/2/2010 - Updated by
1) # sites at yr 3
2) N Trees
3) Ht, Dia, Vol
4) significance

§ Tip Moth Pressure = average percent of shoots infested during the first two years. Mimic was applied to seedlings before each generation (5X/year) during the first two years.

***** Means followed by an asterik are significantly different from checks at the 5% level based on Fisher's Protected LSD.

Table 42. Differences in third-year height, diameter and volume of protected (Mimic-sprayed) and unprotected loblolly pine exposed to different tip moth pressures.

				Mean End of Year 3 Loblolly Pine Seeding Growth Measurements (**Growth Difference (cm/tree, cm³/tree or ft³/acre) Compared to Check**)								
Tip Moth Pressure on Checks	Treatment §	# Sites at Year 3	N Trees	Height (cm)			Diameter (cm)			Volume (cm³/tree)		
Low	Mimic	26	1014	304.3	**15.4**	*	4.25	**0.28**	*	7673.2	**1095.6**	*
(0-10%)	Check		1011	288.9			3.97			6577.6		
Med	Mimic	29	1356	262.6	**23.9**		2.94	**0.47**	*	3937.5	**1073.1**	*
(11-20%)	Check		1366	238.7			2.47			2864.4		
3 High	Mimic	21	1215	255.6	**35.7**	*	3.25	**0.72**	*	3973.0	**1608.2**	*
(>20%)	Check		1217	219.9			2.53			2364.8		

§ Tip Moth Pressure = average percent of shoots infested during the first two years. Mimic was applied to seedlings before each generation (5X/year) during the first two years.

***** Means followed by an asterik are significantly different from checks at the 5% level based on Fisher's Protected LSD.

PINE TIP MOTH TRIALS

Hazard Rating Study – Western Gulf Region

Highlights:

- Data on site characteristics were collected from 18 plots (3 - first-year and 15 - second-year) in the Western Gulf Region in 2009. In total, 138 hazard-rating plots have been established since 2001.
- Trevor Walker, SFA Graduate Student, will provide assistance in the development of the model as part of his Master's Thesis. Some progress was made in 2009 on the development of the hazard-rating model. Regression analysis indicates important predictors of proportion of infested tips include: Age, Generation, Treatment, Site Preparation Release and Additional Herbaceous Control, Fertilization, Depth to Gleying, Boron, Sulfur, pH, Percent Base Saturation of Magnesium, Calcium, and Hydrogen.
- Consolidation of 2001 – 2009 data is ongoing.

Objective: Identify abiotic factors that influence the occurrence and severity of Nantucket pine tip moth infestations in the Western Gulf Region.

Cooperators:

Mr. Conner Fristoe	Plum Creek Timber Co., Crossett, AR
Dr. Nick Chappell	Potlatch Forest Holdings, Warren, AR
Mr. Peter Birks	Weyerhaeuser Co., Columbus, MS
Mr. Bill Stansfield	The Campbell Group, Diboll, TX
Mr. Jeff Hall	Forest Investment Associates, Jackson, MS
Mr. Andrew Burrow	Potlatch Forest Holdings, ID
Mr. Trevor Walker	Stephen F. Austin State University, Nacogdoches, TX
Dr. Dean Coble	Stephen F. Austin State University, Nacogdoches, TX

Study Sites: FPMC members selected from one or five new first-year plantations in 2008 and 2009. These sites were the same as those used in the Impact Study. The untreated Impact plot was also used to collect tip moth and site characteristics data for the Hazard Rating Study. In this situation, a plot area within each plantation was selected, with each plot containing 126 trees (9 rows X 14 trees). The internal 50 trees were evaluated for tip moth damage.

Site Characteristics Data: Site characteristics data collected from 18 Western Gulf plots (3 - first-year and 15 - second-year) in 2009 included:

Soil - Texture and drainage
Soil description/profile: depth of 'A' and to 'B' horizons; color and texture of 'B' horizon
Depth to hard-pan or plow-pan
Depth to gleying
Soil sample (standard analysis plus minor elements and pH)

Tree - Age (1-2)
Percent tip moth infestation of terminal and top whorl shoots – 1^{st}, 2^{nd}, 3^{rd}, and last generation
Height and diameter at 15 cm (6 in) above ground

Site - Previous stand history

Site index (base 25 years)
Silvicultural prescription (for entire monitoring period)
Slope, aspect, and position (ridge, side-slope, bottom, flat)
Competing vegetation: 5 random samples within each plot to determine proportion of bare ground, grasses, forbes and non arborescent woody stems after 2nd and last tip moth generation.
Rainfall (on sight or from nearest weather station)
Estimate of the acreage of susceptible loblolly stands in the 2-5 year age class (< 6 m (15 ft) tall) adjacent to or within 1/2 mile of study stand boundary

Tip Moth Damage Survey: Tip moth infestation levels were determined in each plot by surveying the internal 50 trees during the pupal stage of the first, second and last tip moth generation. Each tree was ranked on the extent of tip moth damage including: 1) tree identified as infested or not, 2) if infested, the proportion of tips infested on the top whorl and terminal was calculated, and 3) separately, the terminal was identified as infested or not. On second-year sites, the 50 sample trees were measured after the last generation for height and diameter at 6 inches and assessed for the occurrence of fusiform rust galls. Incidence of fusiform rust was measured by counting the number of fusiform galls on the main stem and on branches within 30 cm (12 in) of the main stem of each tree.

Data Analysis: Trevor Walker, SFASU, has begun redeveloping the model. With a Bachelors' in Forestry and minor in statistics, Mr. Walker has the expertise the FPMC needs to get the job done. The data (eight years' worth; 2001- 2008) has been consolidated and sent to Mr. Walker by the end of February 2009. Additional data collected from 2009, will be sent to Mr. Walker in April 2010.

The following is an outline provided by Mr. Walker for model development:

A) Choosing a response variable:
    Percent infested => may require variance stabilizing transformation
        By tree or plot/By generation or year => Measuring variability
            -By plot using the first two generations may be the response that is most explained by the predictor variables

B) Identify predictor variables that explain the variation in the response variable:
    Stepwise Regression: Multiple or Logistic
    Regression and Classification Trees
        - Test using subset of data and calculate APER
    Single variable analysis (linear association)
        - simple linear regression, pearson's correlation, graphs
    Interactions between predictor variables - Multicollinearity
        - Correlation Coefficient / Scatterplot Matrix
        - Variable reduction - PCA/Factor Analysis

C) ANOVA – Fabricate a research design using the class variables
    - Unbalanced sample size structure

D) Model infestation levels by generation.
    - Line chart for infestation level by generation by site and both ages (1 and 2).
    - Investigate correlations between infestation levels by generation with predictor variables

E) Develop hazard-rating map.

- Map rating class based on important predictor variables.
- Bayou Bleu Farms, LLC case study/poster.

Results: Figure 28 shows the distribution of all 138 hazard-rating sites established in the Western Gulf Region from 2001 to 2009.

Mr. Burrow's analyses of the first set of data from 57 sites in 2005 resulted in a working model that indicated that, individually, site index, soil texture, soil drainage class, depth to 'B' horizon and stand history were the five important factors that influenced the occurrence and severity of pine tip moth on a site. However, the two-factor model that included site index and soil texture provided the best explanation of site variability (Figure 29).

Data from the second series of sites (2005 – 2006) were used to upgrade the model. The new model indicated that depth to 'B' horizon, texture of 'B' horizon, drainage class, percent silt, sand and clay, and site index were the primary factors influencing tip moth infestation level (Figure 30). Specifically, "good" sites with moderate B horizon depth (30 – 60 cm), good drainage and texture mix are low hazard for tip moth damage (mean annual percent of shoots infested < 10%). On these sites, soil nutrients, texture and water are usually at levels that encourage good growth and allow the trees to resist tip moth attack.

As site characteristics become more extreme, the hazard for tip moth occurrence and damage becomes moderate (11 – 20% shoots infested) and then high (> 20% shoots infested). Such sites will likely have deep or shallow soils with high percentages of sand, silt or clay and tend to be excessively or somewhat poorly drained. Trees growing on such sites are more likely to experience stressful conditions, e.g., poor nutrient availability or anaerobic or drought conditions. A stressed tree would be less able to resist tip moth attack. Thus tip moth damage levels would be higher and impact on growth and form greater.

Although additional data had been collected, time constraints prohibited Mr. Burrow from running any additional analyses and he had to resign from the project in late 2008. Dr. Dean Coble and Mr. Trevor Walker, Stephen F. Austin & State University, have agreed to provide assistance with future analyses and model development. We are in the process of consolidating all available data (2001 – 2008) for these researchers.

Mr. Walker's preliminary regression analysis indicates the following to be important predictors of proportion of infested tips (many of which are confirmed by prior studies):

1) Age - second year sites have higher tip moth populations than first year
2) Generation - there are higher levels seen in later generations
3) Treatment - spraying reduces tip moth population
4) Site Preparation Release and Additional Herbaceous Control- sites with lower levels of competing vegetation tend to show higher tip moth levels.
5) Fertilized sites have significantly lower tip moth top whorl proportion infested (about 8% on average in Ages 1 and 2). Fertilization appears to increase the average number of total shoots while decreasing the average number of infested shoots.

Other variables (depth to gleying, boron, sulfur, pH, percent base saturation of magnesium, calcium, and hydrogen) are regarded as important in the regression model, but have no clear direct effect on proportion of tips infested individually. This suggests that there is an interaction effect between two or more variables in their contribution to the relationship with proportion infested (A good example of this is the soil calcium/site index interaction with the response percent infestation - a graph of which is found in Figure 8, pg 155 of Berisford 1988 in Berryman's Dynamics of Forest Insect Populations). Interactions like this are often tough to find without prior knowledge.

Acknowledgments: We greatly appreciate the efforts of Peter Burk (Weyerhaeuser), Al Cook (independent contractor for International Paper and Plum Creek), Jeff Earl (independent contractor for Plum Creek), Conner Fristoe (Plum Creek), Nick Chappell (Potlatch), Emily Goodwin (Temple-Inland), Bill Stansfield (Campbell Group), Ragan Bounds (Hancock Forest Management), Doug Long (Rayonier), and Jimmy Murphy and Rodney Schroeder (American Forest Management, contractor for Forest Investment Associates), for establishing and monitoring the hazard-rating plots. Many thanks go to Andy Burrow, Potlatch, for his time and efforts in the initial model development phase.

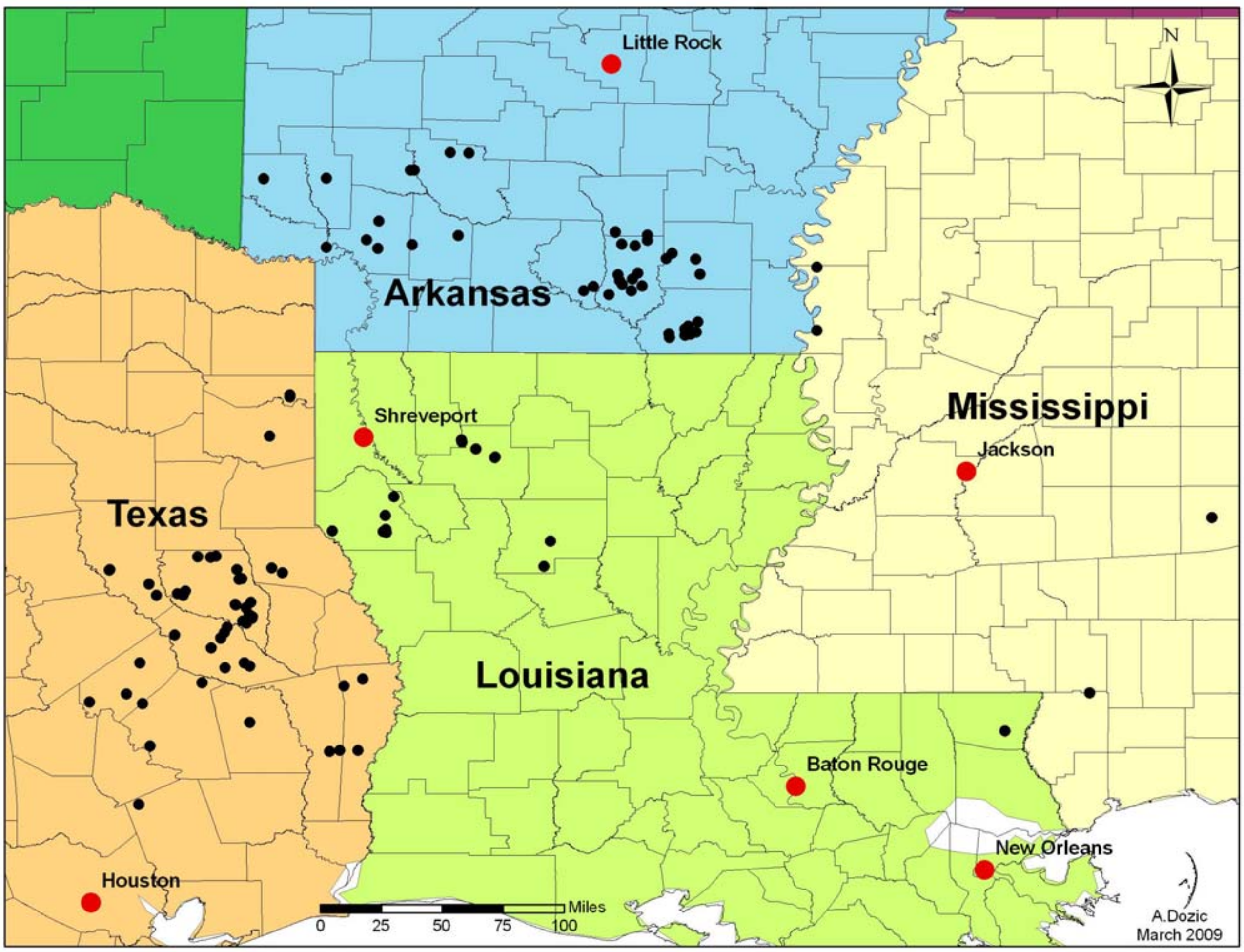


Figure 28. Distribution of 138 hazard-rating plots (●) established from 2001 - 2009 in the Western Gulf Region.

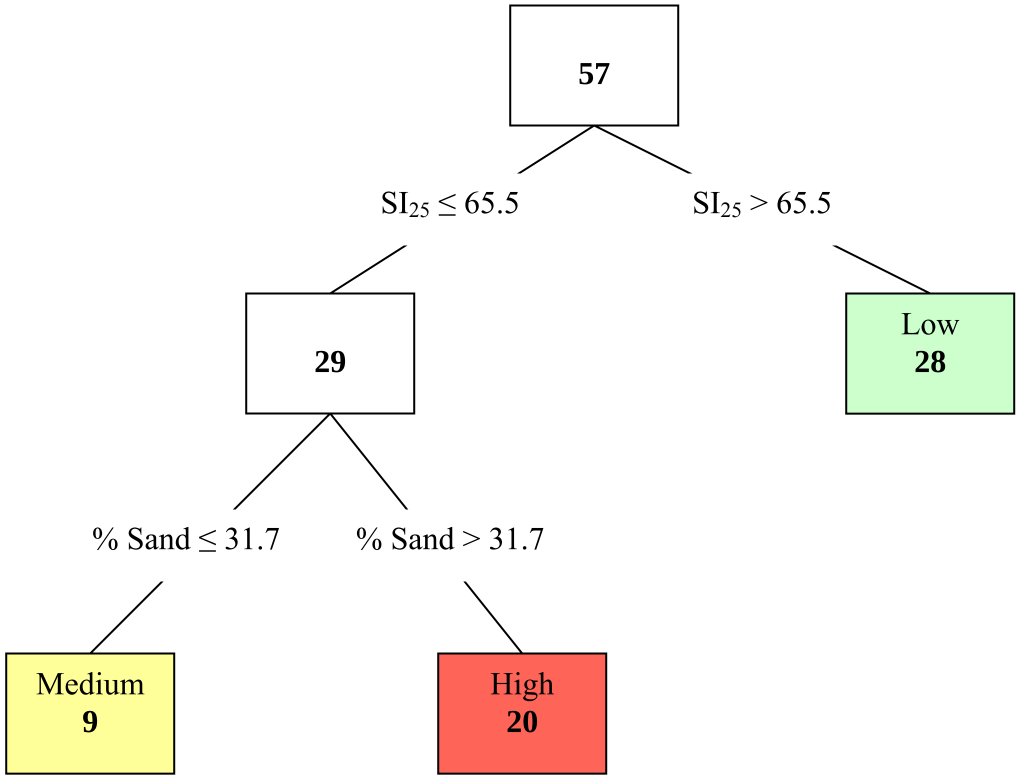


Figure 29. Classification tree describing a hazard rating system for tip moth infestation in one (1) and two (2) year old pine plantations. Bold numbers represent the number of sample points at each node.

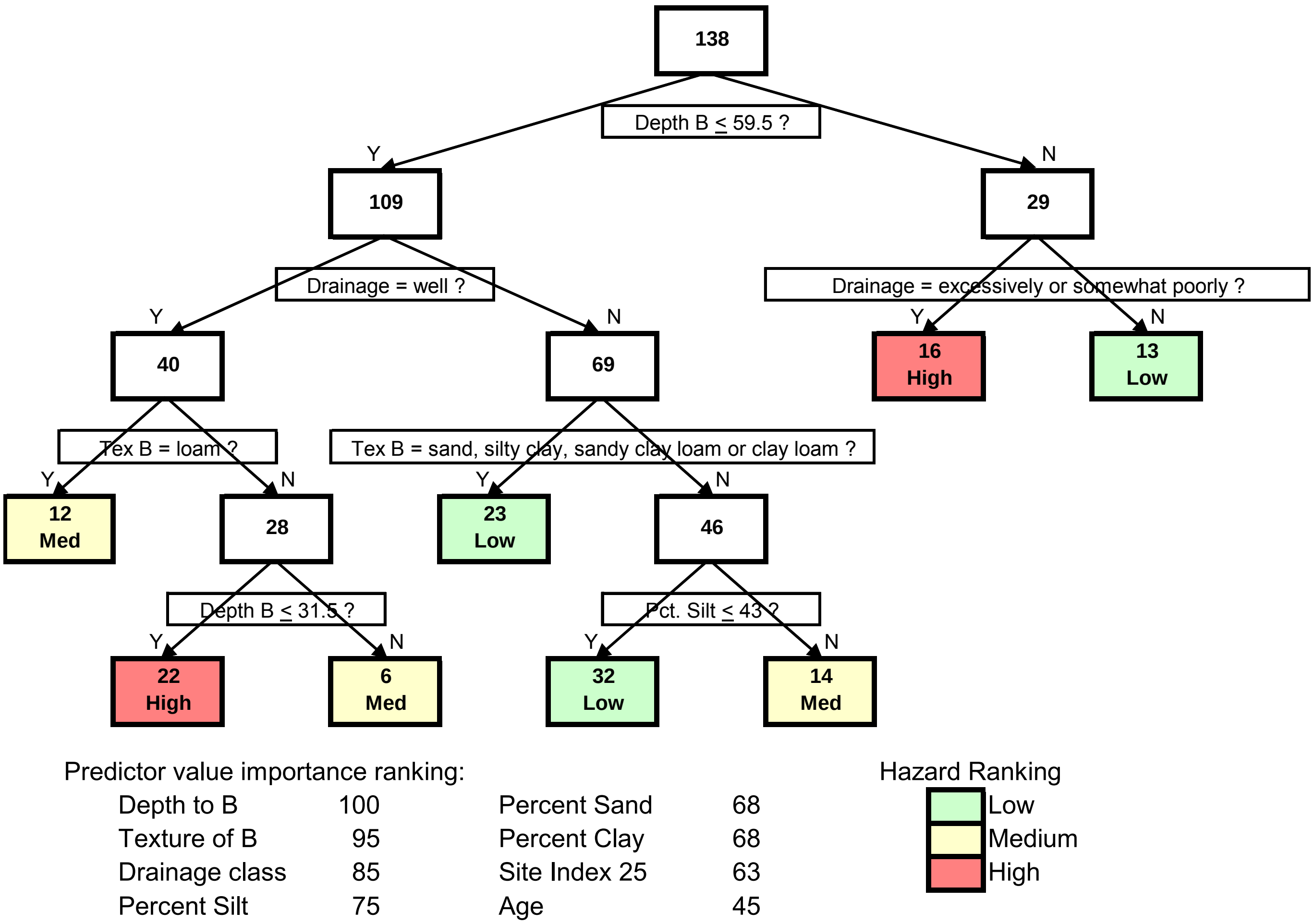


Figure 30. Revised classification tree describing a hazard rating system for tip moth infestation in one (1) and two (2) year old pine plantations. Bold numbers represent the number of sample points at each node; Y is Yes and N is No.

PINE TIP MOTH TRIALS

Evaluation of Fipronil Treatments for Containerized Pine Seedlings

Highlights:

- In 2007, fipronil treatments (1X and 5X) applied to containerized pine seedlings provided exceptional protection against tip moth throughout the first growing season: 99% and 100% reduction in damage compared to check. Fipronil soil injection to bare-root seedlings was less effective, but still reduced damage by 75%. All fipronil treatments significantly improved height, diameter and volume growth
- In 2008, tip population pressures were severe (81 – 100% shoot infestation during generations 4 & 5). Both containerized treatments (1X and 5X) still provided good protection against tip moth through the second growing season: 52% and 65% reduction in damage compared to check. However, effectiveness of the soil injection treatment nearly disappeared after the second generation. Volume growth improvements due to fipronil treatments ranged from 64 – 94%.
- In 2009, tip population pressures were again high (68 - 93% shoot infestation of untreated seedlings during generation 5). Both containerized treatments (1X and 5X) still provided moderate protection against tip moth through the second growing season: 16% and 50% reduction in damage compared to check trees, respectively. Effectiveness of the soil injection treatment improved, reducing damage by 31%. Volume growth improvements due to fipronil treatments ranged from 22 – 70%.

Objectives: 1) Evaluate the efficacy of fipronil applied at different rates to containerized seedlings for reducing pine tip moth infestation levels, 2) evaluate the efficacy of fipronil on containerized versus bare-root seedlings; and 4) determine the duration of chemical activity.

Cooperators:

Mr. Bill Stansfield	The Campbell Group, Diboll, TX
Dr. Harry Quicke	BASF Corp., Auburn, AL

Study Sites: Two first-year Campbell Group (formerly Temple Inland) plantations were selected in Polk County and Angelina County, Texas in February 2007.

Insecticides:

Fipronil SC (fipronil) – a phenyl pyrazole with some systemic activity against Lepidoptera.

Research Approach:

A randomized complete block design was used at each site with sites serving as blocks, i.e., each treatment was randomly selected for placement in an area. For each treatment, one hundred seedlings were monitored in each of two subplots. The treatments included:

1) Containerized Fipronil (1X - 3 ml/seedling) - Injection into cell in July
2) Containerized Fipronil (5X - 15 ml/seedling) - Injection into cell in July
3) Containerized Check (untreated)
4) Bare-root Fipronil (12 ml/seedling) - Soil injection next to transplant in March
5) Bare-root Single Mimic® Foliar - Mimic® applied 5X /year
6) Bare-root Check (untreated)

Two families of loblolly pine containerized and bare-root seedlings were selected at the Temple Inland Nursery (now owned by The Campbell Group), Jasper, TX.

Containerized seedlings were individually treated using a small syringe in July 2006. The seedlings were treated at 1X and 5X the rate designated for transplanted bare-root seedlings (1X = 0.13 lbs AI/acre/year = 0.118 g AI/seedling at 500 seedlings/acre). All bare-root seedlings were operationally lifted by machine in March 2007, culled of small and large caliper seedlings, treated with Terrasorb™ root coating, bagged and stored briefly in cold storage. Each family was planted on each of two plantation sites. At each site, treatments were randomly assigned to 1 of 6 plot areas. One hundred seedlings were planted per plot at 8' X 11' spacing (500 TPA).

Data Evaluation: Tip moth damage was evaluated on 50 seedlings located on the interior of each plot after each tip moth generation (3-4 weeks after peak moth flight) by 1) identifying if the tree was infested or not, 2) if infested, the proportion of tips infested on the top whorl and terminal was calculated; and 3) separately, the terminal was identified as infested or not. Observations also were made as to the occurrence and extent of damage caused by other insects, i.e., aphids, weevils, coneworms, etc. The trees were measured for height and diameter (at 15 cm or 6 in) in December following planting. Data were analyzed by GLM and the Fisher's Protected LSD test using Statview or SAS statistical programs.

Results: In 2007, tip moth populations were quite low on both sites during the first generation; $\leq$ 2% of the shoots were infested on check trees. As a result of the low tip moth pressure, none of the treatments significantly reduced tip moth infestation of top whorl shoots compared to the check during the first generation (Table 43). The fipronil treatments on the containerized seedlings had a significant effect on tip moth damage from the second through the fifth tip moth generation, reducing overall damage by 97 – 100%. The soil injection treatment of the bare-root stock also was quite effective against tip moth but not to the extent observed on the containerized seedlings. All fipronil treatments significantly improved height, diameter and volume index compared to check trees (Tables 46). However, the Mimic® spray treatment had no apparent effect on any of the growth parameters compared to check trees.

In 2008, tip moth population pressure was much greater than in 2007, with an average of >90% of the top-whorl shoots infested on check trees during the 4th and 5th generations and a mean of >57% shoots infested over the entire growing season (5 generations) (Table 44). Efficacies of the two fipronil containerized treatments declined through the second year, but the treatments still reduced overall damage by 52 – 65%. The soil injection treatment only slightly reduced tip moth damage after the second generation. All treatments significantly improved height, diameter and volume index compared to check trees (Tables 46). Volume growth improvements attributed to fipronil treatments ranged from 64 – 94%. Protection with us of Mimic® actually improved with the application of new product and crop oil surfactant, thus the effect of spray treatment on all growth parameters became significant compared to check trees.

In 2009, tip moth population pressure was moderately high, with an average of >67% of the top-whorl shoots infested on check trees during the 5th generation and a mean of >34% shoots infested over the entire growing season (5 tip moth generations) (Table 45). Efficacies of the two fipronil treatments on containerized trees continued to decline through the second year, but the treatments still reduced overall damage by 16-51%. The efficacy of the soil injection treatment actually improved, reducing tip moth damage by 31% (compared to 11% in the second year). All treatments significantly improved height, diameter and volume index compared to check trees (Tables 46). Volume growth improvements attributed to fipronil treatments ranged from 22 – 70%. Seedlings treated previously with Mimic® (2008) continued to exhibit significantly reduced pine tip moth damage and thus the effect of spray treatment on all growth parameters became even greater compared to check trees.

Acknowledgments: Thanks go to Jim Tule, formerly with Temple Island, for providing seedlings and research sites in TX and to Bill Stansfield and The Campbell Group for continued access to study sites. We also thank Dr. Harry Quicke, BASF, for providing the fipronil formulation for the project.

Table 43. Effect of fipronil application technique and rate on pine tip moth infestation of loblolly pine shoots after each of 5 generations on two sites in East Texas - 2007.

		Mean Percent of Loblolly Pine Shoots Infested (**Pct. Reduction Compared to Check**)											
Treatment §	N	Ang.	Polk	Mean		Ang.	Polk	Mean		Ang.	Polk	Mean	
		Generation 1				Generation 2				Generation 3			
Containerized FIP 3 ml	200	0.0	0.0	0.0	**100**	0.0	0.3 *	0.1 *	**97**	0.0 *	0.0 *	0.0 *	**100**
Containerized FIP 15 ml	200	0.0	0.0	0.0	**100**	0.0	0.0 *	0.0 *	**100**	0.0 *	0.0 *	0.0 *	**100**
Containerized Check	200	0.5	0.0	0.2		2.0	7.8	4.9		5.2	4.7	4.9	
BR FIP SI 12 ml	100	1.0	0.0 *	0.5	**62**	4.0 *	0.5	2.3 *	**72**	3.2	2.0 *	2.6	**54**
BR Mimic	100	1.2	0.0 *	0.6	**55**	0.7 *	4.1	2.4 *	**70**	0.0	0.5 *	0.3 *	**96**
BR Check	100	2.0	0.7	1.3		11.8	4.0	7.9		3.0	8.3	5.6	
		Generation 4				Generation 5				Mean			
Containerized FIP 3 ml	200	0.0 *	0.3 *	0.2 *	**100**	1.3 *	0.3 *	0.8 *	**97**	0.3 *	0.2 *	0.2 *	**99**
Containerized FIP 15 ml	200	0.0 *	0.0 *	0.0 *	**100**	0.0 *	0.0 *	0.0 *	**100**	0.0 *	0.0 *	0.0 *	**100**
Containerized Check	200	46.8	39.2	43.0		18.9	38.2	28.5		14.7	18.0	16.3	
BR FIP SI 12 ml	100	3.3 *	6.7	5.0 *	**76**	8.5 *	4.5 *	6.5 *	**79**	4.0 *	2.7 *	3.4 *	**75**
BR Mimic	100	4.2 *	10.2	7.2 *	**65**	4.9 *	21.1 *	13.0 *	**59**	2.2 *	7.2 *	4.7 *	**65**
BR Check	100	26.7	14.7	20.7		25.5	37.7	31.6		13.8	13.1	13.4	

§ SI- Fipronil soil injection

(shaded) = treatment reduced damage by>75% compared to check.

* Means followed by an asterik are significantly different from checks at the 5% level based on Fisher's Protected LSD.

Table 44. Effect of fipronil application technique and rate on pine tip moth infestation of loblolly pine shoots after each of 5 generations on two sites in East Texas - 2008.

Mean Percent of Loblolly Pine Shoots Infested (**Pct. Reduction Compared to Check**)

Treatment §	N	Ang.	Polk	Mean		Ang.	Polk	Mean		Ang.	Polk	Mean	
		Generation 1				Generation 2				Generation 3			
Containerized FIP 3 ml	200	4.7 *	12.0 *	8.3 *	**65**	13.0 *	10.1 *	11.6 *	**73**	16.3 *	32.4 *	24.3 *	**61**
Containerized FIP 15 ml	200	3.8 *	11.1 *	7.4 *	**69**	4.5 *	8.9 *	6.7 *	**84**	10.9 *	31.2 *	21.0 *	**66**
Containerized Check	200	23.5	24.1	23.8		46.6	39.9	43.2		50.0	73.2	61.6	
BR FIP SI 12 ml	100	11.2	15.1	13.1	**29**	33.0	15.2 *	24.1 *	**34**	43.5	46.9 *	45.2	**6**
BR Mimic	100	8.0 *	8.8 *	8.4 *	**54**	11.0 *	3.6 *	7.3 *	**80**	17.9 *	7.1 *	12.5 *	**74**
BR Check	100	15.9	20.9	18.4		37.4	35.8	36.6		36.5	59.8	48.2	

Treatment §	N	Ang.	Polk	Mean		Ang.	Polk	Mean		Ang.	Polk	Mean	
		Generation 4				Generation 5				Mean			
Containerized FIP 3 ml	200	23.8 *	70.4 *	47.1 *	**48**	39.8 *	70.1 *	57.3 *	**37**	20.5 *	39.1 *	29.8 *	**52**
Containerized FIP 15 ml	200	15.0 *	51.6 *	33.2 *	**63**	23.2 *	61.0 *	44.1 *	**52**	11.9 *	32.4 *	22.1 *	**65**
Containerized Check	200	82.0	98.4	90.2		77.9	97.2	91.3		57.8	66.9	62.4	
BR FIP SI 12 ml	100	86.3	95.0	90.7	**0**	65.7 *	93.0	82.7 *	**12**	49.4	53.0 *	51.2 *	**11**
BR Mimic	100	34.3 *	15.3 *	24.8 *	**73**	30.9 *	30.6 *	33.0 *	**65**	20.9 *	12.7 *	16.8 *	**71**
BR Check	100	81.4	100.0	90.7		83.0	96.0	94.1		52.7	62.8	57.6	

§ SI- Fipronil soil injection

[grey shading] = treatment reduced damage by >75% compared to check.

* Means followed by an asterik are significantly different from checks at the 5% level based on Fisher's Protected LSD.

Table 45. Effect of fipronil application technique and rate on pine tip moth infestation of loblolly pine shoots after each of 5 generations on two sites in East Texas - 2009.

Mean Percent of Loblolly Pine Shoots Infested (**Pct. Reduction Compared to Check**)

Treatment §	N	Ang.	Polk	Mean		Ang.	Polk	Mean		Ang.	Polk	Mean	
		Generation 1				Generation 2				Generation 3			
Containerized FIP 3 ml	200	6.9 *	12.3	9.6 *	**39**	3.6	2.4 *	3.0 *	**59**	7.5 *	27.0	17.2 *	**32**
Containerized FIP 15 ml	200	3.2 *	7.4 *	5.3 *	**66**	1.6 *	1.6 *	1.6 *	**79**	7.8 *	16.0 *	11.9 *	**53**
Containerized Check	200	13.9	17.7	15.8		7.2	7.6	7.4		21.6	28.9	25.2	
BR FIP SI 12 ml	100	6.0	5.6 *	5.8 *	**54**	10.5	7.0	8.8	**0**	20.5	6.5 *	13.5 *	**48**
BR Mimic	100	5.1	2.3 *	3.7 *	**71**	4.3	3.5	3.9 *	**55**	12.8 *	14.9	13.8 *	**47**
BR Check	100	7.1	18.3	12.7		9.0	8.4	8.7		26.4	25.4	25.9	

Treatment §	N	Ang.	Polk	Mean		Ang.	Polk	Mean		Ang.	Polk	Mean	
		Generation 4				Generation 5				Mean			
Containerized FIP 3 ml	200	42.5	44.6 *	43.6 *	**13**	73.5	61.4	67.5	**3**	26.8 *	29.5	28.2 *	**16**
Containerized FIP 15 ml	200	19.0 *	31.2 *	25.1 *	**50**	37.9 *	38.8 *	38.3 *	**45**	13.9 *	19.0 *	16.4 *	**51**
Containerized Check	200	44.9	55.4	50.1		76.6	62.8	69.7		32.8	34.5	33.7	
BR FIP SI 12 ml	100	50.3 *	23.3 *	36.8	**8**	67.9 *	34.7 *	51.3 *	**36**	31.1	15.4 *	23.2 *	**31**
BR Mimic	100	24.8	16.7 *	20.8 *	**48**	43.2 *	31.3 *	37.3 *	**54**	18.0 *	13.7 *	15.9 *	**53**
BR Check	100	33.3	46.9	40.1		92.7	68.2	80.5		33.7	33.4	33.6	

§ SI- Fipronil soil injection

(shaded) = treatment reduced damage by >75% compared to check.

* Means followed by an asterik are significantly different from checks at the 5% level based on Fisher's Protected LSD.

Table 46. Effect of fipronil application technique and rate on loblolly pine growth after attack by pine tip moth on two sites in East Texas: 2007-2009.

			Mean End of Season Tree Measurements (**Growth Difference (cm or cm^3) Compared to Check**)											
Year	Treatment	N	Height (cm)				Diameter (cm)				Volume (cm^3)			
			Ang.	Polk	Mean		Ang.	Polk	Mean		Ang.	Polk	Mean	
2007	Containerized FIP 3 ml	100	78.2	93.0	85.6 *	**16.6**	1.31	1.53	1.42 *	**0.27**	165.3	248.7	207.0 *	**86.9**
	Containerized FIP 15 ml	100	77.9	97.0	87.4 *	**18.4**	1.21	1.76	1.49 *	**0.33**	146.7	353.8	250.2 *	**130.1**
	Containerized Check	100	57.6	80.4	69.0		0.96	1.35	1.16		75.8	165.6	120.2	
	BR FIP SI 12 ml	50	64.9	95.2	80.1 *	**12.4**	1.35	1.88	1.62 *	**0.39**	193.4	409.9	301.6 *	**160.4**
	BR Mimic	50	69.3	86.7	78.0	**10.4**	1.35	1.65	1.50	**0.28**	179.5	294.1	236.8	**95.6**
	BR Check	50	51.0	84.3	67.6		0.94	1.50	1.22		62.4	220.1	141.2	
2008	Containerized FIP 3 ml	100	137.6	163.1	150.3 *	**29.4**	2.59	3.36	2.97 *	**0.48**	1127.2	2130.8	1629.0 *	**634.4**
	Containerized FIP 15 ml	100	132.0	178.1	155.0 *	**34.1**	2.51	3.66	3.09 *	**0.60**	1091.3	2794.7	1943.0 *	**948.4**
	Containerized Check	100	104.6	137.4	121.0		1.99	2.99	2.49		607.9	1381.3	994.6	
	BR FIP SI 12 ml	50	130.1	176.2	153.1 *	**33.2**	2.50	3.84	3.17 *	**0.55**	1264.5	3027.6	2146.0 *	**915.9**
	BR Mimic	50	149.4	181.2	165.3 *	**45.4**	2.85	3.68	3.27 *	**0.65**	1658.1	2853.7	2255.9 *	**1025.8**
	BR Check	50	92.0	149.0	119.9		1.83	3.43	2.62		423.2	2070.6	1230.1	
2009	Containerized FIP 3 ml	100	219.7	275.3	247.5 *	**25.9**	4.60	5.67	5.13 *	**0.31**	5481	9726	7604 *	**1345**
	Containerized FIP 15 ml	100	243.9	293.1	268.5 *	**46.9**	5.23	6.22	5.73 *	**0.90**	7878	12627	10253 *	**3994**
	Containerized Check	100	191.9	251.3	221.6		4.07	5.58	4.83		4187	8329	6258	
	BR FIP SI 12 ml	50	219.3	293.7	256.9 *	**50.6**	4.70	6.34	5.53 *	**1.07**	5945	13166	9592 *	**3948**
	BR Mimic	50	280.9	314.2	297.5 *	**91.2**	5.57	6.59	6.08 *	**1.63**	10864	15053	12959 *	**7314**
	BR Check	50	157.5	255.1	206.3		3.42	5.49	4.46		2592	8697	5644	

* Means followed by an asterik are significantly different from checks at the 5% level based on Fisher's Protected LSD.

PINE TIP MOTH TRIALS

Fipronil Soil Injection Treatment Studies – East Texas

Highlights:

- In 2008, all fipronil treatments, regardless of placement and depth, significantly reduced tip moth damage during most tip moth generations in the second year after planting. Overall damage was reduced by 45 - 51% compared to check trees. Only the shallow (4") soil injection and Mimic® spray treatments significantly improved tree growth. In 2009, fipronil protection faded after the first generation. Overall damage was not significantly reduced compared to check trees. Only the shallow (4") soil injection and Mimic® spray treatments significantly improved tree growth.
- In 2009, most fipronil treatments significantly reduced tip moth damage during several generations in the second year after planting. Overall damage was reduced by 30 - 75% compared to check trees. Generally, increasing treatment volume improved protection against tip moth. None of the treatments significantly improved tree growth.

Objectives: 1) Evaluate the efficacy of PTM™ Insecticide (fipronil) applied to second-year pine seedlings for reducing pine tip moth infestation levels, 2) evaluate PTM™ efficacy using different soil injection techniques; and 4) determine the duration of PTM™ activity.

Cooperators

Dr. Harold Quicke	BASF, Auburn, AL
Ms. Francis Peavy	Private landowner, Hudson, TX
Mr. Ragan Bounds	Hancock Forest Management, Woodville, TX

Study Sites: Two one-year-old plantations (one planted in 2007 and one planted in 2008) near Hudson and Colmesneil, Texas, were selected. The plots contained 6 treatments and 300 trees (5 rows X 50 trees).

Insecticides:

Fipronil – PTM™ Insecticide (0.9 lbs ai/gal), BASF Corp.
Imidacloprid – SilvaShield™ Forestry Tablet (20% ai), Bayer Crop Science

Research Approach:

A randomized complete block design was used at each site with beds or site areas serving as blocks, i.e., each treatment was randomly selected for placement along a bed. Ten seedlings from each treatment were planted on each of five beds. 1 site X 6 treatments X 50 trees = 300 monitored trees.

The treatments includes

<u>Trial 1</u>:

1 =	PTM™ (1X - 12 ml/tree) -	single injection into soil 4" deep
2 =	PTM™ (1X - 12 ml/tree) -	double injection (6 ml ea.) into soil 4" deep
3 =	PTM™ (1X - 12 ml/tree) -	single injection into soil 8" deep
4 =	PTM™ (1X - 12 ml/tree) -	double injection (6 ml ea.) into soil 8" deep
5 =.	Foliar spray -	Mimic® applied 5X/ seedling
6 =	Check (untreated) -	Resident seedling

Trial 2:

1 =	PTM™ (1.4 ml/tree LO Vol) -	double injection (7.5 ml ea.) into soil 4" deep
2 =	PTM™ (1.4 ml/tree HI Vol) -	double injection (15 ml ea.) into soil 4" deep
3 =	PTM™ (2.8 ml/tree LO Vol) -	double injection (7.5 ml ea.) into soil 4" deep
4 =	PTM™ (2.8 ml/tree HI Vol) -	double injection (15 ml ea.) into soil 4" deep
5 =.	SilvaShield™ tablet -	2 tablets (1 on ea. side) into soil 4" deep
6 =	Check (untreated) -	Resident seedling

A 1-acre (approximate) area within each site was selected. A randomized complete block design was established with beds (or rows of trees) serving as blocks, i.e., each treatment was randomly selected for placement along a bed. Fifty trees for each treatment were selected on each site. Ten trees were assigned a given treatment on each of five beds (see Plot Design Example). The fipronil soil injection treatments were applied 13 February 2008 (Trial 1) and 4 February 2009 (Trial 2)

All soil injection treatments were applied using the PTM™ soil injector (Figure 20). The injector point was positioned about 4 inches from each seedling and forced into the soil at an angle to a depth of 5 inches. Once the fipronil solution was applied the injector was removed and the hole was covered with soil to prevent root desiccation.

Tip moth damage was evaluated after each tip moth generation (3-4 weeks after peak moth flight; 5 generations in TX) by 1) identifying if the tree was infested or not, 2) if infested, the proportion of tips infested on the top whorl and terminal were calculated; and 3) separately, the terminal was identified as infested or not. Each tree was measured for diameter (at 15 cm or 6 in) and height in winter 2008 and 2009.

Results:

Trial 1: In 2008, tip moth populations were quite high throughout the year with damage levels ranging from 14% of the shoots infested on check trees after generation 1 to >80% after the 5th generation (Table 47). As a result of the late treatment application date, none of the soil injection treatments significantly reduced tip moth infestation of top whorl shoots compared to the check during the first generation. However, all fipronil treatments, regardless of depth or placement, provided moderate to good protection against tip moth during 2nd, 3rd, 4th and 5th generations. Overall reduction in damage compared to checks ranged from 45% to 51%. None of the fipronil treatments negatively affected seedling survival after 5 generations. On Peavy 1, none the treatments significantly improved tree growth parameters (height, diameter, or volume index) compared to check trees (Table 49 & 50). In contrast, growth (height, diameter and volume) was significantly greater for shallow (4") soil injection treatments and Mimic®.

In 2009, tip moth populations were generally low during the first three generations with damage levels ranging from 1-14% of the shoots infested on check trees (Table 48). Damage levels increased in later generations (4 & 5) to 19-48%. Most fipronil treatments provided some protection against tip moth during 1st generation. However, protection faded thereafter. On the Peavy 1 site, none the treatments significantly improved tree growth parameters (height, diameter or volume index) compared to check trees (Table 49 & 50). In contrast, growth (height, diameter and volume) was significantly greater for shallow (4") soil injection treatments and Mimic® on Peavy 2.

Trial 2: In 2009, tip moth populations were fairly low through most of the year with damage levels ranging from 2% of the shoots infested on check trees after generation 1 to 19% after the 5th generation (Table 51). As a result of the late treatment application date, none of the treatments significantly reduced tip moth infestation of top whorl shoots compared to the check during the first generation. However, most fipronil treatments provided moderate protection against tip moth during 2nd and 5th generations. Overall reduction in damage compared to checks ranged from 30% to 75%. The higher volume treatments generally provided better protection. None of the fipronil treatments negatively affected seedling survival after 5 generations. None the treatments significantly improved tree growth parameters (height, diameter or volume index) compared to check trees (Table 52).

Acknowledgments: Thanks go to Ms. Francis Peavy for providing research sites. We also thank Dr. Harry Quicke, BASF, for providing the fipronil formulation, PTM™ Insecticide, for the project.

Table 47. Effect of fipronil application depth and placement on pine tip moth infestation of loblolly pine shoots after each of 5 generations on two sites in East Texas - Trial 1 - 2008.

Treatment §	N	Mean Percent of Loblolly Pine Shoots Infested (**Pct. Reduction Compared to Check**)											
		P 1	P 2	Mean		P 1	P 2	Mean		P 1	P 2	Mean	
		Generation 1				Generation 2				Generation 3			
Single 12 ml SI @ 4" depth	100	12.8	17.9 *	15.2	**27**	13.3 *	27.3 *	20.3 *	**50**	13.5 *	14.2 *	13.9 *	**67**
Single 12 ml SI @ 8" depth	100	12.7	25.8	19.3	**8**	15.2 *	31.0 *	23.2 *	**42**	10.0 *	18.9 *	14.5 *	**65**
Double 6 ml SI @ 4" depth	100	11.6	26.2	18.9	**9**	11.4 *	24.9 *	18.1 *	**55**	8.3 *	16.9 *	12.6 *	**70**
Double 6 ml SI @ 8" depth	100	15.9	16.7 *	16.3	**22**	14.4 *	26.1 *	20.3 *	**50**	8.4 *	24.6 *	16.5 *	**61**
Mimic	100	2.8 *	3.9 *	3.3 *	**84**	18.7 *	23.1 *	20.9 *	**48**	6.0 *	9.6 *	7.7 *	**82**
Check	100	14.1	27.7	20.9		33.3	47.4	40.3		29.2	55.2	42.1	
		Generation 4				Generation 5				Mean			
Single 12 ml SI @ 4" depth	100	28.7 *	38.7 *	33.7 *	**51**	37.0 *	39.3 *	38.1 *	**49**	21.0 *	27.8 *	24.4 *	**51**
Single 12 ml SI @ 8" depth	100	31.5 *	36.1 *	33.9 *	**51**	45.6 *	44.5 *	45.1 *	**40**	23.0 *	31.3 *	27.2 *	**45**
Double 6 ml SI @ 4" depth	100	20.3 *	37.7 *	28.9 *	**58**	31.0 *	51.0 *	41.0 *	**45**	16.7 *	31.2 *	24.0 *	**51**
Double 6 ml SI @ 8" depth	100	36.9 *	39.7 *	38.3 *	**44**	38.4 *	51.9 *	45.2 *	**40**	22.5 *	31.9 *	27.2 *	**45**
Mimic	100	4.0 *	2.1 *	3.1 *	**96**	5.7 *	3.1 *	4.4 *	**94**	7.6 *	8.4 *	8.0 *	**84**
Check	100	62.3	75.1	68.7		68.9	81.1	74.9		41.5	57.3	49.4	

§ SI- Fipronil soil injection   [shaded] = treatment reduced damage by >75% compared to check.

***** Means followed by an asterik are significantly different from checks at the 5% level based on Fisher's Protected LSD.

Table 48. Effect of fipronil application depth and placement on pine tip moth infestation of loblolly pine shoots after each of 5 generations on two sites in East Texas - Trial 1 - 2009.

		Mean Percent of Loblolly Pine Shoots Infested (**Pct. Reduction Compared to Check**)											
Treatment §	N	P 1	P 2	Mean		P 1	P 2	Mean		P 1	P 2	Mean	
		Generation 1				Generation 2				Generation 3			
Single 12 ml SI @ 4" depth	100	3.0 *	4.0	3.5 *	**55**	2.7	2.0	2.4	**39**	0.4	5.4 *	2.8 *	**61**
Single 12 ml SI @ 8" depth	100	9.3	2.0	5.5	**29**	3.8	1.6	2.7	**31**	0.7	5.7 *	3.2	**56**
Double 6 ml SI @ 4" depth	100	2.2 *	3.9	3.1 *	**60**	2.9	2.4	2.7	**31**	2.8	13.0	7.9	**-7**
Double 6 ml SI @ 8" depth	100	2.6 *	3.1	2.8 *	**64**	4.1	2.1	3.1	**21**	1.3	7.7	4.5	**39**
Mimic	100	0.9 *	2.5	1.7 *	**78**	1.0	3.5	2.3	**42**	0.8	8.5	4.7	**37**
Check	100	9.0	6.4	7.8		2.7	5.1	3.9		1.1	14.0	7.3	
		Generation 4				Generation 5				Mean			
Single 12 ml SI @ 4" depth	100	18.5	28.1	23.2	**4**	26.2	41.7	33.8	**5**	10.1	16.3	13.2	**17**
Single 12 ml SI @ 8" depth	100	15.6	28.3	22.0	**9**	30.1	45.2	37.7	**-6**	11.9	16.6	14.3	**10**
Double 6 ml SI @ 4" depth	100	20.0	30.9	25.4	**-5**	26.2	43.8	34.9	**2**	10.8	18.9	14.8	**6**
Double 6 ml SI @ 8" depth	100	24.0	23.3	23.6	**2**	25.9	47.8	37.0	**-4**	11.6	16.8	14.2	**10**
Mimic	100	18.4	24.5	21.4	**11**	27.1	31.7 *	29.4	**18**	9.7	14.2 *	11.9 *	**25**
Check	100	19.3	29.4	24.2		23.9	48.3	35.7		11.2	20.7	15.8	

§ SI- Fipronil soil injection ▒ = treatment reduced damage by >75% compared to check.
***** Means followed by an asterik are significantly different from checks at the 5% level based on Fisher's Protected LSD.

Table 49. Effect of fipronil application depth and placement on loblolly pine growth 8 and 20 months after treatment on two sites in East Texas - Trial 1 - 2008 & 2009.

			Mean End of Season Tree Measurements (**Growth Difference (cm or cm3) Compared to Check**)											
Year	Treatment	N	Height (cm)				Diameter (cm)				Volume (cm^3)			
			P 1	P 2	Mean		P 1	P 2	Mean		P 1	P 2	Mean	
2008	Single 12 ml SI @ 4" depth	100	157.1	115.6 *	136.6 *	**8.2**	3.43	2.50	2.97	**0.14**	2066.5	833.3 *	1456.1 *	**15**
	Single 12 ml SI @ 8" depth	100	140.2	106.7	123.3	**-5.1**	3.14	2.27	2.70	**-0.13**	1675.8	666.0	1165.8	**-275**
	Double 6 ml SI @ 4" depth	100	156.9	118.7 *	137.8 *	**9.4**	3.52	2.56 *	3.04 *	**0.21**	2136.1	887.3 *	1511.7 *	**71**
	Double 6 ml SI @ 8" depth	100	158.8	108.8	133.6	**5.2**	3.60	2.33	2.96	**0.12**	2438.3	654.5	1537.2	**96**
	Mimic	100	148.7	115.6 *	142.1 *	**13.7**	3.28	3.00 *	3.14 *	**0.31**	1890.3	1349.2 *	1619.8 *	**179**
	Check	100	153.2	103.1	128.4		3.38	2.28	2.83		2242.2	623.4	1441.0	
2009	Single 12 ml SI @ 4" depth	100	295.3	232.8 *	264.7 *	**20.4**	6.16	5.08 *	5.63 *	**0.35**	11879.8	6411.8 *	9201.6 *	**1189**
	Single 12 ml SI @ 8" depth	100	266.7	221.4	243.8	**-0.5**	5.60	4.89 *	5.24	**-0.05**	9528.6	5691.5 *	7590.3	**-423**
	Double 6 ml SI @ 4" depth	100	287.6	231.1 *	259.6 *	**15.3**	6.27	5.00 *	5.64 *	**0.36**	11988.2	6234.3 *	9140.9 *	**1128**
	Double 6 ml SI @ 8" depth	100	296.0	219.8	257.5	**13.2**	6.32	4.80	5.55	**0.27**	13087.6	5321.0	9164.2	**1151**
	Mimic	100	282.2	251.5 *	266.8 *	**22.5**	6.04	5.60 *	5.82 *	**0.54**	11389.5	8283.9 *	9836.7 *	**1824**
	Check	100	279.7	206.7	244.3		5.99	4.53	5.28		11217.1	4604.2	8012.9	

* Means followed by an asterik are significantly different from checks at the 5% level based on Fisher's Protected LSD.

Table 50. Effect of fipronil application depth and placement on yearly loblolly pine height growth 8 and 20 months after treatment on two sites in East Texas - Trial 1 - 2008 & 2009.

Year	Treatment	N	Mean Yearly Height Growth (**Growth Difference (cm) Compared to Check**)			
			P 1	P 2	Mean	
2008	Single 12 ml SI @ 4" depth	100	87.1	68.0	77.6 *	**5.1**
	Single 12 ml SI @ 8" depth	100	74.7	63.5	69.0	**-3.6**
	Double 6 ml SI @ 4" depth	100	88.6	70.6 *	79.6 *	**7.0**
	Double 6 ml SI @ 8" depth	100	88.3	62.9	75.5	**2.9**
	Mimic	100	79.1	80.7 *	79.9 *	**7.3**
	Check	100	84.3	60.6	72.6	
2009	Single 12 ml SI @ 4" depth	100	138.2 *	117.1 *	127.9 *	**12.2**
	Single 12 ml SI @ 8" depth	100	126.1	113.6 *	119.8	**4.1**
	Double 6 ml SI @ 4" depth	100	130.7	112.2 *	121.6 *	**5.9**
	Double 6 ml SI @ 8" depth	100	137.2 *	111.0 *	124.0 *	**8.3**
	Mimic	100	132.1	116.3 *	124.2 *	**8.5**
	Check	100	126.5	104.2	115.7	

* Means followed by an asterik are significantly different from checks at the 5% level based on Fisher's Protected LSD.

Table 51. Effect of fipronil application depth and placement on pine tip moth infestation of loblolly pine shoots after each of 5 generations on one site in East Texas - Trial 2 - 2009.

		Mean Percent of Loblolly Pine Shoots Infested (**Pct. Reduction Compared to Check**)											
Treatment §	N	Gen 1		Gen 2		Gen 3		Gen 4		Gen 5		Mean	
PTM (1.4 ml) - 15 ml dilution	50	4.0	**-65**	0.3 *	**91**	0.4	**89**	4.3	**-26**	12.9	**31**	4.4 *	**30**
PTM (1.4 ml) - 30 ml dilution	50	1.5	**38**	1.6	**55**	1.0	**71**	3.9	**-14**	9.3 *	**50**	3.5 *	**45**
PTM (2.8 ml) - 15 ml dilution	50	5.2	**-115**	0.3 *	**91**	1.1	**70**	3.7	**-10**	9.2 *	**51**	3.9 *	**38**
PTM (2.8 ml) - 30 ml dilution	50	1.0	**59**	1.2 *	**67**	0.0 *	**100**	0.0 *	**100**	5.8 *	**69**	1.6 *	**75**
SilvaShield (2 tablets)	50	2.1	**12**	0.0 *	**100**	1.8	**48**	1.5	**57**	7.1 *	**62**	2.5 *	**60**
Check	50	2.4		3.6		3.5		3.4		18.6		6.3	

§ SI- Fipronil soil injection [shaded box] = treatment reduced damage by >75% compared to check.

***** Means followed by an asterik are significantly different from checks at the 5% level based on Fisher's Protected LSD.

Table 52. Effect of fipronil application depth and placement on loblolly pine growth 8 months after treatment on one sites in East Texas - Trial 2 - 2009.

		Mean Second Year Growth (**Growth Difference (cm or cm³) Compared to Check**)					
Treatment	N	Height (cm)		Diameter (cm)		Volume (cm^3)	
PTM (1.4 ml) - 15 ml dilution	50	119.1	**-7.8**	2.70	**0.11**	1005.1	**-31**
PTM (1.4 ml) - 30 ml dilution	50	104.7 *	**-22.2**	2.35	**-0.24**	748.0 *	**-288**
PTM (2.8 ml) - 15 ml dilution	50	112.6 *	**-14.2**	2.66	**0.07**	1116.7	**81**
PTM (2.8 ml) - 30 ml dilution	50	115.8	**-11.1**	2.50	**-0.08**	851.8	**-184**
SilvaShield (2 tablets)	50	126.1	**-0.7**	2.78	**0.19**	1239.7	**204**
Check	50	126.8		2.59		1035.8	

* Means followed by an asterik are significantly different from checks at the 5% level based on Fisher's Protected LSD.

PINE TIP MOTH TRIALS

Fipronil Operational Soil Injection Study - Western Gulf Region

Highlights

- Fipronil treatments were successfully applied by hand after seedling planting using Kioritz and drench applicators in 2006. The treatments were generally effective in later generations of the first year and marginally effective in the second year in reducing tip moth damage, but had no effect on tree growth.
- A soil injection system on a machine planter, was used to treat a series of plots on three sites in 2007. The machine-applied fipronil treatment was nearly as effective (46%) as Mimic® sprays (55%) in reducing tip moth damage during the first three years (2007 – 2009). The hand-applied fipronil was somewhat less effective (33%) than the machine application. Treatment efficacy declined gradually from year to year. Both fipronil treatments significantly improved all growth parameters (height, diameter, and volume) compared to untreated checks.
- The machine planter soil injection system was again successfully used to treat a series of plots on two sites in 2008. The machine-applied fipronil treatment was effective in reducing tip moth damage by an average of 25% over the first two years (2008 –2009). Both fipronil treatments significantly improved all growth parameters (height, diameter and volume) compared to untreated checks.

Objectives: **Site 1:** 1) Determine the efficacy of fipronil in reducing area-wide pine tip moth infestation levels on loblolly pine seedlings; 2) evaluate this product applied via soil injection by hand; and 3) determine the duration of protection provided by this insecticide application. **Sites 2-6:** 1) Evaluate the efficacy of fipronil applied via soil injection by machine planter in reducing pine tip moth infestation levels on loblolly pine seedlings; and 2) determine the duration of protection provided by this insecticide application.

Cooperators:

Mr. Wilson Edwards	Weyerhaeuser Co., New Bern, NC
Mr. Randy Winston	Private landowner, Lufkin, TX
Ms. Lou Ann Miller	Private landowner, Nacogdoches, TX
Mr. Jim Rogers and Mr. Lane Day	Precision Machine Services, Lufkin, TX
Mr. Justin Penick	Acorn Forestry Services, Lufkin, TX
Dr. Harry Quicke	BASF Co., Auburn, AL

Study Sites: One first-year plantation was selected near Crossroads, AR in February 2006 and three others, two in Texas near Lufkin and Nacogdoches in November 2006 and one in AR near Oak Grove, in February 2007. Two other sites were selected and planted in early 2008, one near Many, LA and the other near Mineral Springs, AR.

Insecticides:

Fipronil (PTM™ Insecticide, BASF) – a phenyl pyrazole with some systemic activity against Lepidoptera.

Research Approach:

A randomized complete block design was used at each site with site areas serving as blocks, i.e., each treatment was randomly selected for placement in an area. For each treatment, fifty seedlings were monitored in each subplot. The treatments included:

Site 1:

1) HF = Seedling hand planted; afterwards fipronil applied at 0.1g ai (in 3 ml water) per seedling by Kioritz soil injector.
2) HFS = seedlings hand planted; foliar spray (Pounce® or Mimic®2LV (0.6 ml / liter of water)) applied (5X)
3) HC = seedlings hand planted; no additional treatment (Check).

Sites 2, 3 & 4:

1) MF = seedlings machine planted with fipronil applied at 0.1g active ingredient (in 37 ml water) per seedling as they are planted.
2) MHF = seedlings machine planted; afterwards fipronil applied at 0.1g ai (in 3 ml water) per seedling by Kioritz soil injector.
3) MFS = seedlings machine planted; afterwards foliar spray (Pounce® or Mimic®2LV (0.6 ml / liter of water)) applied (5X)
4) MC = seedlings machine planted; no additional treatment (Check).

Sites 5 & 6:

Main plots

1) MF = seedlings machine planted with fipronil applied at 0.1g active ingredient (in 37 ml water) per seedling as they are planted.
2) MC = seedlings machine planted; no additional treatment (Check).

Subplot

3) MFS = seedlings machine planted; afterwards foliar spray (Pounce® or Mimic®2LV (0.6 ml / liter of water)) applied (5X)
4) MW = seedlings machine planted with 37 ml water per seedling.
5) HF = seedlings hand planted; afterwards fipronil applied at 0.1 g active ingredient (in 12 ml water) per seedling using a Kioritz or PTM™ Spot gun.
6) HSS = seedlings hand planted; afterwards one SilvaShield™ Forestry Tablet was pushed into the soil 4” deep next to each seedling.
7) HC = seedlings hand planted; no additional treatment (Check)

A single family of loblolly pine bare-root seedlings was selected at Weyerhaeuser Nursery in Magnolia, AR in 2006 for Site 1, in 2007 for Site 4, and in 2008 for Sites 5 and 6. Seedlings were lifted in February in a manner to cause the least breakage of roots, culled of small and large caliper seedlings, root-sprayed with Terrasorb slurry, bagged and stored briefly in cold storage. For sites 2 & 3, International Paper’s containerized loblolly pine seedlings from Bullard, TX were used.

When ready, seedlings were hand- or machine planted (spacing was dependent on practices of participating members) in each plantation - preferably near a young (< 4 years old) plantation.

All tracts (40 - 50 acres in size) were selected in AR or TX based on uniformity of soil, drainage and topography in each pair of stands. All tracts were intensively site prepared, i.e., subsoil, bedding, and/or herbicide.

Initially, to evaluate the effects of treatment on large-area tip moth damage level, a randomized complete block design, with sites as blocks, was used. The Site 1 plantation was initially divided in half. One half was operationally hand planted (1.8 X 3.6 m (= 6 X 12 ft) spacing) by a contracted crew. Immediately after planting, this half of the plantation was divided in half again and each seedling in one quarter of the plantation was treated with fipronil (0.3% ai in 3 ml volume) using the Kioritz soil injector or modified drench applicator (Figs. 34 and 35). Using the injector, the chemical solution was injected 4-5 inches below the soil surface near the seedling root ball. The number of trees treated and the time required to treat these trees was recorded at each site.

The other section of the plantation also was to be divided in half and machine planted. Unfortunately, development of the soil injection system was delayed and could not be operationally tested until the following fall.

To further evaluate the effects of treatment on tip moth damage levels, an internal randomized block design, with quarter plots as blocks, was used. At each site, four 0.5 acre plots were established. Each treatment was randomly assigned to one of the four internal plots in each main treatment plot quarter (Figure 31).

For sites 2, 3, and 4 the study design was modified to focus on fipronil treatments applied by machine planting. A C&G planter (owned by Acorn Outdoor Services, Lufkin, TX) was fitted with a 50-gallon tank, electrical pump, tubing and valves (designed by Lane Day and Jim Rogers, Precision Machine Services, Lufkin, TX) (Figures 36 – 38). At each site, 4 replicates of four 0.5 acre plots (16 plots total) were established (Figure 32). On 4 preselected plots, the fitted machine planter injected fipronil solution (0.3% ai in 37 ml volume) into the soil as each seedling was placed in the planting furrow. In all other plots, seedlings were machine planted at the same spacing. Afterward, in 4 plots each, seedlings were treated with fipronil by hand using a Kioritz soil injector or with a foliar spray (5x).

To evaluate the effects of treatment on large-area tip moth damage levels over a large area, a randomized complete block design, with sites as blocks, was used in 2008 (Figure 33). Plantations at sites 5 & 6 were divided in half. One half was operationally machine planted without additional treatment. On the other half, the fitted C&G planter was again used to treat containerized seedlings with PTM™ (fipronil) as they were planted in furrows. To further evaluate the effects of treatment on tip moth damage levels, a subplot (four 0.5 acre plots) were established. Each treatment was randomly assigned to one of the four internal plots in each main treatment plot half.

Ten 10-tree plots were spaced equally within each plantation quarter (but outside the internal treatment plots) to evaluate tip moth damage levels in this area. A 50-tree plot was positioned within each internal treatment plot to evaluate tip moth damage levels in this area. All stands were treated with herbicide after planting to minimize herbaceous and/or woody competition.

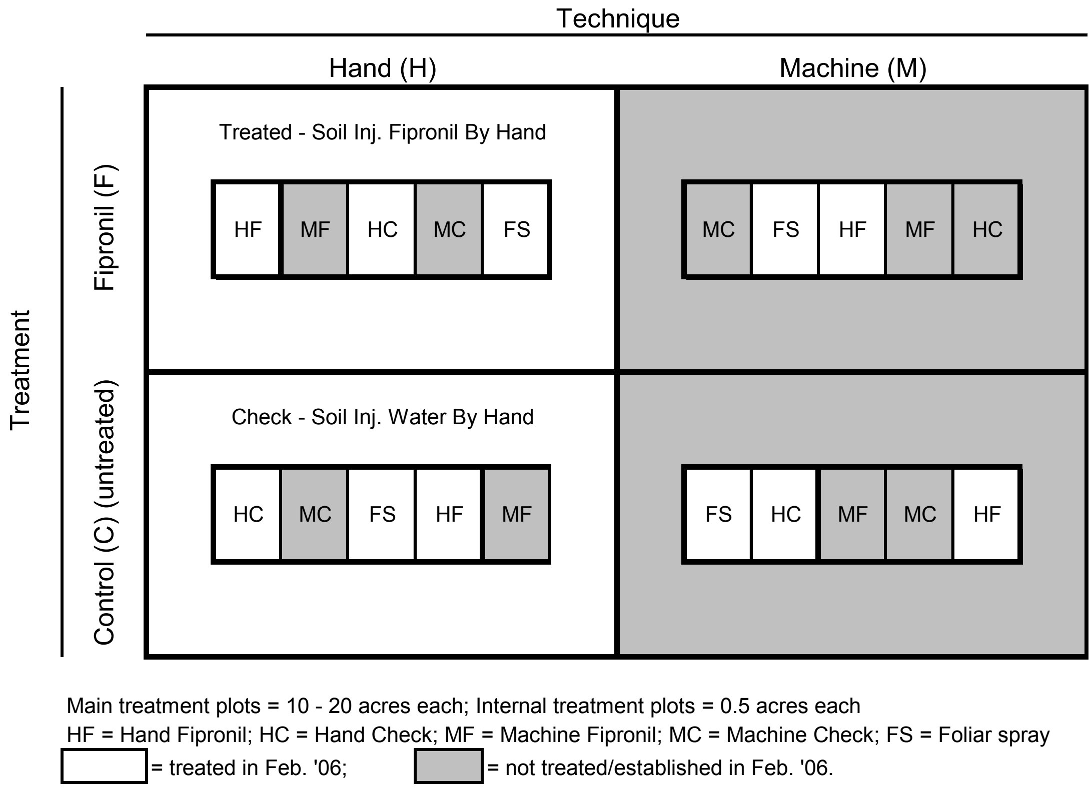


Figure 31. Generalized plot design for one Arkansas site established in February 2006.

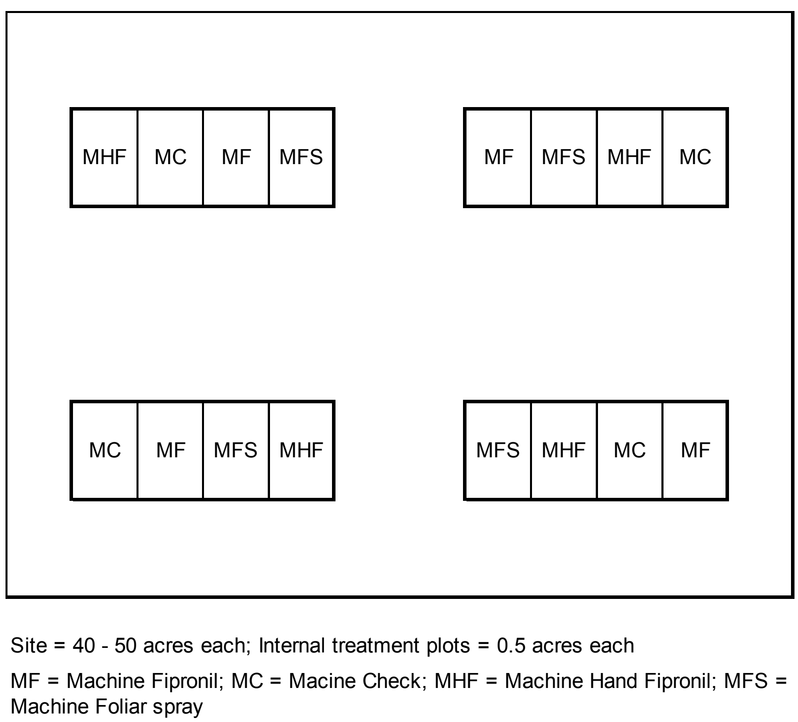
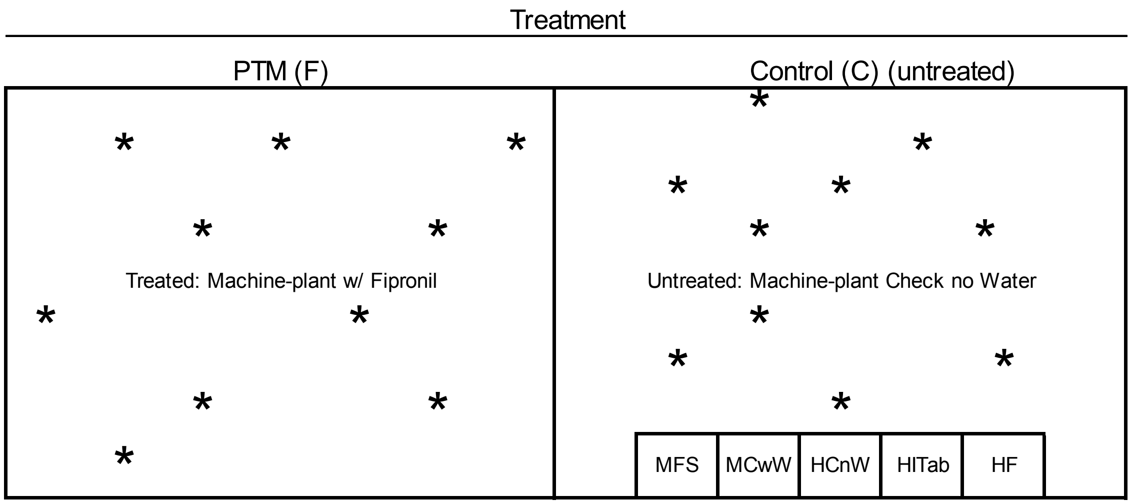


Figure 32. Generalized plot design for two Texas sites established in December 2006 and one Arkansas site established in February 2007.



Main treatment plots = 40 acres each; Internal treatment subplots = 0.5 acres each; ten 10-tree plots (*) evenly spaced within each main plot

Sub-Plot Treatments:

MFS = Machine-plant + Foliar spray;
MCwW = Machine-plant Check with Water;
HCnW = Hand-plant Check no Water;
HITab = Hand-plant + Imid Tablet;
HF = Hand-plant + PTM

Figure 33. Generalized plot design for one Louisiana and one Arkansas sites established in February 2008.

Figure 34. Jason Helvey with Kioritz soil injector.

Figure 35. Bill Upton with modified drencher applicator.

Figure 36. Machine planter and injection system on Winston tract, Lufkin, TX

Figure 37. Injection system (tank, pump and battery power) fitted to top of machine planter.

Figure 38. Dispensing fipronil solution from tubing in planter sleeve.

The sites and cooperators included:

1) Crossroads, AR (Weyerhaeuser provided and monitored)
2) Lufkin, TX (Randy Winston provided and Texas Forest Service monitored)
3) Nacogdoches, TX (Lou Ann Miller provided and Texas Forest Service monitored)
4) Oak Grove, AR (Weyerhaeuser provided and monitored)
5) Many, LA (Weyerhaeuser provided and monitored)
6) Mineral Springs, AR (Weyerhaeuser provided and monitored)

Tip moth damage was evaluated at each site after each tip moth generation (3-4 weeks after peak moth flight) by 1) identifying if the tree is infested or not, 2) if infested, the proportion of tips infested on the top whorl and terminal was calculated; and 3) separately, the terminal was identified as infested or not. Observations also were made as to the occurrence and extent of damage caused by other insects, i.e., coneworm, aphids, sawfly, etc. Each tree was measured for diameter and height in the fall (November - December) following planting.

Efficacy was evaluated by comparing treatment differences for direct and indirect measures of insect-caused losses. Direct treatment effects include reduction in pine tip moth damage. Indirect treatment effects include increases in tree growth parameters (height, diameter and volume index). Data were subjected to analyses of variance using Statview software (SAS Institute, Inc. 1999). Percentage and measurement data were transformed by the arcsine % and log transformations, respectively, prior to analysis.

Results:

Site 1 - 2006: Tip moth populations were quite low on the AR site during the first generation; none of the shoots were infested on check trees. As a result of the low tip moth pressure, none of the treatments reduced tip moth infestation of top whorl shoots compared to the check during the first generation (Table 53). The fipronil treatment within the subplots had a significantly effect on tip moth damage from the second through the fifth generation, reducing overall damage by 44 – 96% (62% overall). None of the fipronil treatments negatively affected seedling survival after 5 generations. The treatments (fipronil or Mimic®) had no apparent effect on height, diameter and volume index compared to check trees (Table 54).

2007: Tip moth populations were much higher during the second year with check trees averaging 10% of their shoots infested during the first generation and 32% infested over the whole growing season. The Mimic® spray application reduced damage by 75% (range: 16% - 89%) (Table 53). However, the efficacy of the fipronil treatment faded dramatically in the second season; it reduced damage by only 14% (range: 8% - 21%). The treatments (fipronil or Mimic®) had no apparent effect on height, diameter, and volume index compared to check trees (Table 54). The trial was discontinued after 2007.

Sites 2, 3 and 4 - 2007: A soil injection system was specifically designed by Mr. Lane Day, Precision Machine Services, in cooperation with the FPMC, to fit on a C&G planter (owned by Acorn Outdoor Services, Lufkin, TX). This type of planter utilizes a "paddle wheel" system that holds seedlings and lays them uniformly spaced in a furrow. Once installed on a planter, the soil injection system was tested to insure accurate dispensing of a dyed solution at each seedling. Cotton pads attached to several test seedlings were found to be stained with dye after being dug up

(Fig. 39). Observations made while treating seedlings with fipronil at the two Texas sites indicate that nearly all solution was applied at each seedling.

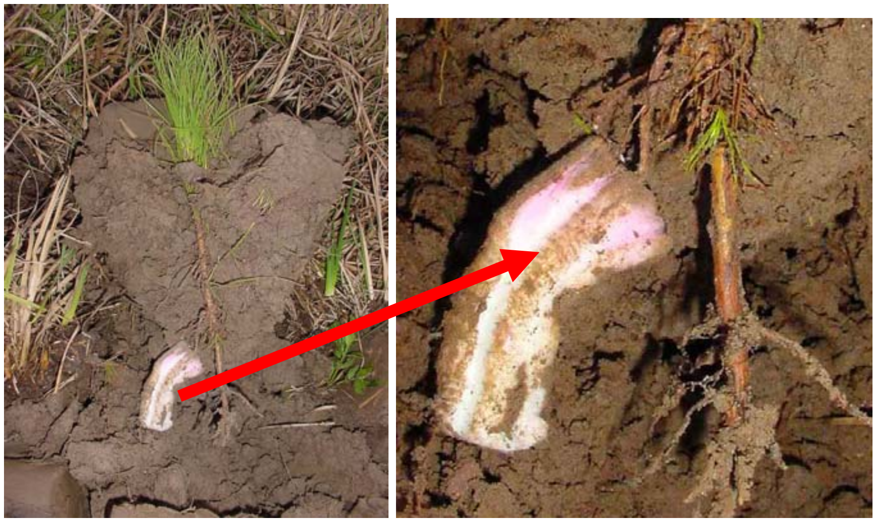


Figure 39. Dye on cotton pads tied to seedlings indicates that the soil injection system was functioning properly in initial tests.

Initially, tip moth damage on check trees was low (2%) but increased to fairly high levels by the 4th generation (29%) (Table 55). The machine-applied fipronil and Mimic® spray were nearly equal in their effectiveness in reducing tip moth damage (74% and 77%, respectively) compared to the check. The fipronil applied by hand also significantly reduced damage (43%) but not nearly as well as the machine-applied treatment. All treatments (both fipronils and Mimic®) significantly improved height growth compared to the check, while only Mimic® improved volume index (Tables 58 - 60).

2008: Tip moth damage on check trees was much higher with averages ranging from 18% of shoots infested during the 1st generation to 73% by the 5th generation (Table 56). The machine- and hand-applied fipronil treatments were nearly equal in their effectiveness in reducing tip moth damage (45% and 40%, respectively) compared to the check. All treatments (both fipronils and Mimic®) significantly improved all growth parameters compared to the check. The Mimic® treatment provided the greatest improvements overall (Tables 58 - 60).

2009: Tip moth damage was evaluated for a third year on the two TX sites. Damage levels on check trees were considerably lower with averages ranging from 4% of shoots infested during the 1st generation to 50% by the 5th generation (Table 57). The machine- and hand-applied fipronil treatments were nearly equal in their effectiveness in reducing tip moth damage (18% and 16%, respectively) compared to the check. All treatments (both fipronils and Mimic®) significantly improved all growth parameters compared to the check. The Mimic® treatment provided the greatest improvements overall (Tables 58 - 60).

Sites 5 & 6 - 2008: Initially, tip moth damage on check trees was low (1-2%) but increased to fairly high levels by the 5th generation (15-45%) (Table 61). On the main plots, the machine-applied fipronil was effective in reducing tip moth damage (50%) compared to the check at the Many site, but showed little effect at Mineral Springs. In the subplots, the fipronil applied by hand

and SilvaShield™ tablet were nearly equal in effectiveness and both significantly reduced damage (54%). All treatments (fipronils and Mimic®) except SilvaShield™ significantly improved height growth compared to the check (Tables 63).

2009: Tip moth damage on check trees was generally higher with averages ranging from 2 - 27% of shoots infested during the 1st generation to 28 - 43% in later generations (Table 62). On the main plots, the machine-applied fipronil was effective in reducing tip moth damage (27%) compared to the check during the first two generations at the Mineral Springs site, but showed little effect at Many, LA. In the subplots, the SilvaShield™ tablet was more effective significantly reducing damage (31%). All treatments (fipronils and Mimic®) except SilvaShield™ significantly improved all growth parameters compared to the check (Table 63). Over the two-year period, area-wide treatment improved height, diameter and volume index by 12%, 20% and 59%, respectively.

Conclusions

The initial data (2007) from Sites 2, 3 & 4 indicates that fipronil applied by machine is directed at the roots of the seedling being planted and provides good protection against tip moth for at least one year. However, data from all sites (1-4) indicate that fipronil applied by hand is not as effective at least initially, but can be more effective through the second year. It is possible that because fipronil is largely soil immobile that precise application (right on the roots) is necessary for optimal protection. Further tests are needed to improve effects of hand applications.

Fipronil (PTM™ Insecticide, BASF) was registered with EPA in September 2007. Use of this product is restricted to at-plant or post-plant soil injections near pine seedlings. Based on the performance of the injection systems (hand and machine) and chemical (fipronil) in 2007, new trials were established during the winter of 2008 on two sites to evaluate PTM™ for reducing area-wide pine tip moth infestation levels on large tracts (40 acres). The machine-applied PTM™ significantly reduced tip moth damage by 25% during the first two years (Table 57). Overall, volume growth was improved by 59%.

Due in part to this research, several hand applicators are now available with costs ranging from $130 – $425 each and are being used operationally by several forest industries and Christmas tree growers. A machine planter system has not been operationally used by forest industry or private landowners other than in these trials. However, forest industries are expressing more interest recently in combining applications of herbicide, fertilizer and insecticide in one pass to reduce application costs. The current machine applicator is a prototype system that runs on pressurized air and car batteries. It should be possible to attach the system to the hydraulic system of the machine planter to make the system more reliable and durable in the field. It is possible that a new operational system could be developed and used by fall 2010.

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Table 53. Effect of fipronil soil injections applied by hand on pine tip moth infestation of loblolly pine shoots (top whorl) after each of 10 generations, Crossroads, AR - 2006 & 2007.

			Mean Percent Top Whorl Shoots Infested by Tip Moth (**Pct. Reduction Compared to Check**)					
Year	Treatment §	N	Gen 1	Gen 2	Gen 3	Gen 4	Gen 5	Overall Mean
2006	Fipronil Hand Appl.	221	0.0 **100**	2.3 **-20**	3.4 **18**	3.3 **39** *	2.4 **71** *	2.3 **43** *
	Mimic Spray Appl.	120	0.6 **-232**	2.5 **-33**	3.4 **17**	2.0 **64** *	0.6 **93** *	1.8 **55** *
	Control	199	0.2	1.9	4.2	5.5	8.5	4.0
2007	Fipronil Hand Appl.	218	7.8 **21**	15.4 **21**	26.3 **8**	46.9 **16** *	53.3 **10**	27.3 **14** *
	Mimic Spray Appl.	120	2.2 **77** *	16.4 **16**	3.1 **89** *	9.6 **83** *	8.3 **86** *	8.0 **75** *
	Control	197	9.9	19.5	28.5	55.9	59.3	31.6

***** Means followed by an asterik are significantly different from Control Sub Plot at the 5% level based on Fisher's Protected LSD.

[shaded box] = treatment reduced damage by >75% compared to check.

Table 54. Effect of fipronil soil injections applied by hand on loblolly pine growth after two season, Crossroads, AR - 2006 & 2007.

			Mean End of Season Tree Measurements (**Growth Difference (cm or cm^3) Compared to Check**)					
Year	Treatment	N	Height (cm)		Diameter (cm)		Volume (cm^3)	
2006	Fipronil Hand Appl.	220	72.8	**-1.6**	1.20	**0.05**	142.6	**13.9**
	Mimic Spray Appl.	120	71.1	**-3.3**	1.16	**0.01**	136.4	**7.7**
	Control	199	74.4		1.15		128.7	
2007	Fipronil Hand Appl.	220	221.1	**-3.2**	1.99	**-0.14**	1168.7	**-115.8**
	Mimic Spray Appl.	120	229.5	**5.2**	2.09	**-0.04**	1280.4	**-4.1**
	Control	199	224.3		2.13		1284.5	

* Means followed by an asterik are significantly different from Control Sub Plot at the 5% level based on Fisher's Protected LSD.

Table 55. Effect of fipronil (FIP) application technique on pine tip moth infestation of loblolly pine top whorl shoots after each of 4-5 generations on three sites in east Texas and southwestern Arkansas - 2007.

Treatment §	Mean Percent of Loblolly Pine Shoots Infested (**Pct. Reduction Compared to Check**)														
	M	W	OG	Mean		M	W	OG	Mean		M	W	OG	Mean	
	Generation 1					Generation 2					Generation 3				
Machine FIP	0.0 *	0.0 *	0.3	0.1 *	**96**	0.6	0.7 *	11.2 *	3.5 *	**55**	1.4 *	0.8	11.8 *	4.0 *	**73**
Machine + Hand FIP SI	2.4	1.0	0.9	1.5	**37**	1.1	1.6 *	11.7	4.2 *	**46**	0.7 *	1.7	28.5 *	8.7 *	**42**
Machine + Mimic Spray	3.1	1.8	0.0	1.8	**25**	1.4	0.4 *	5.7 *	2.2 *	**71**	2.0 *	0.5	6.1 *	2.6 *	**83**
Machine Only (Check)	4.1	2.3	0.0	2.4		2.5	4.5	19.0	7.7		10.7	0.8	39.6	15.0	
	Generation 4					Generation 5					Mean				
Machine FIP	4.4 *	1.4 *	10.8 *	5.0 *	**83**	5.0 *	3.8 *	8.3 *	5.5 *	**64**	2.3 *	1.3 *	8.4 *	3.6 *	**74**
Machine + Hand FIP SI	13.1 *	11.4	22.7 *	15.1 *	**49**	6.4	10.8	13.5	9.9 *	**34**	4.7 *	5.3 *	15.6 *	7.9 *	**43**
Machine + Mimic Spray	9.0 *	3.0 *	5.2 *	5.8 *	**80**	3.5 *	5.2 *	1.7 *	3.6 *	**76**	3.8 *	2.2 *	3.7 *	3.2 *	**77**
Machine Only (Check)	39.7	15.2	34.4	29.4		13.1	13.7	20.0	15.1		14.0	7.3	22.6	13.8	

§ SI- Fipronil soil injection = treatment reduced damage by >75% compared to check.

* Means followed by an asterik are significantly different from checks at the 5% level based on Fisher's Protected LSD.

Table 56. Effect of fipronil (FIP) application technique on pine tip moth infestation of loblolly pine top whorl shoots after each of 4-5 generations on three sites in east Texas and southwestern Arkansas - 2008.

Treatment §	Mean Percent of Loblolly Pine Shoots Infested (**Pct. Reduction Compared to Check**)														
	M	W	OG	Mean		M	W	OG	Mean		M	W	OG	Mean	
	Generation 1					Generation 2					Generation 3				
Machine FIP	5.0 *	9.0 *	13.2	8.6 *	**51**	14.0 *	14.1 *	19.3 *	15.6 *	**54**	9.8 *	10.2 *	24.1	14.2 *	**55**
Machine + Hand FIP SI	5.1 *	9.6 *	23.8	8.6 *	**51**	15.0 *	15.3 *	29.3	19.4 *	**43**	5.4 *	10.3 *	29.0	13.9 *	**56**
Machine + Mimic Spray	3.8 *	8.0 *		4.7 *	**73**	9.0 *	10.8 *		13.3 *	**61**	5.4 *	6.0 *		12.3 *	**62**
Machine Only (Check)	13.1	21.8	19.8	17.7		32.4	36.1	33.5	33.9		37.3	25.0	31.9	32.0	
	Generation 4					Generation 5					Mean				
Machine FIP	42.7 *	20.5 *		33.2 *	**49**	48.0 *	36.5 *	56.8	47.2 *	**35**	23.9 *	18.1 *	28.2 *	23.4 *	**45**
Machine + Hand FIP SI	31.1 *	26.6 *		29.2 *	**55**	45.8 *	37.7 *	67.3	49.8 *	**32**	20.5 *	19.9 *	37.4	25.4 *	**40**
Machine + Mimic Spray	14.8 *	11.0 *		13.2 *	**80**	19.5 *	14.4 *		34.0 *	**53**	10.5 *	10.1 *	31.1 *	16.6 *	**61**
Machine Only (Check)	76.1	49.0		64.5		86.6	66.1	61.5	73.0		49.1	39.6	36.8	42.6	

§ SI- Fipronil soil injection   [shaded box] = treatment reduced damage by >75% compared to check.

* Means followed by an asterik are significantly different from checks at the 5% level based on Fisher's Protected LSD.

Table 57. Effect of fipronil (FIP) application technique on pine tip moth infestation of loblolly pine top whorl shoots after each of 4-5 generations on two sites in east Texas and southwestern Arkansas - 2009.

Treatment §	Mean Percent of Loblolly Pine Shoots Infested (**Pct. Reduction Compared to Check**)														
	M	W	OG	Mean		M	W	OG	Mean		M	W	OG	Mean	
	Generation 1					Generation 2					Generation 3				
Machine FIP	2.1 *	1.5		1.9 *	**54**	3.1	2.1 *		2.7 *	**51**	3.8	2.9		3.4 *	**38**
Machine + Hand FIP SI	1.9 *	4.7		3.1	**22**	1.8 *	1.8 *		1.8 *	**67**	1.5 *	1.2 *		1.4 *	**75**
Machine + Mimic Spray	2.6 *	1.7		2.1	**47**	1.2 *	1.4 *		1.3 *	**76**	2.4 *	4.0		3.2 *	**42**
Machine Only (Check)	4.8	3.0		4.0		4.7	6.6		5.5		5.7	5.3		5.5	
	Generation 4					Generation 5					Mean				
Machine FIP	30.3	18.9		25.4	**14**	43.1 *	44.5		43.7 *	**13**	16.5 *	14.0 *		15.4 *	**18**
Machine + Hand FIP SI	35.1	21.4		29.3	**1**	50.8	34.9 *		44.0 *	**12**	18.2	12.8 *		15.9 *	**16**
Machine + Mimic Spray	31.3	16.4 *		23.8 *	**19**	42.0 *	36.8 *		39.4 *	**21**	15.9 *	12.1 *		14.0 *	**26**
Machine Only (Check)	33.5	24.4		29.6		51.9	47.4		50.0		20.1	17.3		18.9	

§ SI- Fipronil soil injection = treatment reduced damage by >75% compared to check.

* Means followed by an asterik are significantly different from checks at the 5% level based on Fisher's Protected LSD.

Table 58. Effect of fipronil (FIP) application technique on loblolly pine height growth after the first, second and third year on three sites in East Texas and Southwest Arkansas - 2007, 2008 & 2009.

			Mean End of Season Loblolly Pine Seeding Growth Measurements (**Growth Difference (cm) Compared to Check**)								
Year	Treatment §	N	Miller		Winston		Oak Grove		Mean		
2007	Machine + FIP	550	58.4	*	49.9	*	51.6	*	53.4	*	**6.2**
	Machine + Hand FIP SI	550	60.6	*	59.4	*	44.0		55.7	*	**8.5**
	Machine + Mimic Spray	500	64.4	*	52.1	*	49.8	*	55.1	*	**7.9**
	Machine + Check	550	53.1		44.0		43.5		47.2		
2008	Machine + FIP	550	117.9	*	124.8	*	154.8	*	131.0	*	**16.5**
	Machine + Hand FIP SI	550	121.3	*	128.7	*	132.2		126.8	*	**12.3**
	Machine + Mimic Spray	500	134.8	*	124.9	*	157.0	*	138.9	*	**24.4**
	Machine + Check	550	101.3		111.7		135.3		114.5		
2009	Machine + FIP	500	221.4	*	244.8	*	243.4		235.0	*	**15.1**
	Machine + Hand FIP SI	498	221.7	*	269.9	*	214.9	*	234.2	*	**14.3**
	Machine + Mimic Spray	449	231.0	*	242.5		244.6		239.4	*	**19.4**
	Machine + Check	496	197.6		234.5		235.8		219.9		

§ FIP = Fipronil; SI = Kioritz Soil Injection Method

* Means followed by an asterik are significantly different from checks at the 5% level based on Fisher's Protected LSD.

Table 59. Effect of fipronil (FIP) application technique on loblolly pine diameter (ground line) growth after the first, second and third year on three sites in East Texas and Southwest Arkansas - 2007, 2008 & 2009.

			Mean End of Season Loblolly Pine Seeding Growth Measurements (**Growth Difference (cm) Compared to Check**)								
Year	Treatment §	N	Miller		Winston		Oak Grove		Mean		
2007	Machine + FIP	550	0.87		0.69	*	1.04		0.85		**0.03**
	Machine + Hand FIP SI	550	0.88		0.78	*	0.95	*	0.86	*	**0.04**
	Machine + Mimic Spray	500	0.97	*	0.70	*	0.99		0.87	*	**0.05**
	Machine + Check	550	0.85		0.63		1.05		0.82		
2008	Machine + FIP	550	2.16	*	2.33	*	3.32		2.56	*	**0.23**
	Machine + Hand FIP SI	550	2.21	*	2.49	*	2.95		2.52	*	**0.18**
	Machine + Mimic Spray	500	2.58	*	2.32	*	3.44	*	2.78	*	**0.45**
	Machine + Check	550	1.88		2.09		3.19		2.33		
2009	Machine + FIP	500	4.73	*	4.81		6.08		5.16	*	**0.29**
	Machine + Hand FIP SI	498	4.60	*	5.39	*	5.45	*	5.09	*	**0.22**
	Machine + Mimic Spray	449	4.97	*	4.94		6.04		5.32	*	**0.44**
	Machine + Check	496	4.24		4.76		5.85		4.87		

§ FIP = Fipronil; SI = Kioritz Soil Injection Method

* Means followed by an asterik are significantly different from checks at the 5% level based on Fisher's Protected LSD.

Table 60. Effect of fipronil (FIP) application technique on loblolly pine volume growth after the first, second and third year on three sites in East Texas and Southwest Arkansas - 2007, 2008 & 2009.

Year	Treatment §	N	Mean End of Season Loblolly Pine Seeding Growth Measurements (**Growth Difference (cm^3) Compared to Check**) Miller	Winston	Oak Grove	Mean	
2007	Machine + FIP	550	53.0	35.8 *	68.1	50.8 *	**5.8**
	Machine + Hand FIP SI	550	56.5 *	52.9 *	50.2	53.5 *	**8.4**
	Machine + Mimic Spray	500	72.0 *	36.2 *	58.0	53.5 *	**8.4**
	Machine + Check	550	46.1	28.5	66.9	45.1	
2008	Machine + FIP	550	707 *	911 *	2047 *	1168 *	**242**
	Machine + Hand FIP SI	550	719 *	1134 *	1346	1031 *	**105**
	Machine + Mimic Spray	500	1176 *	884 *	2073 *	1378 *	**452**
	Machine + Check	550	474	753	1711	926	
2009	Machine + FIP	500	5846 *	6502	10169	7340 *	**938**
	Machine + Hand FIP SI	498	5286 *	9427 *	7126 *	7080 *	**678**
	Machine + Mimic Spray	449	6375 *	6934	9617	7638 *	**1236**
	Machine + Check	496	4213	6591	9208	6402	

§ FIP = Fipronil; SI = Kioritz Soil Injection Method

* Means followed by an asterik are significantly different from checks at the 5% level based on Fisher's Protected LSD.

Table 61. Effect of fipronil (FIP) application technique on pine tip moth infestation of loblolly pine top whorl shoots after each of 4-5 generations on two sites in Westcentral Louisiana and Southcentral Arkansas - 2008.

		Mean Percent of Loblolly Pine Shoots Infested (**Pct. Reduction Compared to Check**)											
Treatment §	N	Many	MS	Mean		Many	MS	Mean		Many	MS	Mean	
Large Area		Generation 1				Generation 2				Generation 3			
Machine FIP	200	1.4 *	0.2	0.8 *	**69**	4.3 *	20.5	12.4 *	**39**	8.8 *	21.9	15.4	**23**
Machine Only (Check)	200	5.2	0.0	2.6		14.2	26.3	20.3		17.4	22.3	19.9	
Subplots													
Machine + Mimic	100	1.2 *		1.2 3	**82**	3.5		3.5	**41**	2.2 *		2.2	**89**
Machine + water (Check)	100	6.5	0.0	3.3 #		5.9	18.5	12.2		20.2	41.3	30.8 *	
Hand FIP SI	100	1.0	0.0	0.5 #	**58**	0.5	14.6	7.6	**15**	3.7 *	9.8	6.7	**54**
Hand + SS Tablet	100	0.0	0.0	0.0 #	**100**	0.0	7.0	3.5	**61**	1.1 *	16.3	8.7	**41**
Hand (Check)	100	2.4	0.0	1.2		3.7	14.8	8.9		13.8	15.9	14.7	

Treatment §	N	Many	MS	Mean		Many	MS	Mean		Many	MS	Mean	
Large Area		Generation 4				Generation 5				Mean			
Machine FIP	200	15.4 *		15.4 *	**42**	12.4 *	14.5	13.4 *	**36**	8.5 *	14.3	11.4 *	**33**
Machine Only (Check)	200	26.5		26.5		22.0	19.9	20.9		17.0	17.1	17.1	
Subplots													
Machine + Mimic	100	4.4 *		4.4 *	**80**	3.3 *		3.3 *	**83**	2.9 *		2.9 *	**80**
Machine + water (Check)	100	21.5		21.5		20.1	40.3	30.2		14.8	25.0	19.9	
Hand FIP SI	100	10.5 *		10.5 *	**56**	4.0 *	10.5	7.2 *	**77**	3.9 *	8.7	6.3 *	**55**
Hand + SS Tablet	100	2.2 *		2.2 *	**91**	3.7 *	23.7	13.7 *	**57**	1.4 *	11.7	6.6 *	**54**
Hand (Check)	100	23.9		23.9		45.4	15.3	31.5		17.8	9.9	14.2	

§ SI- Fipronil soil injection (shaded) = treatment reduced damage by >75% compared to check.

***** Means followed by an asterik are significantly different from checks at the 5% level based on Fisher's Protected LSD.

Table 62. Effect of fipronil (FIP) application technique on pine tip moth infestation of loblolly pine top whorl shoots after each of 4-5 generations on two sites in Westcentral Louisiana and Southcentral Arkansas - 2009.

Treatment §	N	Mean Percent of Loblolly Pine Shoots Infested (**Pct. Reduction Compared to Check**)											
		Many	MS	Mean		Many	MS	Mean		Many	MS	Mean	
<u>Large Area</u>		Generation 1				Generation 2				Generation 3			
Machine FIP	200	1.3	18.9 *	10.1 *	**31**	2.8	20.5 *	12.7 *	**35**	4.5	36.1	20.3	**19**
Machine Only (Check)	200	2.1	27.2	14.6		2.9	26.3	19.5		7.6	42.6	25.1	
<u>Subplots</u>													
Machine + Mimic	100		22.4	22.4	**11**		36.0	36.0 *	**27**		18.6 *	18.6 *	**48**
Machine + water (Check)	100		25.2	25.2			49.5	49.5			35.6	35.6	
Hand FIP SI	100	0.0	24.7	12.4 #	**-49**	0.0	45.4	22.7	**-14**	4.8	43.3	24.1	**-21**
Hand + SS Tablet	100	0.4	13.3	6.7 #	**20**	1.7	33.4	17.1	**15**	2.2	42.2	21.6	**-9**
Hand (Check)	100	0.8	15.8	8.3		0.9	39.0	20.0		5.2	36.3	19.8	

Treatment §	N	Many	MS	Mean		Many	MS	Mean		Many	MS	Mean	
<u>Large Area</u>		Generation 4				Generation 5				Mean			
Machine FIP	200	30.8		30.8	**-23**	34.4	50.2 *	42.3 *	**-25**	14.8	32.0	20.3	**16**
Machine Only (Check)	200	25.1		25.1		28.4	39.2	33.8		13.2	36.2	24.2	
<u>Subplots</u>													
Machine + Mimic	100						8.2 *	8.2 *	**79**		21.3 *	21.3 *	**43**
Machine + water (Check)	100						39.3	39.3			37.4	37.4	
Hand FIP SI	100	22.8 *		22.8 *	**46**	28.5 *	26.3	27.4 *	**36**	11.2 *	34.9	24.5	**4**
Hand + SS Tablet	100	12.0 *		12.0 *	**72**	15.8 *	23.8	19.7 *	**54**	6.4 *	28.2	17.7 *	**31**
Hand (Check)	100	42.4		42.4		54.4	30.9	42.9		20.7	31.2	25.4	

§ SI- Fipronil soil injection   [shaded] = treatment reduced damage by >75% compared to check.
***** Means followed by an asterik are significantly different from checks at the 5% level based on Fisher's Protected LSD.

Table 63. Effect of fipronil application technique on loblolly pine growth 8 and 20 months after treatment on two sites in Westcentral Louisiana and Southcentral Arkansas - 2008 & 2009.

			Mean End of Season Tree Measurements (**Growth Difference (cm or cm^3) Compared to Check**)											
Year	Treatment	N	Height (cm)				Diameter (cm)				Volume (cm^3)			
			Many	MS	Mean		Many	MS	Mean		Many	MS	Mean	
	Large Area													
2008	Machine FIP	200	48.9	42.6 *	45.7 *	**3.4**	0.83	0.81 *	0.82 *	**0.14**	43.1	34.8 *	38.9 *	**11.4**
	Machine Only (Check)	200	48.2	36.4	42.3		0.77	0.60	0.68		38.7	16.3	27.5	
	Subplots													
	Machine + Mimic	100	45.2 *	40.2	42.7	**-4.4**	0.86 *	0.89	0.88	**-0.03**	42.4 *	39.3	40.8	**-8.7**
	Machine + water (Check)	100	55.1	39.0	47.1		1.03	0.77	0.90		70.3	28.9	49.6	
	Hand FIP SI	100	38.6	47.9 *	43.2 *	**6.3**	0.76	0.87 *	0.82 *	**0.13**	31.3	43.3 *	37.3 *	**13.4**
	Hand + SS Tablet	100	39.9	32.9	36.4	**-0.5**	0.79	0.61	0.70	**0.01**	32.7	16.6	24.7	**0.8**
	Hand (Check)	100	38.8	34.7	36.9		0.80	0.56	0.69		32.6	13.8	23.9	
	Large Area													
2009	Machine FIP	200	156.3 *	130.1 *	143.2 *	**15.6**	2.77 *	2.44 *	2.60 *	**0.44**	1432 *	932 *	1182 *	**435**
	Machine Only (Check)	200	143.7	111.6	127.7		2.39	1.93	2.16		992	502	747	
	Subplots													
	Machine + Mimic	100		136.7 *	136.7 *	**16.5**		2.57 *	2.57 *	**0.33**		1052 *	1052 *	**316**
	Machine + water (Check)	100		120.2	120.2			2.24	2.24			736	736	
	Hand FIP SI	100	167.5	150.1 *	158.8 *	**17.1**	3.21	3.18 *	3.20 *	**0.69**	2014	1701 *	1858 *	**474**
	Hand + SS Tablet	100	148.2 *	122.6 *	135.7	**-6.1**	2.55 *	2.02 *	2.29	**-0.22**	1286 *	640 *	969	**-415**
	Hand (Check)	100	176.5	105.5	141.7		3.27	1.71	2.51		2321	408	1384	

* Means followed by an asterik are significantly different from checks at the 5% level based on Fisher's Protected LSD.

PINE TIP MOTH TRIALS

Imidacloprid Tablet Trials – Western Gulf Region

Highlights:

- All imidacloprid tablet treatments, applied in 2007, significantly reduced tip moth damage levels on nearly all sites through the third year. The tablets significantly improved growth parameters on two of three measured sites.
- All imidacloprid tablet treatments, applied in 2008, significantly reduced tip moth damage levels on all sites through the first year. The tablets only improved growth parameters on sites treated after planting and tree growth improved with higher rates.
- All treatments containing imidacloprid tablets, applied in 2009, significantly reduced tip moth damage levels through most of the first year. The additive treatments (fertilizer and/or herbicide) did not improve protection but may have helped to improve height and diameter growth.

Objectives: 1) Determine the efficacy of imidacloprid tablets in reducing pine tip moth infestation levels on loblolly pine seedlings; 2) evaluate this product applied at different rates to transplanted or resident seedlings; 3) determine the effect of imidacloprid alone or combined with fertilizer on seedling growth; 4) determine the efficacy of SilvaShield™ tablets in reducing pine tip moth infestation levels on loblolly pine seedlings when applied at planting to bedded areas with and without fertilizer and/or herbaceous weed control; and 6) determine the duration of chemical activity.

Cooperators:

Mr. Bill Stansfield	The Campbell Group, Diboll, TX
Mr. Conner Fristoe	Plum Creek Timber Co., Crossett, AR
Dr. Nick Chappell	Potlatch Forest Holdings, Warren, AR
Mr. Peter Birks	Weyerhaeuser Co., Columbus, MS
Mr. Doug Long	Rayonier, Lufkin, TX
Dr. Nate Royalty	Bayer Environmental Science, Research Triangle Park, NC

Study Sites: In 2007, 6 second-year sites were selected in TX (2 near Colmesneil), Mississippi (near Millard) and Arkansas (1 each near Crossroads, Warren and Crossett). Second-year pine plantations were used in the study because tip moth populations are usually well established at this age, increasing the likelihood that significant tip moth pressure would be placed on treated seedlings. The plots contained 4 - 11 treatments with 50 trees per treatment. In 2008, two separate trials were established on three sites in Texas.

Insecticides:

Imidacloprid (SilvaShield™ Forestry Tablet, Bayer) – highly systemic neonictinoid with activity against Lepidoptera.

Fipronil (PTM™ Insecticide, BASF) – a phenyl pyrazole with some systemic activity against Lepidoptera.

Research Approach:

A randomized complete block design was used at each site with beds or site areas serving as blocks, i.e., each treatment was randomly selected for placement along a bed. Ten seedlings from each treatment were planted on each of five beds. The treatments by year and trial included:

2007 All 6 study sites had:

1)	20% Merit® FXT Std. tablet -	1 tablet in plant hole
2)	20% Merit® FXT Std. tablet -	1 tablet in soil next to transplant
3)	Mimic® or Pounce® Foliar -	Apply Mimic® (0.6 ml/L water) 5X / season
4)	Bare-root Check -	Treat w/ Terrasorb™ and plant bare-root

Two sites also had:

5)	10% Merit® (Imid.) FXT Std. tablet -	1 tablet in plant hole
6)	15% Merit® FXT Std. tablet -	1 tablet in plant hole

2008 Trial 1:

1)	SilvaShield™ (20% Imid.) tablet -	1 tablet in plant hole
2)	SilvaShield™ (20% Imid.) tablet -	1 tablet in soil (4") next to transplant
3)	SilvaShield™ (20% Imid.) tablet -	2 tablets in plant hole
4)	SilvaShield™ (20% Imid.) tablet -	3 tablets in plant hole
5)	PTM™ SC Insecticide (fipronil) -	Soil injection at planting
6)	Bare-root Check -	Treat w/ Terrasorb™ and plant bare-root

Trial 2:

1)	SilvaShield™ (20% Imid.) tablet -	1 tablet in soil (4") next to transplant
2)	SilvaShield™ (20% Imid.) tablet -	2 tablets in soil (4") next to transplant
3)	SilvaShield™ (20% Imid.) tablet -	3 tablets in soil (4") next to transplant
4)	SilvaShield™ (20% Imid.) tablet -	1 tablet in soil (8") next to transplant
5)	SilvaShield™ (20% Imid.) tablet -	2 tablets in soil (8") next to transplant
6)	SilvaShield™ (20% Imid.) tablet -	3 tablets in soil (8") next to transplant
7)	SilvaShield™ (20% Imid.) tablet -	1 tablet in plant hole
8)	Bare-root Check -	Treat w/ Terrasorb™ and plant bare-root

2009 Trial 1:

1)	Check (untreated) -	seedling planted by hand
2)	SilvaShield™ (SS, 1 tablet) -	in plant hole (PH) under seedling
3)	SS (2 tablets) -	in PH
4)	Herb. weed control (HWC) only-	banded application of Oust (2) + Arsenal AC (4)
5)	SS (1 tablet) + HWC -	tablet in PH + Oust + Arsenal
6)	SS (2 tablet) + HWC -	tablets in PH + Oust + Arsenal

Trial 2:

1)	Check (untreated) -	seedling planted by hand
2)	SilvaShield™ (SS, 1 tablet) -	in plant hole (PH) under seedling
3)	Diamm. phosphate (DAP 1X) -	applied (125 lb/A) after planting around seedling
4)	SS (1 tablets) + DAP 1/2X -	tablet in PH and fert. after plant
5)	Herb. weed control (HWC) only-	banded application of Oustar (12)
6)	SS (1 tab) + HWC -	tablet in PH + Oustar
7)	SS (1 tab) + DAP 1/2X + HWC -	tablet in PH + fert after plant + Oustar
8)	SS (1 tab) + DAP 1X + HWC -	tablets in PH + fert after plant + Oustar
9)	DAP 1X + HWC -	fert after plant + Oustar

In all research years (2007 – 2009), a single family of loblolly pine bare-root seedlings was selected at the Texas Forest Service Indian Mounds Nursery, Alto, TX, or ArborGen SuperTree Nursery, Livingston, TX. All seedlings were operationally lifted by machine in January or February, culled of small and large caliper seedlings, treated with Terrasorb™ or clay slurry root coating, bagged and stored briefly in cold storage.

Fifty seedlings for each treatment were planted (variable spacing) on new or one-year-old (entering 2nd growing season) plantation sites – to ensure a high level of tip moth pressure on the treatment trees. At the one-year-old site, resident trees were removed and replaced with treatment trees. A randomized complete block design was used at each site with beds or site areas serving as blocks, i.e., each treatment was randomly selected for placement along a bed. Ten seedlings from each treatment were planted on each of five beds. Just after seedling transplant, one treatment tablet (2007) was pushed into the soil 6 cm deep and 4 cm from each assigned seedling. In 2008, a lance was used to make a 4" or 8" deep hole. The tablet(s) was then dropped in the hole. In 2008 & 2009, one to three tablets were dropped into the plant hole just prior to placement of the seedling in the same hole.

In 2009, DAP (diammonia phosphate) was applied by hand around the seedling after planting. Banded applications of herbicide by backpack sprayer were made in May.

Tip moth damage was evaluated after each tip moth generation (3-4 weeks after peak moth flight) for each tablet trial by 1) identifying if the tree was infested or not, 2) if infested, the proportion of tips infested on the top whorl and terminal were calculated; and 3) separately, the terminal was identified as infested or not. Observations also were made as to the occurrence and extent of damage caused by other insects, i.e., aphids, weevils, coneworm, etc. Each tree was measured for diameter (at 6" for one and two-year old trees or at DBH for 3-, 4-, or 5-year old trees) and height in the fall (December). Data were analyzed by GLM and the Tukey's Compromise test using Statview or SAS statistical programs.

Results:

Imidacloprid Tablets (2007)

In 2007, tip moth populations were quite variable across the six sites with mean percent shoots infested on checks ranging from 0% after the first generation on one TX site to 45% and 55% at the end of the year on two AR sites (Table 64 & 65). All tablet treatments placed in the plant hole were highly effective in reducing tip moth damage throughout the year. Overall, damage was reduced by 77-81%. Tablets pushed into the soil after the seedlings were planted and foliar sprays were less effective; reducing damage by 55-68%. Tablet treatments significantly improved growth parameters compared to checks on four of six sites (Table 66).

In 2008, tip moth populations were considerably higher compared to 2007 across the six sites with mean percent shoots infested on checks ranging from 14% after the first tip moth generation on one TX site to 72% and 78% at the end of the year on two AR sites (Table 67 & 68). All treatments in which tablets were placed in the plant hole continued to significantly reduce tip moth damage throughout the year. Overall, damage was reduced by 49 - 57%. Treatments consisting of tablets pushed into the soil after the seedlings were planted and foliar sprays were similarly effective; tthey reduced damage by 37 - 59%. Tablet treatments significantly improved growth parameters compared to checks on four of six sites (Table 69).

In 2009, tip moth damage evaluations were continued on two TX sites. Tip moth levels were considerably lower compared to 2008 with mean percent shoots infested on checks ranging from 1% after the first generation to 33% at the end of the year (Table 70 & 71). All tablet treatments placed in the plant hole continued to significantly reduce tip moth damage throughout the year. Overall, damage was reduced by 65 - 75%. Tablets pushed into the soil after the seedlings were planted and foliar sprays were less effective; reducing damage by 38 - 51%. Tablet treatments significantly improved growth parameters compared to checks on two of three sites measured so far (Table 72).

<u>Imidacloprid Tablets</u>
<u>Rate at Planting (Moffet)</u>: In 2008, tip moth populations were low on the single site during the first and second generations with averages of 0.5% and 2.5% of the shoots infested on check trees, respectively (Table 73). As a result of the low tip moth pressure, none of treatments significantly reduced tip moth infestation levels compared to the check during the first generation. In contrast, all tablet treatments provided very good protection during the third through fifth generations, reducing damage by 78 – 100% (77 – 96% overall). The post plant tablet and fipronil soil injection (at planting) both had similar effects on tip moth damage levels. Surprisingly, none of the study treatments significantly improved any of the growth parameters compared to check trees (Table 74).

In 2009, tip moth populations were initially higher during the first through third generations with averages of 17%, 9% and 16% of the shoots infested on check trees, respectively (Table 73). Most treatments significantly reduced tip moth infestation levels compared to the check during the first three generations. In contrast, most tablet treatments appeared to fade during the fourth generation, reducing damaged by -6 – 70% (47 – 73% overall). The post plant tablet and fipronil soil injection (at planting) treatments both had similar effects on tip moth damage levels. Again, none of the study treatments significantly improved any of the growth parameters compared to check trees (Table 74).

<u>Rate and Depth Just After Plant (Loving Ferry & Moffett)</u>: In 2008, tip moth populations were low on the both sites during the first generation with averages of 0.8% (Loving Ferry) and 0% (Moffet) of the shoots infested on check trees (Table 75). As a result of the low tip moth pressure, none of the treatments significantly reduced tip moth infestation levels compared to the check during the first generation. In contrast, nearly all treatments provided very good protection during the second through fifth generations, reducing damaged by 48 – 100% (62 – 99% overall). Treatment efficacy

against tip moth did not appear to be influenced by dose rate or treatment depth. However, height and diameter growth tended to improve with dose rate compared to check trees (Tables 77 & 78). Growth parameters did not appear to be affected by treatment depth.

In 2009, tip moth populations were low on the both sites during the first generation with averages of 22% (Loving Ferry) and 7% (Moffet) of the shoots infested on check trees (Table 76). All treatments provided good protection during the first through fifth generations, reducing damaged by 22 – 100% (44 – 76% overall). Treatment efficacy against tip moth did not appear to be influenced by dose rate or treatment depth. However, height and diameter growth tended to improve with dose rate compared to check trees (Tables 77 & 78). Growth parameters did not appear to be affected by treatment depth.

<u>Rate and Depth 1 year after Plant (Peavy)</u>: Understandably, tip moth populations were higher during the first generation on this second-year site with an average of 15% of the shoots infested on check trees (Table 79). Because of the late treatment date, none of treatments significantly reduced tip moth infestation levels compared to the check during the first generation. In contrast, all treatments provided very good protection during the second through fifth generations, reducing damaged by 35 – 99% (49 – 83% overall). Treatment efficacy against tip moth appears to be influenced by dose rate but not treatment depth. However, growth parameters did not appear to be affected by treatment depth (Table 80).

Tip moth populations were considerably lower during the third growing season with an average of 15% of the shoots infested on check trees (Table 79). Because of low levels, most treatments did not significantly reduced tip moth infestation levels compared to the check during the first two generation. In contrast, all treatments provided very good protection during the third through fifth generations, reducing damaged by 48 – 100% (54 – 90% overall). Treatment efficacy against tip moth appears to be influenced by dose rate but not treatment depth. However, growth parameters did not appear to be affected by treatment depth (Table 80).

<u>Input Comparison (2009)</u>
Trial 1: Tip moth populations were extremely low with mean percent shoots infested on checks ranging from 0% after the first generation to 2.4% at the end of the third generation (Table 81). Due to the low levels, none of the treatments was effective in reducing tip moth damage. The final damage assessment and tree measurements are pending (Table 82).

Trial 2: Tip moth populations were low on the single site during the first and second generations with averages of 5% and 4% of the shoots infested on check trees, respectively (Table 81). As a result of the low tip moth pressure, none of treatments significantly reduced tip moth infestation levels compared to the check during the first generation. In contrast, treatments containing tablets provided good protection during the third and four generations, reducing damaged by 43 – 100% (35 – 52% overall). The effects of the tablets appeared to be fading by the fifth generation. Most treatments with tablets significantly improved growth parameters compared to check trees (Table 82).

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Table 64. Effect of Bayer tablets on percent shoots infested by pine tip moth after each of five generations during the first growing season on six sites - 2007.

Mean Percent Shoots Infested (Pct. Reduction Compared to Check)

		Generation 1								Generation 2							
Treatment §	N	TX1	AR1	TX2	AR2	AR3	MS1	Mean		TX1	AR1	TX2	AR2	AR3	MS1	Mean	
20% FXT Ball PH	50	0.0	0.9	1.7	4.0 *	1.7 *	1.9 *	1.7	**85**	0.0 *	3.1	2.0	2.8 *	3.1 *	1.3 *	2.1	**84**
20% FXT Ball Adjacent	50	0.0	0.4	1.0	12.7 *	0.0 *	11.3	4.2	**63**	2.5 *	10.8	0.0	9.2 *	3.4 *	9.1 *	5.8	**56**
Mimic foliar spray	50	2.1	0.5	1.2	10.0 *	10.7	8.8	5.5	**51**	3.2 *	2.8	2.0	19.1	10.2 *	6.1 *	7.2	**46**
Check	50	0.0	0.9	5.8	25.4	16.6	19.2	11.3		13.3	9.4	4.9	21.5	25.9	19.6	15.8	

		Generation 3								Generation 4							
Treatment §	N	TX1	AR1	TX2	AR2	AR3	MS1	Mean		TX1	AR1	TX2	AR2	AR3	MS1	Mean	
20% FXT Ball PH	50	0.0 *	6.5 *	0.0 *	4.7 *	1.6	0.4 *	2.2	**83**	1.8 *		0.0 *			NA	0.9	**96**
20% FXT Ball Adjacent	50	0.0 *	6.8 *	0.0 *	39.3	2.9	1.5	8.4	**34**	0.0 *		0.0 *			NA	0.0	**100**
Mimic foliar spray	50	2.2	8.2	0.0 *	49.7	0.9	4.5	10.9	**15**	2.4 *		0.4 *			NA	1.4	**93**
Check	50	5.4	16.4	4.3	40.3	4.0	6.5	12.8		24.6		17.8			NA	21.2	

		Generation 5 (Last)								Mean							
Treatment §	N	TX1	AR1	TX2	AR2	AR3	MS1	Mean		TX1	AR1	TX2	AR2	AR3	MS1	Mean	
20% FXT Ball PH	50	2.1 *	8.3 *	0.0 *	20.9 *	0.0	11.4 *	8.5	**74**	0.6 *	4.8 *	0.7 *	7.7 *	1.5 *	3.7 *	3.8	**81**
20% FXT Ball Adjacent	50	0.0 *	12.1	2.5 *	48.5	3.8	9.4 *	15.3	**53**	0.4 *	7.2 *	0.6 *	27.4	2.5 *	7.7 *	9.1	**55**
Mimic foliar spray	50	2.4 *	8.9 *	0.0 *	27.6 *	2.6	35.9	15.5	**52**	2.1 *	5.5 *	0.7 *	22.8 *	6.1 *	13.4 *	10.1	**50**
Check	50	24.5	21.5	14.8	54.7	1.7	45.0	32.4		11.0	12.7	8.8	34.7	11.5	22.6	20.2	

§ PH- placed in plant hole; Adjacent- tablet placed in soil next to seedling

(shaded box) = treatment reduced damage by >75% compared to check.

* Means followed by an asterik are significantly different from checks at the 5% level based on Fisher's Protected LSD.

Table 65. Effect of Bayer tablets on percent shoots infested by pine tip moth after each of five generations during the first growing season on six sites - 2007.

Mean Percent Shoots Infested (Pct. Reduction Compared to Check)

		Generation 1				Generation 2			
Treatment §	N	TX1	AR1	Mean		TX1	AR1	Mean	
10% FXT Ball PH	50	0.5	0.4	0.4	**4**	5.4	0.6 *	3.0	**78**
15% FXT Ball PH	50	1.5	0.0	0.7	**-63**	0.0 *	5.1	2.6	**81**
20% FXT Ball PH	50	0.0	0.9	0.5	**0**	0.0 *	3.1	1.6	**88**
20% FXT Ball Adjacent	50	0.0	0.4	0.2	**56**	2.5 *	10.8	6.7	**50**
Mimic foliar spray	50	2.1	0.5	1.3	**-192**	3.2 *	2.8	3.0	**78**
Check	50	0.0	0.9	0.5		13.3	9.4	11.3	

		Generation 3				Generation 4			
Treatment §	N	TX1	AR1	Mean		TX1	AR1	Mean	
10% FXT Ball PH	50	0.6 *	3.8 *	2.2	**80**	1.0 *		1.0	**96**
15% FXT Ball PH	50	0.0 *	5.6 *	2.8	**74**	3.0 *		3.0	**88**
20% FXT Ball PH	50	0.0 *	6.5 *	3.2	**70**	1.8 *		1.8	**93**
20% FXT Ball Adjacent	50	0.0 *	6.8 *	3.4	**69**	0.0 *		0.0	**100**
Mimic foliar spray	50	2.2	8.2	5.2	**52**	2.4 *		2.4	**90**
Check	50	5.4	16.4	10.9		24.6		24.6	

		Generation 5 (Last)				Mean			
Treatment §	N	TX1	AR1	Mean		TX1	AR1	Mean	
10% FXT Ball PH	50	0.0 *	12.6	6.3	**73**	1.2 *	3.4 *	2.3	**81**
15% FXT Ball PH	50	6.3 *	5.2 *	5.7	**75**	1.4 *	3.4 *	2.4	**79**
20% FXT Ball PH	50	2.1 *	8.3 *	5.2	**77**	0.6 *	4.8 *	2.7	**77**
20% FXT Ball Adjacent	50	0.0 *	12.1	6.1	**74**	0.4 *	7.2 *	3.8	**68**
Mimic foliar spray	50	2.4 *	8.9 *	5.6	**75**	2.1 *	5.5 *	3.8	**68**
Check	50	24.5	21.5	23.0		11.0	12.7	11.8	

§ PH- placed in plant hole; Adjacent- tablet placed in soil next to seedling [shaded box] = treatment reduced damage by >75% compared to check.

***** Means followed by an asterik are significantly different from checks at the 5% level based on Fisher's Protected LSD.

Table 66. Effect of Bayer tablets on height, diameter and volume index after the first growing season on six sites - 2007.

		Mean Parameter Growth (**Growth Difference (cm or cm³) Compared to Check**)									
		Height (cm)		6 Trt Site		Height (cm)				4 Trt Site	
Treatment §	N	TX1	AR1	Mean		TX2	AR2	AR3	MS1	Mean	
10% FXT Ball PH	50	48.8 *	63.3 *	54.9 *	**10.3**						
15% FXT Ball PH	50	48.2 *	61.5 *	55.0 *	**10.3**						
20% FXT Ball PH	50	53.5 *	57.7	55.6 *	**11.0**	46.9 *	56.4 *	42.2	91.4	58.0 *	**8.6**
20% FXT Ball Adjacent	50	54.6 *	58.0	56.3 *	**11.7**	40.7 *	53.9 *	39.6	97.2	57.3 *	**7.9**
Mimic foliar spray	50	45.8	48.3	47.0	**2.3**	42.9 *	56.1 *	37.9	83.6	52.4	**3.0**
Check	50	39.1	50.3	44.6		33.5	47.3	35.6	90.7	49.4	
		Diameter (cm)		6 Trt Site		Diameter (cm)				4 Trt Site	
Treatment §	N	TX1	AR1	Mean		TX2	AR2	AR3	MS1	Mean	
10% FXT Ball PH	50	0.83 *	0.80	0.81	**0.12**						
15% FXT Ball PH	50	0.85 *	0.74	0.79	**0.10**						
20% FXT Ball PH	50	0.91 *	0.77	0.84	**0.15**	0.68 *	1.05	0.53	1.82	0.96	**0.08**
20% FXT Ball Adjacent	50	0.87 *	0.73	0.80	**0.11**	0.56	0.99	0.47	2.01	0.94	**0.06**
Mimic foliar spray	50	0.74	0.73	0.74	**0.05**	0.66 *	1.06 *	0.47	1.85	0.92	**0.04**
Check	50	0.68	0.70	0.69		0.54	0.93	0.47	1.94	0.88	
		Volume Index (cm³)		6 Trt Site		Volume Index (cm³)				4 Trt Site	
Treatment §	N	TX1	AR1	Mean		TX2	AR2	AR3	MS1	Mean	
10% FXT Ball PH	50	42.9 *	63.6 *	51.7 *	**25.3**						
15% FXT Ball PH	50	44.6 *	42.0	43.3 *	**16.9**						
20% FXT Ball PH	50	59.0 *	48.8	53.8 *	**27.4**	24.6 *	75.1 *	15.3	355.0	96.3 *	**12.5**
20% FXT Ball Adjacent	50	51.3 *	39.1	45.0 *	**18.6**	15.6	65.6	11.7	355.0	89.7 *	**6.0**
Mimic foliar spray	50	32.5	31.7	32.1	**5.8**	21.8 *	73.7 *	10.7	346.8	86.2	**2.4**
Check	50	22.9	30.0	26.4		11.2	50.7	11.6	376.2	83.8	

§ PH- placed in plant hole; Adjacent- tablet placed in soil next to seedling

* Means followed by an asterik are significantly different from checks at the 5% level based on Fisher's Protected LSD.

Table 67. Effect of Bayer tablets on percent shoots infested by pine tip moth after each of five generations during the second growing season on six sites - 2008.

Mean Percent Shoots Infested (Pct. Reduction Compared to Check)

Treatment §	N	Generation 1 TX1	AR1	TX2	AR2	AR3	MS1	Mean		Generation 2 TX1	AR1	TX2	AR2	AR3	MS1	Mean	
20% FXT Ball PH	50	9.9	12.0	3.1 *	12.9 *	6.3 *	NA	8.8 *	**64**	5.9 *	12.8 *	5.4 *	4.3 *	NA	NA	6.9 *	**78**
20% FXT Ball Adjacent	50	4.5 *	10.8	6.3 *	26.0 *	8.5 *	NA	11.2 *	**55**	4.0 *	12.5 *	12.0 *	33.4	NA	NA	16.4 *	**47**
Mimic foliar spray	50	3.0 *	12.4	6.0 *	35.4	6.1 *	NA	12.6 *	**49**	3.7 *	32.8	5.1 *	7.6 *	NA	NA	11.5 *	**63**
Check	50	13.5	20.2	26.3	46.0	17.6	NA	24.7		17.8	32.7	31.1	41.9	NA	NA	31.2	

Treatment §	N	Generation 3 TX1	AR1	TX2	AR2	AR3	MS1	Mean		Generation 4 TX1	AR1	TX2	AR2	AR3	MS1	Mean	
20% FXT Ball PH	50	1.9 *	12.0 *	0.6 *	11.3 *	NA	38.2	13.9 *	**55**	8.9 *		7.5 *			NA	8.1 *	**83**
20% FXT Ball Adjacent	50	4.9 *	16.3 *	10.8 *	38.0	NA	30.7	21.3 *	**31**	11.9 *		21.4 *			NA	16.6 *	**65**
Mimic foliar spray	50	0.5 *	36.7	4.7 *	24.3 *	NA	29.8	15.4 *	**50**	3.5 *		2.7 *			NA	3.1 *	**93**
Check	50	14.4	33.9	27.9	45.4	NA	32.7	31.0		49.3		45.6			NA	47.4	

Treatment §	N	Generation 5 (Last) TX1	AR1	TX2	AR2	AR3	MS1	Mean		Mean TX1	AR1	TX2	AR2	AR3	MS1	Mean	
20% FXT Ball PH	50	16.6 *	53.9	13.4 *	15.9 *	28.9	69.0	33.5 *	**46**	8.6 *	22.7 *	5.9 *	11.1 *	17.6 *	43.9	19.0 *	**50**
20% FXT Ball Adjacent	50	16.8 *	39.9 *	20.8 *	60.1 *	35.6	49.3	38.3 *	**38**	8.4 *	19.9 *	14.4 *	39.4 *	22.1	34.8	24.1 *	**37**
Mimic foliar spray	50	0.6 *	NA	2.3 *	30.5 *	22.5 *	13.9 *	14.4 *	**76**	2.3 *	NA	4.2 *	24.5 *	14.4 *	24.3 *	14.3 *	**63**
Check	50	56.0	72.3	66.8	78.7	35.5	67.6	62.3		30.2	39.4	38.9	53.5	26.6	45.0	38.2	

§ PH- placed in plant hole; Adjacent- tablet placed in soil next to seedling

[shaded box] = treatment reduced damage by >75% compared to check.

* Means followed by an asterik are significantly different from checks at the 5% level based on Fisher's Protected LSD.

Table 68. Effect of Bayer tablets on percent shoots infested by pine tip moth after each of five generations during the second growing season on two sites - 2008.

		Mean Percent Shoots Infested (Pct. Reduction Compared to Check)							
		Generation 1				Generation 2			
Treatment §	N	TX1	AR1	Mean		TX1	AR1	Mean	
10% FXT Ball PH	50	9.3	16.5	12.8	**24**	4.4 *	18.8	10.4 *	**58**
15% FXT Ball PH	50	1.1 *	12.6	6.8 *	**59**	2.1 *	11.8 *	7.0 *	**72**
20% FXT Ball PH	50	9.9	12.0	11.0	**35**	5.9 *	12.8 *	9.4 *	**62**
20% FXT Ball Adjacent	50	4.5 *	10.8	7.7 *	**54**	4.0 *	12.5 *	8.3 *	**67**
Mimic foliar spray	50	3.0 *	12.4	7.6 *	**55**	3.7 *	32.8	17.9	**28**
Check	50	13.5	20.2	16.8		17.8	32.7	24.9	
		Generation 3				Generation 4			
Treatment §	N	TX1	AR1	Mean		TX1	AR1	Mean	
10% FXT Ball PH	50	6.1 *	17.4 *	10.8 *	**54**	11.5 *		11.5 *	**77**
15% FXT Ball PH	50	4.9 *	13.9 *	9.5 *	**60**	11.4 *		11.4 *	**77**
20% FXT Ball PH	50	1.9 *	12.0 *	7.1 *	**70**	8.9 *		8.9 *	**82**
20% FXT Ball Adjacent	50	4.9 *	16.3 *	10.7 *	**55**	11.9 *		11.9 *	**76**
Mimic foliar spray	50	0.5 *	36.7	18.1	**24**	3.5 *		3.5 *	**93**
Check	50	14.4	33.9	23.8		49.3		49.3	
		Generation 5 (Last)				Mean			
Treatment §	N	TX1	AR1	Mean		TX1	AR1	Mean	
10% FXT Ball PH	50	15.6 *	74.9	41.1 *	**36**	9.4 *	29.8	17.7 *	**49**
15% FXT Ball PH	50	16.9 *	50.6 *	33.8 *	**47**	7.3 *	22.6 *	14.7 *	**57**
20% FXT Ball PH	50	16.6 *	53.9	36.0 *	**44**	8.6 *	22.7 *	15.8 *	**54**
20% FXT Ball Adjacent	50	16.8 *	39.9 *	28.6 *	**55**	8.4 *	19.9 *	14.3 *	**59**
Mimic foliar spray	50	0.6 *	84.9	41.7 *	**35**	2.3 *	41.7	21.5 *	**38**
Check	50	56.0	72.3	63.8		30.2	39.4	34.6	

§ PH- placed in plant hole; Adjacent- tablet placed in soil next to seedling [shaded box] = treatment reduced damage by >75% compared to check.

***** Means followed by an asterik are significantly different from checks at the 5% level based on Fisher's Protected LSD.

Table 69. Effect of Bayer tablets on height, diameter and volume index after the second growing seasons on six sites - 2008.

		Mean Parameter Growth (**Growth Difference (cm or cm^3) Compared to Check**)									
		Height (cm)		6 Trt Site		Height (cm)				4 Trt Site	
Treatment §	N	TX1	AR1	Mean		TX2	AR2	AR3	MS1	Mean	
10% FXT Ball PH	50	118.7 *	128.1	122.5 *	**15.3**						
15% FXT Ball PH	50	120.8 *	137.7 *	129.0 *	**21.7**						
20% FXT Ball PH	50	130.4 *	120.7	125.5 *	**18.2**	95.3 *	109.9 *	144.6 *	210.7	120.1 *	**21.8**
20% FXT Ball Adjacent	50	123.4 *	132.6	128.1 *	**20.9**	87.4	96.3 *	133.4 *	220.6	115.2 *	**16.8**
Mimic foliar spray	50	113.3	108.6	111.0	**3.7**	102.2 *	93.1 *	143.1 *	213.6	111.9 *	**13.6**
Check	50	100.5	114.6	107.3		80.5	81.5	114.7	188.0	98.4	
		Diameter @ 6" (cm)		6 Trt Site		Diameter @ 6" or DBH (cm)				4 Trt Site	
Treatment §	N	TX1	AR1	Mean		TX2	AR2	AR3	MS1	Mean	
10% FXT Ball PH	50	2.13	2.50	2.28	**0.21**						
15% FXT Ball PH	50	2.18 *	2.71	2.44 *	**0.37**						
20% FXT Ball PH	50	2.30 *	2.53	2.42 *	**0.35**	1.47 *	1.70 *	2.77 *	1.91	2.15 *	**0.38**
20% FXT Ball Adjacent	50	2.20 *	2.54	2.37 *	**0.31**	1.34	1.57	2.60 *	2.08	2.07 *	**0.30**
Mimic foliar spray	50	2.00	2.24	2.12	**0.05**	1.57 *	1.51	2.72 *	1.90	1.99 *	**0.22**
Check	50	1.80	2.36	2.07		1.17	1.39	2.15	2.10	1.77	
		Volume Index (cm^3)		6 Trt Site		Volume Index (cm^3)				4 Trt Site	
Treatment §	N	TX1	AR1	Mean		TX2	AR2	AR3	MS1	Mean	
10% FXT Ball PH	50	718	1284	950 *	**350**						
15% FXT Ball PH	50	724 *	1213	961 *	**361**						
20% FXT Ball PH	50	856 *	1115	987 *	**387**	251 *	380 *	1247 *	987	761 *	**319**
20% FXT Ball Adjacent	50	723 *	1148	940 *	**340**	189 *	300 *	1040 *	1253	689 *	**248**
Mimic foliar spray	50	564	750	655	**55**	321 *	277	1167 *	973	607 *	**165**
Check	50	396	820	600		156	217	636	1117	441	

§ PH- placed in plant hole; Adjacent- tablet placed in soil next to seedling

* Means followed by an asterik are significantly different from checks at the 5% level based on Fisher's Protected LSD.

Table 70. Effect of Bayer tablets on percent shoots infested by pine tip moth after each of five generations during the third growing season on two of six sites - 2009.

Mean Percent Shoots Infested (Pct. Reduction Compared to Check)

		Generation 1								Generation 2							
Treatment §	N	TX1	AR1	TX2	AR2	AR3	MS1	Mean		TX1	AR1	TX2	AR2	AR3	MS1	Mean	
20% FXT Ball PH	50	0.9		0.0 *				0.4 *	**89**	0.0		0.0 *				0.0 *	**100**
20% FXT Ball Adjacent	50	1.2		0.7 *				1.1 *	**73**	0.9		0.0 *				0.5 *	**84**
Mimic foliar spray	50	3.1		0.7 *				2.2	**46**	0.0		0.5 *				0.3 *	**89**
Check	50	1.5		6.0				4.1		0.8		4.5				2.9	

		Generation 3								Generation 4							
Treatment §	N	TX1	AR1	TX2	AR2	AR3	MS1	Mean		TX1	AR1	TX2	AR2	AR3	MS1	Mean	
20% FXT Ball PH	50	0.0		1.2 *				0.8 *	**81**	2.9 *		4.8				4.2 *	**61**
20% FXT Ball Adjacent	50	0.0		0.7 *				0.4 *	**90**	2.7 *		7.6				5.2 *	**53**
Mimic foliar spray	50	4.0		1.0 *				2.6	**36**	7.8		6.2				7.5	**32**
Check	50	1.9		5.4				4.1		12.1		10.5				11.0	

		Generation 5 (Last)								Mean							
Treatment §	N	TX1	AR1	TX2	AR2	AR3	MS1	Mean		TX1	AR1	TX2	AR2	AR3	MS1	Mean	
20% FXT Ball PH	50	8.8 *		9.1 *				9.0 *	**66**	2.5 *		3.0 *				4.7 *	**68**
20% FXT Ball Adjacent	50	14.9 *		14.3				14.2 *	**47**	3.9 *		4.6 *				7.2 *	**51**
Mimic foliar spray	50	22.0		9.5 *				15.0 *	**44**	7.4		3.6 *				8.9 *	**38**
Check	50	32.9		23.6				26.8		9.8		9.8				14.5	

§ PH- placed in plant hole; Adjacent- tablet placed in soil next to seedling

[shaded box] = treatment reduced damage by >75% compared to check.

* Means followed by an asterik are significantly different from checks at the 5% level based on Fisher's Protected LSD.

Table 71. Effect of Bayer tablets on percent shoots infested by pine tip moth after each of five generations during the second growing season on two sites - 2009.

		Mean Percent Shoots Infested (Pct. Reduction Compared to Check)							
		Generation 1				Generation 2			
Treatment §	N	TX1	AR1	Mean		TX1	AR1	Mean	
10% FXT Ball PH	50	0.3		0.3	**78**	0.6		0.6	**23**
15% FXT Ball PH	50	0.8		0.8	**48**	0.0		0.0	**100**
20% FXT Ball PH	50	0.9		0.9	**36**	0.0		0.0	**100**
20% FXT Ball Adjacent	50	1.2		1.2	**21**	0.9		0.9	**-3**
Mimic foliar spray	50	3.1		3.1	**-112**	0.0		0.0	**100**
Check	50	1.5		1.5		0.8		0.8	
		Generation 3				Generation 4			
Treatment §	N	TX1	AR1	Mean		TX1	AR1	Mean	
10% FXT Ball PH	50	1.5		1.5	**20**	2.5 *		2.5 *	**79**
15% FXT Ball PH	50	0.5		0.5	**73**	1.8 *		1.8 *	**85**
20% FXT Ball PH	50	0.0		0.0	**100**	2.9 *		2.9 *	**76**
20% FXT Ball Adjacent	50	0.0		0.0	**100**	2.7 *		2.7 *	**77**
Mimic foliar spray	50	4.0		4.0	**-115**	7.8		7.8	**35**
Check	50	1.9		1.9		12.1		12.1	
		Generation 5 (Last)				Mean			
Treatment §	N	TX1	AR1	Mean		TX1	AR1	Mean	
10% FXT Ball PH	50	7.3 *		7.3 *	**78**	2.4 *		2.4 *	**75**
15% FXT Ball PH	50	14.2 *		14.2 *	**57**	3.5 *		3.5 *	**65**
20% FXT Ball PH	50	8.8 *		8.8 *	**73**	2.5 *		2.5 *	**75**
20% FXT Ball Adjacent	50	14.9 *		14.9 *	**55**	3.9 *		3.9 *	**60**
Mimic foliar spray	50	22.0		22.0	**33**	7.4		7.4	**25**
Check	50	32.9		32.9		9.8		9.8	

§ PH- placed in plant hole; Adjacent- tablet placed in soil next to seedling   = treatment reduced damage by >75% compared to check.

***** Means followed by an asterik are significantly different from checks at the 5% level based on Fisher's Protected LSD.

Table 72. Effect of Bayer tablets on height, diameter and volume index after the second growing seasons on three of six Western Gulf sites - 2009.

Mean Parameter Growth (**Growth Difference (cm or cm³) Compared to Check**)

Treatment §	N	TX1	AR1	6 Trt Site Mean		TX2	AR2	AR3	MS1	4 Trt Site Mean	
		Height (cm)				Height (cm)					
10% FXT Ball PH	50	220.2 *	249.1	234.6 *	**20.8**						
15% FXT Ball PH	50	219.3 *	275.9	247.6 *	**33.8**						
20% FXT Ball PH	50	235.8 *	253.7	244.8 *	**31.0**	209.7 *	211.6 *	225.2 *	362.7	252.3	**26.2**
20% FXT Ball Adjacent	50	219.7 *	271.7	245.7 *	**31.9**	205.1 *	192.5	212.9 *	371.9	245.6	**19.6**
Mimic foliar spray	50	207.1	215.7	211.4	**-2.4**	217.7 *	184.8	224.3 *	360.2	246.8	**20.7**
Check	50	192.9	234.7	213.8		184.2	169.4	180.4	370.2	226.0	
		Diameter (cm)				Diameter (cm)					
10% FXT Ball PH	50	2.19 *	4.45	3.32 *	**0.35**						
15% FXT Ball PH	50	2.20 *	4.92	3.56 *	**0.59**						
20% FXT Ball PH	50	2.57 *	4.86	3.72 *	**0.74**	2.06 *	1.95 *	2.38 *	5.28	2.92 *	**0.57**
20% FXT Ball Adjacent	50	2.18 *	4.71	3.44 *	**0.47**	1.94 *	2.01 *	2.00 *	5.38	2.83 *	**0.49**
Mimic foliar spray	50	1.86	3.93	2.89	**-0.08**	2.22 *	1.42	2.34 *	5.22	2.80	**0.46**
Check	50	1.64	4.31	2.97		1.48	1.14	1.28	5.47	2.34	
		Volume Index (cm³)				Volume Index (cm³)					
10% FXT Ball PH	50	1509 *	7215	4362 *	**1323**						
15% FXT Ball PH	50	1536 *	7826	4681 *	**1642**						
20% FXT Ball PH	50	2188 *	7542	4865 *	**1827**	1194	1098 *	1743 *	11146	3795 *	**430**
20% FXT Ball Adjacent	50	1416 *	7492	4454 *	**1415**	949	697 *	1193 *	11997	3709 *	**344**
Mimic foliar spray	50	1037	4573	2805	**-234**	1451 *	598	1644 *	10794	3622	**257**
Check	50	782	5295	3039		741	487	409	11822	3365	

§ PH- placed in plant hole; Adjacent- tablet placed in soil next to seedling

***** Means followed by an asterik are significantly different from checks at the 5% level based on Fisher's Protected LSD.

Table 73. Effect of SilvaShield tablet dose on pine tip moth infestation of loblolly pine shoots (top whorl) on one site (Moffett) in east Texas, 2008 & 2009.

			Mean Percent Top Whorl Shoots Infested by Tip Moth (**Pct. Reduction Compared to Check**)															
Year	Treatment §	N	Gen 1			Gen 2			Gen 3			Gen 4			Gen 5			Overall Mean		
2008	1 Tablet at Planting	50	0.7	**-40**		0.0	**100**	*	0.0	**100**	*	2.2	**96**	*	5.9	**91**	*	0.7	**96**	*
	2 Tablets at Planting	50	0.0	**100**		2.0	**26**		2.1	**83**	*	11.7	**78**	*	10.5	**83**	*	3.9	**78**	*
	3 Tablets at Planting	50	0.0	**100**		0.0	**100**	*	0.0	**100**	*	6.0	**89**	*	9.0	**86**	*	1.5	**91**	*
	1 Tablet Adjacent	50	0.4	**20**		0.3	**89**		1.1	**91**	*	2.7	**95**	*	4.8	**92**	*	1.1	**94**	*
	Fipronil at Planting	50	1.7	**-240**		0.4	**85**		0.0	**100**	*	1.3	**98**	*	2.0	**97**	*	0.9	**95**	*
	Check	100	0.5			2.7			12.6			52.6			63.3			17.5		
2009	1 Tablet at Planting	50	2.7	**84**	*	4.2	**50**		1.2	**92**	*	7.5	**55**	*	0.0	####		3.0	**72**	*
	2 Tablets at Planting	50	4.1	**76**	*	0.9	**89**	*	6.8	**58**	*	17.7	**-6**		0.0	####		5.8	**47**	*
	3 Tablets at Planting	50	0.4	**98**	*	2.1	**75**	*	3.4	**79**	*	4.9	**70**	*	4.1	####		2.9	**73**	*
	1 Tablet Adjacent	50	3.6	**79**	*	3.7	**55**		2.7	**83**	*	1.7	**90**	*	0.0	####		2.3	**79**	*
	Fipronil at Planting	50	1.0	**94**	*	0.5	**94**	*	5.4	**67**	*	9.0	**46**		0.0	####		3.2	**71**	*
	Check	100	17.1			8.4			16.1			16.6			0.0			10.8		

***** Means followed by an asterik are significantly different from checks at the 5% level based on Fisher's Protected LSD.

(shaded) = treatment reduced damage by 75% or better compared to check.

Table 74. Effect of SilvaShield tablet dose on loblolly pine growth on one site (Moffet) in east Texas, 2008 & 2009.

			Mean End of Season Loblolly Pine Seeding Growth Measurements (**Growth Difference (cm or cm3) Compared to Check)**						
Year	Treatment	N	Height (cm)		Diameter (cm) [a]		Volume (cm^3)		Mean Percent Tree Survival
2008	1 Tablet at Planting	50	42.8	**-4.2**	0.77	**-0.10**	28.6	**-16.7**	96
	2 Tablets at Planting	50	44.1	**-2.9**	0.81	**-0.06**	35.1	**-10.2**	100
	3 Tablets at Planting	50	46.8	**-0.2**	0.88	**0.01**	40.1	**-5.2**	100
	1 Tablet Adjacent	50	43.4	**-3.6**	0.81	**-0.06**	35.3	**-10.0**	98
	Fipronil Adjacent	50	48.9	**1.9**	0.88	**0.01**	43.5	**-1.8**	100
	Check	50	47.0		0.87		45.3		94
2008	1 Tablet at Planting	50	95.8	**-11.3**	2.20	**-0.41**	512.0	**-306.2**	96
	2 Tablets at Planting	50	102.1	**-5.0**	2.41	**-0.19**	693.8	**-124.4**	98
	3 Tablets at Planting	50	104.1	**-3.0**	2.39	**-0.21**	671.8	**-146.4**	98
	1 Tablet Adjacent	50	99.4	**-7.6**	2.38	**-0.22**	666.6	**-151.6**	98
	Fipronil Adjacent	50	114.9	**7.9**	2.69	**0.08**	925.9	**107.7**	100
	Check	50	107.0		2.60		818.2		92

[a] Diameter taken at 6" above ground.

***** Means followed by an asterik are significantly different from checks at the 5% level based on Fisher's Protected LSD.

Table 75. Effect of SilvaShield tablet dose and depth on pine tip moth infestation of loblolly pine shoots (top whorl) on two first year sites (Loving Ferry & Moffet) in east Texas, 2008.

			Mean Percent Top Whorl Shoots Infested by Tip Moth (**Pct. Reduction Compared to Check**)															
Site	Treatment §	N	Gen 1			Gen 2			Gen 3			Gen 4			Gen 5			Overall Mean		
Loving Ferry	1 Tablet at 4"	50	1.7	**-108**		2.6	**66**		3.2	**63**	*	5.5	**87**	*	10.0	**78**	*	4.5	**79**	*
	2 Tablets at 4"	50	1.3	**-68**		3.9	**48**		0.0	**100**	*	5.0	**88**	*	10.3	**77**	*	4.1	**81**	*
	3 Tablets at 4"	50	2.3	**-193**		1.6	**78**	*	3.0	**66**	*	9.8	**77**	*	10.0	**78**	*	5.4	**75**	*
	1 Tablet at 8"	50	0.0	**100**		0.4	**95**	*	1.2	**86**	*	13.9	**67**	*	11.7	**74**	*	5.5	**75**	*
	2 Tablets at 8"	50	1.5	**-88**		3.1	**58**		0.0	**100**	*	0.7	**98**	*	7.1	**85**	*	2.0	**91**	*
	3 Tablets at 8"	50	0.5	**36**		0.0	**100**	*	0.5	**94**	*	4.6	**89**	*	7.6	**83**	*	2.7	**88**	*
	Check	50	0.8			7.5			8.7			42.7			45.7			21.6		
Moffet	1 Tablet at 4"	50	0.5	####		0.0	**100**	*	3.2	**76**	*	3.0	**93**	*	1.3	**97**	*	1.6	**93**	*
	2 Tablets at 4"	50	1.0	####		0.0	**100**	*	0.0	**100**	*	0.0	**100**	*	0.0	**100**	*	0.2	**99**	*
	3 Tablets at 4"	50	0.0	####		1.5	**89**	*	1.0	**93**	*	1.0	**98**	*	1.0	**98**	*	0.9	**96**	*
	1 Tablet at 8"	50	0.7	####		0.0	**100**	*	0.0	**100**	*	0.0	**100**	*	0.0	**100**	*	0.1	**99**	*
	2 Tablets at 8"	50	0.8	####		1.8	**86**	*	5.1	**62**	*	15.4	**64**	*	18.4	**57**	*	8.5	**62**	*
	3 Tablets at 8"	50	2.9	####		0.5	**96**	*	0.0	**100**	*	1.4	**97**	*	0.7	**98**	*	1.1	**95**	*
	1 Tablet at 8" PH	50	0.0	####		0.0	**100**	*	2.0	**85**	*	0.7	**98**	*	1.1	**97**	*	0.8	**97**	*
	Check	100	0.0			12.9			13.5			43.0			42.7			22.4		

***** Means followed by an asterik are significantly different from checks at the 5% level based on Fisher's Protected LSD.

[shaded box] = treatment reduced damage by 75% or better compared to check.

Table 76. Effect of SilvaShield tablet dose and depth on pine tip moth infestation of loblolly pine shoots (top whorl) on two first year sites (Loving Ferry & Moffet) in east Texas, 2009.

			Mean Percent Top Whorl Shoots Infested by Tip Moth (**Pct. Reduction Compared to Check**)																	
Site	Treatment §	N	Gen 1			Gen 2			Gen 3			Gen 4			Gen 5			Overall Mean		
Loving Ferry	1 Tablet at 4"	50	2.0	**91**	*	4.5	**46**		7.1	**49**	*	34.7	**38**	*	60.7	**29**	*	22.3	**40**	*
	2 Tablets at 4"	50	3.8	**83**	*	3.1	**62**	*	5.7	**59**	*	20.7	**63**	*	41.7	**51**	*	15.0	**59**	*
	3 Tablets at 4"	50	2.1	**90**	*	1.6	**81**	*	4.8	**66**	*	35.6	**36**	*	53.8	**37**	*	19.6	**47**	*
	1 Tablet at 8"	50	2.9	**87**	*	4.2	**50**		8.3	**40**		36.0	**35**	*	66.1	**22**	*	23.6	**36**	*
	2 Tablets at 8"	50	3.3	**85**	*	1.4	**83**	*	3.3	**77**	*	17.0	**69**	*	32.9	**61**	*	11.9	**68**	*
	3 Tablets at 8"	50	2.5	**88**	*	4.7	**43**		5.7	**59**	*	33.3	**40**	*	58.1	**32**	*	20.8	**44**	*
	Check	50	21.9			8.3			13.9			55.7			85.2			37.0		
Moffet	1 Tablet at 4"	50	3.7	**45**	*	3.4	**52**	*	1.1	**90**	*	12.8	**42**	*	31.0	**47**	*	10.4	**50**	*
	2 Tablets at 4"	50	0.4	**94**	*	0.0	**100**	*	1.0	**90**	*	4.4	**80**	*	28.0	**52**	*	6.9	**67**	*
	3 Tablets at 4"	50	0.0	**100**	*	1.2	**83**	*	1.2	**89**	*	7.5	**66**	*	27.8	**52**	*	7.3	**65**	*
	1 Tablet at 8"	50	1.6	**77**	*	0.4	**94**	*	1.0	**90**	*	6.1	**72**	*	31.2	**46**	*	8.1	**61**	*
	2 Tablets at 8"	50	1.8	**73**	*	0.6	**92**	*	4.1	**61**	*	7.8	**65**	*	29.7	**49**	*	8.8	**58**	*
	3 Tablets at 8"	50	0.0	**100**	*	0.0	**100**	*	1.0	**90**	*	3.3	**85**	*	21.1	**64**	*	5.1	**76**	*
	1 Tablet at 8" PH	50	0.4	**94**	*	0.5	**92**	*	1.7	**84**	*	5.8	**74**	*	29.3	**49**	*	7.6	**64**	*
	Check	100	6.9			7.1			10.4			22.0			58.1			20.9		

***** Means followed by an asterik are significantly different from checks at the 5% level based on Fisher's Protected LSD.

[shaded] = treatment reduced damage by 75% or better compared to check.

Table 77. Effect of SilvaShield tablet dose and depth on loblolly pine growth during first year and second year (Loving Ferry) in east Texas, 2008 & 2009.

Year	Treatment	N	Mean End of Season Loblolly Pine Seeding Growth Measurements (**Growth Difference (cm or cm^3) Compared to Check)** Height (cm)		Diameter (cm) [a]		Volume (cm^3)		Mean Percent Tree Survival
2008	1 Tablet at 4"	50	40.2	**8.3**	0.74	**0.13**	44.6	**27.7**	92
	2 Tablets at 4"	50	43.8 *	**11.9**	0.74 *	**0.13**	33.6 *	**16.7**	88
	3 Tablets at 4"	50	44.2 *	**12.4**	0.77 *	**0.16**	36.4 *	**19.4**	88
	1 Tablet at 8"	50	39.6 *	**7.7**	0.72	**0.11**	31.2 *	**14.2**	98
	2 Tablets at 8"	50	43.8 *	**11.9**	0.81 *	**0.20**	40.4 *	**23.5**	92
	3 Tablets at 8"	50	44.6 *	**12.7**	0.82 *	**0.21**	39.1 *	**22.2**	86
	Check	50	31.9		0.61		16.9		96
2009	1 Tablet at 4"	50	126.5 *	**24.2**	2.46	**0.45**	1439.2	**763.6**	82
	2 Tablets at 4"	50	129.5 *	**27.1**	2.39 *	**0.38**	974.6 *	**298.9**	82
	3 Tablets at 4"	50	130.2 *	**27.8**	2.61 *	**0.60**	1248.8 *	**573.2**	88
	1 Tablet at 8"	50	115.3	**12.9**	2.34	**0.34**	987.5	**311.8**	94
	2 Tablets at 8"	50	128.6 *	**26.2**	2.53 *	**0.5**	1199.4 *	**523.7**	84
	3 Tablets at 8"	50	129.2 *	**26.8**	2.46 *	**0.45**	1052.2 *	**376.5**	86
	Check	50	102.3		2.01		675.7		96

[a] Diameter taken at 6" above ground.

***** Means followed by an asterik are significantly different from checks at the 5% level based on Fisher's Protected LSD.

Table 78. Effect of SilvaShield tablet dose and depth on loblolly pine growth during first and second year (Moffet) in east Texas, 2008 & 2009.

Year	Treatment	N	Mean End of Season Loblolly Pine Seeding Growth Measurements (**Growth Difference (cm or cm^3) Compared to Check)** Height (cm)			Diameter (cm) [a]		Volume (cm^3)			Mean Percent Tree Survival
2008	1 Tablet at 4"	50	40.1		**3.7**	0.69	**0.00**	22.1		**1.6**	100
	2 Tablets at 4"	50	38.2		**1.8**	0.68	**-0.01**	21.6		**1.1**	90
	3 Tablets at 4"	50	41.2		**4.8**	0.74	**0.05**	29.2		**8.7**	98
	1 Tablet at 8"	50	40.1		**3.7**	0.70	**0.01**	23.1		**2.6**	96
	2 Tablets at 8"	50	42.3	*	**5.8**	0.71	**0.0**	26.2		**5.7**	90
	3 Tablets at 8"	50	43.7	*	**7.3**	0.75	**0.06**	31.2	*	**10.7**	96
	1 Tablet at 8" PH	50	39.9		**3.4**	0.69	**0.0**	23.9		**3.4**	90
	Check	50	36.4			0.69		20.5			100
2009	1 Tablet at 4"	50	86.1		**-2.8**	1.91	**-0.07**	368.0		**-55.2**	100
	2 Tablets at 4"	50	87.9		**-1.0**	1.88	**-0.10**	371.0		**-52.2**	88
	3 Tablets at 4"	50	92.4		**3.6**	2.05	**0.07**	511.7		**88.5**	98
	1 Tablet at 8"	50	86.3		**-2.6**	1.85	**-0.13**	333.7		**-89.5**	96
	2 Tablets at 8"	50	95.6		**6.8**	2.07	**0.1**	503.6		**80.4**	90
	3 Tablets at 8"	50	96.4		**7.5**	2.02	**0.04**	472.5		**49.3**	96
	1 Tablet at 8" PH	50	90.7		**1.9**	1.91	**-0.1**	396.9		**-26.3**	90
	Check	50	88.9			1.98		423.2			100

[a] Diameter taken at 6" above ground.

***** Means followed by an asterik are significantly different from checks at the 5% level based on Fisher's Protected LSD.

Table 79. Effect of SilvaShield tablet dose and depth on pine tip moth infestation of loblolly pine shoots (top whorl) on one second year site (Peavy) in east Texas, 2008.

Site	Treatment §	N	Gen 1			Gen 2			Gen 3			Gen 4			Gen 5			Overall Mean		
			Mean Percent Top Whorl Shoots Infested by Tip Moth (**Pct. Reduction Compared to Check**)																	
2008	1 Tablet at 4"	50	14.4	**1**		20.9	**35**	*	8.7	**64**	*	13.5	**80**	*	20.9	**65**	*	15.4	**61**	*
	2 Tablets at 4"	50	17.1	**-17**		14.1	**56**	*	6.2	**74**	*	5.4	**92**	*	5.7	**90**	*	9.9	**75**	*
	3 Tablets at 4"	50	13.2	**9**		7.4	**77**	*	0.9	**96**	*	0.4	**99**	*	13.2	**78**	*	7.0	**82**	*
	1 Tablet at 8"	50	12.7	**13**		15.2	**53**	*	10.2	**58**	*	30.2	**55**	*	33.3	**44**	*	20.3	**49**	*
	2 Tablets at 8"	50	13.3	**9**		5.8	**82**	*	3.7	**85**	*	7.8	**88**	*	7.3	**88**	*	7.7	**81**	*
	3 Tablets at 8"	50	14.5	**1**		11.5	**65**	*	2.5	**90**	*	3.0	**95**	*	2.5	**96**	*	6.8	**83**	*
	Check	50	14.6			32.4			24.2			66.5			59.6			39.6		
2009	1 Tablet at 4"	50	1.6	**39**		3.5	**-602**	*	1.0	**79**	*	5.4	**83**	*	15.1	**61**	*	5.3	**66**	*
	2 Tablets at 4"	50	1.0	**64**		1.0	**-96**		0.4	**91**	*	2.2	**93**	*	5.8	**85**	*	2.1	**86**	*
	3 Tablets at 4"	50	0.0	**100**	*	1.2	**-138**		0.7	**85**	*	3.1	**90**	*	2.7	**93**	*	1.5	**90**	*
	1 Tablet at 8"	50	2.0	**25**		1.2	**-138**		1.9	**58**	*	10.1	**68**	*	20.1	**48**	*	7.1	**54**	*
	2 Tablets at 8"	50	1.0	**62**		0.4	**20**		0.5	**89**	*	5.6	**82**	*	10.2	**73**	*	3.5	**77**	*
	3 Tablets at 8"	50	1.3	**50**		0.8	**-60**		0.0	**100**	*	0.4	**99**	*	1.7	**95**	*	0.9	**94**	*
	Check	50	2.6			0.5			4.6			31.2			38.4			15.5		

***** Means followed by an asterik are significantly different from checks at the 5% level based on Fisher's Protected LSD.

[shaded] = treatment reduced damage by 75% or better compared to check.

Table 80. Effect of SilvaShield tablet dose and depth on loblolly pine growth on one second year site (Peavy) in east Texas, 2008 & 2009.

Site	Treatment	N	Mean End of Season Loblolly Pine Seeding Growth Measurements (**Growth Difference (cm or cm^3) Compared to Check)**						Mean Percent Tree Survival
			Height (cm)		Diameter (cm) [a]		Volume (cm^3)		
2008	1 Tablet at 4"	50	156.2 *	**21.3**	3.31 *	**0.39**	2076 *	**775**	92
	2 Tablets at 4"	50	135.6	**0.7**	2.80	**-0.12**	1228	**-73**	96
	3 Tablets at 4"	50	141.5	**6.6**	2.90	**-0.02**	1293	**-8**	100
	1 Tablet at 8"	50	141.6	**6.7**	2.91	**-0.01**	1327	**26**	98
	2 Tablets at 8"	50	150.6 *	**15.7**	3.08	**0.16**	1632	**331**	100
	3 Tablets at 8"	50	143.4	**8.5**	2.87	**-0.04**	1401	**100**	98
	Check	50	134.9		2.92		1301		98
2009	1 Tablet at 4"	50	284.1 *	**26.8**	5.69	**0.40**	10232 *	**2443**	92
	2 Tablets at 4"	50	256.4	**-1.0**	5.05	**-0.24**	7135	**-654**	92
	3 Tablets at 4"	50	280.3 *	**23.0**	5.49	**0.20**	9459	**1669**	98
	1 Tablet at 8"	50	265.4	**8.1**	5.26	**-0.03**	7700	**-90**	98
	2 Tablets at 8"	50	273.8	**16.5**	5.47	**0.18**	8936	**1147**	100
	3 Tablets at 8"	50	269.0	**11.6**	5.20	**-0.09**	7935	**146**	98
	Check	50	257.4		5.29		7789		98

[a] Diameter taken at 6" above ground.

***** Means followed by an asterik are significantly different from checks at the 5% level based on Fisher's Protected LSD.

Table 81. Effect of SilvaShield tablet dose and depth on pine tip moth infestation of loblolly pine shoots (top whorl) on one second year site (Peavy) in east Texas, 2008 & 2009.

			Mean Percent Top Whorl Shoots Infested by Tip Moth (**Pct. Reduction Compared to Check**)															
Site	Treatment §	N	Gen 1		Gen 2		Gen 3			Gen 4			Gen 5			Overall Mean		
POT	1 SS	50	0.0	**####**	0.0	**####**	0.0	**100**						**####**		0.0	**100**	
Bradley	2 SS	50	0.0	**####**	0.0	**####**	0.0	**100**						**####**		0.0	**100**	
Rd	HWC	50	0.0	**####**	0.0	**####**	1.6	**33**						**####**		0.5	**33**	
	1 SS + HWC	50	0.0	**####**	0.0	**####**	3.6	**-46**						**####**		1.2	**-46**	
	2 SS + HWC	50	0.0	**####**	0.0	**####**	0.0	**100**						**####**		0.0	**100**	
	Check	50	0.0		0.0		2.4									0.8		
CG	1 SS	50	6.6	**-34**	3.0	**26**	0.7	**93**	*	15.9	**62**	*	46.6	**25**	*	14.7	**41**	*
Cottingham	DAP 1X	50	2.1	**57**	6.2	**-53**	10.4	**2**		42.3	**-2**		55.0	**12**		23.4	**5**	
Bridge	1 SS + DAP 1/2X	50	2.5	**49**	2.7	**33**	2.3	**79**	*	21.0	**49**	*	52.0	**17**		16.1	**35**	*
	HWC	50	8.0	**-63**	9.5	**-136**	10.1	**6**		38.8	**6**		58.7	**6**		25.0	**-1**	
	1 SS + HWC	50	3.1	**36**	0.7	**82**	1.4	**86**	*	11.7	**72**	*	48.1	**23**		12.8	**48**	*
	1 SS + DAP 1/2X + HWC	50	1.0	**80**	0.3	**91**	0.0	**100**	*	13.0	**69**	*	45.1	**28**	*	11.9	**52**	*
	1 SS + DAP 1X + HWC	50	3.3	**33**	1.2	**70**	1.7	**84**	*	23.5	**43**	*	45.4	**27**	*	14.6	**41**	*
	DAP 1X + HWC	50	5.7	**-16**	11.7	**-189**	14.7	**-37**		32.1	**22**		55.7	**11**		24.2	**2**	
	Check	50	4.9		4.0		10.7			41.3			62.3			24.7		

***** Means followed by an asterik are significantly different from checks at the 5% level based on Fisher's Protected LSD.
[shaded] = treatment reduced damage by 75% or better compared to check.

Table 82. Effect of SilvaShield tablet dose and depth on loblolly pine growth on one second year site (Peavy) in east Texas, 2008 & 2009.

			Mean End of Season Loblolly Pine Seeding Growth Measurements (**Growth Difference (cm or cm^3) Compared to Check)**						
Site	Treatment	N	Height (cm)		Diameter (cm) [a]		Volume (cm^3)		Mean Percent Tree Survival
POT	1 SilvaShield (SS)	50		**0.0**		**0.00**		**0**	
Bradley	2 SS	50		**0.0**		**0.00**		**0**	
Rd	HWC	50		**0.0**		**0.00**		**0**	
	1 SS + HWC	50		**0.0**		**0.00**		**0**	
	2 SS + HWC	50		**0.0**		**0.00**		**0**	
	Check	50							
CG	1 SS	50	68.8	**7.1**	1.63	**0.17**	212.4	**33.0**	90
Cottingham	DAP 1X	50	71.4 *	**9.7**	1.73 *	**0.26**	255.6 *	**76.2**	80
Bridge	1 SS + DAP 1/2X	50	80.4 *	**18.7**	1.91 *	**0.45**	322.2 *	**142.8**	98
	HWC	50	58.9	**-2.8**	1.38	**-0.08**	144.7	**-34.7**	84
	1 SS + HWC	50	73.1 *	**11.4**	1.74 *	**0.28**	257.5 *	**78.1**	92
	1 SS + DAP 1/2X + HWC	50	72.0 *	**10.3**	1.73 *	**0.27**	256.0 *	**76.6**	96
	1 SS + DAP 1X + HWC	50	75.1 *	**13.4**	1.79 *	**0.33**	273.9 *	**94.5**	78
	DAP 1X + HWC	50	59.4	**-2.3**	1.50	**0.03**	169.7	**-9.7**	94
	Check	50	61.7		1.46		179.4		94

[a] Diameter taken at 6" above ground.

***** Means followed by an asterik are significantly different from checks at the 5% level based on Fisher's Protected LSD.

PINE TIP MOTH TRIALS

SilvaShield™ Operational Soil Injection Study - Western Gulf Region

Highlights:

- SilvaShield™ Forestry Tablets operationally applied by hand (2008) significantly reduced tip moth damage in the first year (by 77%) and second year (by 69%) after application. The treatment significantly improved tree growth.
- Operational treatment of second-year trees only reduced overall tip moth damage by 38% (first year) and 52% (second year) after application compared to untreated checks, but the treatment improved height, diameter and volume growth by 7%, 11% and 24%, respectively.
- SilvaShield™ operationally applied by hand into plant holes significantly reduced tip moth damage (by 85%) in the first year after application. The treatment significantly improved tree volume growth (45%).

Objectives: To 1) determine the efficacy of SilvaShield™ tablets in reducing area-wide pine tip moth infestation levels on loblolly pine seedlings; 2) evaluate this product applied after planting to bedded or unbedded areas; and 3) determine the duration of protection provided by this insecticide application.

Cooperators:

Mr. Steve Anderson	Texas Forest Service, Hudson, TX
Ms. Francis Peavy,	Private land owner, Hudson, TX
R. Ragan Bounds	Hancock Forest Management, Woodville, TX
Dr. Nate Royalty	Bayer Environmental Science, Research Triangle Park, NC

Study Sites: One first-year plantation and one second-year plantation were selected east of Lufkin, TX and north of Hudson, TX (Angelina Co.) in February 2008. A second first-year site was selected near Rockland (Tyler Co.) in February 2009.

Insecticides:

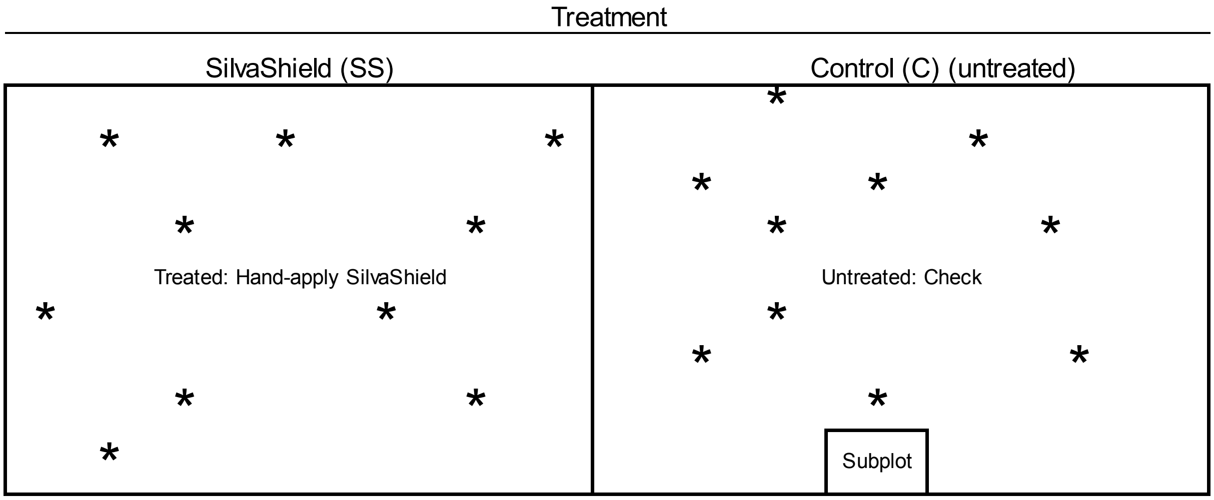
SilvaShield™ Forestry Tablet (imidacloprid + fertilizer) – imidacloprid is highly systemic neonictinoid with activity against Lepidoptera. The fertilizer has a N:P:K ratio of 12:9:4.

Research Approach:

A randomized complete block design was used at each site with site areas serving as blocks, i.e., each treatment was randomly selected for placement in one-half of the area. For each treatment, one hundred seedlings were monitored in each main plot area. The treatments (per 40 acre block) included:

1) SilvaShield™ (one tablet) applied after planting next to each seedling to a depth of 8 inches.
2) Check –seedlings planted by hand

Two tracts about to be planted, and one one-year old tract, each 80 acres in size, were selected in Texas based on uniformity of soil, drainage, topography and susceptibility to tip moth infestation (based on FPMC Tip Moth Hazard-Rating Model, Andy Burrow, and Temple Inland Forest Products).



Main treatment plots = 40 acres each; Internal treatment subplots = 0.5 acres each; ten 10-tree plots (*) evenly spaced within each main plot

Figure 40. Generalized plot design

In 2008, each plantation was hand-planted. On one half of the plantation, the applicator applied one SilvaShield™ tablet to each seedling after planting (Figure 40). A lance was used to create an 8-inch deep hole in the soil, angled toward the seedling. The tablet was then dropped into the hole and covered up. In the other half of the plantation, seedlings were hand or machine planted at the same spacing without SilvaShield™ tablets. In 2009, tablets were placed in the planting hole prior to placement of the containerized seedling.

Ten 10-tree plots were spaced equally within each main plantation half (but outside the internal treatment plots) to evaluate tip moth damage levels in these area. All stands were treated with herbicide after planting to minimize herbaceous and/or woody competition.

Tip moth damage was evaluated after each tip moth generation (3-4 weeks after peak moth flight) by 1) identifying if the tree is infested or not, 2) if infested, the proportion of tips infested on the top whorl and terminal was calculated; and 3) separately, the terminal was identified as infested or not. Observations also were made as to the occurrence and extent of damage caused by other insects, i.e., coneworm, aphids, sawfly, etc. Each tree was measured for diameter (at ground line) and height and in the fall (November).

Efficacy was evaluated by comparing treatment differences for direct and indirect measures of insect-caused losses. Direct treatment effects consist of a reduction in pine tip moth damage. Indirect treatment effects consist of increases in tree growth parameters (height, diameter and volume index). Data was subjected to analyses of variance using Statview software (SAS Institute, Inc. 1999). Percentage and measurement data were transformed by the arcsine % and log transformations, respectively, prior to analysis.

Results:

In 2008, tip moth populations were low on the first-year site (Moffet) during the first generation with an average of 3.4% of the shoots infested on check trees. As a result of the low tip moth pressure, the tablet treatment did not significantly reduced tip moth infestation levels compared to the check during this generation (Table 83). In contrast, the treatment provided very good protection during the second through fifth generations, reducing damaged by 74 – 85% (77% overall). The tablet treatment significantly improved all (height, diameter & volume) growth parameters compared to check trees (Table 84).

Tip moth populations were higher on the second-year site (Peavy) during the first generation with an average of 19.4% of the shoots infested on check trees. The tablet treatment was not applied until the end of March, so it is understandable that the treatment did not significantly reduce tip moth infestation levels compared to the check during this generation (Table 83). In contrast, the treatment provided good protection during the second through fifth generations, reducing damaged by 31 – 52% (38% overall). The tablet treatment significantly improved all (height, diameter, and volume) growth parameters compared to check trees (Table 84).

In 2009, tip moth populations were generally low on the first-year site (Rockland) during the first two generations with an average of 2.6 – 2.8% of the shoots infested on check trees. As a result of the low tip moth pressure, the tablet treatment did not significantly reduced tip moth infestation levels compared to the check during this generation (Table 85). In contrast, the treatment provided very good protection during the second through fifth generations, reducing damaged by 65 – 90% (85% overall). The tablet treatment significantly improved height, and volume growth parameters compared to check trees (Table 86).

Conclusions:

Data from new sites (Moffet and Rockland) indicate that SilvaShield™ tablets operationally applied by hand provide very good protection against tip moth and improves growth during the first year after planting. Good efficacy can extend through the second year (Moffett). Additional data indicate that tablets applied to one-year-old trees are not quite as effective against tip moth, but the treatment still can significantly improve growth. The trials will be continued in 2010 to evaluate for duration of treatment effects.

Acknowledgments: Thanks go to Mr. Steve Anderson, TFS, Ms. Francis Peavy, private landowner, and Ragan Bounds, Hancock Forest Management, for providing research sites in Texas. We thank Weyerhaeuser Company for donating the seedlings. We also thank Dr. Nate Royalty, Bayer, for providing the SilvaShield™ tablets for the project.

Table 83. Effect of SilvaShield tablet on areawide pine tip moth infestation of loblolly pine shoots (top whorl) on two sites (Moffet and Peavy) in east Texas, 2008 & 2009.

				Mean Percent Top Whorl Shoots Infested by Tip Moth (**Pct. Reduction Compared to Check**)																	
Site	Year	Treatment §	N	Gen 1			Gen 2			Gen 3			Gen 4			Gen 5			Overall Mean		
Moffet 1st Yr	2008	1 Tablet at 8"	100	1.7	**50**		2.8	**74**	*	3.0	**76**	*	2.4	**85**	*	5.6	**77**	*	3.1	**77**	*
		Check	100	3.4			10.9			12.6			16.3			24.6			13.6		
	2009	1 Tablet at 8"	100	1.1	**70**		1.9	**72**	*	4.3	**80**	*	9.6	**82**	*	32.0	**55**	*	9.8	**69**	*
		Check	100	3.6			6.9			21.0			54.3			71.4			31.4		
Peavy 2nd Yr	2008	1 Tablet at 8"	100	19.6	**-1**		25.4	**30**	*	20.2	**48**	*	37.3	**52**	*	48.4	**30**	*	30.2	**38**	*
		Check	100	19.4			36.5			38.6			78.0			69.3			48.4		
	2009	1 Tablet at 8"	100	2.3	**71**	*****	5.0	**0**		1.5	**71**	*	15.1	**56**	*	28.8	**51**	*	10.5	**52**	*
		Check	100	7.8			5.0			5.2			34.2			58.5			22.1		

***** Means followed by an asterik are significantly different from checks at the 5% level based on Fisher's Protected LSD.

[grey shading] = treatment reduced damage by 75% or better compared to check.

Table 84. Effect of SilvaShield tablet on areawide loblolly pine growth on two sites (Moffet and Peavy) in east Texas, 2008 & 2009.

Site	Year	Treatment	N	Mean End of Season Loblolly Pine Seeding Growth Measurements (**Growth Difference (cm or cm^3) Compared to Check)** Height (cm)		Diameter (cm) [a]		Volume (cm^3)		Mean Percent Tree Survival
Moffet 1st Yr	2008	1 Tablet at 8"	100	60.9 *	**15.9**	0.95 *	**0.23**	69.9 *	**41.6**	100
		Check	100	45.1		0.72		28.3		100
	2009	1 Tablet at 8"	100	132.2 *	**25.4**	2.32 *	**0.33**	845.2 *	**319.4**	100
		Check	100	106.8		1.99		525.8		100
Peavy 2nd Yr	2008	1 Tablet at 8"	100	156.2 *	**14.5**	3.10 *	**0.45**	1724.0 *	**512.0**	100
		Check	100	141.7		2.65		1212.0		100
	2009	1 Tablet at 8"	100	278.2 *	**17.7**	5.25 *	**0.50**	8296.2 *	**1620.7**	100
		Check	100	260.5		4.75		6675.5		100

[a] Diameter taken at 6" above ground.

***** Means followed by an asterik are significantly different from checks at the 5% level based on Fisher's Protected LSD.

Table 85. Effect of SilvaShield tablet on areawide pine tip moth infestation of loblolly pine shoots (top whorl) on one site (Rockland) in east Texas, 2009.

				Mean Percent Top Whorl Shoots Infested by Tip Moth (**Pct. Reduction Compared to Check**)					
Site	Year	Treatment §	N	Gen 1	Gen 2	Gen 3	Gen 4	Gen 5	Overall Mean
Rockland 1st Yr	2009	1 Tablet in PH	100	0.6 **78**	1.0 **65** *	2.2 **81** *	2.5 **85** *	2.5 **90** *	1.7 **85** *
		Check	100	2.6	2.8	11.4	16.9	24.0	11.5
	2010	1 Tablet in PH	100						
		Check	100						

***** Means followed by an asterik are significantly different from checks at the 5% level based on Fisher's Protected LSD.
[shaded box] = treatment reduced damage by 75% or better compared to check.

Table 86. Effect of SilvaShield tablet on areawide loblolly pine growth on two sites (Moffet and Peavy) in east Texas, 2008 & 2009.

Site	Year	Treatment	N	Mean End of Season Loblolly Pine Seeding Growth Measurements (**Growth Difference (cm or cm^3) Compared to Check)** Height (cm)		Diameter (cm) [a]		Volume (cm^3)		Mean Percent Tree Survival
Rockland 1st Yr	2009	1 Tablet in PH	100	75.3 *	**7.7**	1.19	**0.10**	146.8 *	**45.9**	100
		Check	100	67.7		1.09		100.9		100
	2010	1 Tablet in PH	100							
		Check	100							

[a] Diameter taken at 6" above ground.

***** Means followed by an asterik are significantly different from checks at the 5% level based on Fisher's Protected LSD.

PINE TIP MOTH TRIALS

Summary and Registration Status of Tested Systemic Insecticides

Over the past 12 years (1998 – 2009), the FPMC has been monitoring and assessing the impact of pine tip moth on pine tree growth. It has been well established through our impact, hazard-rating, and control trials that this insect significantly impacts seedling growth and form, at least in the short term. However, several questions remain to be answered in their entirety, particularly 1) What is the long term impact of tip moth on tree growth? and 2) what are the primary factors that influence the occurrence and severity of tip moth infestations? During the past nine years, we have established 106 impact plots and 138 hazard-rating plots in the Western Gulf Region and accumulated a large pool of data from which to address these two questions. Data analyses have determined the damage threshold for impact to be about 11% of shoots infested during the first two years after planting. Regression analyses continue to determine the relationship between time and extent of tip moth protection and tree growth. Andy Burrows, Potlatch, developed a preliminary hazard-rating model in 2005 that identified site index and soil texture composition as the two primary factors that influence the occurrence and severity of pine tip moth damage. A revised model developed in 2007 based on data from numerous sites indicated that sites with deep, excessively or poorly drained soils are more prone to tip moth damage. This model needs to be validated with data from additional sites. Unfortunately, Mr. Burrow could no longer provide assistance, so Dr. Dean Coble and Mr. Trevor Walker, Stephen F. Austin State University will work cooperatively to further develop the model in 2010. It is important that evaluations and data collections continue on already established impact and hazard-rating sites in 2009 and beyond and that new impact sites be established that utilize PTM™ as the protective agent.

Fipronil: Over the past eight years (2002 – 2009), fipronil has proven to be highly effective in reducing tip moth damage to first-year seedlings. Further evaluations indicate that residual effects can occur into the second and third year after planting. However, application techniques and rates can influence treatment efficacy and need to be considered in the development of one or more operational treatments.

The treatment of pine seedlings in the nursery, prior to lifting, are likely to be the most cost effective and least hazardous (exposure-wise) application technique. However, EPA has restricted the amount of active ingredient that can be applied per acre per year, to 0.13 lb. – this is a very small amount of active ingredient spread over approximately 600,000 seedlings per acre of nursery. We tried to push the envelope in the 2004 and 2005 trials by applying fipronil in the nursery at 2X, 4X, 8X and 16X the annual rate. Unfortunately, none of the treatments was found to be effective in reducing tip moth damage.

Three methods of treating bare-root seedlings after lifting were evaluated in 2003 and 2004: root soak, root dip or plant hole treatment. All three treatment techniques proved to be effective in reducing tip moth damage at least through the first year. The root dip and plant hole treatments provide extended protection into the second year, but only the high rate plant hole treatment significantly reduced damage through the third year. However, BASF and EPA are concerned about the potential for excessive chemical exposure when treating or handling treated bare-root seedlings. Given these concerns and limitations, it was decided to focus on the development of treatments made at or post plant of seedlings.

Three hand applicators, the Kioritz™ ($350 - $460), PTM Spot Gun™ ($80), and PTM Injection Probe™ ($420), have been successfully used to apply fipronil solution by hand. Soil injection trials established in 2005-2009 showed that this application technique is consistently effective in reducing pine tip moth damage. A trial established in 2008 showed that post-plant applications of fipronil are effective even when applied at the beginning of the 2nd year. However it is important to note that fipronil solution applied directly into a plant hole at time of planting is consistently more effective in reducing tip moth damage compared to applications made to the soil after the seedlings are planted.

Planting seedlings by machine has become more popular because: 1) hand-planting crews have become scarce, 2) machine-planted seedlings tend to show better survival and growth compared to hand-planted seedlings. A safe and efficient way of treating machine-planted bare-root or containerized seedlings with fipronil would be to apply the chemical as they are placed by the machine in the furrow. Mr. Lane Day and Jim Rogers, contracted by the FPMC, were able to develop and successfully test a new soil injection system in late 2006. The treatment applied by machine was consistently effective in protecting first-year seedlings on three sites through 2007. Additional machine planter trials established early in 2008 indicated that fipronil can reduce tip moth damage for two years across large areas. These trials will be continued in 2010 and beyond to determine long-term effects on area-wide tip moth populations and damage.

Fipronil treatments with containerized seedlings and rooted cuttings also were highly effective in reducing tip moth damage in 2004. A second trial established in 2007 in which fipronil was applied to containerized plugs 7 month in advance of planting showed outstanding first year results (≥99% reduction in damage), good results the second year (≥52% reduction) and moderate results the third year (≥ 16% reduction). As this segment of the seedling market is continuing to build, a safe and efficient method of treating these containerized and rooted-cutting seedlings in trays should be developed. Unfortunately, because EPA is considering several other fipronil uses, BASF has postponed a request to modify the PTM™ label to include use on containerized seedlings.

In response to the results described above, BASF submitted a package to EPA to register a formulation of fipronil for use to protect conifers against pine tip moth in May 2006. EPA approved the full registration (Section 3) of PTM™ for use against tip moth and aphids by soil injection in June 2007. The product became available for the winter 2007/2008 planting season. Table 61 provides updated information about the PTM™ product (distributors, cost, etc.).

Trials established in 2009 to refine treatment rates and timing and determine effects on second-year trees will be monitored again in 2010. Additional trials are planned for 2010 to directly compare the efficacy and duration of PTM™ and SilvaShield™.

Imidacloprid: Imidacloprid has been shown in the past to be highly effective in reducing tip moth damage levels on treated seedlings. However, the cost of treatment per seedling had been a deterrent to its registration for forestry use (Scott Cameron, personal communication). Bayer Environmental Science has registered imidacloprid/fertilizer spikes (Advance Garden™ 2-in-1 plant spikes) for residential use against tip moth. Although the plant spikes have performed well in single trial replicates (Technique and Rate Trial, 2003-2004), again the cost of treatment per seedling for operational forestry use is prohibitive.

Bayer Environmental Science also is interested in the potential for using tablets containing imidacloprid + fertilizer to protect seedlings against tip moth. Trials in 2004 and 2005 indicated that these tablets provided good protection against tip moth in the first year after planting. A new trial in 2006 evaluated several new tablets, granular and gel formulations. All tablet and granular formulations were effective. As a result of the above trials as well as other trials on the East Coast, Bayer requested and EPA approved a full Section 3 registration for SilvaShield™ Forestry Tablets in 2006**.** The tablets can be applied for protection of pine against tip moth, aphids and soft scales and hybrid poplar against leaf beetles. Table 61 provides updated information about the PTM™ product (distributors, cost, etc.).

Trials were established in 2008 to refine treatment rates and timing, application depth and determine effects on second year trees. Application rate or depth had no significant effect on tip moth damage and growth of first year seedling, but high rates did provide greater protection and improved growth of second-year trees. Assessments made in 2009 indicate protection is provided through the second year.

Additional trials are planned for 2010 to determine the relative effects of input types (SilvaShield™, fertilizer and/or weed control) occurrence and severity of tip moth damage and effects on tree growth.

Comparison of SilvaShield™ and PTM™ products for Pine Tip Moth Control.

Characteristic	SilvaShield™ Forestry Tablet	PTM™ Insecticide
Active Ingredient(s)	Imidacloprid (20%) + Fertilizer (12N:9P:4K)	Fipronil (9.1%)
Manufacturer	Bayer Environmental Science	BASF Corporation
Distributors	Helena Red River Specialties (RRS) UAP	C3M Helena ProSource Red River Specialties (RRS) UAP
Cost per container	RRS quote: $245 per bag (contains 1200 tablets); cost depends on quantity purchased.	RRS quote: $320 per gallon; cost depends on quantity purchased.
Restrictions on Amount per Acre	450 tablets per acre per year	21 fluid oz per acre per year
Chemical Cost per Acre	$92.00	$52.50
Treatments at Planting into Plant Holes or Furrows	No equipment required; tablets easily applied by gloved hand into plant holes created by dibble bars.	Not easily applied with hand applicator system, but can be applied effectively with a machine planter system: **System for C&G planter** Available on a per order basis; contact Mr. Lane Day (phone:936-240-8294) for a price quote **System for Whitfield planter** Not currently available; under development by Mr. Lane Day.
Duration of At Planting Treatment Efficacy	18 - 24 months	24 - 36 months
Post-plant Treatments into Soil Adjacent to Seedling	No equipment available; tablets can be pushed into soil next to seedling with gloved hand; hand applicator system is being developed.	Easily applied with hand applicator systems: **Kioritz Soil Injector** (0.8 gallon capacity) $354.99 thru Amazon.com $365.00 thru treestuff.com $394.50 thru treecaresupplies.com $401.78 + shipping thru Rittenhouse.com **PTM Spot Gun** (1.2 gallon capacity) $88.00 thru feltonmedical.com $150.00 thru RRS **PTM Injection Probe** (4.0 gallon capacity) ~$255.00 for probe assembly only ~$425.00 for gun + backpack sprayer thru enviroquipinc.com
Recommended Quantity per Seedling	1 tablet	1.3 ml PTM + 13.7 ml water = 15 ml dilution per tree
Duration of Post-Plant Treatment Efficacy	Currently less than plant hole applications; research underway to improve efficacy.	Currently less than plant hole or machine planter applications; research underway to improve efficacy.

OTHER

Evaluation of Kairomones for Attraction of Hardwood Pests to Traps

Highlights:

- A fall trap trial tested the attractiveness of three kairomones to hardwood insects. Only 256 insect specimens were collected in 40 days. None of the kairomones improved attraction over an unbaited trap.

Justification: Syngenta and Synergy Semiochemical are interested in generating additional data related to the attractiveness of hardwood pests to various kairamones.

Objective: Evaluate the seasonal attractiveness of hardwood insects in East Texas to three kairomones alone or combined.

Cooperators:

Mr. Joe Hernandez	Western Gulf Tree Improvement Program, College Station, TX
Dr. Jackie Driver	Syngenta, Waco, TX
Dr. David Cox	Syngenta, Modesta, CA
Dr. David Wakerchuk	Synergy Semiochemicals, BC

Study Site: Texas Forest Service Hudson Hardwood Seed Orchard, Angelina Co., TX.

Kairamones:

Ethanol – ethyl alcohol (90%)

BeetleBlock GLV - Leaf alcohol (Z3-hexenol and cis-3-hexenol) + 1-Hexanol (Amylcarbinol * Caproyl alcohol)

Manuka Oil Lure – manuka oil

Research Approach:

A complete randomized complete block with position as blocks. 8 Lindgren funnel traps (8 positions; Figure 41) placed 50 meters apart along orchard road. Treatments randomly assigned to initial position. Every 5 days, traps rotated to new position until each treatment has been in each position.

Figure 41. Lindgren Funnel Trap

The treatments included:

A = ethanol in amber bottle w/ wick
B = BeetleBlock GLV lure
C = Manuka oil

Treatments combinations:

1) Check (no lure)
2) A alone
3) B alone
4) C alone
5) A + B
6) B + C
7) A + C
8) A + B + C

The trial was initiated August 20th, 2009. After each 5 day period, insects (know to attack hardwoods) were collected and brought back to lab for identification. As needed, voucher specimens were pinned and retained in a collection.

Data were transformed by $\log_{10}(x + 1)$ if necessary to satisfy criteria for normality and homoscedasticity (Zar 1984) and analyzed for treatment effect, species richness, diversity by GLM and the Fisher's Protected LSD test using the Statview® statistical program (SAS Institute Inc.).

Results:

Relatively few (256) insect specimens from important families were captured in the first trial replicate (August & September). By far, the most abundant group were Scolytinae (83%, bark and ambrosia beetles), followed by Cerambycidae (11%, long horned beetles), weevils (5%, Curculionidae) and flat-headed wood borers (1%, Buprestidae). No difference was found in the attractiveness of the three kairomones to hardwood insects compared to checks (Table 87). We plan to replicate the trial in the spring (April) and summer (June).

Table 87: Coloeoptera captured in kairomone-baited funnel traps, Hudson, TX; 2009.

	Mean Numbers Captured $\pm$ SE		
Treatment*	Cerambycidae	Cuculionidae	Scolytinae
Eth.	0.4 $\pm$ 0.3 †	0.1 $\pm$ 0.1	4.7 $\pm$ 1.2
BB	0.4 + 0.3	0.3 + 0.2	2.0 + 0.8
MO	0.1 + 0.1	0.1 + 0.1	3.3 + 1.3
Eth. + BB	0.6 $\pm$ 0.3	0.0 $\pm$ 0.0	4.4 $\pm$ 1.1
BB + MO	0.1 $\pm$ 0.1	0.3 $\pm$ 0.2	1.8 $\pm$ 0.7
Eth. + MO	0.6 $\pm$ 0.4	0.1 $\pm$ 0.1	3.8 $\pm$ 0.9
Eth. + BB + MO	0.9 + 0.7	0.3 + 0.2	4.1 + 0.6
Check	0.5 + 0.3	0.5 + 0.3	2.5 + 0.5

* Eth=Ethanol; BB=BeetleBlockGLV; MO=Manuka oil

† Means followed by an asteriks in each column of the same site are significantly different from the checks at the 5% level based on Fisher's Protected LSD.