Forest Pest Management Cooperative

Research Accomplishments in 2011

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Executive Summary

The Forest Pest Management Cooperative (FPMC) made significant progress on many fronts in 2011. 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 2010. These projects contained **20** 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 2012 Project Proposals.

A couple of important changes occurred in the FPMC membership in 2011. Potlatch and Cellfor left due to financial problems. **Thank you to all members 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 projects. Resource Specialist, Larry Spivey, and seasonals James Fox, Chris Bartley, and Regine Skelton provided assistance with field and lab studies. Southern Pine Beetle Prevention Forester Mike Murphrey assisted with cone evaluations. 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 has always been an important part of the FPMC. To this end, four issues of the *PEST* newsletter were prepared and distributed in 2011. Also, 9 presentations, 18 meeting requests, 3 training sessions, and 123 phone/e-mail requests were addressed relating to the following topics: drought effects, leaf-cutting ants, pine tip moths, reproduction weevils, cone and seed insects, bark beetles (*Ips* engravers, black turpentine beetle and mountain pine beetle), fall webworm, scales, saltcedar beetle, soapberry borer, pitch canker, and hypoxylon canker. We are in the process of updating the Forestry Pesticide web page.

In 2011, rainfall was below normal in many locations across the South (Table 1). Lufkin, which normally receives 46+ inches of rainfall per year, finished the year a little less than 13 inches below average. Similarly, AR, LA, MS, GA, and FL had large deficits (Table 1). In contrast, other areas (AL, VA, NC, and GA) had relatively close to normal rainfall. Thankfully, no significant hurricanes made landfall in the South in 2011.

Table 1: Total rainfall (inches) at locations across the South compared to annual average: 2003 - 2011. (Black is surplus and red is a deficit)

Location	2003	2004	2005	2006	2007	2008	2009	2010	2011	Average	11 to Avg Difference
Lufkin, TX	44.98	78.14	27.26	41.08	50.49	40.63	55.19	30.01	33.77	46.62	-12.85
Monticello, AR	36.52	66.77	26.96	---	37.61	51.58	68.21	32.27	35.24	55.33	-20.09
Alexandria, LA	44.92	59.33	33.45	53.62	47.92	57.02	55.53	37.31	35.12	61.44	-26.32
Jackson, MS	55.48	46.45	31.45	41.92	32.63	54.55	58.79	37.84	31.42	58.64	-27.22
Birmingham, AL	61.30	55.62	49.17	56.55	28.86	55.64	71.66	47.89	58.32	52.16	6.16
Macon, GA	56.74	47.95	48.53	34.45	39.85	48.14	61.63	44.13	33.14	45.00	-11.86
Richmond, VA	60.23	55.49	37.56	53.29	37.90	48.90	48.32	35.86	47.72	44.10	3.62
Raleigh, NC	49.08	45.87	37.56	53.69	35.81	50.22	40.43	36.94	43.70	46.55	-2.85
Columbia, SC	52.99	39.71	39.44	38.95	30.19	46.38	49.15	35.92	43.84	50.14	-6.30
Tallahassee, FL	63.59	56.24	68.21	49.34	44.52	60.28	57.91	58.67	34.69	63.21	-28.52

Source: Weather Underground (www.wunderground.com).

The Texas leaf-cutting ant can be a significant pest in newly-planted pine plantations. PTM™ Insecticide was registered for use against leaf-cutting ants in 2009. Several companies have used this product in 2010 and 2011 and all have reported excellent results. A new modified (larger) Amdro® bait was developed in cooperation with Central Garden and Pet (CGP). Efficacy trials conducted throughout 2009 and 2010 have demonstrated that this new bait was significantly more effective in completely halting ant activity compared to the standard Amdro® Ant Block treatment after 16 weeks. The FPMC has requested that CGP submit this product for EPA registration. Unfortunately, 12 months have passed since the end of trials and CGP has yet to submit a request to EPA. If and when the request is submitted, EPA approval should be given within just a few months.

Populations and damage caused by several defoliators, including forest tent caterpillar, oak leaf roller and walnut caterpillars, were light and localized in the Western Gulf Region. Pine tip moth damage levels declined considerably on second-year trees from 59% of shoots infested in 2010 to nearly 25% in 2011; at least one location (Waveland, MS) averaged 100% infested shoots by mid-summer (Figure 1). Coneworm and seed bug pressure were generally stable at moderate levels in 2011 compared to 2010 in several Western Gulf seed orchards. On the positive side, no infestations of the southern pine beetle were reported in Texas, Louisiana, Arkansas or Oklahoma in 2011 (Table 2), as predicted by early season pheromone traps. Southern pine beetle populations continued to decline on state and national forests in Georgia, North Carolina and Mississippi, but remained stable and low in Virginia and Alabama. 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 extensive drought conditions, *Ips* engraver beetle (and in some cases deodar weevil) populations increased dramatically in the Western Gulf Region, particularly in Texas, resulting in considerable tree mortality (Figure 2).

Figure 1. Extensive 4th generation pine tip moth damage to loblolly pine at end of the third growing season, October 2011, (A) Waveland, MS.

Figure 2. Dramatic increase in *Ips* engraver beetle-caused mortality of loblolly pine in East Texas, 2011.

Table 2: Southern pine beetle infestations by state, 2001 - 2011 and latest trend.

State	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Latest Trend
OK	0	0	0	0	0	0	0	0	0	0	0	Stable
AR	0	0	0	0	0	0	0	0	0	0	0	Stable
TX	0	0	0	0	0	0	0	0	0	0	0	Stable
LA	0	0	0	0	0	0	5	1	1	0	0	Stable
MS	143	689	65	158	92	50	208	31	0	10	2	Down
AL	11,849	4,991	206	1,434	1,791	1,286	765	222	9	22	28	Stable
GA	4,938	9,070	333	73	0	0	2,077	115	24	4	0	Down
TN	12,746	6,394	1,294	257	5	14	39	1	0	0	0	Stable
KY	3,456	NA	NA	0	0	0	0	0	1	0	0	Stable
VA	763	274	50	10	0	0	64	33	25	25	31	Stable
FL	2,892	650	2	10	7	3	43	22	15	1	1	Stable
SC	22,270	67,127	9,514	4,324	2,388	2,267	734	990	142	0	0	Stable
NC	3,871	4,028	181	10	24	49	15	131	5	5	0	Down
Total	62,928	93,223	11,645	6,276	4,307	3,669	3,950	1,546	222	67	62	Down

Progress continues on the evaluation and development of systemic insecticides and injection systems. Emamectin benzoate continues to be the most effective insecticide tested to date for protection of trees against bark beetles, woodborers, lepidopteran and coleopteran defoliators and several non-native, invasive pests. Several trials have shown effectiveness for 3+ year following a single applications. Other chemicals, including abamectin and fipronil, also were tested and showed promise against bark beetles and pine coneworm. Still others, like acelopryn, dinoteferon, and imidacloprid, were active against seed bugs or coneworm.

We also are interested in determining if some of these chemicals are effective against more aggressive *Dendroctonus* species. Trials established in 2005, 2006 and 2007 in Mississippi and Alabama for southern pine beetle (*D. frontalis*) on loblolly pine, in California for western pine beetle (*D. brevicomis*) on ponderosa pine, in Utah for spruce beetle (*D. rufipennis*) on Englemann spruce, and in Idaho, British Columbia and Colorado for mountain pine beetle (*D. ponderosae*) 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. Abamectin has shown activity in Utah 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. Two additional trials (AL and UT) were established in 2009 and continued in 2011, to evaluate the potential of combining emamectin benzoate with a fungicide mix to improve tree survival. In the both trials, the combination treatment was only slightly better on average than emamectin benzoate alone for protecting trees against either southern pine beetle or mountain pine beetle. Treatment efficacy against mountain pine beetle was markedly improved by increasing the number injection points and making applications in the fall prior to insect attack.

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 and 2010 data indicated that emamectin benzoate had excellent activity against coneworms, but no treatment reduced seed bug damage levels. Additional trials were established in Texas and Arkansas pine seed orchards in 2010 to evaluate several systemic insecticides alone or combined with emamectin benzoate for protection against pine seed bug. The Texas trial showed emamectin benzoate, abamectin, imidacloprid and dinotefuran to be most effective in the second year after injection. The Arkansas trial showed that imidacloprid and dinotefuran were effective against seed bug, but did not add significantly when combined with emamectin benzoate.

A trial established in 2009 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 bur oaks compared to untreated checks. Second-year effects were observed against leaf beetles, borers, oakworm caterpillars and leafminers. Third–year effects, though diminished, were observed against leafminers and lace bugs. Two more small trials were established in 2009 to determine the efficacy of emamectin benzoate against a chalcid wasp (unknown species) attacking Afghan pine near El Paso and the soapberry borer (*Agrilus prionurus*) attacking western soapberry near Dallas and Houston. Emamectin benzoate was highly effective in preventing additional chalcid wasp colonization of hosts and markedly improved the health of treated western soapberry trees. A final study was established in fall 2010 to evaluate emamectin benzoate and imidacloprid against the saltcedar leaf beetle, *Diorhabda elongate*, that was defoliating athel tree along the Rio Grande River in Big Bend National Park and near Presidio and Ruidosa, TX. Imidacloprid was more effective than emamectin benzoate in reducing beetle defoliation.

EPA approved the registration of emamectin benzoate (TREE-äge™) for use in deciduous trees, conifers and palms for several forest pests (seed and cone insects, bark beetles, etc.) in December 2010. Approval of the final label is required at the state level as well. As of March 2012, all of the lower 48 states have approved the full label.

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 fully analyzed by Mr. Trevor Walker, graduate student at Stephen F. Austin State University, in 2011. One hundred and four (104) impact plots on 76 sites were established in the Western Gulf Region. An additional five hazard-rating plots were established in 2011, bringing the total to 150. The analysis of impact data indicates that protected trees continue to grow at an accelerated rate through the fifth year after establishment. The threshold at which tip moth damage significantly impacts growth was calculated to be an average of 40% or greater of the terminal shoots infested over the first two growing seasons. Mr. Walker, also completed work on hazard-rating model development and cost:benefit analysis as part of his Master's degree in Forestry with the guidance of Drs. Dean Coble and Jimmie Yeiser, Stephen F. Austin State University. Unfortunately, Mr. Walker's analysis revealed that there was considerable variability among the variables as influenced by time and place. Thus, an operational model could not be developed at this time.

Systemic insecticide trials revealed that single applications of PTM™ (fipronil) and SilvaShield™ (imidacloprid) continued to be effective against pine tip moth using different application techniques and for extended periods of time.

Trials were established in 2008 to assess the efficacy of fipronil applied at different depths to one-year old pine seedlings. 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 indicated good protection through the third growing season. BASF has indicated willingness to consider a request to modify the PTM™ label to include use on containerized seedlings if FPMC can address concerns related to chemical leaching and worker exposure. A new trial was established in 2011 to evaluate the performance of plug injections of PTM™ at different rates on ten sites across the South. Preplant treatment of container seedlings with PTM significantly improved tip moth protection, seedling growth and survival in the first year compared to postplant PTM-treated seedlings and/or untreated checks.

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 2009 to reduce tip moth damage and improve tree growth. Tablets applied next to seedlings after planting were less effective. 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.

A trial established in 2010 directly compared the performance of PTM™ and SilvaShield™. Second-year results indicated that both products are highly and equally effective when applied at planting. However, SilvaShield™ generally performed better when applied post plant.

TEXAS LEAF-CUTTING ANT

Control Option Development and Evaluation - East Texas

Highlights:

● Efficacy trials were conducted in fall 2010 and winter 2010/2011 to evaluate the efficacy of modified Amdro® Ant Block (Schirm 4) against the Texas leaf-cutting ant.

● The moderate-sized (Schirm 4) Amdro treatment was more effective than Amdro® Ant Block and quickly reduced ant activity after 2 weeks during fall and winter trials. After 8 weeks, 67% of the treated colonies were still inactive, a 34% improvement in efficacy over the standard Ant Block.

● Bait stations were ineffective: in many cases, fire ants inhibited leaf-cutting ant bait retrieval or animal(s) disturbed the stations.

Objective: Continue evaluating the efficacy of new bait modified from Amdro® Ant Block for eliminating or reducing activity in Texas leaf-cutting ant colonies and determine if efficacy changes with season.

Study Sites: Active colonies (111) were located in East Texas on lands owned by Campbell Group, Hancock Forest Management, Rayonier and private landowners.

Insecticides:

Hydramethylnon – Amdro® Ant Block bait
Fipronil – PTM™ Insecticide

Research Approach:

Amdro® Ant Block bait plus water were run through a pellet mill (Schirm USA) to create larger pellets [2.3 mm (3/32") dia. X 7 mm (1/4") length (Schirm 4)] for fall and winter 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 2-14 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. Three trials were conducted in 2010 (so far); the treatments included:

Trial 1 (fall 2010):

1) Schirm 4 Amdro® bait (Optimal - medium diameter and long length) - bait was spread uniformly over CNA at 10.0 g/m^2.
2) Schirm 4 Amdro® bait (Optimal - medium diameter and long length) - bait stations (containing 23 g of bait) were deployed uniformly (@ 4 stations / 9.3 m) over CNA (= 10.0 g/m^2).
3) Small Amdro® Ant Block - bait was spread uniformly over CNA at 3/4 lb per colony.
4) PTM (soil injection)
5) Untreated colony (Check)

Trial 2 (winter 2010/2011):

1) Schirm 4 Amdro® bait (Optimal - medium diameter and long length) - bait was spread uniformly over CNA at 10.0 g/m^2.
2) Small Amdro® Ant Block - bait was spread uniformly over CNA at 3/4 lb per colony.
3) PTM (soil injection)
4) Untreated colony (Check)

Bait treatments were applied with a cyclone spreader to evenly spread amounts over the CNA (Trials 1 & 2) or in bait stations (5" X 3" X 3"; Trial 1) (Figure 3). Stations, each containing 23 g of bait, were even spaced within the CNA at four stations per 100 ft^2 (Fig. 2 and 3). 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.

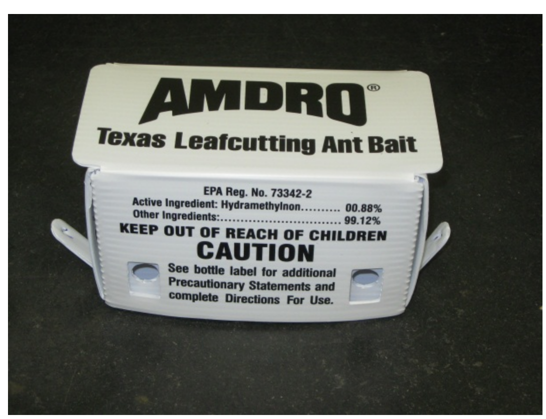

Figure 3. Amdro bait station

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 2, 4, 8, and 16 weeks. Six 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:
The fall trial was initiated the week of November 15th 2010 after temperatures had cooled and some rainfall had been received. However, conditions quickly became dry and ant activity was reduced throughout December. The new modified Amdro (optimal) even spread treatment again reduced ant activity (>79%) on treated colonies compared to initial activity within 2 weeks after treatment (Table 3). After 8 weeks, 7 of 13 colonies (54%) had gone completely inactive, but by 16 weeks, 5 of 13 (38%) were inactive. Those colonies (8) that remained active, had recovered to only 23% of their initial activity. In contrast, the standard Amdro Ant Block treatment only halted ant activity in one of six colonies. Of those colonies still active after 16 weeks, activity recovered to 66% of their initial activity. None of the colonies treated with bait stations went completely inactive through the 16 week monitoring period, although ant activity was reduced by 27%. PTM soil injection was the most effective treatment with 4 of 5 (80%) colonies going inactive after 16 weeks. Very little activity was observed (1% of initial) at the end of the monitoring period.

The winter trial was initiated the first week of January 2011 after moisture conditions improved (over 7" of rainfall was received for the month). The new modified Amdro (optimal) even spread treatment again quickly reduced ant activity (>96%) on treated colonies compared to initial activity within 2 weeks after treatment (Table 4). By 4 weeks, 14 of 17 (82%) colonies had gone inactive. However, by 16 weeks, 10 of 17 colonies were still inactive. The activity of the remaining seven colonies was only 3% of the initial activity. In this trial, Amdro Ant Block was as effective at 4 weeks as was the modified bait. However, half (3 of 6) of the Ant Block treated colonies were still active after 16 weeks. Again, PTM soil injection was the most effective treatment with 100% (5 of 5) colonies going inactive after 16 weeks.

Conclusions:
The fall 2010 and winter 2010/2011 efficacy trials again showed that the modified (optimal; Schirm 4) bait was more effective in halting ant activity compared to the standard Amdro Ant Block baits. Based on field observations and trial results, the larger modified Amdro bait (Schirm 4) is a significant improvement over the standard Ant Block. The dimensions - 2.3 mm (3/32") in diameter X 7 mm (1/4") long and weight of about 0.04 g (25 particles per gram) allow for maximum retrieval by average-sized, semi-energetic worker ants.

Bait treatments applied in bait stations were largely ineffective in halting ant activity in two separate trials.

Acknowledgements: Thanks go to Campbell Group, Hancock Forest Management, Rayonier and several private landowners who provided access to ant colonies. We appreciate the donation of Amdro formulation from Central Garden and Pet for the trials.

Table 3. Efficacy of modified (Optimal) Amdro bait (even spread or bait station) and Amdro Ant Block applied during the fall to control the Texas leaf-cutting ant, *Atta texana* , in East Texas (November 2010 - March 2011).

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 (4) Amdro (optimal) (10.0g/m^2) even spread	13	559	219	20.4 **a**	(15)	10.4 **a**	(38)	5.1 **a**	(54)	22.6 **ab**	(38)
Schirm (4) Amdro (optimal) (10.0g/m^2) in bait station	9	373	163	64.2 **b**	(0)	61.1 **b**	(0)	61.0 **bc**	(22)	73.0 **c**	(0)
Amdro Ant Block (0.75-1.5 lb / colony = 9g/m^2)	6	713	161	28.0 **a**	(0)	28.0 **b**	(33)	32.5 **ab**	(33)	66.0 **bc**	(17)
PTM Soil Injection (40ml / hole to all holes)	5	713	161	0.3 **a**	(80)	0.6 **a**	(80)	0.8 **a**	(80)	1.3 **a**	(80)
Check (no treatment)	6	647	182	96.6 **c**	(0)	91.1 **c**	(0)	90.1 **c**	(0)	86.8 **c**	(0)
Total/Mean	39	553	189								

[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 (Optimal) Amdro bait (even spread) and Amdro Ant Block applied during the winter to control the Texas leaf-cutting ant, *Atta texana* , in East Texas (January - April 2011).

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 (4) Amdro (optimal) (10.0g/m^2) even spread	17	597	247	3.9 **a**	(53)	1.6 **a**	(82)	2.8 **a**	(76)	3.1 **a**	(59)
Amdro Ant Block (0.75-1.5 lb / colony = 9g/m^2)	6	738	241	2.1 **a**	(83)	2.1 **a**	(83)	3.1 **a**	(50)	6.9 **a**	(50)
PTM Soil Injection (40ml / hole to all holes)	5	365	144	0.5 **a**	(80)	0.0 **a**	(100)	0.0 **a**	(100)	0.0 **a**	(100)
Check (no treatment)	6	719	226	99.6 **b**	(0)	98.3 **b**	(0)	102.9 **b**	(0)	103.3 **b**	(0)
Total/Mean	34	658	242								

[a] 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

PTM™ Insecticide (fipronil) applied into entrance holes within the central nest area of leaf-cutting ant colonies was highly effective during most seasons. As a result of these trials, EPA approved the addition of leaf-cutting ants to the PTM™ label in December 2009. Additional trials in 2010 showed PTM™ applications to imported fire ant colonies are similarly effective. BASF submitted a request to EPA in 2011 to add fire ants to the PTM™ label as well. However, EPA is currently evaluating fipronil for reregistration. The outcome of the fire ant request is uncertain.

Two soil injection systems are available for application of PTM™ dilution for leaf-cutting ant control: Reddick's (formerly Aqumix's and Enviroquip) PTM™ Injection Probe, a durable, high capacity system, and Prima Tech's PTM™ Spot Gun - a cheaper, less durable, lower capacity system (Figure 4). The Kioritz soil injector has been discontinued.

Evaluation of an alternative option was continued in 2011. A modified Amdro® Ant Block™ bait with larger pellets was tested in fall 2010 and winter 2010/2011. Central Garden and Pet (CGP) provided bait for modification. As in several previous trials (2010) the larger modified bait provided significantly better control compared to the original Ant Block bait. According to CGP, EPA registration of the modified bait would be simple since the active and inert ingredients are already registered for other species of ants (fire ants). However, due to company reorganization, the request has yet to be submitted to EPA. Hopefully, a new leaf-cutting ant bait could be registered and available by fall 2012.

Recently, Syngenta has expressed an interest in developing a new leaf-cutting ant bait in anticipation of new regulations that would prohibit use of other baits containing fipronil, sulfluramid, and hydramethylnon in South American forest plantations by 2015. The FPMC is considering participation in this project.

A B

Figure 4. Soil injection systems: A) PTM™ Injection Probe and B) PTM™ Spot Gun

SYSTEMIC PESTICIDE INJECTION TRIALS

Potential Insecticides for Seed Bug Control in Pine Seed Orchards - Arkansas and Texas

Highlights:

● Tree IV injections of imidacloprid, abamectin and emamectin bezoate at Woodville, TX significantly reduced seed bug damage compared to checks during the second year after treatment application, but no single insecticide was better than the others. These chemicals improved the number of filled seeds per cone by 28 - 35%. Abamectin, acelepryn, emamectin benzoate, and fipronil, all significantly reduced coneworm damage; emamectin benzoate was best, reducing damage by 100%. .

● Tree IV injections of imidacloprid and dinotefuran at Magnolia, AR, significantly reduced seed bug damage on second-year cones by 44% and 31%, respectively, during the second year after injection. Treatments containing emamectin benzoate were best, reducing coneworm damage by >97%.

Objectives: 1) Evaluate the potential efficacy of new formulations of abamectin, acephate, azadiractin, chlorantraniliprole, dinotefuran, emamectin benzoate, fipronil and imidacloprid against seed bugs in pine seed orchards and 2) determine the duration of treatment efficacy.

Study Sites

ArborGen's Woodville Seed Orchard, Woodville, Texas (Tyler Co.)

Weyerhaeuser's Magnolia Seed Orchard, Magnolia, Arkansas (Columbia 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.

Dinotefuran (Valent/Mauget) - neonicotinoid insecticide with reported activity against sucking insects.

Chlorantraniliprole (Acelepryn, DuPont) - Anthranilic diamide insecticide with activity against moths, beetles, caterpillars, etc.

Azadiractin (TreeAzin, BioForest Tech.) – a liminoid compound that affect over 200 species of insects (including sucking insects) by acting mainly as an antifeedant and growth disruptor

Acephate (Ace-jet, Arborjet) – an organophosphate with reported activity against sucking insects

Fipronil (BASF) - a phenyl pyrazole insecticide with reported activity against sucking insects.

Research Approach: The first phase of the study was initiated in fall 2009 in a loblolly pine block (ArborGen's Woodville Seed Orchard, Texas). A second phase of the study was also initiated in fall 2009 in a loblolly pine block (Weyerhaeuser's Magnolia Seed Orchard, Arkansas). A block in each orchard was selected that had not been sprayed with insecticide for one or more years prior to initiation of this experiment. In September 2009, 10 ramets from each of 7 clones were selected in Texas and 6 ramets from each of 6 clones were selected in Arkansas. The treatments were evaluated using the experimental design protocol described by Gary DeBarr (1978) (i.e., randomized complete block with clones as blocks).

Treatments:

TX Orchard (Loblolly pine)

1) Imidacloprid (Ima-jet™, Arborjet) (0.4 g AI per inch DBH of tree) in Fall 2009
2) Emamectin benzoate (TREE-äge™, Arborjet) (0.4 g AI per inch DBH of tree) in Fall 2009
3) Dinotefuran (Valent/Mauget) 0.4 g AI per inch DBH of tree) in Spring 2010
4) Abamectin (Abacide™ 2, Mauget) (0.4g AI per inch DBH of tree) in Fall 2009
5) Chlorantraniliprole (Acelepryn, DuPont) 0.4g AI per inch DBH of tree) in Fall 2009
6) Azadiractin (TreeAzin®, BioForest Tech.) (0.4g AI per inch DBH of tree) in Fall 2009
7) Acephate (Ace-jet™, Arborjet) (0.4g AI per inch DBH of tree) in Spring 2010
8) Fipronil (BASF) 0.4g AI per inch DBH of tree) in Fall 2009
9) Emamectin benzoate (TREE-äge™, Arborjet) (0.4 g AI per inch DBH of tree) in Fall 2009 plus two foliar sprays (1 in spring and 1 in late summer).
10) Check

AR Orchard (Loblolly pine)

1) Imidacloprid (IMA-jet™) (0.4 g AI per inch DBH of tree) applied in fall 2009
2) Imidacloprid (IMA-jet™) (0.4 g AI per inch DBH of tree) applied in fall 2009 and spring 2010
3) Imidacloprid + Emamectin benzoate (each at 0.4 g AI per inch DBH of tree) applied in fall 2009
4) Imidacloprid + Emamectin benzoate (each at 0.4 g AI per inch DBH of tree) applied in fall 2009 and Imidacloprid applied again in spring 2010.
5) Dinotefuran + Emamectin benzoate (each at 0.4g AI per inch DBH of tree) applied in spring 2010.
6) Check

At each location, 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 at the base of 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.

In Texas, Asana® XL, was applied to foliage beginning in April and July using a hydraulic sprayer at 10 gal/tree. The distance between test trees was $\geq$20 m to minimize the effects of drift.

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 *Dioryctria*, evidence of 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:

Several of the study trees treated in spring 2010 with imidacloprid or dinotefuran at the AR orchard exhibited phytotoxic symptoms. Severe drought condition (20+" below normal rainfall) may have made certain clones ((H35 and S4PT6) more sensitive to these compounds. Trees treated with these compounds at other locations (TX and FL) have not exhibited phytotoxic symptoms.

The study orchard blocks have been sprayed for several years suggesting that pressure from coneworms and seed bugs (in particular) would likely be low to moderate. This was confirmed for coneworm by 25% (TX) and 58% (AR), damage on check cones (Table 6 and 9). In 2011, several leaffooted and shieldbacked pine seed bugs were observed in the study trees (Steve Smith, personal communication). This was confirmed for seed bugs by 35% (TX) and 50% (AR) damage on second-year seeds from check cones (Table 7 and 10).

Texas (2011):

Treatment Effect on Conelet and Cone Survival:
Three injection treatments (abamectin, emamectin benzoate and emamectin benzoate + 2 sprays) again significantly improved conelet survival compared to checks in 2011 (Table 5). The treatment containing abamectin had the highest survival (91%). Similarly, the abamectin treatment and also emamectin benzoate, acelopryn and fipronil improved cone survival.

Treatment Effect on Coneworm Damage:
Injection treatments containing abamectin, acelopryn, emamectin benzoate and fipronil again significantly reduced early and late coneworm damage compared to the checks in 2011 (Table 6). Overall, the emamectin benzoate treatments provided the greatest reductions in total coneworm damage (99 - 100%) compared to the check. Emamectin benzoate, acelopryn, abamectin and fipronil significantly improved the percentage of healthy cones; by 29-36%.

Treatment Effect on Seed Bug Damage to First-Year Conelets and Second-Year Cones: In 2011, evaluation of conelet ovules from the Woodville seed orchard showed that none of the treatments reduced the percentage of damaged ovules in conelets compared to checks (Table 7). In contrast, evaluation of seed lots showed abamectin, emamectin benzoate, and imidacloprid treatments reduced the percentage of damaged seed in cones compared to checks (Table 7). The best treatment, emamectin benzoate + 2 sprays, reduced seed damage by 55%. Both emamectin benzoate treatments and abamectin and imidacloprid improved the number of filled seeds per cone by 28 - 35%.

Arkansas (2011):

Treatment Effect on Conelet and Cone Survival:
All injection treatments containing emamectin benzoate significantly improved conelet survival compared to checks (Table 8). These treatments had the highest survival (83-96%). All treatments improved cone survival, but again treatments with emamectin benzoate had the highest survival (89 – 94%).

Treatment Effect on Coneworm Damage:
All injection treatments containing emamectin benzoate significantly reduced early and late coneworm damage compared to the checks (Table 9). The imidacloprid only treatments also reduced early damage. Overall, the emamectin benzoate treatments provided the greatest reductions in total coneworm damage (97 - 99%) compared to the check. All injection treatments significantly improved the percentage of healthy cones; but Imid + EB (fall) had the greatest improvement at 51%.

Treatment Effect on Seed Bug Damage to First-Year Conelets and Second-Year Cones: In 2011, evaluation of conelet ovules and seed lots from Magnolia Orchard showed that emamectin benzoate plus imidacloprid or dinotefuran applied in the fall reduced the percentage of damaged ovules in conelets compared to checks, while all injection treatments reduced the percentage of early-damaged seed in cones (Table 10). The best treatment was the Imid + EB (fall), which reduced conelet and seed damage by 71% and 44%, respectively. Treatments containing emamectin benzoate + imidacloprid or dinotefuran improved the number of filled seeds per cone by 85-161%.

Conclusions:

In the past, imidacloprid and dinotefuran alone or combined with other chemicals significantly improved protection against seed bug damage compared to checks (standard foliar spray of Asana®). However, neither appears to be any more effective than emamectin benzoate alone.

Also as in past trials, emamectin benzoate was highly effective against coneworms in 2010. The fall 2009 application at the Woodville seed orchard allowed emamectin benzoate to completely circulate in treated trees through the winter, thus trees were completely protected from the start of the next season. Abamectin, acelopryn and fipronil also significantly reduced coneworm damage but none was equal to or better than emamectin benzoate.

Based on the above results, we recommend applications of emamectin benzoate alone or abamectin primarily for control of coneworm damage. Both of these chemicals also provide limited suppression of seed bug damage through the second year after treatment application. None of the other chemical candidates (including imidacloprid and dinotefuran) proved any more effective against seed bug alone or combined with emamectin benzoate. Nor was there any gain made when combining emamectin benzoate with 2 “strategic” sprays.

The abamectin-, emamectin benzoate-e, and imidacloprid-treated trees at both locations will be followed in 2012 (and beyond if warranted) to evaluate for treatment duration against coneworm and seed bug.

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Table 5. Mean percentages (± SE) of surviving conelets and cones on branches of loblolly pine pine protected with trunk injection of different systemic insecticides at Arborgen's Woodville Seed Orchard, 2010 & 2011.

		Mean Survival (%)			
		Conelets		Cones	
Treatment	N	2010	2011	2010	2011
Abamectin	7	98.7 ± 0.9 *	90.6 ± 1.6 *	80.3 ± 7.7	99.2 ± 0.6 *
Acephate	7	87.4 ± 4.9	----------------	80.8 ± 5.3	----------------
Acelopryn	7	91.4 ± 3.1	73.3 ± 5.0	95.5 ± 1.0 *	97.0 ± 1.6 *
Azadirachtin	7	89.1 ± 4.0	----------------	81.4 ± 6.2	----------------
Dinotefuran	4	95.3 ± 2.2	38.7 ± 15.1	85.5 ± 5.9	72.0 ± 14.6
Emamectin benzoate	6	99.1 ± 0.6 *	82.4 ± 9.3 *	90.1 ± 4.6 *	93.9 ± 2.7 *
Emamectin benzoate + 2 sprays	7	99.3 ± 0.5 *	88.8 ± 7.4 *	92.7 ± 1.8 *	97.5 ± 1.6 *
Fipronil	7	90.1 + 4.0	70.5 + 12.9	87.6 ± 3.3	96.4 ± 1.3 *
Imidacloprid	7	93.9 ± 2.1	62.0 ± 8.6	80.6 ± 3.7	78.5 ± 5.8
Check	7	89.5 + 3.6	58.4 + 11.9	77.8 ± 2.9	79.2 ± 3.2

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

Table 6. Mean percentages (+ SE) of cones killed early and late by coneworms, other-damaged cones, and healthy cones on loblolly pine protected with trunk injections of different systemic insecticides, Woodville, TX, 2010 & 2011.

Year	Treatment	N	Mean Coneworm Damage (%) Early (small dead)	Late (large dead and infested)	Total	Mean Other Damage (%) *	Mean Healthy (%)
2010	Abamectin	7	0.6 ± 0.6 *†	4.3 ± 3.0 *	5.0 ± 3.6 *	23.0 ± 6.9	72.0 ± 8.2
	Acephate	7	3.0 ± 0.8 *	16.0 ± 3.0	19.0 ± 3.3	13.5 ± 2.3	67.5 ± 4.9
	Acelopryn	7	0.5 ± 0.4 *	3.8 ± 2.2 *	4.3 ± 2.6 *	12.5 ± 2.6	83.2 ± 4.3 *
	Azadirachtin	7	2.7 ± 0.7 *	12.5 ± 3.3	15.2 ± 3.1	13.4 ± 4.7	71.4 ± 5.6
	Dinotefuran	4	1.3 ± 0.4 *	14.8 ± 4.6	16.1 ± 4.8	12.1 ± 4.0	71.9 ± 8.4
	Emamectin benzoate	6	0.0 ± 0.0 *	0.6 ± 0.3 *	0.6 ± 0.3 *	10.5 ± 2.5	88.9 ± 2.5 *
	Emamectin benzoate + 2 sprays	7	0.3 ± 0.2 *	0.0 ± 0.0 *	0.3 ± 0.2 *	15.5 ± 3.4	84.2 ± 3.5 *
	Fipronil	7	1.8 ± 0.8 *	2.3 ± 0.9 *	4.1 ± 1.3 *	11.0 ± 3.5	85.0 ± 4.4 *
	Imidacloprid	7	3.7 ± 0.5	20.5 ± 4.4	24.2 ± 4.8	9.9 ± 2.3	65.9 ± 6.0
	Check	7	4.9 ± 0.7	17.4 ± 3.4	22.3 ± 3.3	14.5 ± 3.8	63.2 ± 4.2
2011	Abamectin	6	0.6 ± 0.2 *	5.7 ± 2.0 *	6.3 ± 2.1 *	6.2 ± 1.5	87.5 ± 3.3 *
	Acephate		---------	---------	---------	---------	---------
	Acelopryn	5	1.7 ± 0.4 *	5.9 ± 1.0 *	7.7 ± 1.1 *	3.7 ± 0.9	88.6 ± 1.4 *
	Azadirachtin		---------	---------	---------	---------	---------
	Dinotefuran	3	11.7 ± 2.0	21.8 ± 7.6	33.5 ± 7.4	6.6 ± 1.9	59.9 ± 9.3
	Emamectin benzoate	4	0.0 ± 0.0 *	0.0 ± 0.0 *	0.0 ± 0.0 *	6.7 ± 2.2	93.3 ± 2.2 *
	Emamectin benzoate + 2 sprays	7	0.0 ± 0.0 *	0.3 ± 0.2 *	0.3 ± 0.2 *	5.9 ± 2.0	93.8 ± 2.1 *
	Fipronil	7	1.5 ± 0.6 *	2.5 ± 1.1 *	4.0 ± 1.7 *	9.2 ± 1.5	86.9 ± 2.8 *
	Imidacloprid	7	15.7 ± 2.1 *	21.3 ± 4.1	37.0 ± 5.6 *	5.0 ± 0.6	58.0 ± 5.5
	Check	7	8.8 ± 2.8	15.9 ± 2.5	24.8 ± 4.9	16.9 ± 11.8	58.3 ± 10.5

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

Table 7. Seed bug damage, seed extracted, and seed quality (Mean + SE) from first- and second-year cones of loblolly pine and slash pine protected with trunk injections of different systemic insecticides,Woodville, TX, 2010 & 2011.

			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
2010	Abamectin	7	1.1 ± 0.3 *†	3.8 ± 2.0	27.7 ± 5.3	31.6 ± 5.3	90.7 ± 7.3
	Acephate	7	17.1 ± 4.8	8.5 ± 6.2	27.7 ± 6.7	36.2 ± 6.9	82.8 ± 8.8
	Acelopryn	7	9.8 ± 3.5	7.1 ± 2.7	35.6 ± 5.1	42.7 ± 4.6	73.0 ± 8.8
	Azadirachtin	7	25.8 ± 3.0	10.9 ± 3.0	27.5 ± 5.7	38.4 ± 7.9	77.3 ± 10.4
	Dinotefuran	4	3.6 ± 2.4 *	2.0 ± 0.7	17.1 ± 5.6 *	19.1 ± 5.3 *	114.2 ± 13.9 *
	Emamectin benzoate	6	1.7 ± 1.1 *	2.2 ± 0.5	25.2 ± 4.7	27.4 ± 4.5 *	90.2 ± 7.3
	Emamectin benzoate + 2 sprays	7	0.3 ± 0.1 *	2.8 ± 0.6	25.9 ± 4.2	28.7 ± 4.3 *	85.1 ± 5.0
	Fipronil	7	13.9 ± 6.0	3.9 ± 1.3	33.4 ± 7.1	37.3 ± 7.4	81.4 ± 9.1
	Imidacloprid	7	6.3 ± 3.3 *	1.8 ± 0.4 *	20.5 ± 3.5 *	22.3 ± 3.4 *	99.0 ± 6.4 *
	Check	7	18.2 ± 4.9	7.4 ± 2.3	34.0 ± 3.8	41.3 ± 3.7	73.2 ± 4.9
2011	Abamectin	6	10.2 ± 2.8	1.4 ± 0.4 *	18.0 ± 4.2 *	19.4 ± 4.1 *	102.9 ± 4.7 *
	Acephate		---------	---------	---------	---------	---------
	Acelopryn	5	13.0 ± 3.5	7.2 ± 3.2	19.2 ± 3.6 *	26.4 ± 3.8	92.6 ± 9.5
	Azadirachtin		---------	---------	---------	---------	---------
	Dinotefuran	3	23.5 ± 10.5	7.3 ± 2.3	24.5 ± 10.4	31.9 ± 9.7	82.9 ± 13.2
	Emamectin benzoate	4	7.9 ± 5.8	1.7 ± 0.7	21.3 ± 5.8	23.0 ± 5.3	104.1 ± 7.1 *
	Emamectin benzoate + 2 sprays	7	11.0 ± 3.9	1.1 ± 0.2 *	18.2 ± 3.9 *	19.2 ± 4.0 *	107.4 ± 6.7 *
	Fipronil	7	11.6 ± 3.0	4.0 ± 1.0	22.0 ± 2.7	26.0 ± 2.9	83.0 ± 5.2
	Imidacloprid	7	11.8 ± 2.3	3.5 ± 1.0	19.8 ± 3.3 *	23.3 ± 3.4 *	101.7 ± 6.9 *
	Check	7	19.2 ± 5.4	5.1 ± 1.0	29.7 ± 3.8	34.9 ± 4.2	79.7 ± 7.1

† 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.

Table 8. Mean percentages (+ SE) of surviving conelets and cones on branches of loblolly pine pine protected with systemic injections of imidacloprid (Imid), dinotefuran (Dino) or emamectin benzoate (EB), Weyerhaeuser's Magnolia Seed Orchard, 2010 and 2011.

		Mean Survival (%)			
		Conelets		Cones	
Treatment	N	2010	2011	2010	2011
Imidacloprid (IMID) (fall '09)	6	95.6 + 0.9 *	62.0 + 6.7	84.0 + 3.7	70.6 + 11.2 *
IMID (fall '09 + spring '10)	5	95.0 + 2.0 *	67.9 + 11.0	85.5 + 6.3	78.0 + 7.9 *
IMID + Emamectin benzoate (EB) (fall '09)	6	98.2 + 1.4 *	93.4 + 3.4 *	96.1 + 1.7 *	93.6 + 1.4 *
IMID + EB (fall ' 09) + IMID (spring '10)	5	96.2 + 2.3 *	83.1 + 8.8 *	89.9 + 5.1	88.7 + 4.2 *
Dinotefuran + EB (spring '10)	5	95.2 + 3.0 *	96.0 + 2.1 *	93.7 + 3.8 *	91.8 + 3.6 *
Check	6	72.8 + 6.5	45.1 + 9.2	83.9 + 5.4	42.9 + 12.1

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

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 (Imid), dinotefuran (Dino), emamectin benzoate (EB) or fipronil (FIP), Magnolia, AR, 2010 & 2011.

			Mean Coneworm Damage (%)				
Year	Treatment	N	Early (small dead)	Late (large dead and infested)	Total	Mean Other Damage (%) *	Mean Healthy (%)
2010	Imidacloprid (IMID) (fall '09)	6	4.3 ± 0.6 †	8.3 ± 2.0	12.5 ± 2.6	19.5 ± 6.4 *	68.0 ± 8.1 *
	IMID (fall '09 + spring '10)	5	2.8 ± 0.7 *	7.8 ± 2.6	10.6 ± 2.7	20.9 ± 8.1 *	68.5 ± 10.7 *
	IMID + Emamectin benzoate (EB) (fall '09)	6	1.5 ± 1.1 *	1.7 ± 1.0 *	3.2 ± 2.2 *	17.2 ± 8.6 *	79.6 ± 10.4 *
	IMID + EB (fall ' 09) + IMID (spring '10)	6	1.6 ± 1.0 *	7.1 ± 5.7	8.7 ± 6.4 *	18.9 ± 7.4 *	72.4 ± 11.9 *
	Dinotefuran + EB (spring '10)	6	3.2 ± 2.3 *	3.2 ± 1.2 *	6.5 ± 3.6 *	18.4 ± 7.1 *	75.2 ± 9.3 *
	Check	6	6.2 ± 1.1	8.2 ± 2.7	14.4 ± 3.6	30.0 ± 9.5	55.6 ± 12.8
2011	Imidacloprid (IMID) (fall '09)	6	4.4 ± 0.8 *	38.1 ± 8.8	42.5 ± 9.4 *	17.4 ± 7.9	40.2 ± 10.3 *
	IMID (fall '09 + spring '10)	6	5.1 ± 1.9 *	32.1 ± 5.0	37.2 ± 5.6 *	15.6 ± 5.3	47.2 ± 8.3 *
	IMID + Emamectin benzoate (EB) (fall '09)	6	0.0 ± 0.0 *	0.6 ± 0.5 *	0.6 ± 0.5 *	25.0 ± 9.1	74.4 ± 9.2 *
	IMID + EB (fall ' 09) + IMID (spring '10)	6	0.1 ± 0.1 *	0.5 ± 0.2 *	0.6 ± 0.2 *	27.0 ± 11.1	72.4 ± 11.1 *
	Dinotefuran + EB (spring '10)	6	0.1 ± 0.1 *	1.6 ± 0.8 *	1.8 ± 0.9 *	27.7 ± 9.7	70.5 ± 10.2 *
	Check	6	15.1 ± 4.3	43.2 ± 5.3	58.3 ± 8.0	18.6 ± 5.7	23.1 ± 5.2

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

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 (Imid), dinotefuran (Dino), emamectin benzoate (EB) and/or fiprinil (FIP) or foliar sprays (Spray), Magnolia, AR, 2010 & 2011.

			Mean Seed Bug Damage (%) to:				
			First-year Conelet Ovules	Second-year Cone Seed			Mean No.
Year	Treatment	N	Early (July)	Early (2nd Yr Abort)	Late	Total	Filled Seed per Cone
	Imidacloprid (IMID) (fall '09)	6	12.7 ± 4.4 *	15.5 ± 7.2 *	25.9 ± 7.0	41.5 ± 10.5 *	55.0 ± 16.8
	IMID (fall '09 + spring '10)	6	2.4 ± 1.5 *	5.4 ± 2.5 *	25.6 ± 5.2	31.0 ± 5.3 *	52.6 ± 13.0
	IMID + Emamectin benzoate (EB) (fall '09)	6	1.6 ± 0.4 *	3.1 ± 1.0 *	22.4 ± 5.6 *	25.5 ± 5.6 *	60.6 ± 8.0 *
2010	IMID + EB (fall ' 09) + IMID (spring '10)	6	0.6 ± 0.5 *	3.8 ± 1.1 *	20.5 ± 5.3 *	24.3 ± 5.7 *	68.4 ± 13.8 *
	Dinotefuran + EB (spring '10)	6	0.8 ± 0.4 *	5.1 ± 1.6 *	28.8 ± 7.3	33.9 ± 6.4 *	55.6 ± 9.2 *
	Check	6	40.7 ± 5.8	25.2 ± 5.6	36.5 ± 5.4	61.7 ± 5.0	36.1 ± 5.9
	Imidacloprid (IMID) (fall '09)	6	38.5 ± 12.2	9.9 ± 1.5 *	27.2 ± 7.2	37.1 ± 8.1 *	58.4 ± 10.4 *
	IMID (fall '09 + spring '10)	6	23.9 ± 8.3	8.4 ± 3.2 *	24.3 ± 5.7	32.7 ± 5.0 *	82.5 ± 8.0 *
	IMID + Emamectin benzoate (EB) (fall '09)	6	12.5 ± 4.0 *	5.1 ± 1.1 *	23.0 ± 5.4	28.1 ± 5.2 *	78.4 ± 8.9 *
2011	IMID + EB (fall ' 09) + IMID (spring '10)	6	20.9 ± 4.7	4.4 ± 0.8 *	27.6 ± 5.2	32.1 ± 5.6 *	75.8 ± 8.9 *
	Dinotefuran + EB (spring '10)	6	10.1 ± 3.4 *	9.4 ± 1.8 *	24.8 ± 7.1	34.3 ± 6.7 *	66.6 ± 9.1 *
	Check	6	43.9 ± 8.7	21.4 ± 5.1	28.6 ± 6.0	50.0 ± 10.5	31.6 ± 6.9

† 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-äge™) for Protection of Oaks Against Insect Pests

Highlights:

● Tree IV injections of emamectin benzoate (EB) significantly reduce occurrence/damage caused by insects, including leaf beetles, borers, oakworm caterpillars, solitary oak leafminer for two years on cherrybark and bur oaks compared to untreated checks. Some limited suppression of solitary oak leafminer and oak lace bug damage was obtained during the third year (2011) after treatment.

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

Study Site: Three acre orchard block containing 10 - 20 year-old cherrybark oak (*Q. pagoda*), and bur oak (*Q. macrocarpa)* -- 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.

The treatments include:

Bur Oak Trial

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

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) 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:

All study trees (both bur and cherrybark oaks) 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, 2009 and May 11, June 29, August 20 and October 29, 2010). 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.

Treatment efficacy was determined by comparing the occurrence and severity of insect damage for each evaluation 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 bur oaks. Many trees had to put out new shoots. Early season damage due to insects was difficult to see. A significant drought occurred in 2010 and 2011 (April – December), making trees more susceptible to certain insect pests.

Observations in 2009 - 2011 indicated that several insect species attack oaks through the year: most common were a chrysomelid beetle (May and June 2009, 2010 and 2011), trunk borer (family and species unknown, June 2009 and 2010), and tussock moth caterpillars (June 2009) on cherrybark oaks, and a leaf-rolling weevil (Coleoptera: Attelabidae**,** June 2009), oakworm caterpillars (September 2009, 2010 and 2011), solitary oak leafminer (August and September 2010 and 2011), and oak lace bug (August 2011) on bur oaks (Table 11 and Figures 5-13). 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, twig girdler and slug caterpillars.

Conclusions:

A moderate concentration of emamectin benzoate in treated trees can protect hardwoods against several defoliators and can suppress damage from leaf beetles, weevils, caterpillars, leafminers, and lace bugs for 2+ years. The results in 2011 suggest that treatment effects are beginning to fade. Thus, no additional evaluations will be made.

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 of edible nut crop trees (pecan, walnut, etc.) against several important pests while keeping the nuts safe for consumption. No protection would be provided from nut-infesting insects (acorn weevil).

Acknowledgements:
We appreciate the assistance provide by Todd Nightingale, Joe Hernandez and Marvin Lopez of the Texas Forest Service. We thank Arborjet, Inc. and Syngenta Crop Protection for the financial support, chemical donations, and/or loans of injection equipment.

Figure 5. A) Leaf beetle (Coleoptera: Chrysomelidae) and B) skeletonized leaves of bur oak.

Figure 6. Leaf-rolling weevil, *Homoeolabus analis* (Coleoptera: Curculionidae), and damage on bur oak leaves.

Figure 7. Banded tussock moth caterpillar, *Halysidota tessellaris* (Lepidoptera: Arctiidae).

Figure 8. Borer damage on trunk of cherrybark oak.

Figure 9. Spiny oakworm caterpillar, *Anisota stigma* (Lepidoptera: Saturnidae) and pink-striped caterpillar, *A. virginiensis*, on bur and cherrybark oaks.

Figure 10. Acorn weevil and damage in cherrybark oak acorns.

Figure 11. Oak lace bug and damage on top side of bur oak leaves.

Figure 12. Solitary oak leafminer, *Cameraria hamadryadella* (Lepidoptera: Gracillariidae) damage on bur oak leaves.

Figure 13. Bur oak (left) defoliated as a result of solitary oak leafminer attack. Tree on right was treated with emamectin benzoate.

Table 11: Occurrence/severity of insect damage on burr and cherrybark oak treated with emamectin benzoate, Hudson, TX; 2009, 2010 & 2011

Tree Species	Year	Treatment	N	Chrysomelid leaf skeletinizer	Borer	Tussock moth caterpillar	Leaf-rolling weevil	Oakworm caterpillar	Solitary Oak Leafminer	Oak Lace Bug
				Insect Family or Species						
Burr Oak	2009	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	-------	-------
	2010	Emamectin benzoate	14	0.07 ± 0.07 *	-------	-------	-------	0.21 ± 0.11 *	0.50 ± 0.17 *	-------
		Check	14	1.14 ± 0.23	-------	-------	-------	1.07 ± 0.25	3.21 ± 0.23	-------
	2011	Emamectin benzoate	14	1.36 ± 0.12	-------	-------	-------	0.14 ± 0.10	0.21 ± 0.11 *	0.21 ± 0.11 *
		Check	14	1.32 ± 0.15	-------	-------	-------	0.29 ± 0.16	0.79 ± 0.16	0.93 ± 0.22
Cherrybark Oak	2009	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	-------	-------
	2010	Emamectin benzoate	14	0.00 ± 0.00 *	0.00 ± 0.00 *	-------	-------	0.00 ± 0.00 *	0.36 ± 0.13 *	-------
		Check	14	0.86 ± 0.14	0.50 ± 0.20	-------	-------	0.43 ± 0.14	1.43 ± 0.17	-------
	2011	Emamectin benzoate	14	1.82 ± 0.12	0.00 ± 0.00	-------	-------	-------	0.36 ± 0.13	-------
		Check	14	2.15 ± 0.16	0.23 ± 0.12	-------	-------	-------	0.23 ± 0.12	-------

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 concentration (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.

SYSTEMIC INSECTICIDE INJECTION TRIALS

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

Highlights:

● 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.

● Both 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 22 to 28 months after injection.

● Neither azadiractin nor dinotefuran applied in the spring showed any activity against *Ips* engraver beetles or wood borers 1 month after injection.

Study Sites: One 20-year-old, recently-thinned loblolly pine plantation was selected on land owned by Rayonier, Polk Co., TX. 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:

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

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

Azadirachtin (AzaSol™, Arborjet) - water soluble powder product with azadirachtin from the neem tree

Dinotefuran (Safari™ 20 SG, Valent) – highly systemic neonicotinoid insecticide.

Treatments:

Trial 1: Established April 2008

Trt #	Chemical	Formulation	Application Timing	Rate (g ai/inch dbh)	No. of Trees Treated	Felling Dates
1	Abamectin	Abacide II	Apr-08	0.4	40	Sept '08, July '09, '10 & '11
2	Abamectin	Abacide II	Apr-08	0.8	40	Sept '08, July '09, '10 & '11
3	Abamectin	Abacide II	Oct-08	0.4	30	Jul '09, '10 & '11
4	Abamectin	Abacide II	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 2: Established October 2010

Trt #	Chemical	Formulation	Application Timing	Rate (g ai/inch dbh)	No. of Trees Treated	Felling Dates
1	Abamectin	Abacide II	Oct-10	0.4	30	July '11, '12 & '13
2	Abamectin	Abacide II	Oct-10	0.2	30	July '11, '12 & '13
2	Abamectin	Abacide II	Oct-10	0.1	30	July '11, '12 & '13
4	Abamectin	Abacide II	Apr-11	0.4	30	July '11, '12 & '13
5	Abamectin	Abacide II	Apr-11	0.2	30	July '11, '12 & '13
6	Abamectin	Abacide II	Apr-11	0.1	30	July '11, '12 & '13
7	Untreated				30	July '11, '12 & '13

Trial 3: Established April 2011

Trt #	Chemical	Formulation	Application Method	Dose (g ai/tree)	No. of Trees Treated	Felling Dates
1	Azadiractin	AzaSol	Tree Injection	2g/12 ml	15	May, July, Sept '11
2	Azadiractin	AzaSol	Bark Spray	1g/ 3.8 L	15	May, July, Sept '11
2	Azadiractin	AzaSol	Soil Drench	8g/3.8 L	15	May, July, Sept '11
4	Azadiractin	AzaSol	Spray and Drench	9g/7.6 L	15	May, July, Sept '11
5	Dinotefuran	Safari	Bark Spray	1g/ 3.8 L	15	May, July, Sept '11
6	Untreated				15	May, July, Sept '11

Treatment Methods and Evaluation:
Loblolly pine trees, 15 – 20 cm DBH, were selected. Thirty - forty trees were each injected with one of two treatments: abamectin (April and October 2008, October 2010 or April 2011) at four different rates (0.1g, 0.2g, 0.4g or 0.8g per 1 inch of tree diameter) , or fipronil (October 2008) at two different rates (0.4g or 0.8g per 1 inch of tree diameter). 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™.

At different intervals 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 many cerambycid egg niches were observed 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.

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: Higher rates

In 2011, the total number of attacks by male *Ips* engraver beetles did not differ among the abamectin and fipronil treatments (Table 14 and 18). All (100%) 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 14 and 18). All abamectin treatments completely prevented brood development compared to check trees (Tables 15 and 16, Figure 14). There was a little brood development in one log treated with the low rate of fipronil, but overall significantly less brood developed occurred in treated logs compared to check logs (Tables 19 and 20, Figure 15).

The attack level of wood borers (egg niches) on logs from most treated trees did not differ from that on check logs (Table 17 and 21). Only cerambycid attacks on high rate fipronil trees were higher than those on checks. A moderate level of cerambycid feeding (38%) occurred on untreated bolts during the 3-week period between tree felling and bolt evaluation

(Table 17 and 21). All abamectin and fipronil treatments markedly reduced the amount of cerambycid larval feeding and development compared to the check.

Trial 2: Lower rates

The total number of attacks (nuptial chambers constructed) by male *Ips* engraver beetles differed somewhat among the abamectin treatments (Table 22). The lower rate abamectin treatments had higher attack levels compared to the checks. All (100%) of the nuptial chambers were successfully constructed on untreated bolts; at least one egg gallery radiated from each nuptial chamber. In contrast, all abamectin treatments, regardless of timing, had significantly fewer nuptial chambers with egg galleries (Table 22). All treatments completely prevented brood development compared to check trees (Tables 23 and 24, Figure 16).

The attack level of wood borers (egg niches) on logs from most injected trees did not differ from that on check logs (Table 25). A moderate level of cerambycid feeding (22%) occurred on untreated bolts during the 3-week period between tree felling and bolt evaluation (Table 25). All abamectin treatments reduced the amount of larval feeding and development compared to the check.

Trial 3: AzaSol and Safari

The total number of attacks by male *Ips* engraver beetles did not differ among the azadirachtin and dinotefuran treatments (Table 26). All (100%) of the nuptial chambers were successfully constructed on all insecticide-treated and untreated bolts; at least one egg gallery radiated from each nuptial chamber. All azadirachtin and dinotefuran treatments had the same number of nuptial chambers with egg galleries (Table 26). None of the treatments prevented brood development compared to check trees (Tables 27 and 28).

The attack level of wood borers (egg niches) on logs from most injected trees did not differ from that on check logs (Table 29). None of the insecticide treatments reduced the amount of cerambycid larval feeding and development compared to the check.

Conclusions:

The trial continues to show that abamectin and fipronil are highly effective for extended periods. No significant differences in the efficacy of abamectin or fipronil at the two rates were observed 34 - 40 months after injection.

Lower rates of abamectin are also highly effective against engraver beetles and cerambycids 9 months after injection. This trial will be continued into 2012.

Azadirachtin and dinotefuran were ineffective against southern pine engraver beetles and wood borers one month after application. Thus, the trial was discontinued.

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Table 14: Attack success and gallery construction of *Ips* engraver beetles on loblolly pine bolts cut 5 to 40 months after trunk injection with abamectin using the Tree IV injection system; Lufkin, Texas - 2008 - 2011.

Evaluation period	Season/Yr. Injected	Treatment	N	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	
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 (August '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 (August '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
22 month post-injection (August '10)	Fall 2008	Aba 0.8 g AI	10	2.0 *	80	0.5 *	20	2.5
		Aba 0.4 g AI	10	2.0 *	91	0.2 *	9	2.2
28 month post-injection (August '10)	Spring 2008	Aba 0.8 g AI	10	2.2 *	88	0.3 *	12	2.5
		Aba 0.4 g AI	10	3.1 *	86	0.5 *	14	3.6
		Check	10	0.2	6	2.5	94	2.6
34 month post-injection (August '11)	Fall 2008	Aba 0.8 g AI	10	8.5 *	96	0.4 *	4	8.9
		Aba 0.4 g AI	9	7.6 *	96	0.3 *	4	7.9
40 month post-injection (August '11)	Spring 2008	Aba 0.8 g AI	9	5.6 *	98	0.1 *	2	5.7
		Aba 0.4 g AI	10	6.5 *	98	0.1 *	2	6.6
		Check	9	0.0	0	5.4	100	5.4

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

Table 15: Mean number of egg galleries constructed by *Ips* engraver beetles (per 1000 cm^2) in loblolly pine bolts cut 5 to 40 months after trunk injection with abamectin using the Tree IV injection system; Lufkin, Texas: 2008 - 2010.

				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 (August '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 (August '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
22 month post-injection (August '10)	Fall 2008	Aba 0.8 g AI	10	0.4	100	0.0 *	0	0.4 *
		Aba 0.4 g AI	10	0.3	100	0.0 *	0	0.3 *
28 month post-injection (August '10)	Spring 2008	Aba 0.8 g AI	10	0.3	100	0.0 *	0	0.3 *
		Aba 0.4 g AI	10	0.5	100	0.0 *	0	0.5 *
		Check	10	1.2	21	4.5	79	5.7
34 month post-injection (August '11)	Fall 2008	Aba 0.8 g AI	10	0.7	100	0.0 *	0	0.7 *
		Aba 0.4 g AI	9	0.4	100	0.0 *	0	0.4 *
40 month post-injection (August '11)	Spring 2008	Aba 0.8 g AI	9	0.3	100	0.0 *	0	0.3 *
		Aba 0.4 g AI	10	0.2	100	0.0 *	0	0.2 *
		Check	9	0.0	0	15.6	100	15.6

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

Table 16: Mean length of egg galleries constructed by *Ips* engraver beetles (per 1000 cm^2) in loblolly pine bolts cut 5 to 40 months after trunk injection with abamectin using the Tree IV injection system; Lufkin, Texas: 2008 - 2011.

				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 (August '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 (August '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
22 month post-injection (August '10)	Fall 2008	Aba 0.8 g AI	10	1.4	100	0.0 *	0	1.4 *
		Aba 0.4 g AI	10	1.7 *	100	0.0 *	0	1.7 *
28 month post-injection (August '10)	Spring 2008	Aba 0.8 g AI	10	0.8 *	100	0.0 *	0	0.8 *
		Aba 0.4 g AI	10	3.2	100	0.0 *	0	3.2 *
		Check	10	14.7	20	73.2	83	87.9
34 month post-injection (August '11)	Fall 2008	Aba 0.8 g AI	10	2.0	100	0.0 *	0	2.0 *
		Aba 0.4 g AI	9	1.2 *	100	0.0 *	0	1.2 *
40 month post-injection (August '11)	Spring 2008	Aba 0.8 g AI	9	1.0 *	100	0.0 *	0	1.0 *
		Aba 0.4 g AI	10	0.7	100	0.0 *	0	0.7 *
		Check	9	0.0	0	208.4	100	208.4

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

Table 17: Extent of feeding by cerambycid larvae (per 1000 cm^2) in loblolly pine bolts cut 5 to 40 months after trunk injection with abamectin using the Tree IV injection systems; Lufkin, Texas: 2008 - 2011.

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 (August '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 (August '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	
22 month post-injection (August '10)	Fall 2008	Aba 0.8 g AI	10	7.9		0.0	*
		Aba 0.4 g AI	10	5.6		0.1	*
28 month post-injection (August '10)	Spring 2008	Aba 0.8 g AI	10	5.9		0.0	*
		Aba 0.4 g AI	10	8.2		0.0	*
		Check	10	6.8		22.0	
34 month post-injection (August '11)	Fall 2008	Aba 0.8 g AI	10	6.6		0.3	*
		Aba 0.4 g AI	9	5.6		0.2	*
40 month post-injection (August '11)	Spring 2008	Aba 0.8 g AI	9	4.0		0.0	*
		Aba 0.4 g AI	10	4.6		0.4	*
		Check	9	4.6		38.7	

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

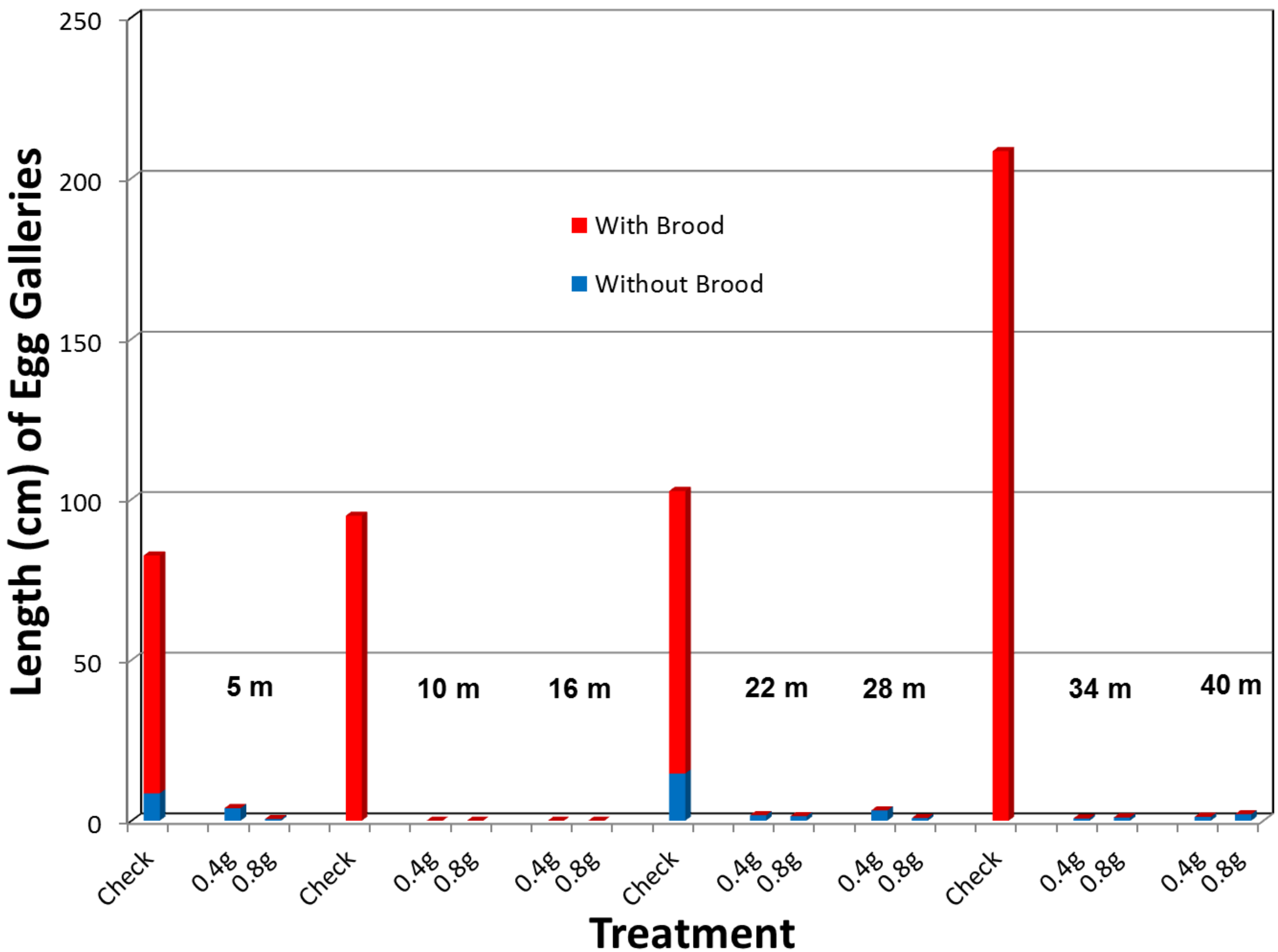

Figure 14. Mean length egg galleries (with and without brood) constructed by *Ips* engraver beetles (per 1000 cm^2) in loblolly pine bolts cut 5 to 40 months after injection with two rates of abamectin using the Tree IV Injection System; Lufkin, TX: 2008 - 2011.

Table 18: Attack success and gallery construction of *Ips* engraver beetles on loblolly pine bolts cut 10 to 34 months after trunk injection with fipronil using the Tree IV injection system; Lufkin, Texas: 2009 - 2011.

Evaluation period	Season/Yr. Injected	Treatment	N	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	
10 month post-injection (August '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
22 month post-injection (August '10)	Fall 2008	Fip 0.8 g AI	10	2.6 *	79	0.7 *	21	3.3
		Fip 0.4 g AI	10	2.5 *	81	0.6 *	19	3.1
		Check	10	0.2	6	2.5	94	2.6
34 month post-injection (August '11)	Fall 2008	Fip 0.8 g AI	9	9.3 *	92	0.8 *	8	10.1 *
		Fip 0.4 g AI	9	7.9 *	76	2.4 *	24	10.3 *
		Check	9	0.0	0	5.4	100	5.4

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

Table 19: Mean number of egg galleries constructed by *Ips* engraver beetles (per 1000 cm^2) in loblolly pine bolts cut 10 to 34 months after trunk injection with fipronil using the Tree IV injection system; Lufkin, Texas: 2009 - 2010.

				Number of egg galleries				
				Without larvae		With larvae		
Evaluation period	Season/Yr. Injected	Treatment	N	No.	% of total	No.	% of Total	Total #
10 month post-injection (August '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
22 month post-injection (August '10)	Fall 2008	Fip 0.8 g AI	10	0.6	86	0.1 *	14	0.7 *
		Fip 0.4 g AI	10	1.3	100	0.0 *	0	1.3 *
		Check	10	1.2	21	4.5	79	5.7
34 month post-injection (August '11)	Fall 2008	Fip 0.8 g AI	9	1.7	100	0.0 *	0	1.7 *
		Fip 0.4 g AI	9	4.0 *	90	0.4 *	10	4.4 *
		Check	9	0.0	0	15.6	100	15.6

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

Table 20: Mean length of egg galleries constructed by *Ips* engraver beetles (per 1000 cm^2) in loblolly pine bolts cut 10 to 34 months after trunk injection with fipronil using the Tree IV injection system; Lufkin, Texas: 2009 & 2011.

				Length of egg galleries				
				Without larvae		With larvae		
Evaluation period	Season/Yr. Injected	Treatment	N	cm	% of Total	cm	% of Total	Total length
10 month post-injection (August '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
22 month post-injection (August '10)	Fall 2008	Fip 0.8 g AI	10	4.2	525	0.8 *	16	5.0 *
		Fip 0.4 g AI	10	6.5	100	0.0 *	0	6.5 *
		Check	10	14.7	20	73.2	83	87.9
34 month post-injection (August '11)	Fall 2008	Fip 0.8 g AI	9	4.7	#####	0.0 *	0	4.7 *
		Fip 0.4 g AI	9	12.2 *	80	3.1 *	20	15.3 *
		Check	9	0.0	0	208.4	100	208.4

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

Table 21: Extent of feeding by cerambycid larvae (per 1000 cm^2) in loblolly pine bolts cut 10 to 34 months after trunk injection with fipronil using the Tree IV injection systems; Lufkin, Texas: 2009 - 2011.

Evaluation period	Season/Yr. Injected	Treatment	N	No. of cerambycid egg niches on bark	Percent phloem area consumed by larvae
10 month post-injection (August '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
22 month post-injection (August '10)	Fall 2008	Fip 0.8 g AI	10	6.6	0.3 *
		Fip 0.4 g AI	10	6.3	1.0 *
		Check	10	6.8	22.0
34 month post-injection (August '11)	Fall 2008	Fip 0.8 g AI	9	* 7.7	0.6 *
		Fip 0.4 g AI	9	3.9	0.9 *
		Check	9	4.6	38.7

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

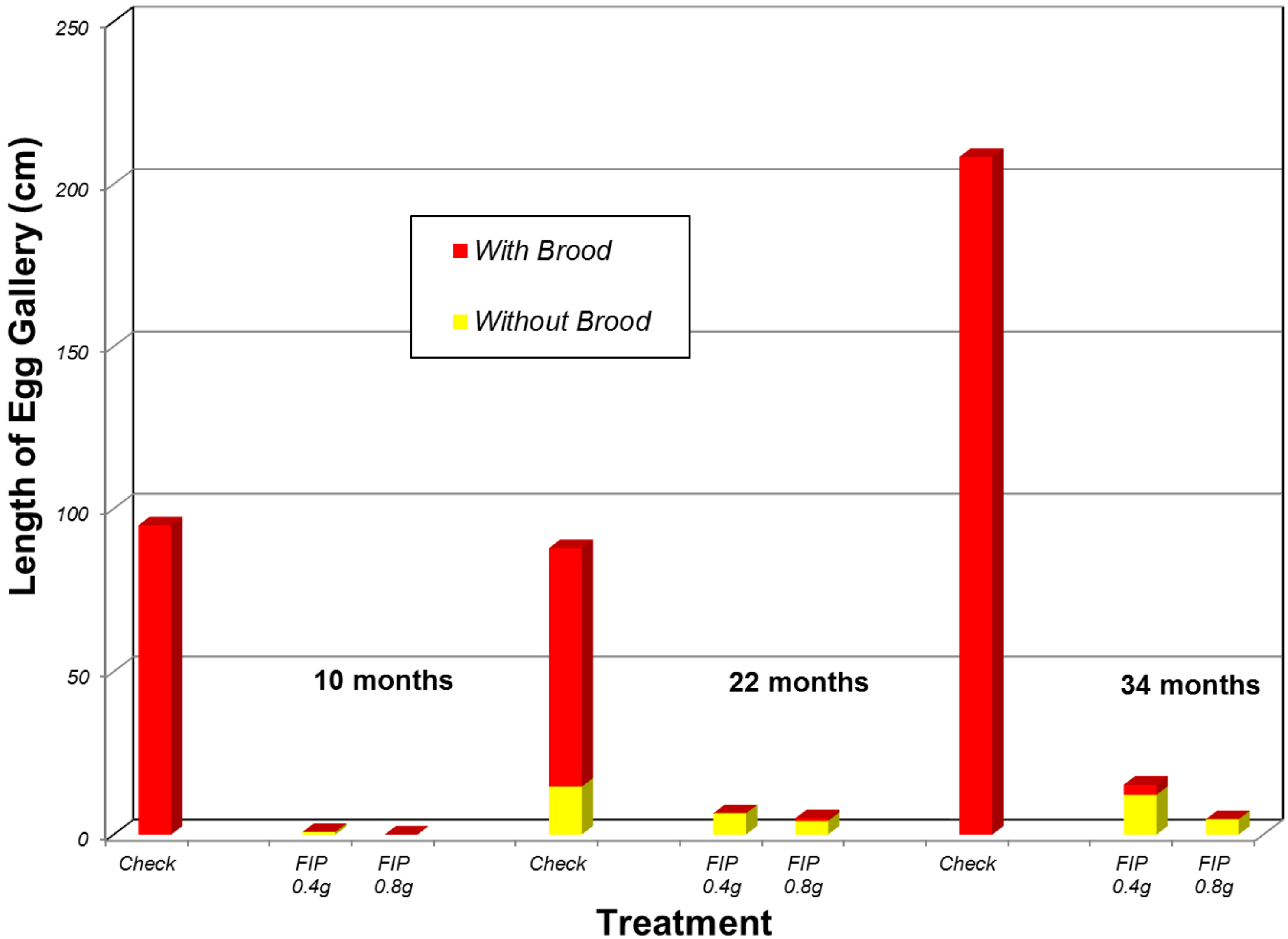

Figure 15. Effect of two fipronil injection treatments on *Ips* engraver beetle attack success 10 to 34 months after injection expressed as length of egg galleries with and without brood, Diboll, TX: 2009 - 2011.

Table 22: Attack success and gallery construction of *Ips* engraver beetles on loblolly pine bolts cut 3 to 9 months after trunk injection with abamectin using the Tree IV injection system; Lufkin, Texas - 2011.

Evaluation period	Season/Yr. Injected	Treatment	N	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	
3 month post-injection (August '11)	Spring 2011	Aba 0.4 g AI	10	5.7 *	98	0.1 *	2	5.8
		Aba 0.2 g AI	10	4.6 *	96	0.2 *	4	4.8
		Aba 0.1 g AI	10	4.4 *	100	0.0 *	0	4.4
9 month post-injection (August '11)	Fall 2010	Aba 0.4 g AI	10	6.1 *	98	0.1 *	2	6.2
		Aba 0.2 g AI	10	7.2 *	99	0.1 *	1	7.3 *
		Aba 0.1 g AI	10	7.2 *	95	0.4 *	5	7.6 *
		Check	10	0.0	0	5.1	100	5.1

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

Table 23: Mean number of egg galleries constructed by *Ips* engraver beetles (per 1000 cm^2) in loblolly pine bolts cut 3 to 9 months after trunk injection with abamectin using the Tree IV injection system; Lufkin, Texas - 2011.

				Number of egg galleries				
				Without larvae		With larvae		
Evaluation period	Season/Yr. Injected	Treatment	N	No.	% of total	No.	% of Total	Total #
3 month post-injection (August '11)	Spring 2011	Aba 0.4 g AI	10	0.1	100	0.0 *	0	0.1 *
		Aba 0.2 g AI	10	0.4	100	0.0 *	0	0.4 *
		Aba 0.1 g AI	10	0.0	#####	0.0 *	#####	0.0 *
9 month post-injection (August '11)	Fall 2010	Aba 0.4 g AI	10	0.1	100	0.0 *	0	0.1 *
		Aba 0.2 g AI	10	0.1	100	0.0 *	0	0.1 *
		Aba 0.1 g AI	10	0.5 *	100	0.0 *	0	0.5 *
		Check	10	0.0	0	17.3	100	17.3

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

Table 24: Mean length of egg galleries constructed by *Ips* engraver beetles (per 1000 cm^2) in loblolly pine bolts cut 3 to 9 months after trunk injection with abamectin using the Tree IV injection system; Lufkin, Texas - 2011.

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
3 month post-injection (August '11)	Spring 2011	Aba 0.4 g AI	10	0.1	100	0.0 *	0	0.1 *
		Aba 0.2 g AI	10	0.9	100	0.0 *	0	0.9 *
		Aba 0.1 g AI	10	0.0	#####	0.0 *	#####	0.0 *
9 month post-injection (August '11)	Fall 2010	Aba 0.4 g AI	10	0.4	100	0.0 *	0	0.4 *
		Aba 0.2 g AI	10	0.3	100	0.0 *	0	0.3 *
		Aba 0.1 g AI	10	1.0	100	0.0 *	0	1.0 *
		Check	10	0.0	0	244.1	100	244.1

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

Table 25: Extent of feeding by cerambycid larvae (per 1000 cm^2) in loblolly pine bolts cut 3 to 9 months after trunk injection with abamectin using the Tree IV injection systems; Lufkin, Texas - 2011.

Evaluation period	Season/Yr. Injected	Treatment	N	No. of cerambycid egg niches on bark		Percent phloem area consumed by larvae	
3 month post-injection (August '11)	Spring 2011	Aba 0.4 g AI	10	3.6		0.0	*
		Aba 0.2 g AI	10	2.3	*	0.0	*
		Aba 0.1 g AI	10	2.8		0.1	*
9 month post-injection (August '11)	Fall 2010	Aba 0.4 g AI	10	3.1		0.0	*
		Aba 0.2 g AI	10	4.6		0.0	*
		Aba 0.1 g AI	10	4.1		0.0	*
		Check	10	5.1		21.9	

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

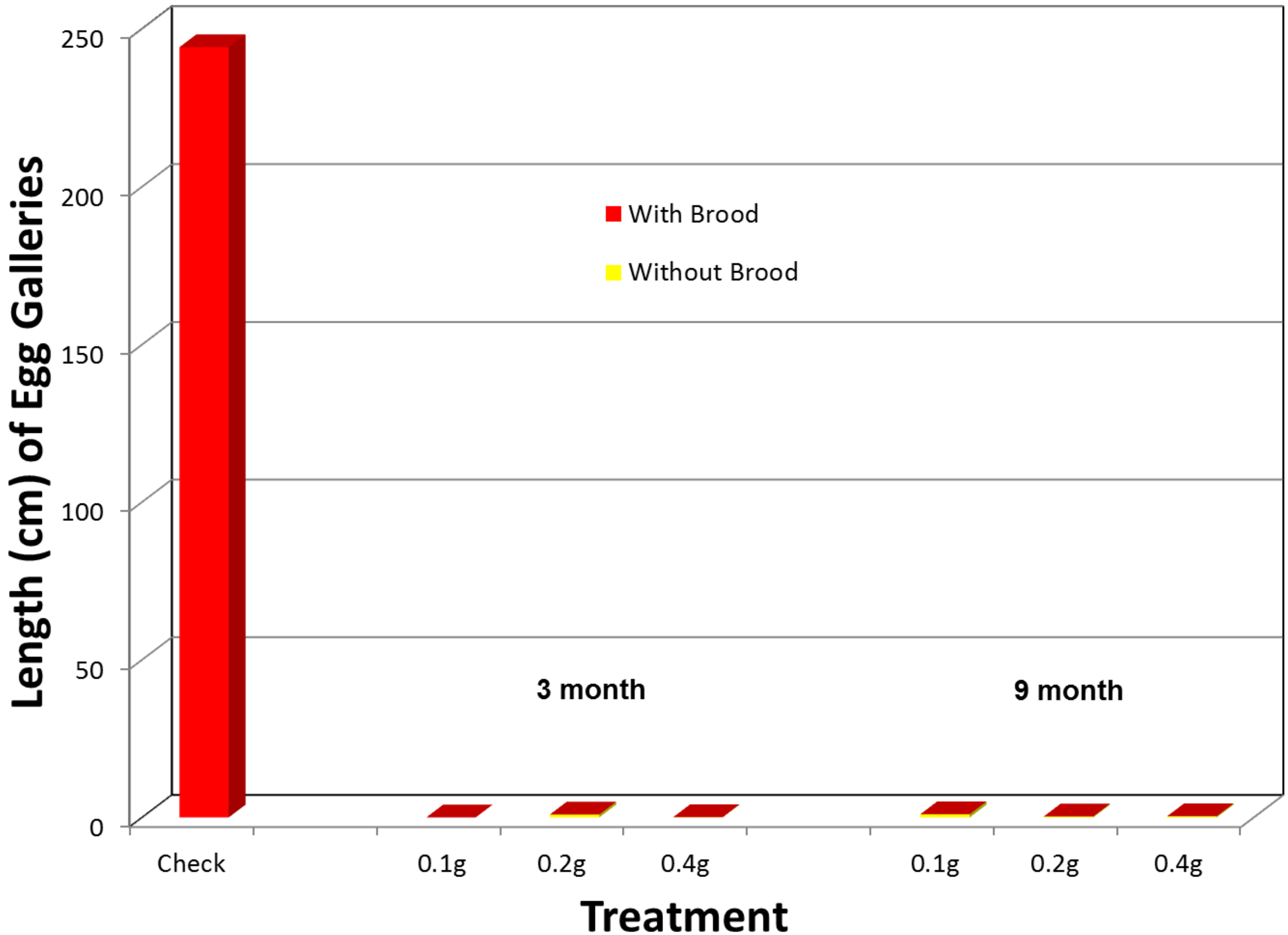

Figure 16. Mean length egg galleries (with and without brood) constructed by *Ips* engraver beetles (per 1000 cm^2) in loblolly pine bolts cut 5 to 40 months after injection with two rates of abamectin using the Tree IV Injection System; Lufkin, TX: 2008 - 2011.

Table 26: Attack success and gallery construction of *Ips* engraver beetles on loblolly pine bolts cut 1 month after treatment with azadirachtin (AzaSol) or dinotefuran (Safari); Lufkin, Texas - 2011.

			Mean # of nuptial chambers without egg galleries		Mean # of nuptial chambers with egg galleries		
Evaluation period	Treatment	N	No.	% of total	No.	% of total	Mean total # of nuptial chambers
1 month post-injection (April '11)	Azasol Tree Inj.	10	0.0	0	6.3	100	6.3
	Azasol Bark Spray	10	0.0	0	5.7	100	5.7
	Azasol Soil Drench	8	0.0	0	6.6	100	6.6
	Azasol Spray + Drench	10	0.0	0	5.4	100	5.4
	Safari Bark Spray	10	0.0	0	6.2	100	6.2
	Check	10	0.0	0	6.2	100	6.2

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

Table 27: Mean number of egg galleries constructed by *Ips* engraver beetles (per 1000 cm^2) in loblolly pine bolts cut 1 month after treatment with azadirachtin (AzaSol) or dinotefuran (Safari); Lufkin, Texas -2011.

			Number of egg galleries				
			Without larvae		With larvae		
Evaluation period	Treatment	N	No.	% of total	No.	% of Total	Total #
1 month post-injection (April '11)	Azasol Tree Inj.	10	0.0	0	20.9	100	20.9
	Azasol Bark Spray	10	0.1	1	15.9	99	16.0
	Azasol Soil Drench	8	0.0	0	20.5	100	20.5
	Azasol Spray + Drench	10	0.0	0	18.0	100	18.0
	Safari Bark Spray	10	0.0	0	22.4	100	22.4
	Check	10	0.3	1	20.8	99	21.1

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

Table 28: Mean length of egg galleries constructed by *Ips* engraver beetles (per 1000 cm^2) in loblolly pine bolts cut I month after treatment with azadirachtin (AzaSol) or dinotefuran (Safari); Lufkin, Texas - 2011.

			Length of egg galleries				
			Without larvae		With larvae		
Evaluation period	Treatment	N	cm	% of Total	cm	% of Total	Total length
1 month post-injection (April '11)	Azasol Tree Inj.	10	0.0	0	237.7	100	237.7
	Azasol Bark Spray	10	0.1	0	207.7	100	207.8
	Azasol Soil Drench	8	0.0	0	274.5	100	274.5
	Azasol Spray + Drench	10	0.0	0	249.2	100	249.2
	Safari Bark Spray	10	0.0	0	238.5	100	238.5
	Check	10	5.2	2	242.3	98	247.5

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

Table 29: Extent of feeding by cerambycid larvae (per 1000 cm^2) in loblolly pine bolts cut 1 month after treatment with azadirachtin (AzaSol) or dinotefuran

Evaluation period	Treatment	N	No. of cerambycid egg niches on bark	Percent phloem area consumed by larvae
1 month post-injection (April '11)	Azasol Tree Inj.	10	8.7	16.9
	Azasol Bark Spray	10	10.8	22.9
	Azasol Soil Drench	8	16.6 *	19.5
	Azasol Spray + Drench	10	7.9	21.8
	Safari Bark Spray	10	12.8	24.2
	Check	10	10.9	29.0

* 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 or Abamectin Combined with Fungicide for Protection of High-Value Southern and Western Conifers from Bark Beetles and Blue Stain Fungi – Alabama and Utah

Highlights:

● The FPMC continued to evaluate the efficacy of emamectin benzoate or abamectin alone or combined with fungicide for preventing mortality of conifers by *Dendroctonus* bark beetles (Coleoptera: Curculionidae, Scolytinae) in Alabama and Utah in 2011.

● Results indicate that tree injections that included emamectin benzoate are still effective in reducing/preventing tree mortality by southern pine beetle in the third year after treatment. The addition of a propiconazole/thiabendazole mix did improve tree survival to some extent.

● The injection trial in Utah showed that tree injections that included emamectin benzoate and abamectin are largely effective in reducing/preventing lodgepole pine mortality by mountain pine beetle in the second year following treatment.

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 effect of injection timing on treatment efficacy, and 3) determine the duration of treatment efficacy.

Study Sites: The study is being conducted at 2 sites:

1) Talladega National Forest, Oakmulgee Ranger District in Bibbs and Perry Co., Alabama with southern pine beetle (SPB, *D. frontalis*) attacking loblolly pine,
2) Uinta-Wasatch-Cache National Forest, Mountain View-Evanston Ranger District, Utah, with mountain pine beetle (MPB, *D. ponderosae*) 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 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 2

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

	SPB (AL)	MPB (UT)
Project Leader(s)	Grosman & Clarke	Fettig
Injection Dates	Apr 2009	Apr 2009 Sept 2009
Baiting Period	May - Jun 2009 Apr - Jun 2010 Apr - Jun 2011	Jul - Aug 2009 Jul - Aug 2010 Jul - Aug 2011
Prelim Evaluation	Jun - Nov 2009 May - Nov 2010 May - Nov 2011	Oct 2009 Oct 2010 Sept 2011
Final Evaluation	Dec. 2009 Dec. 2010 Dec. 2011	Jun 2010 Jun 2011 Jun 2012

SPB = Southern pine beetle; MPB = Mountain pine beetle

Each insecticide (injection or spray) treatment was applied to 30-35 randomly-assigned trees. A similar number of trees were 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 using the 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 and high elevation, at the Utah site, the trees were not baited until 2009 (Table 30). 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 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 were no more than 6 killed by the bark beetle challenge), and the second set of check trees were 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 bark beetle 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 ($\alpha = 0.05$) to reject Ho when more than six trees die from bark beetle attack (Shea et al., 1984).

Results:

Southern pine beetle on loblolly pine (AL) – Trial 1

2011 at Oakmulgee NF - The study trees were baited with the three-component bait for three 6 week periods starting in April. The results showed 35% (10 of 29) of the check trees exhibited fading crowns by the end of October 2011 (Figure 17). In contrast, 16%, 8%, and 4% of the EB-, fungicide-, and EB plus fungicide-treated trees had faded, respectively. All fading 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 fungi infection (Table 31). SPB was not successful in trees injected with EB.

Mountain pine beetle on lodgepole pine (UT) – Trial 2

2009 at Uinta-Wasatch-Cache NF - Nearly all baited trees were heavily attacked by MPB within 3 weeks. A final assessment in September 2010 showed heavy mortality (80%, 24 of 30) of untreated lodgepole pine trees (Figure 18). Mortality of trees treated with EB alone and EB + fungicide in the spring of 2011 were 30% and 13%, respectively. Thus, only the latter treatment was below the 20% threshold.

2010 at Uinta-Wasatch-Cache NF - A final assessment of tree mortality was conducted in September 2011. Mortality of untreated checks was at the 60% threshold. In contrast, mortality of EB- and AB-treated trees (both spring and fall) was low (≤10%) (Figure 18). Final assessment is planned for summer 2012.

Conclusions:

The results of trials presented above indicate that emamectin benzoate injection treatments can provide good protection against southern pine beetle. Spring applications were marginal for mountain pine beetle. However, fall applications when applied at closer spacing did provide very good protection It appears that the addition of a fungicide may reduce the success of blue stain fungi colonization. It is not yet apparent if the combination treatment improved protection compared to EB alone.

The AL and UT trials will be monitored in 2012 to evaluate the duration of efficacy of combination treatments of emamectin benzoate and fungicide and combination treatments of abamectin and fungicide at the Utah site.

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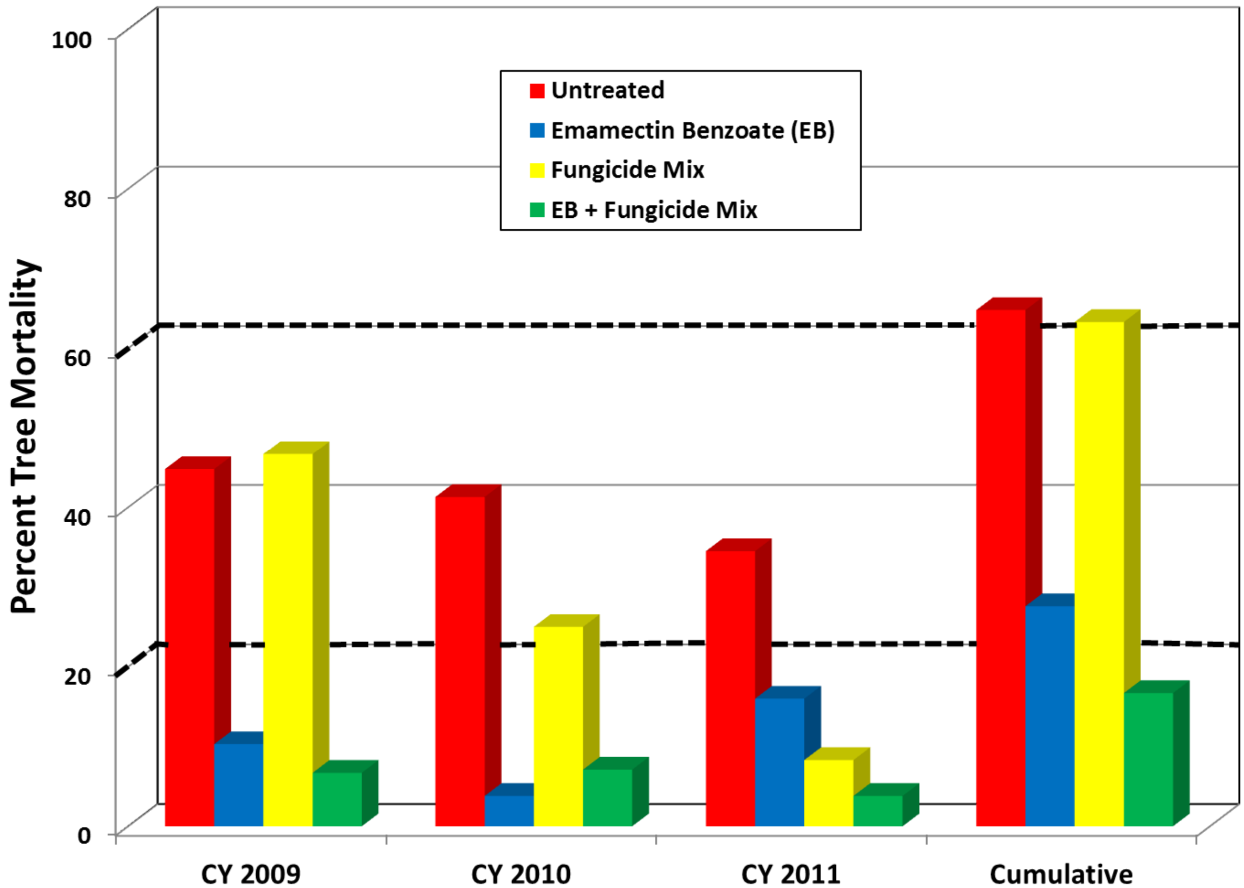


Figure 17. Effects of emamectin benzoate injection treatments on loblolly pine mortality caused by southern pine beetle, Talladega National Forest, AL, in 2009, 2010 and 2011. The dashed line at 60% cumulative mortality is the level of control tree mortality necessary for a valid test; the dashed line at 20% cumulative mortality is the maximum allowable mortality of treatments to be considered efficacious.

Table 31. Effects of emamectin benzoate and fungicide injection treatments on the success of bark beetle, cerambycids and blue stain colonization in loblolly pine, Talladega National Forest, AL - 2009.

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.

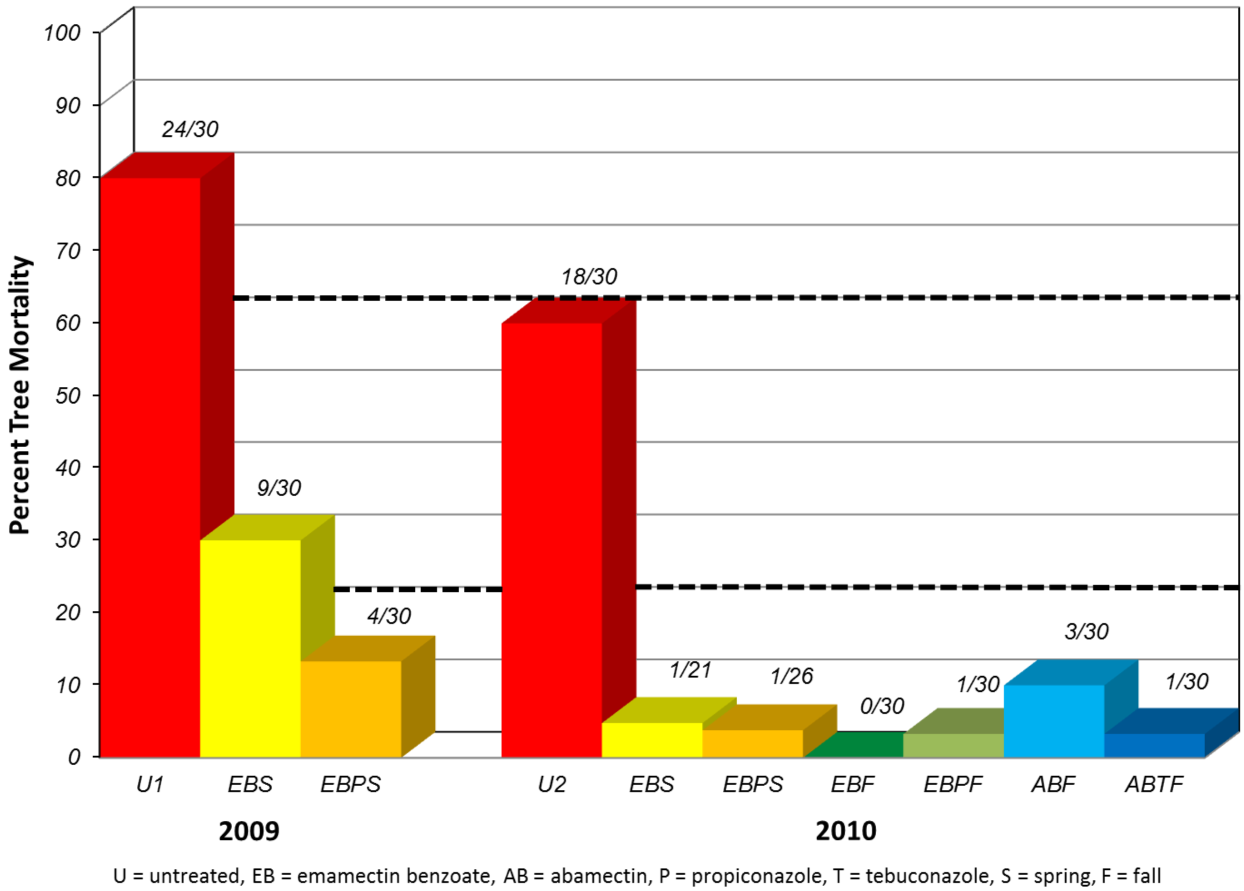


Figure 18. Effects of emamectin benzoate and abamectim $\pm$ fungicide injection treatments on lodgepole pine mortality caused by mountain pine beetle, Uinta-Wasatch-Cache National Forest, UT, in 2009 and 2010. The dashed line at 60% cumulative mortality is the level of control tree mortality necessary for a valid test; the dashed line at 20% cumulative mortality is the maximum allowable mortality of treatments to be considered efficacious.

SYSTEMIC PESTICIDE INJECTION TRIALS

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

Highlights:

● Data indicates that the health of EB-treated western soapberry trees previously attacked by invasive soapberry borer, *Agrilus prionurus* (Coleoptera: Buprestidae) were considerably better compared to checks by the end of 2011.

● The imidacloprid treatment significantly reduced defoliation by saltcedar beetles on athel trees during the first year after treatment.

Objectives: 1) To determine the efficacy of emamaectin benzoate or imidacloprid for protecting individual western soapberry (*Sapindus saponaria* var. *drummondii*) and/or athel trees (*Tamarix aphylla*) from damage and/or mortality attributed to different invasive insect pests; and 2) To determine the duration of protection provided by emamectin benzoate or imidacloprid against invasive insect pests.

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

1) Private and municipal property in or near Rosharon, Allen, Mesquite, Anderson, Belton, Colleyville, Southlake, Forney, Rockwall, and Rockport, TX with soapberry borer (SBB) attacking western soapberry,

2) Private, municipal, and national park property in or near Big Bend N.P., Presidio, and Ruidosa, TX with saltcedar beetle attacking athel trees.

Research Approach:

Treatments by trial included:

Trial 1 (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 and June, July and September, 2010,
2) Untreated (control)

Trial 2 (Saltcedar beetle)

1) Emamectin benzoate (0.2g AI per inch; TREE-äge™, Arborjet Inc.) trunk injection at 5 ml per inch DBH in Nov. 2010 and Feb. 2011,
2) Imidacloprid (0.2g AI per inch; IMA-jet™, Arborjet Inc.) trunk injection at 4 ml per inch DBH in Nov. 2010 and Feb. 2011,
3) Untreated (control)

<u>Trial 1</u>: At each location, 1 – 30 western soapberry (2 – 18" DBH) were selected. 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.

Tree health and survival were evaluated at the time of treatment application as well as July and November 2010 and 2011. If warranted, evaluations will be continued in 2012 using the following ranking criteria.

Health Condition:

1= Excellent - Full crown, good foliage, no epicormic branches, no apparent SBB attacks
2= Good - Mostly full crown, a few SBB attacks, no epicormic branches
3= Fair - Thinning crown; several SBB attacks, a few epicormic branches
4= Poor - Moderately thin crown, many SBB attacks, several epicormic branches
5= Near Death - Mostly dead crown; many epicormic branches; bark starting to flake
6= Dead - No leaves, many areas of flaking bark

<u>Trial 2</u>: At each location, one or more athel trees (7 – 50" DBH) were selected. Eleven to 16 trees were injected with a standard rate of TREE-äge™ (5 ml per inch diameter) or IMA-jet™ (4 ml per inch diameter) in the fall (late November 2009) or spring (February 2010) 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 served as untreated controls at each location in each season.

Tree health and survival was evaluated in at the time of treatment application as well as August and October 2011 and, if warranted, 2012 using the following ranking criteria.

Health Condition:

0 = no defoliation;
1 = light defoliation, <20%;
2 = moderate defoliation, 20-80%;
3 = severe defoliation, 80-99%;
4 = complete defoliation, 100%.

Data was analyzed by GLM and the Fisher's Protected LSD test using the Statview statistical program.

Results:

Trial 1: In 2011, the health of EB-treated trees previously attacked by SBB continued to improve (Figures 19 and 21). However, there was very little evidence of new SBB attacks in 2011, presumably due to a prolonged freeze in February 2011. Thus, even surviving untreated trees began to show improvements in health by the end of 2011.

Figure 19. Emamectin benzoate-treated (left) vs untreated (right) western soapberry, 2011, Mesquite, TX.

Trial 2: In February 2011, an extended cold snap caused considerable dieback of most athel trees in Big Bend National Park, Presidio and Ruidosa. Most trees began to resprout from the base. The efficacy of EB and imidicloprid treatments on saltcedar beetle was difficult to evaluate, even after 11 months post treatment because of the frost caused dieback as well as relatively low saltcedar beetle populations at most locations. However, extensive defoliation was observed on untreated trees at the Muniz ranch, between Presidio and Ruidosa. At this site, trees treated with imidiclopid had little or no defoliation, while EB-treated trees were partially defoliated (Figures 20 and 22).

Figure 20. Imidacloprid-treated athel (left) versus untreated check (right) near Ruidosa, TX.

Conclusions:

The EB treatment significantly reduced the success of soapberry borer in western soapberry during the first and second year. Thus, EB-treated western soapberry trees are healthier compared to checks. The duration of treatment efficacy will be further evaluated in 2012.

Both imidacloprid and EB treatmenst significantly reduced defoliation by saltcedar beetle on athel during the first year. However, imidaclroprid provided better protection at sites with higher beetle populations. The duration of treatment efficacy will be further evaluated in 2012.

Acknowledgements: Many thanks go to our cooperators: Tom French, Dennis Moore, Joe Sirotnak and Chad Krajca 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.

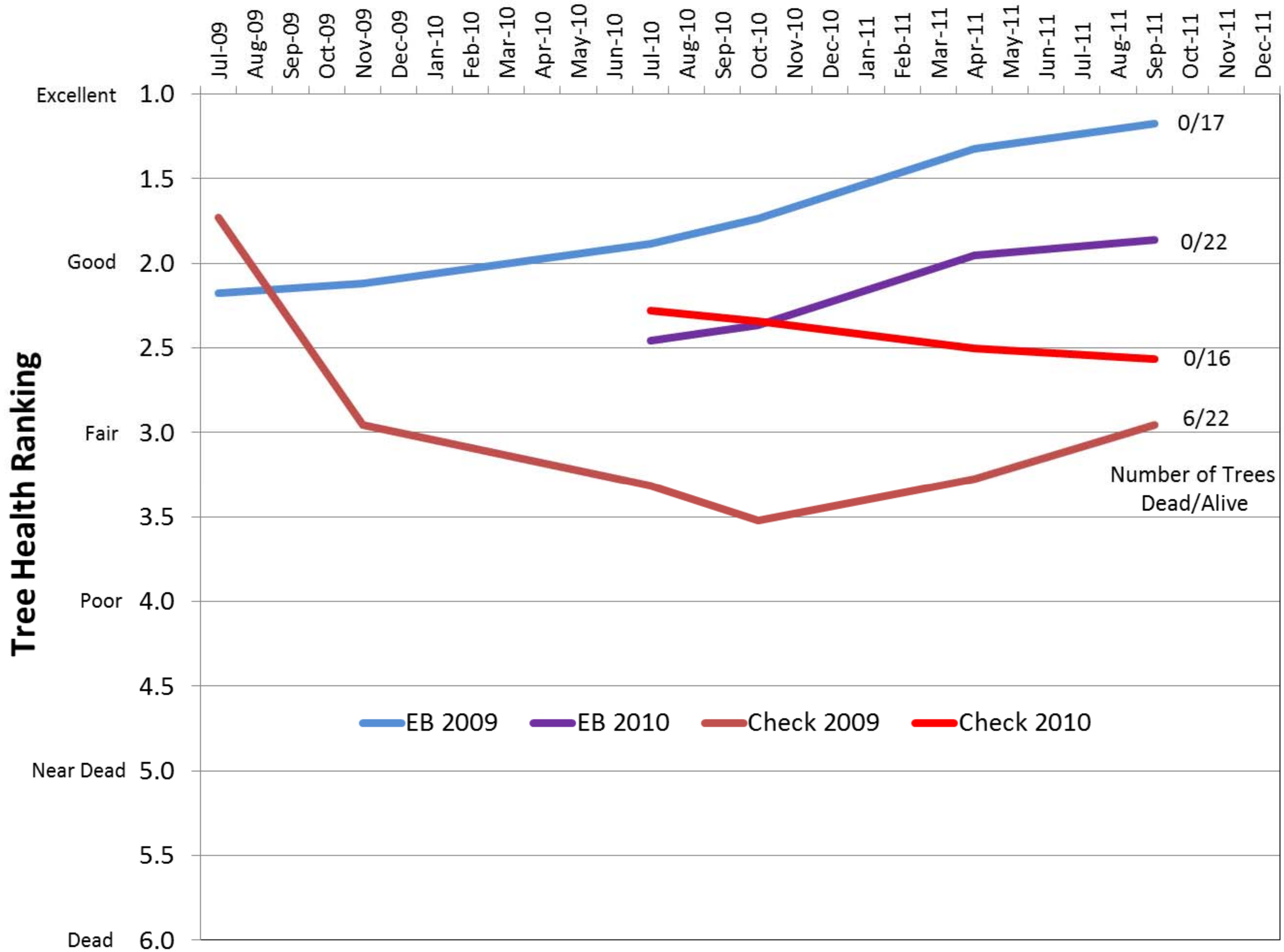
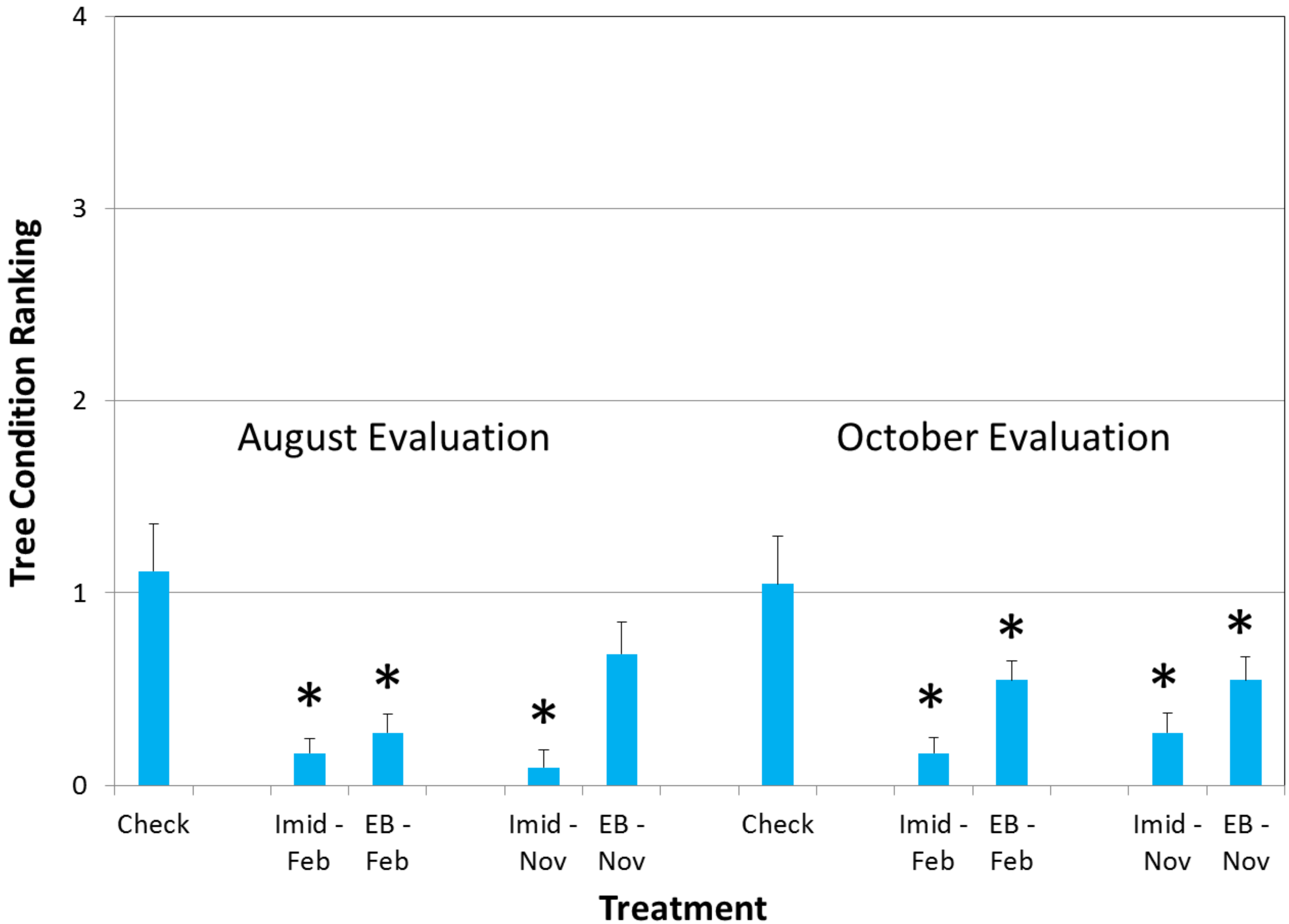


Figure 21. Effects of EB treatments (2009 and 2010) on health of western soapberry in central Texas, 2009, 2010 and 2011.



0 = no defoliation; 1 = light defoliation, <20%; 2 = moderate defoliation, 20-80%; 3 = severe defoliation, >80%; 4 = complete defoliation, 100%.

Figure 22. Condition of athel trees 6 – 11 months after treatment with imidacloprid or emamectin benzoate.

SYSTEMIC PESTICIDE INJECTION TRIALS

Evaluation of Microinjection Systems for Application of Propiconazole in Live Oak in Central Texas

Highlights:

- Six injection systems were evaluated based on their potential to inject propiconazole (Alamo®) into live oaks; all systems were found capable of injecting the product in all/nearly all trees. The Tree IV and Chemjet systems ranked best overall, followed by Mauget capsules, Pine Infuser, Macro-Infusion and Portle.
- Propiconazole treatments made by these six systems are being evaluated for their ability to prevent development of oak wilt symptoms after inoculation with cultures of the oak wilt fungus *Ceratocystis fagacearum*. Nearly eight months after injection, disease symptoms were observed on 50% of the study trees that received no fungicide treatments (checks). In contrast, no more than 25% of fungicide-treated trees have shown symptoms as of February 2012. Evaluations will continue in 2012.

Objectives:

1) Evaluate ability of various delivery systems to inject propiconazole formulation based on time to prepare/load, install and treat each tree and safety.
2) Evaluate speed and distribution of propiconazole movement based on protection 4 weeks after injection, and then every 8 weeks thereafter for 18 months.

Research Approach: Six injection/infusion systems were evaluated, as follows:

Mauget (capsule) System (Mauget; contact: Marianne Waindle) low volume (10 ml/inj pt); low pressure (10 psi)

Pine Infuser System (Rainbow Treecare Scientific Advancements; contact: Shawn Bernick); moderate volume (30 ml/inj pt); moderate pressure (40 psi)

Portle (Direct Inject) System (ArborSystems; contact: Chip Doolittle) – low volume (1 - 10 ml/inj pt); moderate - high pressure determined by applicator (50+ psi)

Chemjet System (Chemjet Trading Pty; contact: Jim Redicker) – low volume (20 ml/inj pt); low - moderate pressure (23 - 37 psi)

Tree IV System (Arborjet, Inc.; contact: Joe Doccola) – moderate volume (50-100 ml/inj pt); moderate pressure (60 psi)

Macro-Infusion System (Rainbow Treecare Scientific Advancements; contact: Shawn Bernick); high volume (200-600 ml/inj pt); low pressure (25 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 maximum potential points in parentheses:

1) system cost (5 pts)
2) Can the system be left alone on tree (2 pts) or does the applicator need to manually operate system continuously? (1 pts)
3) Does chemical come prepackaged; can you inject product undiluted (2 pts) or is it necessary to dilute with water? (0 pts)
4) Weather restrictions (moisture, temperature) (2 pts if none)
5) Time and ease to fill system with chemical product (5 pts)
6) Number of injection points required per tree (5 pts)
7) Time and ease to install system on tree (10 pts)
8) Time and ease to inject X amount of product (20 pts)
9) Cumulative time applicator spends at each tree (10 pts)
10) System disposable or time and ease to clean system (4 pts)
11) Potential for chemical exposure (5 pts)
12) Effectiveness of treatment 1 month after treatment (30 pts)

Treatment Methods and Evaluation:

This study is being conducted within the range of plateau live oak (*Quercus fusiformis*) at three locations (near Johnson City, Stonewall and Fredericksburg) in central Texas (Figures 29, 30 and 31). Non-symptomatic test trees (84), ranging from 14 to 80 cm (6 – 32 in) DBH (diameter at breast height) were selected between root barriers (trenches installed for oak wilt suppression within the past year) and active oak wilt centers. There were four groups of seven study trees (28 total) at each site. On May 17-19, 2011, twelve (12) trees per delivery system were injected with propiconazole (Alamo®, Syngenta) at the label rate (10 ml/inch tree dbh) using each of the six systems described above. Twelve trees are serving as untreated controls. The application procedure used to inject the propiconazole formulation was based on the recommendations of each system manufacturer. The injected trees were allowed 10 weeks to translocate chemicals prior to being challenged with fungal inoculations.

Inoculations were performed using standard procedures (Camilli et al. 2009, Peacock and Fulbright 2009) on three of the four groups of trees at each site. Two *Ceratocystis fagacearum* isolates were cultured from samples recovered in spring 2011 from infected live oak and Spanish oak (*Q. buckleyi*) in an active oak wilt center in central Texas. The pathogen cultures were serially "plated" on petri plates containing Potato Dextrose Agar. Following 2 weeks of growth, the plates were flooded with 20 ml of sterile distilled water. The surfaces of the plates were scraped with a glass rod, resulting in a suspension of conidia. The conidia were harvested by pouring the water from the plates, combining the aliquots, and quantifying the total suspension with a hemacytometer. The suspension was adjusted to a level of 1×10^6 spores/ml with appropriate dilutions to make a quantity of the inoculum sufficient for the inoculations. On June 28, 2011, three groups of trees (21 total) were selected at each site. Two inoculation points (North and South sides) were located on each tree's roots >23 cm below injection points. At each point, a 14mm-wide wood chisel was used to cut through the bark into the xylem tissue (~ 2 cm deep). A dropper was used to apply 1 ml of conidia suspension into each wound site. Note: due to extreme drought conditions during the initial inoculation, it will be necessary to re-inoculate trees in March, 2012.

The fourth group of trees at each site was evaluated for potential phytotoxic symptoms resulting from the injection of concentrated propiconazole under drought conditions.

A photograph of the crown of each study tree was taken at the time of fungal inoculation. Trees will be initially evaluated for crown condition every 4 weeks. The date of oak wilt symptom (veinal chlorosis and necrosis, leaf drop, thinning crown) appearance will be recorded and then evaluations will switch to once every 8 weeks thereafter for 80 weeks (18 months). Each oak crown will be given a rating of 0 (healthy), 1 (wilt symptoms comprising up to one-third of the crown), 2 (wilt symptoms comprising greater than one-third of the crown) (Mayfield et al. 2008), or 3 (dead tree). At each rating period, trees with a crown rating of 2 may be felled and wood samples taken from the stem and branches to determine the presence of *Ceratocystis fagacearum*.

At the termination of the experiment in November 2012 (about 18 months after the first pathogen inoculation), final crown ratings will be made. An analysis of variance will be used to test for differences among injection systems. A χ^2 (Chi-square) test for homogeneity will be used to test the null hypothesis that the percentage of trees with a crown rating of 2 did not differ between the fungicide-treated trees and the untreated control group (Mayfield et al. 2008). The null hypothesis will be rejected if more than 20% of the fungicide-treated trees reached a crown rating of 2. The test will be invalidated if fewer than 60% of the control trees reach a crown rating of 2.

Results:

Field evaluations of injection systems were performed May 17, 18 and 19, 2011. Three (Tree IV, Infuser, and Macro-infusion) of the six systems were found to be capable of injecting the desired amount of propiconazole into all study trees (Table 32). Of the remaining systems, two (Chemjet and Mauget) were successful on most trees, but each had one tree where chemical remained in a few injectors even after 10 hours post-installation and the third system (Portle) had considerable leakage around most injection points; thus, it was uncertain how much product was injected into each tree.

Based on the time needed to inject product, there was no apparent advantage to injecting undiluted Alamo (Mauget capsule or Portle) than to inject a diluted (Infuser, Tree IV, Chemjet and Macro) solution. However, higher pressure systems (> 40 psi; Portle, Tree IV, and Infuser) were able to push product into the tree faster than were lower pressure systems (Chemjet, Macro and Mauget capsules). Although the average injection rate for the Macro-infusion (84.1 ml/minute) was 89% or more faster compared to that of the Tree IV (9.4 ml/min), Portle (6.9 ml/minute), Infuser (3.0 ml/minute), Chemjet (0.4 ml/minute), and Capsules (0.2 ml/min), the cumulative time spent at a given tree with the Tree IV was 0.5 – 21 minutes shorter than the other systems.

Table 33 compares the six tested injection systems relative to twelve criteria (cost, 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, disposable or ease/time to clean system, potential for chemical exposure, effectiveness of treatment). The criteria had a value ranging from 2 to 30 points.

The Tree IV system (Arborjet Inc., Figure 23) accumulated the greatest number of points (83) (Figure 28), so far, based on the fact it was very consistent in its ability to inject propiconazole into live oaks, it can be installed and left alone on a tree, and there is very little chance of chemical exposure. Other attractive features include that it 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 restrictions. Some important limitations include that it is fairly expensive system ($900 for 3 units), the need to install plugs and manage spaghetti tubing, the need to mix product with water prior to injection, and the need to measure product and fill the system for each tree.

Figure 23. Arborjet's Tree IV installed on live oak.

The Chemjet system (Chemjet Trading, Figure 24) was second with 77 points. It has several attractive features including that it is inexpensive, the system it can be filled and installed quickly and left alone on the tree, it requires fewer injection points to treat the tree, and it's reusable and easy to clean. Some limitations include that the system requires considerable time (averaged 4+ hrs, but 19 hr for one tree; in this case a few units never emptied completely) to push chemical into the tree, there is some potential for chemical exposure, and it is more limited by weather restrictions than the Tree IV because of lower system pressure.

Figure 24. Chemjet installed on live oak

The Mauget capsules system (JJ Mauget, Figure 25) was third with 74 points. Advantages include the system is prepackaged, fairly cheap per unit, easy to install; does not require constant monitoring, the capsules are disposable (convenience), and showed little potential for chemical exposure. However, Mauget does not normally carry the higher volume (10 ml) of Alamo®, it requires considerable time (averaged near 10 hr, 26 hrs for two trees) to treat trees, and use maybe more limited by weather restrictions (cold or dry conditions) than other higher pressure systems.

Figure 25. Mauget's capsules installed on live oak.

The Pine Infuser (Rainbow Treecare Scientific, Figure 26) system was fourth with 62 points. Advantages include that it requires fewer injection points to treat the tree (compared to the standard Macro), fairly short injection time, it is reusable, and can be left alone on the tree. Limitations include: fairly expensive, there are several steps involved in installation and filling the system, there is some potential for chemical exposure, and it is more limited by weather restrictions than the Tree IV because of lower system pressure.

Figure 26. Rainbow Treecare's Pine Infuser installed on live oak.

The Macro-infusion (Rainbow Treecare Scientific, Figure 27) system was fifth with 51 points. The system has a large product capacity (13,000 ml), is reusable, can be left alone on a tree, and has been shown to effectively apply product to all trees. However, the overall cost is high (particularly if the operator was to purchase an air spade and compressor), the need to mix large volumes of chemical dilutions, considerable time is required to expose the root flare and install the system, and the need to remove air from the lines during installation. Thus, there is a higher potential for chemical exposure and cleaning the system took longer than should be expected.

Figure 27. Rainbow Treecare's Macro-Infusion installed on live oak.

The Portle System (ArborSystem, Figure 28) was sixth with 48 points. Its attractive features are that the product would be prepackaged, the system has a large product capacity (1000 ml), is reusable, and easy to install on the tree. Some important limitations include the need for several more injection points compared to most other systems (more time and effort), the need for the applicator to remain with the system during the injection, there is considerable potential for chemical exposure (particularly when attempting to inject 10 ml per site) because of leakage out of injection points, and a fairly high cost.

Figure 28. ArborSystems' Direct-Inject Portle being used to inject Alamo® into live oak.

Most of the above systems were effective in injecting the desired amount of product into each of 12 trees; the exceptions being one tree each for the Chemjet and Mauget capsules where a few units still held chemical after 19 and 26 hrs, respectively, and the Portle was ineffective at injecting the desired amount as there was considerable leakage. The evaluation of study trees 1, 2, 3, and 4 months after injection revealed that none of the trees exhibited symptoms (veinal necrosis, dieback, mortality) attributable to oak wilt. Note: one oak treated with the Macro-infusion system has died, apparently due to extreme drought stress. However, once rain began to fall in October, some of the trees began to exhibit oak wilt symptoms in November and December and February (Figure 32). Thus far, the Tree IV system is the only one without symptomatic trees. The positions of newly infected trees relative to the old oak wilt centers suggest that all trees were infected naturally (Figures 29. 30 & 31). Three trees treated via the macro injection system exhibited oak wilt symptoms by February, but the level of defoliation at this time is relatively light (25%) compared to the higher levels (35 – 70%) of defoliation observed on symptomatic trees treated by other systems (Chemjet, Capsules, Infuser, and Portle) (Figure 33). This suggests that, generally, the macro injection treatment is better able to keep the fungal infection at bay than the other systems.

Conclusions:

Two microinjection systems (Tree IV and Pine Infuser) and macro-infusion were found to be operationally effective in the injection of a full dose of propiconazole into live oak. Two other microinjection systems (Mauget capsules and Chemjet) were effective on most (not all) trees. The arborist / tree care provider needs to consider several factors (cost, convenience, injection rate, safety, etc.) before selecting a system to use. These four microinjection systems can be more convenient to use compared to the Macro-Infusion system. Thus far, all systems reduced the development of oak wilt symptoms, but the Tree IV and Chemjet seem to be faring better than the others. Based on results observed in February 2012, all study trees will be reinoculated in March and then evaluated through the remainder of 2012.

It is important to note that for two systems, the unit (Mauget capsules) or protocol (Portle) was modified to make them comparable to other systems used in this study (10 ml per inch rate). Mauget capsules normally deliver less product (4 ml or 6 ml of tebuconizole). However, each unit was filled with 10 ml of propiconazole for the study. Nevertheless, they performed well (except for one tree) even under drought conditions. ArborSystems' (Direct-Inject)

Portle system was designed to normally deliver up to 2 ml product per injection site. However, it would have required 5X (>100) the number of injection points and considerably increased the time of injection. Thus, we attempted to push the amount per site to 10 ml. Unfortunately, this resulted in considerable leakage around needles at most sites.

The development of new and/or improved injection systems continues with the realization that protection of trees and crops with systemic chemicals is an economically viable option. All participating companies continue to upgrade their systems. Other untested systems, such as Sidewinder™ and Eco-ject (BioForest Technologies) may also prove to be effective options.

Acknowledgements: Many thanks go to our cooperators: Dr. Robert Conner, David Kuhlken and Bruce Fairchild for providing research sites. We appreciate the chemical donations made by Syngenta Crop Science and injection equipment loans made by Arborjet, Inc., ArborSystems, Mauget, Rainbow Treecare Scientific Advancements, Scenic Hills Nursery, and Urban Renewal. Field assistance by Dr. David Appel, Robert Edmonson, Bill Upton, James Houser, Gene Gehring, Dale Amstutz, Jerry Pulley, and Jim Redicker is greatly appreciated. These trials were supported by funds from the International Society of Aboriculture - Texas.

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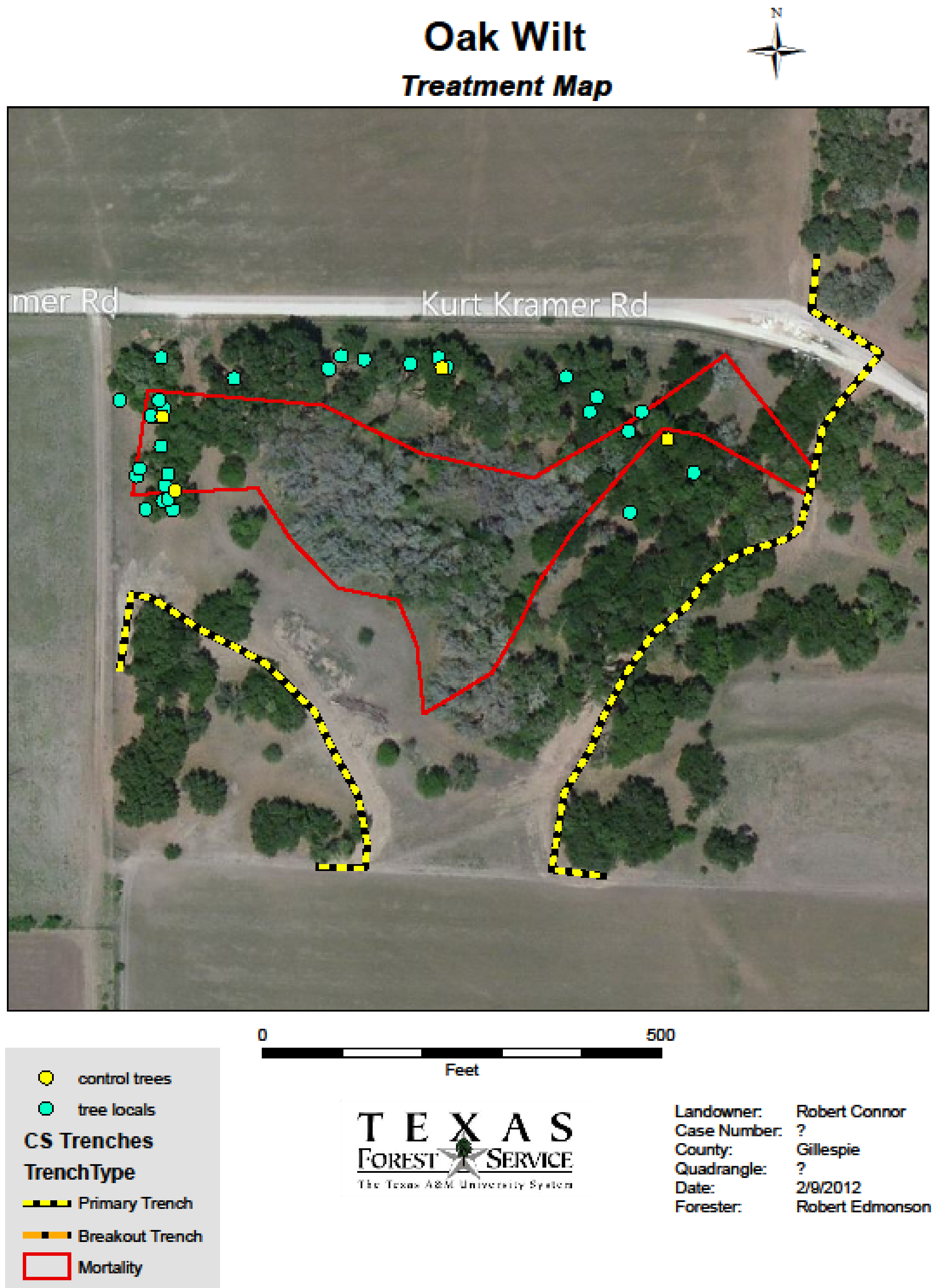


Figure 29: Map of micro and macro-injection study trees at Conner oak wilt center, near Fredericksburg, TX. Red boundary shows extent of oak wilt infection as of February 9, 2012.

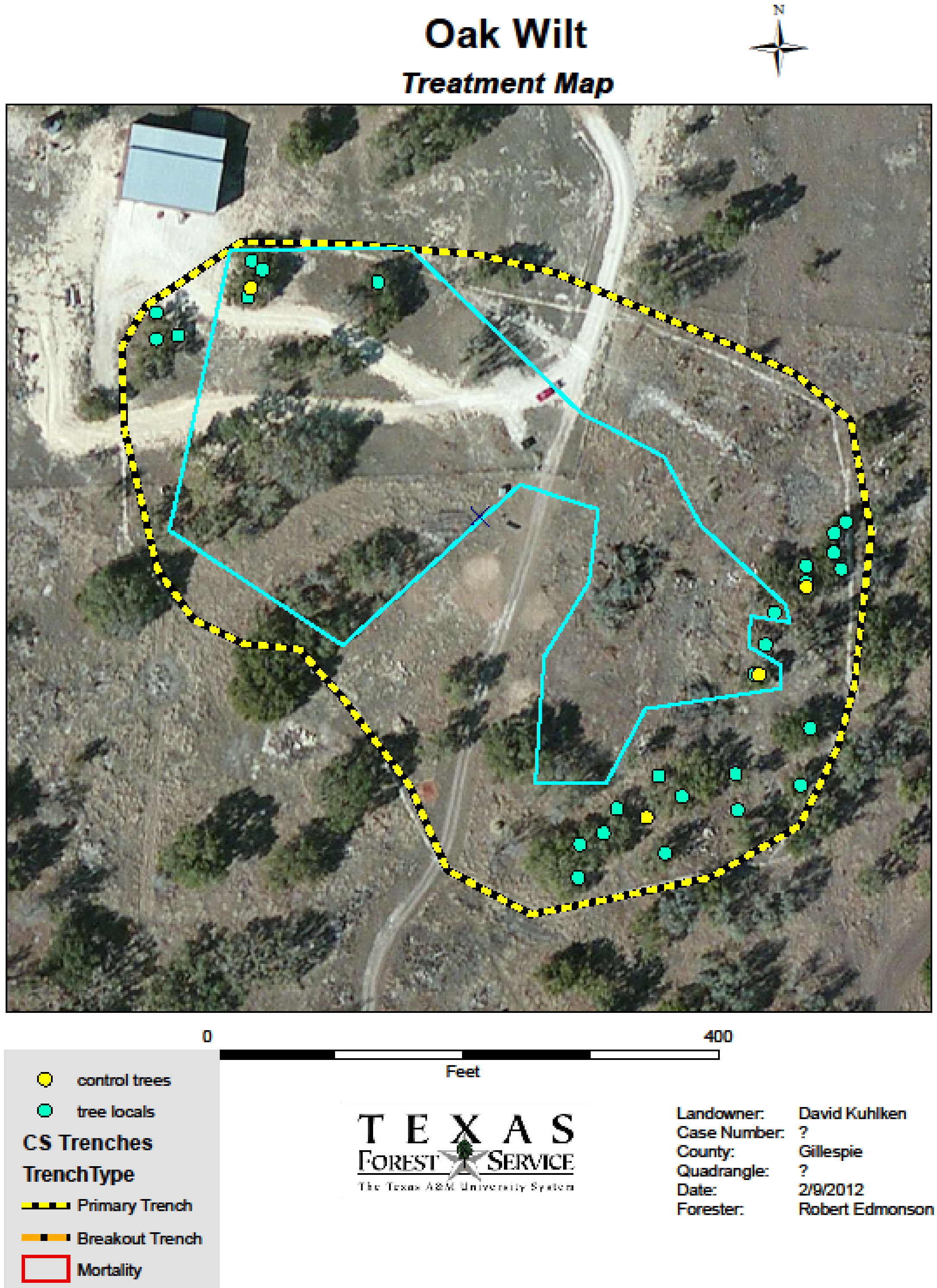


Figure 30: Map of micro and macro-injection study trees at Kuhlken oak wilt center, near Stonewall, TX. Blue boundary shows extent of oak wilt infection as of February 9, 2012.

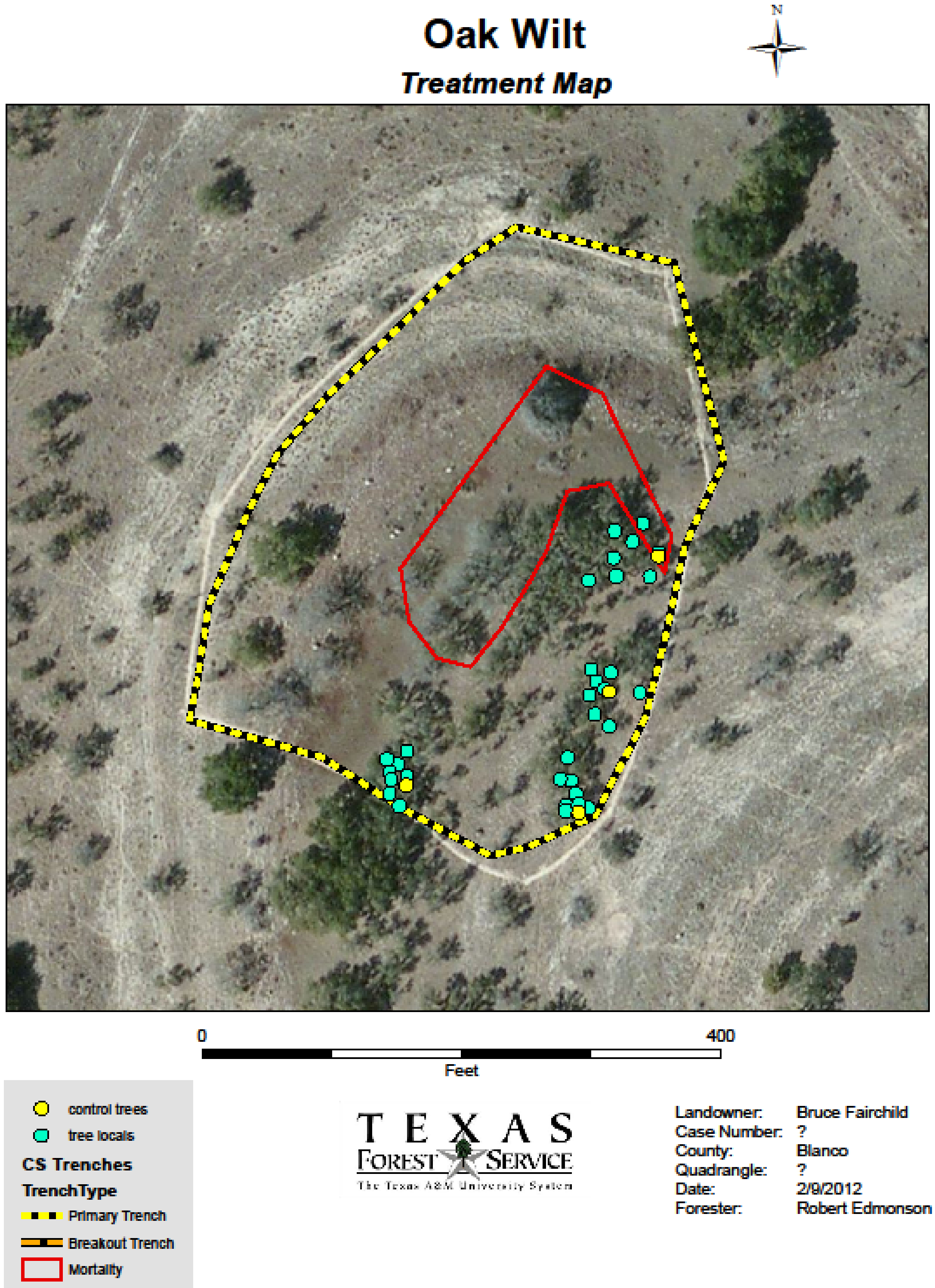


Figure 31: Map of micro and macro-injection study trees at Fairchild oak wilt center, near Johnson City, TX. Red boundary shows extent of oak wilt infection as of February 9, 2012.

Table 32: Comparison of six injection system characteristics during operational use in May 2011.

System Evaluated:	Mauget Capsules	Pine Infuser	Tree IV	Chemjet	Portle	Macro-infusion
No. Trees Injected	12	12	12	12	12	12
Mean DBH	12.8	11.9	12.4	12.8	11.7	12.8
Mean Volume Injected (mls)	128.2	237.0	496.7	127.6	117.3	12,625
No. Units used at a time:	12.9	7.9	2	12.6	1	1.4
Time (min) needed to fill system unit with chemical product:	0.0	4.0	3.2	2.6	0.0	3.3
Number of injection points required:	12.9	7.9	6.3	4	23.5	31.4
Time (min) needed to install system on tree:	6.4	7.0	6.1	6.2	11.6	27.8
Time (min) required to inject/infuse X-amount of product:	594.8	80.1	52.7	287.8	17.0	135.4
Cumulative time at tree (min):	6.4	4.3	6.4	6.5	28.6	29.8
Time (min) needed to clean system units	0	4.6	5.9	2.6	3.8	2.5

Table 33: Comparison of characteristics of several injection systems that were evaluated for application of propiconazole (Alamo®) in live oak in central Texas, 2011.

Characteristics (Potential Points)	System: Tree IV		Chemjet		Capsules		Pine Infuser		Portle		Macro-infusion	
Manufacturer	Arborjet		Chemjet Trading		Mauget		Rainbow TreeCare		ArborSystems		Rainbow TreeCare	
Retail Cost to treat 12 study trees = 150" (5)	Equipment ($900) + Plugs ($38) + Chemical ($168) = **$1106**	1	Equipment ($270) + Chemical ($168) = **$438**	5	$3.85 / unit = **$578**	4	Equipment ($656) + Chemical ($168) = **$824**	3	Equipment ($775) + Chemical ($168) = **$943**	2	Equipment ($652) + Chemical ($168) = **$820**	3
Can System be Left Alone on Tree? (2)	Yes	2	Yes	2	Yes	2	Yes	2	No	1	Yes	2
Chemical Prepackaged, Undilute, or Mixed (2)	mixed w/ water	1	mixed w/ water	1	prepackaged	2	mixed w/ water	1	prepackaged	2	mixed w/ high volume water	0
Weather restriction(s) (2)	cold and dry, but less so because of higher pressure	2	cold and dry	1	cold and dry	1	cold and dry	1	cold and dry, but less so because of higher pressure	2	cold and dry	1
Ease / time to fill system with chemical product (5)	3.2 min - need to fill system for each tree	2	2.6 min. - each unit filled separately prior to installation on each tree	3	prepackaged	5	4 min. - each unit needs to be filled separately as it is installed on tree	1	if prepackaged	5	2.7 min. - each unit filled separately prior to installation on each tree	3
No. of injection points required per tree (5)	5.7 points	5	12.6 points	4	12.9 points	4	7.9 points	5	23.5 points	2	31.4 points	1
Ease / time of system installation on tree (10)	install plugs at few pts, but more steps - 6.1 min / tree	7	generally easy, few steps - 6.2 min / tree	10	generally easy, few steps - 6.4 min / tree	10	generally easy, but several steps involved - 7.0 min / tree	6	generally easy, but several injection pts - 11.6 min / tree	6	labor intensive to expose roots and many injection points - 27.8 min / tree	1
Ease and time to inject X amount of product (20)	effectively applied to all trees - 53 min / tree	17	effectively applied <u>almost</u> always - 210 min / tree	8	effectively applied <u>almost</u> always - 255 min / tree	7	effectively applied to all trees - 42 min / tree, but have to monitor pressure	13	application time short (17.4 min / tree), but not easy to get all chemical into tree	10	effectively applied to all trees - 134 min / tree	11
Cumulative time spent at each tree (10)	present at tree only to install and remove - 9 min / tree	10	present at tree only to install and remove - 10 min / tree	10	present at tree only to install and remove - 9.5 min / tree	10	present at tree only to install and remove - 10 min / tree	10	moderate time and must remain at tree - 29 min / tree	1	considerable time for install and removal - 30 min / tree	1
System disposable or ease / time to clean system (4)	need to clean several units at end of day - 5.8 min	3	need to clean several units after each tree - 3 min / tree	2	disposable	4	need to clean several units after each tree - 3.8 min / tree	2	should be easy flush, but chemical was also on outer surface of injector and needles - 11 min	1	need to clean several units, tees and lines at end of day - 10 min	1
Potential for chemical exposure (5)	very little exposure potential	3	little potential for exposure	3	very little exposure potential	5	little potential for exposure	3	frequent leaks from and around needles	1	some potential exposure	2
Effectiveness of treatment as of Dec 21, 2011 (6 month after injection) (30)	excellent	30	excellent	28	good	20	fair	15	fair	15	good	25
Total Score (out of 100 possible points)	**83**		**77**		**74**		**62**		**48**		**51**	

Excellent | Good | Fair | Poor | Bad

Scored 80% or higher

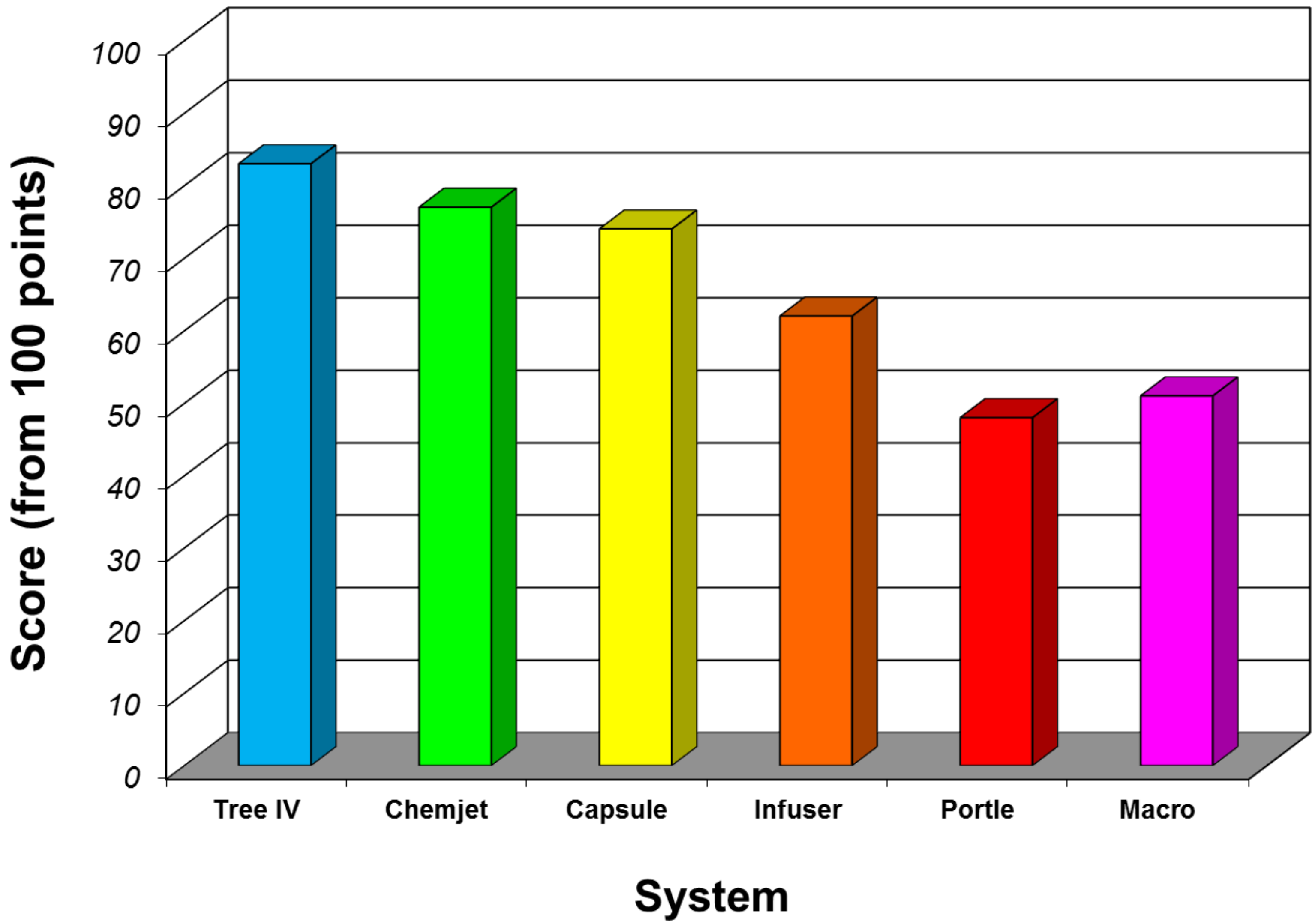


Figure 32. Total score (of 100 points) received by different injection systems when injecting propiconazole into live oaks.

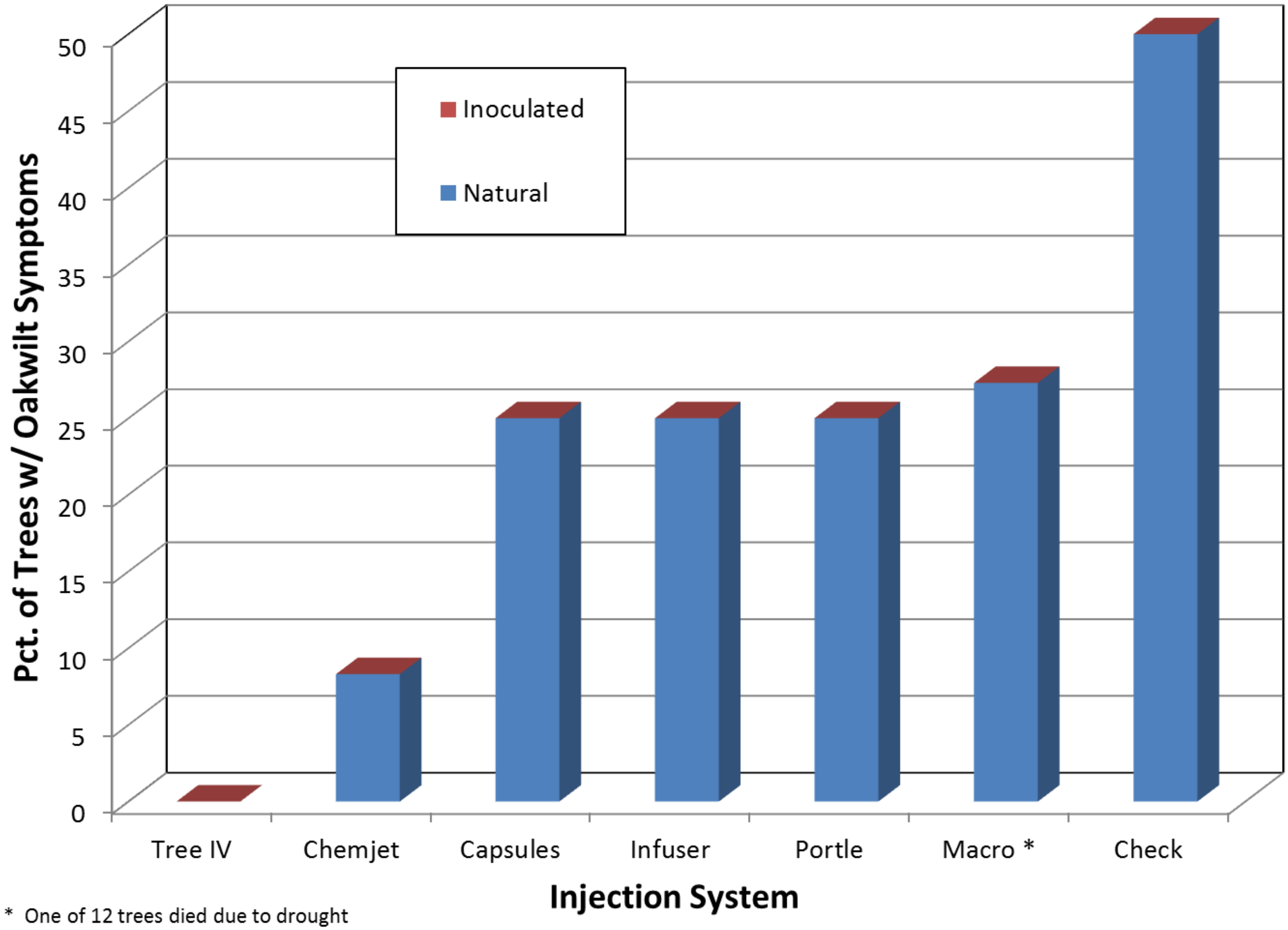


Figure 33. Effect of propiconazole treatments using different injection systems on the occurrence of oak wilt symptoms (veinal necrosis) on live oak in central Texas as of February 9, 2012.

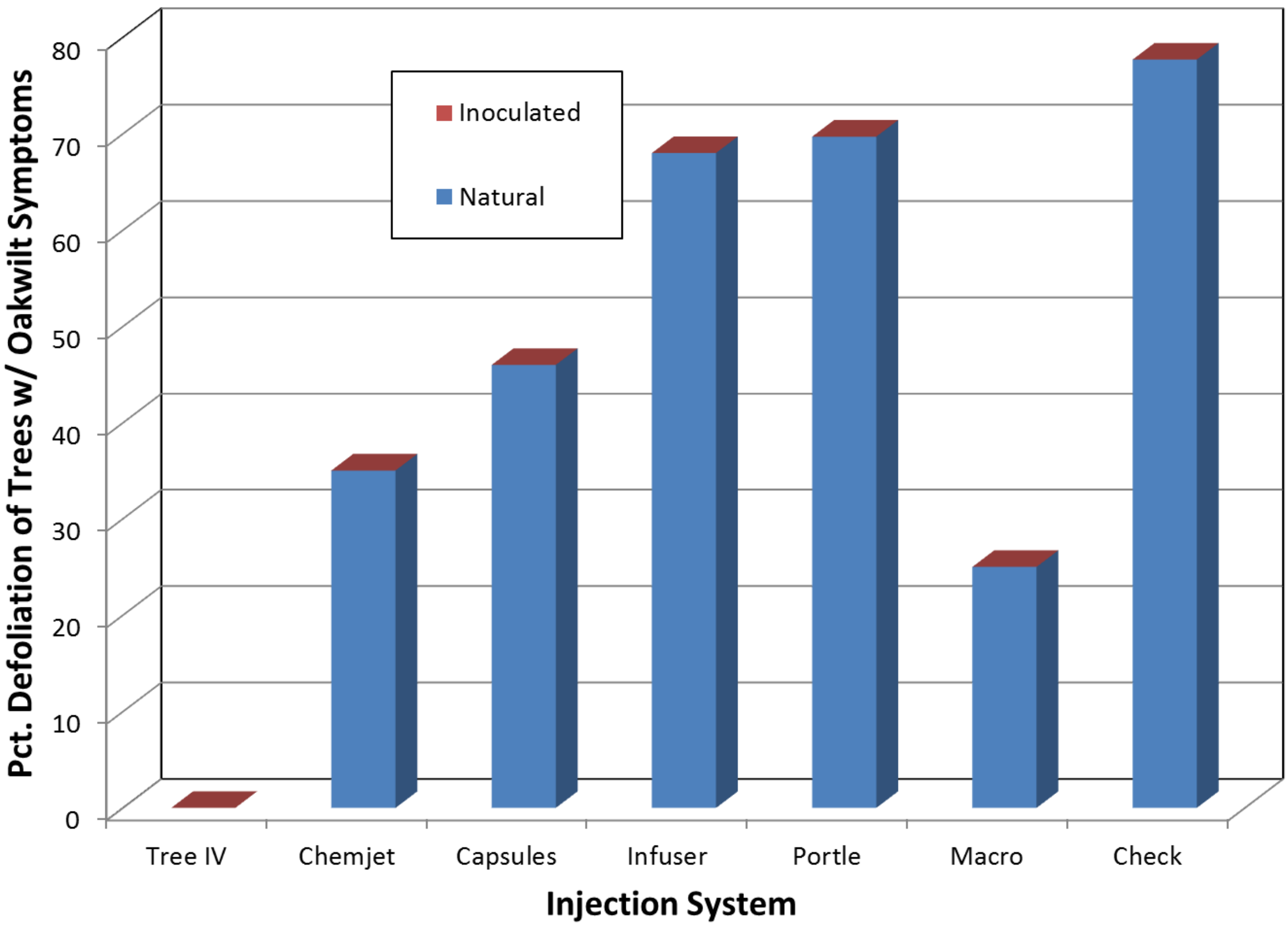


Figure 34. Effect of propiconazole treatments using different injection systems on the amount of defoliation caused by oak wilt on live oak in central Texas as of February 9, 2012.

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, single applications of 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, attempts have been 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 - 2011, 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 of oak; and 5) efficacy against three 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 December 2010, EPA approved the extension of the TREE-äge® label to include use of EB for "control of mature and immature arthropod pests of deciduous, coniferous and palm trees, including, but not limited to, those growing in residential and commercial landscapes, parks, plantations, seed orchards, and forested sites (in private, municipal, state, tribal and national areas)." Approval of the final label is required at the state level as well. As of March 2012, all of the lower 48 states have approved the full label. Registration in Alaska and Hawaii is pending.

TREE-äge® is available in 1-liter containers from several distributors including Arborjet Inc., Rainbow Treecare, and John Deer Landscapes (more to come). Arborjet has quoted a price of $525 per liter (discounts are available when purchasing a case of 8 liters or more). Thus, the cost to treat a 10 inch DBH tree at a medium rate (0.2 g AI per inch DBH) would be about $28 while a treatment of a large (25 inch DBH) tree would be about $68 (labor excluded). **NOTE: TREE-äge® insecticide is a Restricted Use Pesticide and must only be sold to and used by a state certified pesticide applicator or by persons under their direct supervision.** It is important that all users read the label and follow all precautions and guidelines.

Imidacloprid – Imidacloprid is another neonictinoid chemical tested by the FPMC in 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 problematic. 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™ significantly reduced seed bug damage but had no effect against coneworm and efficacy was not enhanced by EB. The effects declined markedly in the 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 reduced seed bug damage but had little effect against coneworms. New trials initiated in 2010 again indicate dinotefuran alone has good activity against seed bugs but little or no activity against coneworns. The combined dinotefuran +EB treatment was effective against coneworm, but no more effective than EB alone.

Dinotefuran (Sufari) bole spray was tested for protection of logs against *Ips* engraver beetles in 2011 based on claims on the supplementary label for mountain pine beetle. However, this treatment was completely ineffective in reducing adult beetle attack success.

Abamectin – Abamectin (Syngenta) is an avermectin derivative 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 for three growing seasons. A follow up trial established in 2009 indicated this chemical is effective against mountain pine beetle attacking lodgepole pine in Utah. Seed orchard trials were established in 2008 at the Yulee, FL and in 2010 at Woodville, TX. The Florida results indicate no initial activity against coneworms and/or seed bugs, whereas a single injection of abamectin was very effective against coneworm at Woodville for two season. The *Ips* trial and TX seed orchard trial will be extended through 2012 to further evaluate efficacy duration. It is likely that Mauget will submit a request to EPA to add certain bark beetles and coneworms to their Abacide 2 label.

Chlorantraniliprole (Acelepyrn, DuPont) - Chlorantraniliprole is an anthranilic diamide insecticide with reported activity against moths, beetles, caterpillars, etc. The seed orchard trial established in 2010 at Woodville, TX indicated that this chemical is active against coneworms, but not seed bugs.

<u>Fungicides</u>

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 to protect oaks against oak wilt disease. Propiconazole is considered to be fungistatic or growth inhibiting rather than fungicidal or lethal to target fungi.

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 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.

A trial was initiated in 2009 in Utah to determine if EB combined with propiconazole only would improve survival of baited lodgepole pine after MPB attack. So far, the results again indicate that the addition of propiconazole does not improve survival of pine.

Tebuconazole – Tebuconazole is another triazole fungicide used in agriculture to treat a wide range of plant pathogenic fungi. In the same Utah trial (mentioned above), abamectin was combined with tebuconazole. So far, the results indicate that the addition of tebuconazole does not improve survival of pine.

PINE TIP MOTH TRIALS

Impact Study – Western Gulf Region

Highlights:

● Trevor Walker, graduate student at Stephen F. Austin State University (SFASU), analyzed the impact of tip moth on the growth of young loblolly pine based on data collected from 2001 to 2009 on 105 Western Gulf sites.

● The impact of pine tip moth on tree height and diameter was greatest around age 5, after which the growth parameters of treated and check trees began to converge.

● The response of the trees to the tip moth protection treatment was most certain for sites where check trees had greater than 40% of their terminals infested.

Objectives: 1) Evaluate the impact of 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.

Study Sites: The FPMC has established several impact study sites in east Texas each year from 2009 – 2011. In most plantation sites, one to two areas were selected.

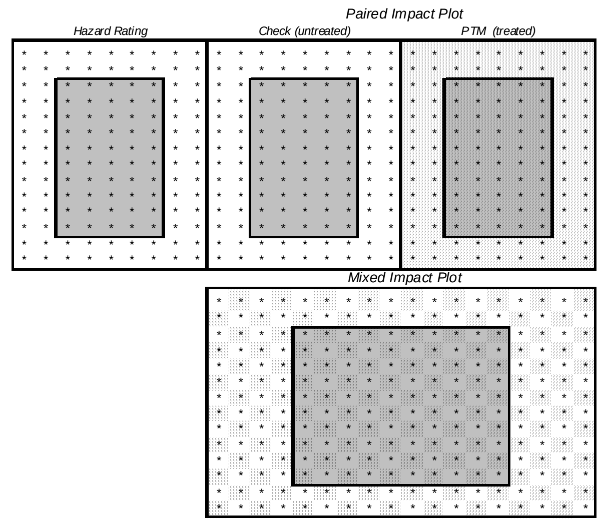
Insecticide:
PTM™ Insecticide (fipronil) – used since 2009.

Design: 76 sites X 1-2 plots X 2 treatments X 50 trees = 10,100 monitored trees.

Treatments:
1) PTM™ dilution applied just after planting (5.6 ml PTM™ in 54 ml water per seedling) on first–year sites.
2) Check

Application Methods: A mixed plot design was used whereby only one block (plot) is established at each site and every other tree within that plot is treated. Mixed plots contain 252 trees (9 rows X 28 columns with spacing at the discretion of the cooperator; see below).

Insecticide PTM® is applied immediately after seedlings are planted. It is to be applied at the rate of 5.6 ml/PTM + 54.4 ml/H2O per seedling using a PTM Spot Gun or comparable soil injection equipment. The product is applied evenly at four points around the seedling at alternating depths of four inches and eight inches.



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. Data on tree height, diameter at breast height (DBH) and form 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 provided the following outline for data analysis:

A) Evaluate the efficacy of the tip moth protection treatment.
B) Identify an infestation threshold where a response to protection is shown
C) Incorporate tip moth protection into a local growth and yield system using a dominant height modifier equation
D) Use the modified growth and yield system to estimate the economic impact of tip moth. The willingness to pay (Asaro 2006) for tip moth

protection was calculated under various site indices and alternative rates of return using a fixed price for stumpage ($7.76 per ton for pulpwood and $26.97 per ton for sawtimber).

Results: More than a quarter of the sites (Figure 35) had 100% insecticide efficacy (full protection), and another quarter of the sites had 66 to 99% control. No particular generation appeared to be resistant to control, but the efficacy of protection was strongest and most consistent during later annual generations (third, fourth, and fifth). Only a handful of sites (8 out of the 104 considered) did not have consistently lower infestation levels on their protected trees. Neither site productivity nor soil texture appeared to influence the efficacy of the insecticide treatment.

The graph of tree response against infestation level shows that most sites with 40% or more of the terminal tips infested on their check trees showed a height and diameter response to tip moth protection (Figures 36 and 37, respectively, for height and diameter). During the first three growing seasons there were many sites with lower infestation levels that showed a response to protection, but their gains began to dwindle. By age 10, only sites with more than 40% terminal infestation had protected trees with larger average height and diameter.

The sites that showed a strong response to the tip moth protection treatment shared a general pattern: the gain in height and diameter from protection increased until around age 5 and began to diminish as the stand aged. By age 10 the response from protection became negligible for most sites. This sort of response pattern is known as a Type C silvicultural response. To incorporate the pattern of response from tip moth protection into a local growth and yield system, a modifier equation for the dominant height was built using the sites that showed a strong response to treatment. The modified growth and yield system indicated that the maximum gain in yield from tip moth protection ranged from 0.5 to 2.5 tons per acre around age 10, with larger gains experienced on more productive sites (Figure 38). By age 30, the gains from tip moth protection had diminished to less than 0.5 tons.

The maximum willingness to pay for tip moth protection occurred around age 10. For high productivity sites, this value was as high as $17.21 per acre using a low alternative rate of return (3%) and around $11.00 per acre using a high alternative rate of return (11%). For average site productivity (site index 70), the willingness to pay ranged from around $5.00 per acre to $8.00 per acre, depending on the alternative rate of return.

Conclusions: The impact of pine tip moth on tree height and diameter was greatest around age 5, after which the growth parameters for treated and check trees began to converge. Merrifield et al. (1967), Stephen and Wallis (1980), Thomas and Oprean (1984), and Cade and Hedden (1987) observed similar response patterns in their studies with tip moth.

The response to the tip moth protection treatment was most certain for sites with greater than 40% of their terminals infested, which roughly coincides with an average whole-tree infestation rate of 30% that was suggested by Asaro et al. (2006).

The predicted gains in yield from pine tip moth protection were similar in magnitude with those predicted by Stephen and Wallis (1980), while those estimated by Williston and Barras (1977) were much greater than what was predicted in this study. The estimated value of protection was much lower than the values that Asaro et al. (2006) estimated. However, the economic simulations done in this study and Asaro et al. (2006) did not consider the impact of tip moth attack on tree form. In addition, neither study included an inflation rate. Both of these factors would tend to increase the estimated value of control.

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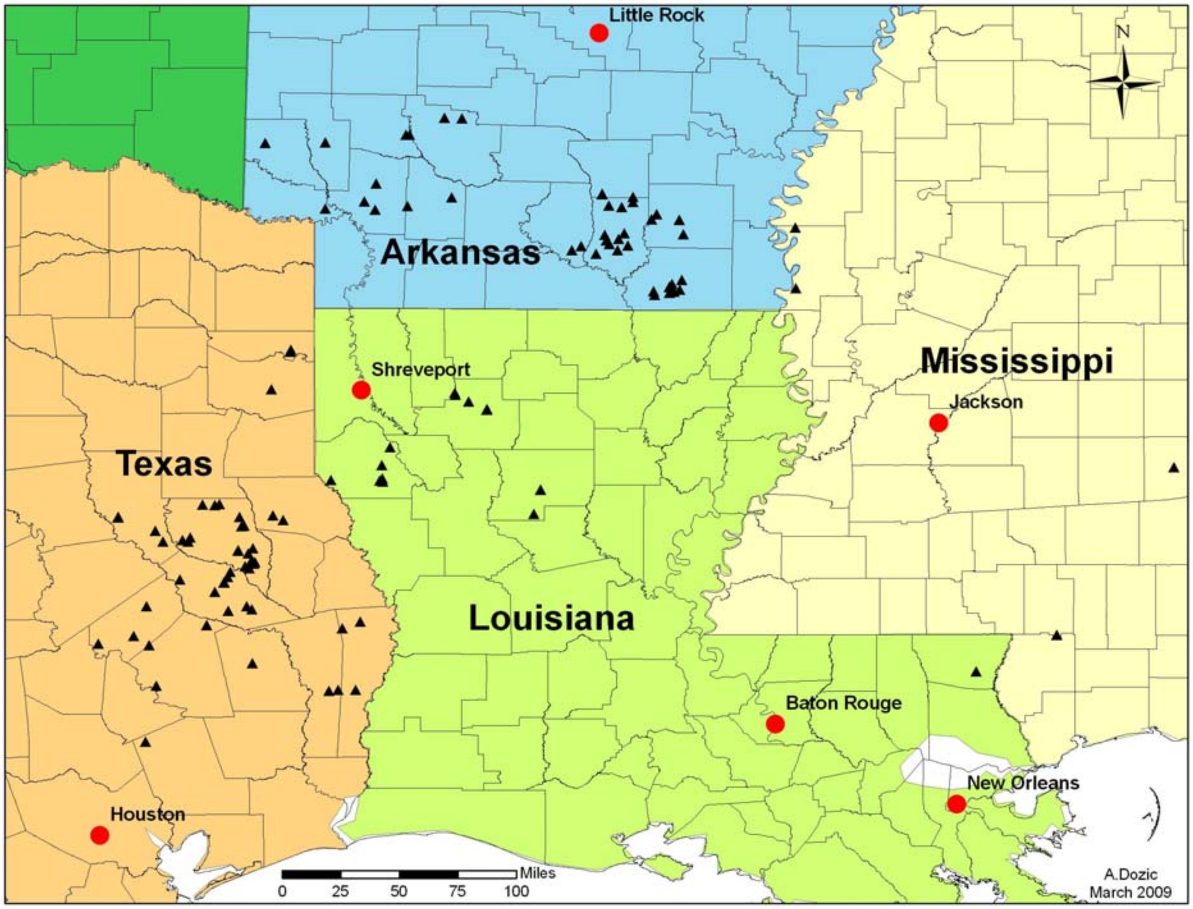


Figure 35. Distribution of 110 one- to five-year old impact sites (▲) for pine tip moth from 2001 – 2010 in the Western Gulf Region.

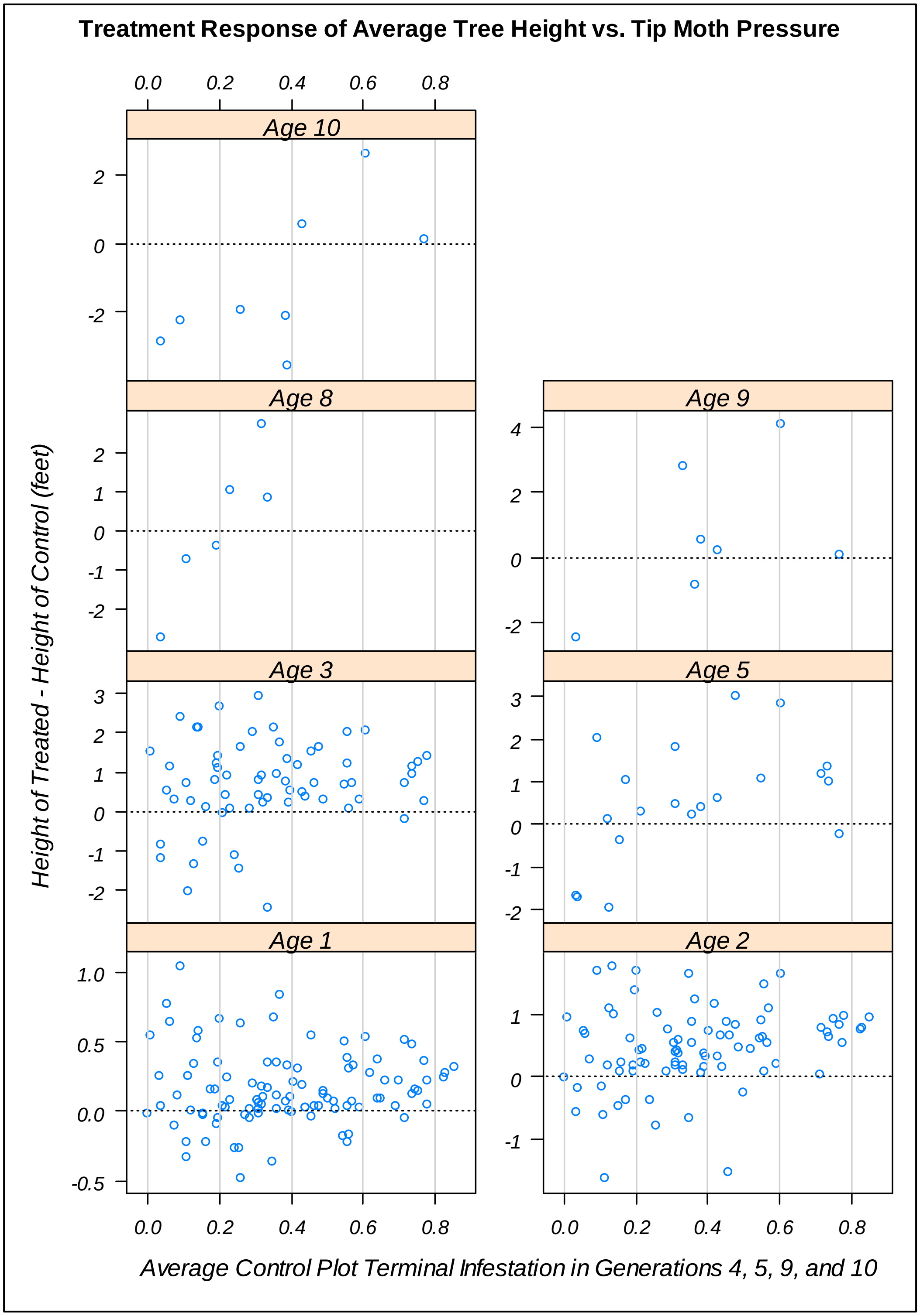


Figure 36. Difference in average height between the insecticide-treated and control plots for each study site plotted against average terminal infestation during the last two annual generations on the control plot.

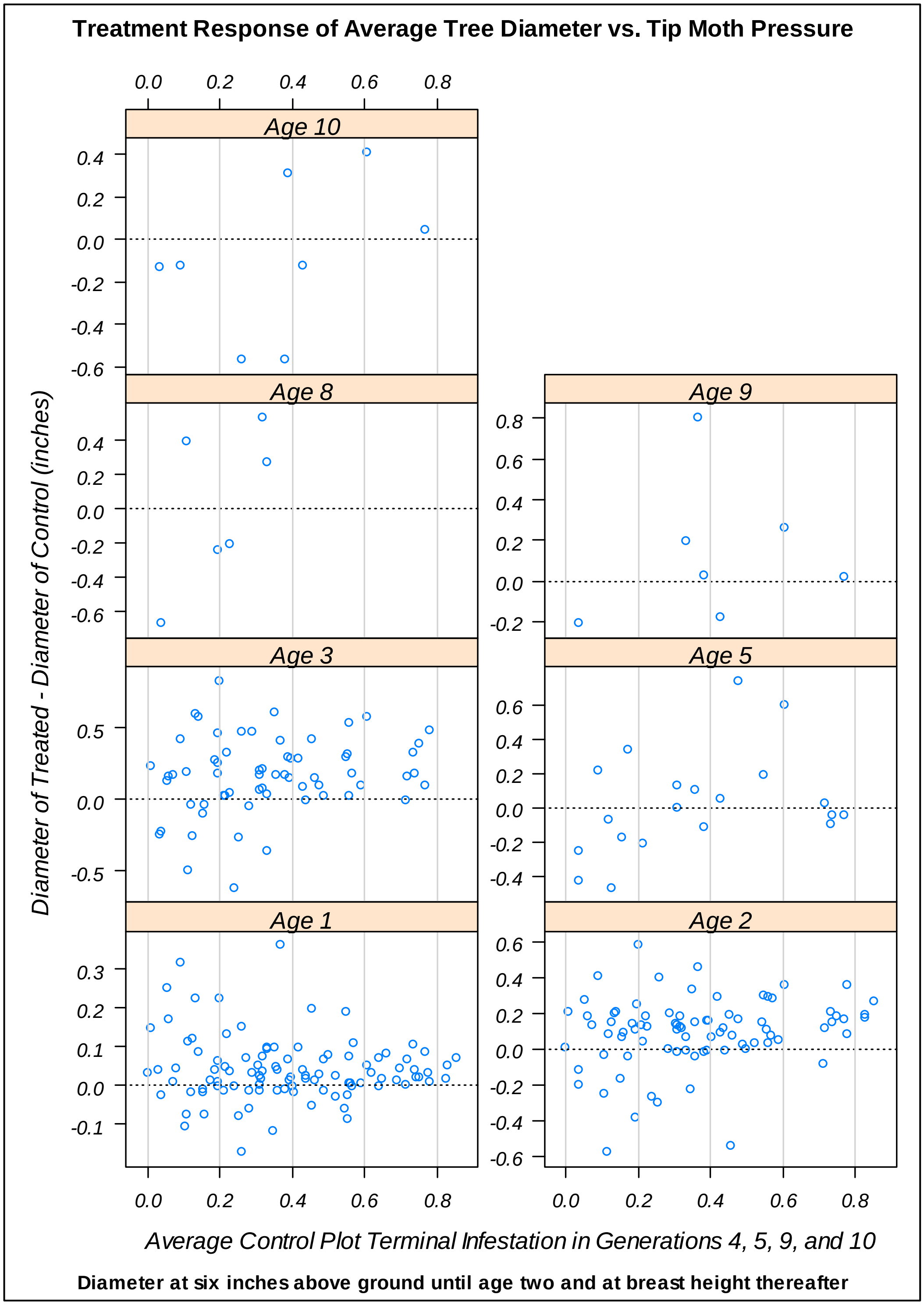


Figure 37. Difference in average diameter between insecticide-treated and control plots against average terminal infestation during the last two annual generations on the control plot.

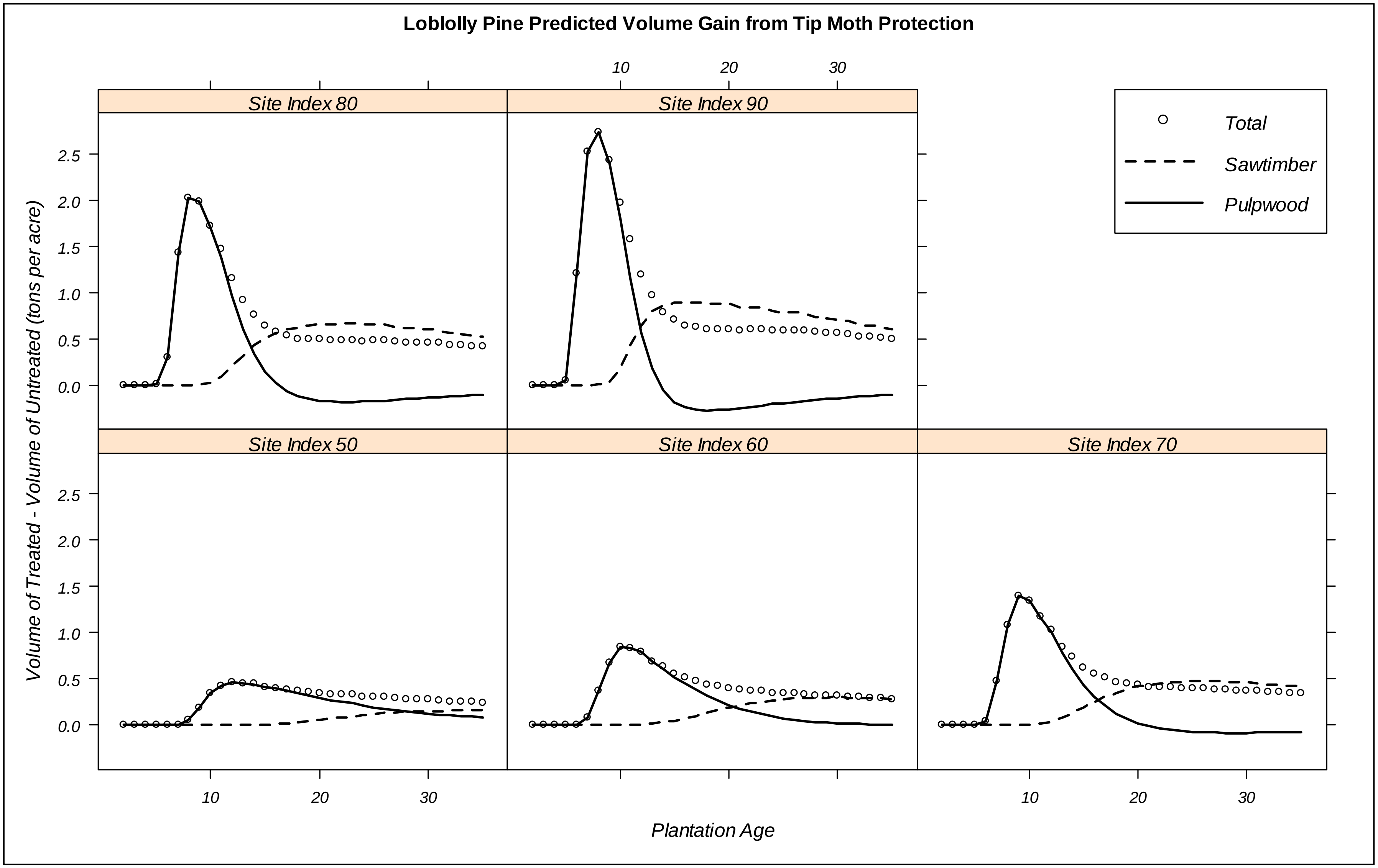


Figure 38. Predicted increase in yield from pine tip moth protection for loblolly pine pulpwood and sawtimber.

PINE TIP MOTH TRIALS

Hazard Rating Study – Western Gulf Region

Highlights:

- Data on site characteristics were collected from 142 hazard-rating plots from 2001 to 2009.
- Trevor Walker, graduate student at SFASU, attempted to develop a pine tip moth hazard-rating model as part of his Master's Thesis. Due to considerable variability among sites within the region and baseline infestation rates from year to year, an effective hazard rating model could not be developed.

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

Study Sites: FPMC members selected from one to five new first-year plantations from 2001 to 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 135 Western Gulf plots from 2001 to 2010 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 – 1st, 2nd, 3rd, 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.

Data Analysis: Trevor Walker, SFASU graduate student, has completed his attempt to develop the tip moth hazard rating model. The following is an outline provided by Mr. Walker for model development:

A) Investigate the relationship between tip moth infestations measures and identify which measure best characterizes the impact of tip moth for a site.

B) Identify stand and site factors that influence tip moth infestation to develop a hazard rating model.

Results: Figure 39 shows the distribution of all 142 hazard-rating sites established in the Western Gulf Region from 2001 to 2010.

A strong correlation was found between the two tip moth measures used, top-whorl infestation rate and terminal infestation rate. The terminal infestation rate for any particular site was usually higher than the top-whorl infestation rate, which was attributed to a tendency for the moth to attack the highest part of the tree. The terminal infestation rate requires less time to measure, and due to the correlation observed, it was concluded that this measure could be used to successfully classify a site's tip moth infestation level. Equations were developed to convert between the two measures depending on generation (Figure 40).

The study protocol required measurement during each tip moth generation during the first two growing seasons, where there are four to five generations per growing season and thus eight to ten measurements per site. A general trend was observed in the development of infestation rates from generation to generation:

infestation levels tend to start low during the beginning of the growing season (when seedling growth flushes are most vigorous) and become higher as the season progresses. Also, infestation rates were usually higher in the second growing season, potentially due to an establishment period for the population. Sites with high relative infestation in the early generations tended to have high relative infestation in the later generations, but the relationship was not consistently strong. For this reason, it was concluded that measuring tip moth infestation rates during later generations would produce a more consistent classification of tip moth hazard. This relationship is demonstrated in Figure 41, where the relationship between infestation rate during a particular generation and the average over all generations is stronger for the later generations in the growing season (generations 4, 5, 9, and 10).

When investigating the relationships between site and stand factors and tip moth infestation rate, it became apparent that two major sources of variability were preventing the identification of trends. First, regional differences between study sites in different states were confounding the effect of site and stand properties. For example, comparing infestation rates on high productivity sites to low productivity sites must be done separately for east Texas and southern Arkansas sites, because the factors that contribute to site productivity are different between the two regions (e.g. slope, aspect, soil texture). Secondly, differences between baseline infestation rates from year to year prevented comparing the effects of site and stand properties during different years. For example, comparing the infestation rates of a high productivity site to those of a low productivity site cannot be done if the two were measured during different years, presumably due to weather differences. For these two reasons, investigating the relationship between site and stand factors and infestation rates had to be done for sites having the same state and establishment year. This course of action effectively reduced the sample size to prevent identification of stand and site factors that influence tip moth infestation. Thus, an effective hazard rating model could not be developed.

Conclusions: The descriptive analysis of the hazard-rating data indicated that terminal infestation rate was as good an indicator of infestation level as the top-whorl infestation rate. Also, it was concluded that only later generations in the growing season need to be measured to classify a site's infestation level. Both of these results can be used to reduce the time in the field required to measure a site's tip moth infestation level.

The development of a hazard rating model was prevented due to differences in regional site characteristics and differences in baseline population levels from year to year. However, these discoveries were used to develop a stronger protocol for an enhanced hazard rating study. Data collection efforts were focused to one region (within 60 miles of Lufkin) and during the second year after planting (2011). Also, sites were selected based on their site characteristics so that factors that were suspected to influence infestation could be isolated for comparison.

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 Trevor Walker, SFA Graduate, for his time and efforts on the tip moth impact analysis, hazard-rating model development, and input in the writing of these summaries and Dr. Dean Coble, Stephen F. Austin State University, Nacogdoches, TX, for his comments, ideas and support.

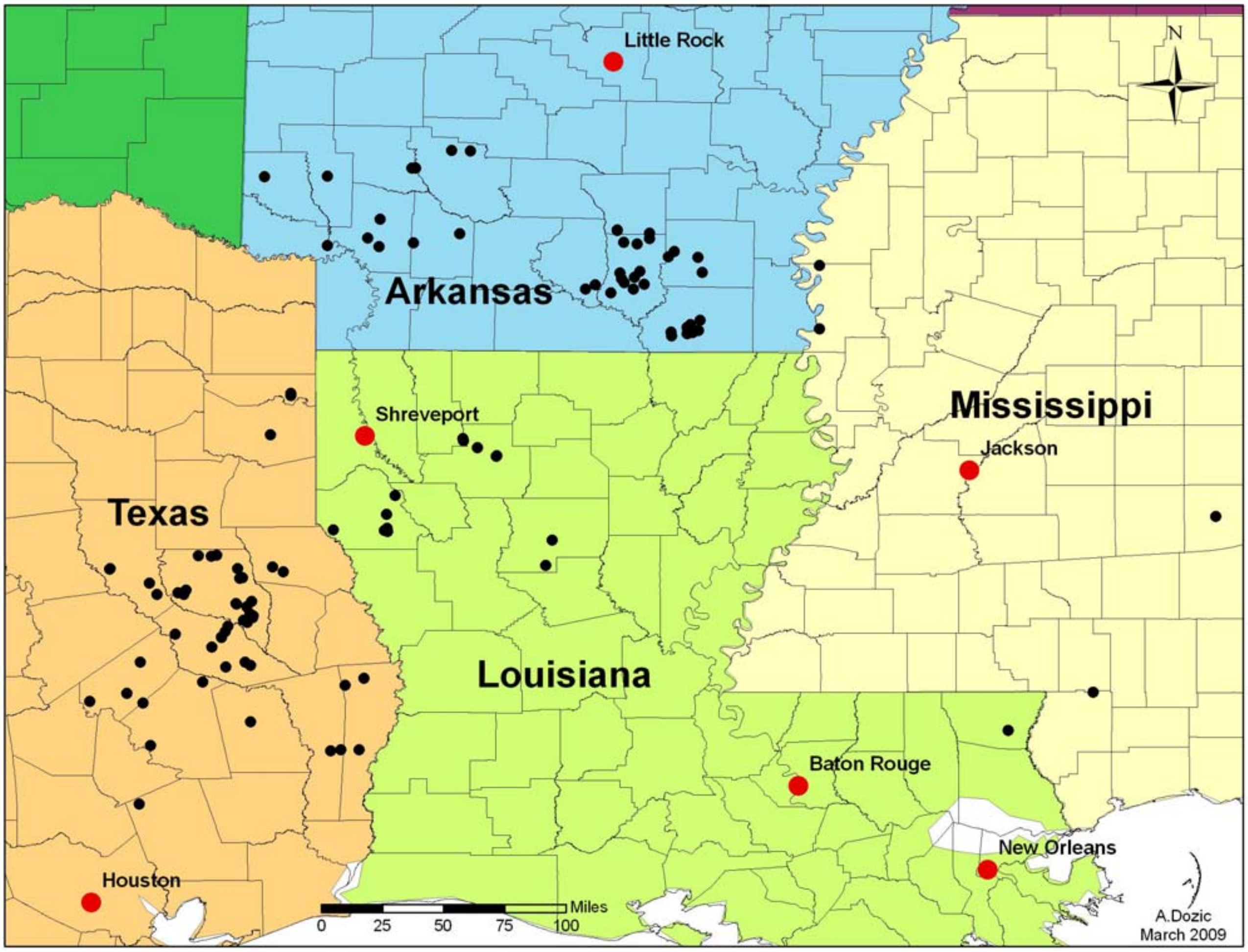


Figure 39. Distribution of 142 hazard-rating plots (●) established from 2001 - 2010 in the Western Gulf Region.

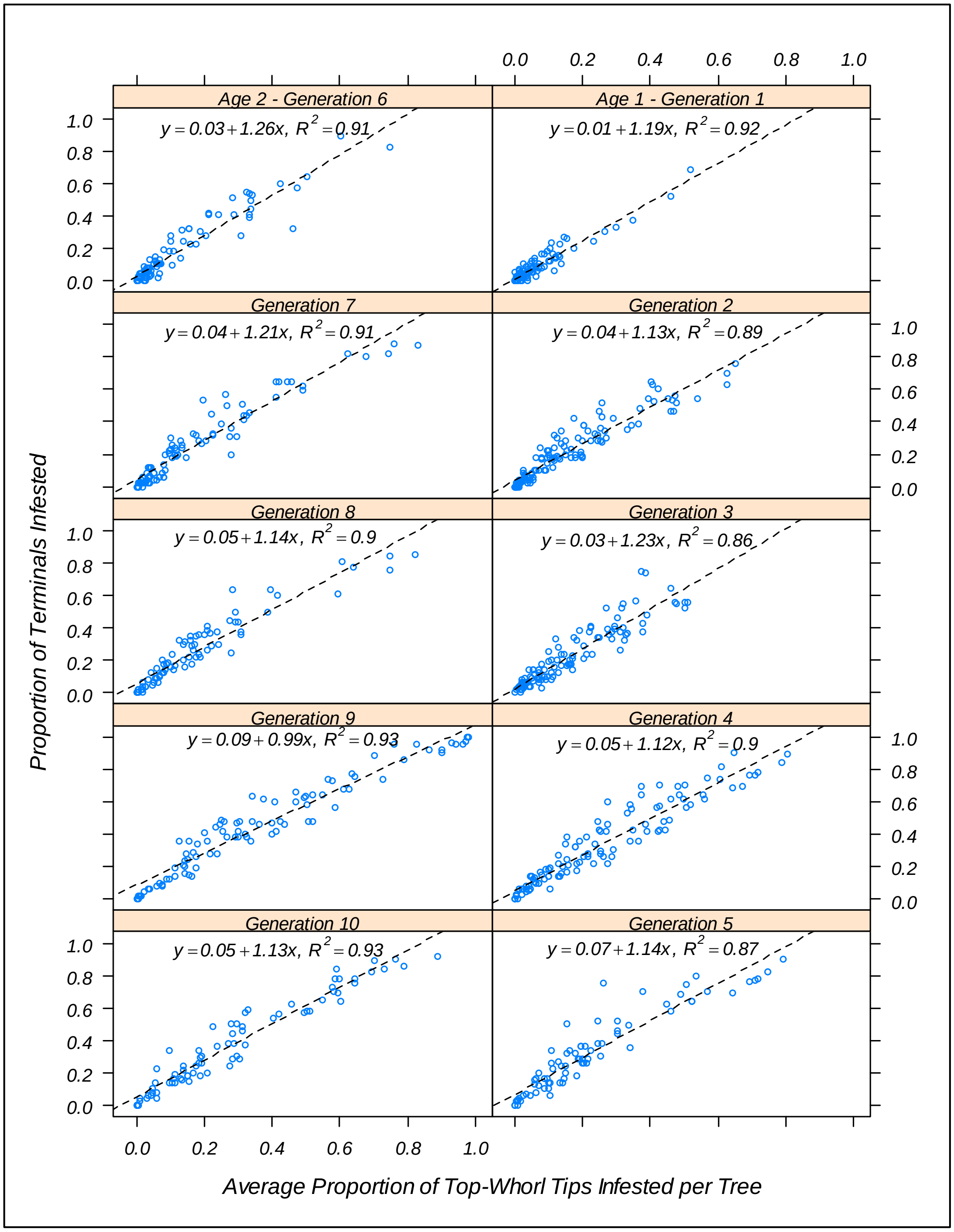


Figure 10. Proportion of infested terminal per plot against the average proportion of top-whorl tips per tree by generation including simple linear regression fits for hazard-rating (control) plots.

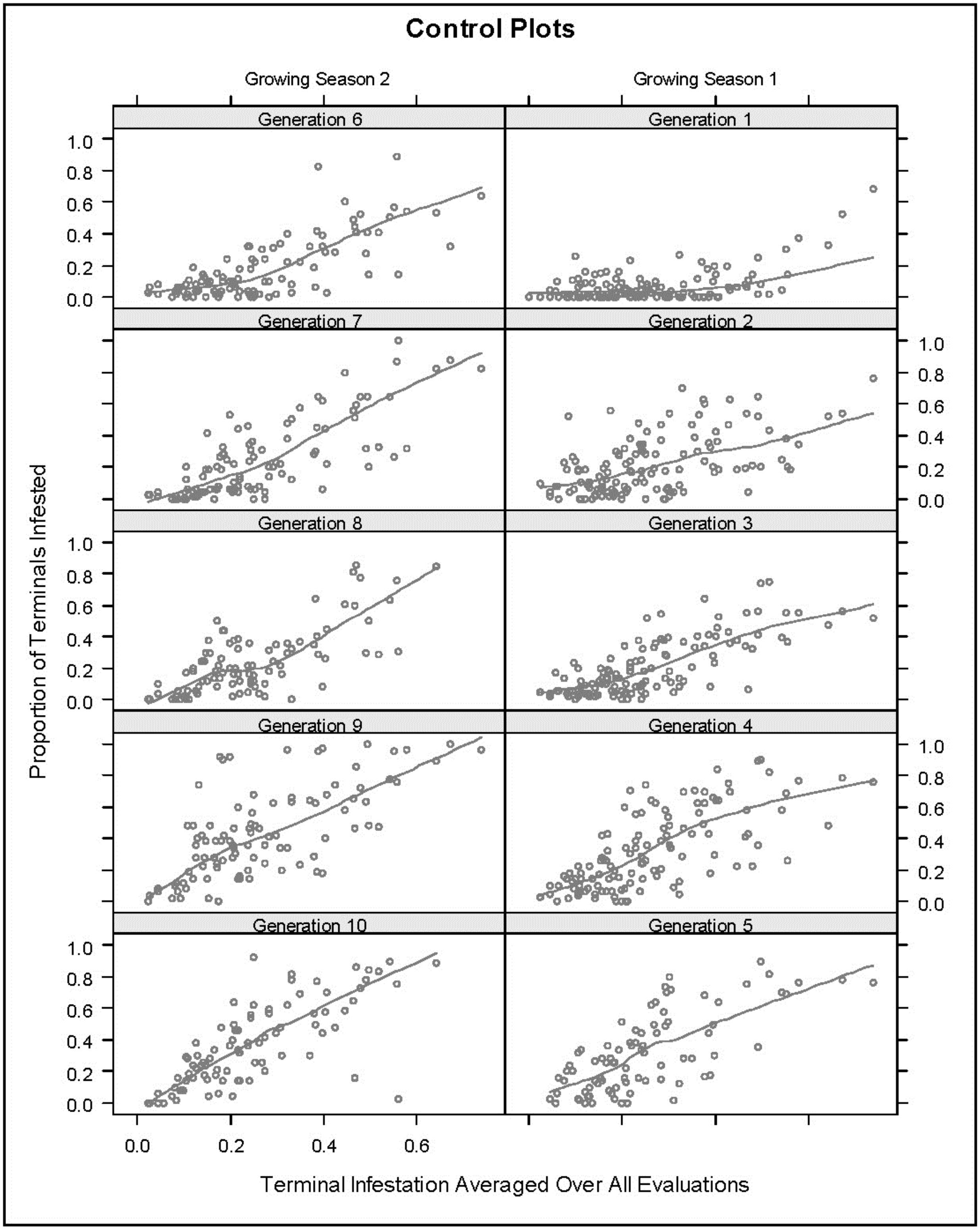


Figure 41. The proportion of infested terminals on a plot by generation against the average over all generations including Lowess line.

PINE TIP MOTH TRIALS

Evaluation of Fipronil Treatments for Containerized Pine Seedlings

Highlights:

- Fipronil treatments (1X and 5X) applied to containerized pine seedlings provided good protection against tip moth through three full growing seasons: 57% and 72% reduction in damage compared to check. Fipronil soil injection to bare-root seedlings was less effective, but still significantly reduced damage for 3 years by 39%. All fipronil treatments significantly improved tree height, diameter and volume growth
- In 2011, volume growth improvements due to fipronil treatments ranged from 14 – 63%.

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.

Study Sites: Two first-year pine plantations owned byCampbell Group (formerly Temple Inland) 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)
2) Containerized Fipronil (5X - 15 ml/seedling)
3) Containerized Check (untreated)
4) Bare-root Fipronil (12 ml/seedling)
5) 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 of each year 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 (Table 34). 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 35).

In 2008, tip moth population pressure was much greater than in 2007, wth 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 34). 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 (Table 35). Volume growth improvements attributed to fipronil treatments ranged from 64 – 94% (Figure 42).

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 34). Efficacies of the two fipronil treatments on containerized trees continued to decline through the third 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 (Table 35). Volume growth improvements attributed to fipronil treatments ranged from 22 – 70% (Figure 42).

In 2010, tip moth population pressure was extremely high, with an average of 100% of the top-whorl shoots infested on check trees during the 5th generation and a mean of 71% shoots infested over the entire growing season (5 tip moth generations) (Table 34). Efficacies of the two fipronil treatments on containerized trees continued to decline and faded by the end of the third generation. Overall, treatments still reduced overall damage by 5 - 7%. The soil injection treatment reduced tip moth damage by 10%. All treatments significantly improved height, diameter and volume index compared to check trees (Table 35). Volume growth improvements attributed to fipronil treatments ranged from 36 – 69% (Figure 42).

In 2011, all treatments significantly improved height growth compared to check trees (Table 35). However, diameter and volumes were only significantly greater for container 5X and bareroot injection. Volume growth improvements attributed to fipronil treatments ranged from 14 – 63% (Figure 42).

Acknowledgments: Thanks go to Bill Stansfield and The Campbell Group for continued access to study sites.

Table 34. Effect of fipronil application technique and rate on mean pine tip moth infestation of loblolly pine shoots over four years on two sites in East Texas: 2007-2010.

Treatment §	N	Mean Percent of Loblolly Pine Shoots Infested (**Pct. Reduction Compared to Check**) Ang.	Polk	Mean		Ang.	Polk	Mean	
		Year 1 (2007)				Year 2 (2008)			
Containerized FIP 3 ml	200	0.3 *	0.2 *	0.2 *	**99**	20.5 *	39.1 *	29.8 *	**52**
Containerized FIP 15 ml	200	0.0 *	0.0 *	0.0 *	**100**	11.9 *	32.4 *	22.1 *	**65**
Containerized Check	200	14.7	18.0	16.3		57.8	66.9	62.4	
BR FIP SI 12 ml	100	4.0 *	2.7 *	3.4 *	**75**	49.4	53.0 *	51.2 *	**11**
BR Check	100	13.8	13.1	13.4		52.7	62.8	57.6	
		Year 3 (2009)				Year 4 (2010)			
Containerized FIP 3 ml	200	26.8 *	29.5	28.2 *	**16**	63.8	Trees too Tall to evaluate	63.8	**5**
Containerized FIP 15 ml	200	13.9 *	19.0 *	16.4 *	**51**	62.6 *		62.6 *	**7**
Containerized Check	200	32.8	34.5	33.7		67.4		67.4	
BR FIP SI 12 ml	100	31.1	15.4 *	23.2 *	**31**	63.7 *		63.7 *	**10**
BR Check	100	33.7	33.4	33.6		70.6		70.6	

§ 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 35. Effect of fipronil application technique and rate on loblolly pine growth after attack by pine tip moth on two sites in East Texas: 2007 - 2010.

Year	Treatment	N	Mean End of Season Tree Measurements (**Growth Difference (cm or cm^3) Compared to Check**)											
			Height (cm)				Ground Line 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 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	2131	1629 *	**634**
	Containerized FIP 15 ml	100	132.0	178.1	155.0 *	**34.1**	2.51	3.66	3.09 *	**0.60**	1091	2795	1943 *	**948**
	Containerized Check	100	104.6	137.4	121.0		1.99	2.99	2.49		608	1381	995	
	BR FIP SI 12 ml	50	130.1	176.2	153.1 *	**33.2**	2.50	3.84	3.17 *	**0.55**	1265	3028	2146 *	**916**
	BR Check	50	92.0	149.0	119.9		1.83	3.43	2.62		423	2071	1230	
							Diameter at Breast Height (cm)							
2009	Containerized FIP 3 ml	100	219.7	275.3	247.5 *	**25.9**	2.23	3.37	2.80 *	**0.44**	1597	3736	2666 *	**806**
	Containerized FIP 15 ml	100	243.9	293.1	268.5 *	**46.9**	2.77	3.95	3.36 *	**1.00**	2643	5439	4041 *	**2180**
	Containerized Check	100	191.9	251.3	221.6		1.66	3.07	2.36		998	2723	1861	
	BR FIP SI 12 ml	50	219.3	293.7	256.9 *	**50.6**	2.30	4.01	3.17 *	**1.06**	1908	5766	3857 *	**1956**
	BR Check	50	157.5	255.1	206.3		0.94	3.26	2.10		411	3390	1900	
2010	Containerized FIP 3 ml	100	325.3	422.4	373.9 *	**25.6**	3.81	5.94	4.88 *	**0.38**	5934	16146	11040 *	**1668**
	Containerized FIP 15 ml	100	371.1	440.1	405.6 *	**57.3**	4.72	6.30	5.51 *	**1.01**	10183	19456	14819 *	**5447**
	Containerized Check	100	296.5	400.1	348.3		3.36	5.63	4.49		5143	13602	9372	
	BR FIP SI 12 ml	50	323.5	441.0	382.2 *	**61.6**	3.93	6.26	5.09 *	**1.27**	6897	20527	13712 *	**5616**
	BR Check	50	240.7	400.6	320.7		2.12	5.54	3.83		1791	14401	8096	
2011	Containerized FIP 3 ml	100	394.9	528.5	461.7 *	**23.7**	5.10	7.60	6.30	**0.30**	12371	31840	22106	**2656**
	Containerized FIP 15 ml	100	457.0	543.9	500.4 *	**62.4**	6.30	7.90	7.10 *	**1.10**	21166	37292	29229 *	**9779**
	Containerized Check	100	375.2	500.8	438.0		4.80	7.20	6.00		11220	27680	19450	
	BR FIP SI 12 ml	50	407.8	529.4	468.6 *	**74.5**	5.50	7.70	6.60 *	**1.40**	15716	36397	26056 *	**10104**
	BR Check	50	305.1	483.1	394.1		3.30	7.10	5.20		4690	27215	15952	

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

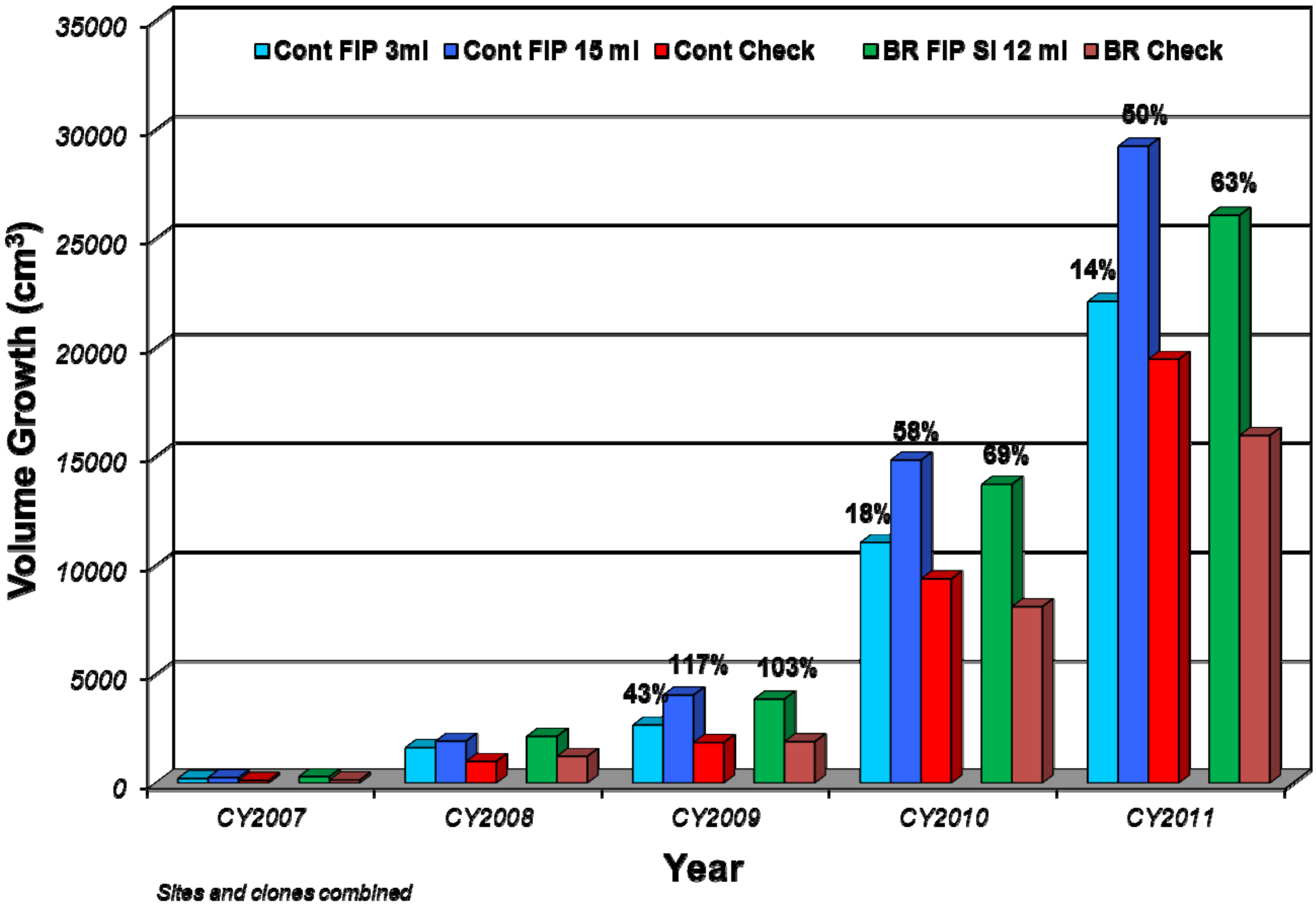


Figure 42. Effects of fipronil soil treatment on volume (cm^3) growth of containerized and bareroot loblolly pine seedlings on two Texas sites: 2007 – 2011.

PINE TIP MOTH TRIALS

Evaluation of Fipronil Treatments for Second-year Pine Seedlings – East Texas

Highlights:

- In 2011, most fipronil treatments provided moderate reduction in tip moth damage over the course of the second year after application. Treatments applied in the fall at higher volumes tended to perform better. Silvashield™ (2 tablets) again reduced damage more than fipronil. However, trees treated with fipronil were generally larger than those treated with Silvashield™ (imidacloprid).

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 3) determine the duration of PTM™ activity.

Study Sites: A one-year-old plantation (planted in 2008) off CR 3260 near Colmesneil, Texas, was selected. The plots contained 11 treatments and 550 trees (5 rows X 110 trees).

Insecticides:

Fipronil – PTM™ Insecticide (0.9 lbs ai/gal), BASF Corp.

Imidacloprid – SilvaShield™ Forestry Tablet (20% ai), Bayer Crop Science

Research Approach:

The treatments include:

Trial 1 (CR 3260):

1= Check (untreated) - Resident seedling

Fall 2009

2 = PTM™ (1.4 ml/tree LO Vol) - double injection (7.5 ml ea.) into soil 4” deep

3 = PTM™ (1.4 ml/tree HI Vol) - double injection (15 ml ea.) into soil 4” deep

4 = PTM™ (2.8 ml/tree LO Vol) - double injection (7.5 ml ea.) into soil 4” deep

5 = PTM™ (2.8 ml/tree HI Vol) - double injection (15 ml ea.) into soil 4” deep

6 = SilvaShield™ tablet -2 tablets (1 on ea. side) into soil 4” deep

Spring 2010

7 = PTM™ (1.4 ml/tree LO Vol) - double injection (7.5 ml ea.) into soil 4” deep

8 = PTM™ (1.4 ml/tree HI Vol) - double injection (15 ml ea.) into soil 4” deep

9 = PTM™ (2.8 ml/tree LO Vol) - double injection (7.5 ml ea.) into soil 4” deep

10 = PTM™ (2.8 ml/tree HI Vol) - double injection (15 ml ea.) into soil 4” deep

11 =SilvaShield™ tablet - 2 tablets (1 on ea. side) into soil 4” deep

A 1-acre (approximate) area within each site was selected. A randomized complete block design was used 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 (11 treatments X 50 trees = 550 monitored trees). All soil injection treatments were applied using the PTM™ injection probe (Figure 43) on 8 October 2009 and 5 March 2010. 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.

Figure 43. PTM™ Injection Probe, Aqumix, Inc. (formerly Enviroquip Inc.)

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:

In 2010, tip moth populations were quite high through most of the year with damage levels ranging from 11% of the shoots infested on check trees after generation 2 to 97% after the 4th generation (Table 36). As a result of the late treatment application date, none of the soil injection treatments applied in March 2010 significantly reduced tip moth infestation of top whorl shoots compared to the check during the first generation. However, all fipronil treatments, regardless of application date, rate or volume, provided moderate to good protection against tip moth during the 2nd, 3rd, 4th and 5th generations. Overall reduction in damage compared to checks ranged from 28% to 57%. The SilvaShield™ treatments performed better, reducing overall damage by 72 – 86%. All treatments (fipronil and imidacloprid) significantly improved tree height growth compared to check trees (Table 37), but only fipronil treatments significantly improved volume index. Growth (height, diameter, and volume) tended to be greater for high volume fipronil treatments and/or those applied in the fall.

In 2011, tip moth populations were generally low (3 – 11%) through the first four generation but increased to 57% in the fifth generation (Table 36). None of the soil injection treatments significantly reduced tip moth infestation of top whorl shoots compared to the check during the first two tip moth generations in 2011. However, most fipronil treatments, regardless of application date, rate or volume, provided moderate protection against tip moth during the 5th generation. Overall reduction in damage compared to checks ranged from 20% to 42%. The SilvaShield™ treatments performed better, reducing overall damage by 79 – 84%. All treatments (fipronil and imidacloprid) significantly improved tree height growth compared to that of check trees (Table 37), but only fipronil treatments significantly improved diameter growth. Growth (height, diameter, and volume) tended to be greater for high volume fipronil treatments and/or those applied in the fall.

Acknowledgments: Thanks go to Mr. Ragan Bounds for providing research site. We also thank Dr. Harry Quicke, BASF, and Mr. Bruce Monke, Bayer, for providing chemical product for the project.

Table 36. Effect of fipronil application timing, rate and volume on pine tip moth infestation of loblolly pine shoots after each of 5 generations on one site (CR 3260) in East Texas - 2010 & 2011.

				Mean Percent of Loblolly Pine Shoots Infested (**Pct. Reduction Compared to Check**)											
Year	Treatment §	Timing	N	Gen 1		Gen 2		Gen 3		Gen 4		Gen 5		Mean	
2010	PTM (1.4 ml) - 15 ml dilution	Oct. '09	50	25.2	**17**	5.7	**50**	24.8 *	**52**	75.7 *	**22**	70.2 *	**26**	40.3 *	**29**
	PTM (1.4 ml) - 30 ml dilution	Oct. '09	50	23.1	**24**	11.3	**1**	22.1 *	**57**	53.0 *	**45**	55.4 *	**42**	33.0 *	**42**
	PTM (2.8 ml) - 15 ml dilution	Oct. '09	50	17.2 *	**43**	2.7 *	**76**	17.9 *	**65**	59.5 *	**39**	48.3 *	**49**	29.1 *	**49**
	PTM (2.8 ml) - 30 ml dilution	Oct. '09	50	20.1	**34**	4.2 *	**63**	7.9 *	**85**	43.8 *	**55**	46.1 *	**52**	24.4 *	**57**
	SilvaShield (2 tablets)	Oct. '09	50	13.5 *	**55**	3.5 *	**69**	11.2 *	**78**	24.7 *	**74**	28.4 *	**70**	16.1 *	**72**
	PTM (1.4 ml) - 15 ml dilution	Mar. '10	50	28.9	**5**	5.9	**48**	21.5 *	**58**	61.0 *	**37**	53.7 *	**44**	34.2 *	**40**
	PTM (1.4 ml) - 30 ml dilution	Mar. '10	50	22.4	**26**	11.8	**-4**	23.5 *	**54**	78.9 *	**19**	68.1 *	**29**	41.0 *	**28**
	PTM (2.8 ml) - 15 ml dilution	Mar. '10	50	20.3	**33**	3.0 *	**74**	13.6 *	**74**	47.6 *	**51**	47.9 *	**50**	26.5 *	**54**
	PTM (2.8 ml) - 30 ml dilution	Mar. '10	50	29.2	**4**	5.8	**49**	27.9 *	**46**	73.2 *	**24**	76.2 *	**20**	42.5 *	**26**
	SilvaShield (2 tablets)	Mar. '10	50	27.0	**11**	3.0 *	**74**	4.1 *	**92**	2.5 *	**97**	4.3 *	**95**	8.2 *	**86**
	Check		50	30.4		11.4		51.3		96.8		95.5		57.1	
2011	PTM (1.4 ml) - 15 ml dilution	Oct. '09	50	9.1	**15**	0.8	**68**	3.1 *	**69**	8.9	**-7**	46.0	**20**	13.6 *	**24**
	PTM (1.4 ml) - 30 ml dilution	Oct. '09	50	9.5	**12**	2.7	**-8**	3.7 *	**63**	5.0	**40**	37.7 *	**34**	11.7 *	**34**
	PTM (2.8 ml) - 15 ml dilution	Oct. '09	50	10.6	**2**	0.5	**80**	3.6 *	**64**	4.8	**42**	36.8 *	**36**	11.2 *	**37**
	PTM (2.8 ml) - 30 ml dilution	Oct. '09	50	3.9	**64**	2.2	**12**	6.0	**40**	2.6	**69**	36.6 *	**36**	10.3 *	**42**
	SilvaShield (2 tablets)	Oct. '09	50	7.1	**34**	0.7	**72**	2.5 *	**75**	1.4 *	**83**	6.3 *	**89**	3.7 *	**79**
	PTM (1.4 ml) - 15 ml dilution	Mar. '10	50	9.7	**10**	3.1	**-24**	10.0	**0**	7.6	**8**	35.2 *	**39**	13.1 *	**26**
	PTM (1.4 ml) - 30 ml dilution	Mar. '10	50	9.5	**12**	1.7	**32**	3.2	**68**	10.6	**-28**	46.4	**19**	14.3	**20**
	PTM (2.8 ml) - 15 ml dilution	Mar. '10	50	10.6	**2**	2.2	**12**	5.0	**50**	6.8	**18**	34.2 *	**41**	11.5 *	**35**
	PTM (2.8 ml) - 30 ml dilution	Mar. '10	50	10.7	**1**	2.2	**12**	6.2	**38**	5.2	**37**	37.8 *	**34**	12.4 *	**30**
	SilvaShield (2 tablets)	Mar. '10	50	5.8	**46**	0.0	**100**	0.0	**100**	3.3	**60**	5.0 *	**91**	2.8 *	**84**
	Check		50	10.8		2.5		10.0		8.3		57.5		17.8	

§ 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 37. Effect of fipronil application timing, rate and volume on loblolly pine growth 9 - 26 months after treatment on one site (CR 3260) in East Texas - 2010 & 2011.

Year	Treatment	Timing	N	Height (cm)			GLD (cm)			Volume (cm^3)		
				Mean Second Year Growth (**Growth Difference (cm or cm^3) Compared to Check**)								
2010	PTM (1.4 ml) - 15 ml dilution	Oct. '09	50	182.3	*	**26.4**	4.63	*	**0.67**	4376	*	**1519**
	PTM (1.4 ml) - 30 ml dilution	Oct. '09	50	174.0	*	**18.1**	4.36		**0.40**	3770	*	**913**
	PTM (2.8 ml) - 15 ml dilution	Oct. '09	50	173.4	*	**17.5**	4.27		**0.31**	3529	*	**672**
	PTM (2.8 ml) - 30 ml dilution	Oct. '09	50	179.3	*	**23.4**	4.56	*	**0.60**	4092	*	**1236**
	SilvaShield (2 tablets)	Oct. '09	50	181.0	*	**25.1**	4.12		**0.16**	3350		**493**
	PTM (1.4 ml) - 15 ml dilution	Mar. '10	50	170.8	*	**14.9**	4.27		**0.31**	3444		**588**
	PTM (1.4 ml) - 30 ml dilution	Mar. '10	50	170.5	*	**14.6**	4.29		**0.33**	3447	*	**590**
	PTM (2.8 ml) - 15 ml dilution	Mar. '10	50	168.3	*	**12.4**	4.06		**0.10**	3178		**322**
	PTM (2.8 ml) - 30 ml dilution	Mar. '10	50	174.2	*	**18.4**	4.31		**0.35**	3663	*	**807**
	SilvaShield (2 tablets)	Mar. '10	50	180.7	*	**24.8**	3.97		**0.01**	3366		**509**
	Check		50	155.9			3.96			2857		
2011	PTM (1.4 ml) - 15 ml dilution	Oct. '09	50	311.4	*	**47.0**	6.53	*	**1.0**	14253	*	**5163**
	PTM (1.4 ml) - 30 ml dilution	Oct. '09	50	302.7	*	**38.3**	6.20	*	**0.7**	12659	*	**3568**
	PTM (2.8 ml) - 15 ml dilution	Oct. '09	50	301.9	*	**37.5**	6.11	*	**0.6**	12341	*	**3251**
	PTM (2.8 ml) - 30 ml dilution	Oct. '09	50	312.6	*	**48.2**	6.49	*	**1.0**	14117	*	**5027**
	SilvaShield (2 tablets)	Oct. '09	49	299.2	*	**34.8**	5.94		**0.4**	11251	*	**2161**
	PTM (1.4 ml) - 15 ml dilution	Mar. '10	50	290.7	*	**26.3**	6.00	*	**0.5**	11284	*	**2194**
	PTM (1.4 ml) - 30 ml dilution	Mar. '10	50	290.9	*	**26.5**	6.13	*	**0.6**	11869	*	**2779**
	PTM (2.8 ml) - 15 ml dilution	Mar. '10	50	292.8	*	**28.4**	5.97		**0.4**	11519	*	**2429**
	PTM (2.8 ml) - 30 ml dilution	Mar. '10	50	293.8	*	**29.4**	6.17	*	**0.6**	12299	*	**3209**
	SilvaShield (2 tablets)	Mar. '10	50	290.8	*	**26.4**	5.90		**0.4**	11789	*	**2699**
	Check		50	264.4			5.53			9090		

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

PINE TIP MOTH TRIALS

Evaluation of PTM™ Treatments for Containerized Pine Seedlings (Initiated in 2010)

Highlights:

- Preplant treatment of container seedlings with PTM significantly improved tip moth protection, seedling growth and survival in the first year compared to postplant PTM-treated seedlings and/or untreated checks.

Objectives: 1) Evaluate techniques for application of PTM™ (fipronil) to containerized seedlings in the nursery or planting site; 2) evaluate efficacy of PTM™ (fipronil) applied to containerized and bareroot seedlings for reducing pine tip moth infestation levels; and 3) determine the duration of chemical activity.

Research Approach:
One family of loblolly pine containerized seedlings was selected by Cellfor.

Treatments**:**

1 = PTM™ High Concentration/Undiluted Plug Injection [5.6 ml PTM undilute/seedling (**110 tpa rate**)] - Injection into **container** seedling plug just prior to shipping.

2 = PTM™ High Concentration/Diluted Soil Injection [5.6 ml PTM in 9.4 ml water (15 ml total volume)/seedling] - Soil injection next to transplanted **container** plug just after planting.

3 = PTM™ High Concentration/Diluted Soil Injection [5.6 ml PTM in 9.4 ml water (15 ml total volume)/seedling] - Soil injection next to transplanted **bareroot** just after planting.

4 = PTM™ Mid Concentration/Undiluted Plug Injection [1.4 ml PTM undilute/seedling (**435 tpa rate**)] - Injection into **container** seedling plug just prior to shipping.

5 = PTM™ Mid Concentration/Diluted Plug Injection [1.4 ml PTM in 1.7 ml water (3ml total volume)/seedling] -Injection into **container** seedling plug just prior to shipping.

6 = PTM™ Mid Concentration/Diluted Soil Injection [1.4 ml PTM in 13.6 ml water (15 ml total volume)/seedling] - Soil injection next to transplanted **container plug** just after planting.

7 = PTM™ Mid Concentration/Diluted Soil Injection [1.4 ml PTM in 13.6 ml water (15 ml total volume)/seedling] - (**Standard 1**) Soil injection next to transplanted **bareroot** just after planting.

8 = PTM™ Low Concentration/Undiluted Plug Injection [1 ml PTM undilute/seedling (**600 tpa rate**)] - Injection into **container** seedling plug just prior to shipping.

9 = PTM™ Low Concentration/Diluted Plug Injection [1 ml PTM in 2 ml water (3ml total volume)/seedling] - Injection into **container** seedling plug just prior to shipping.

10 = PTM™ Low Concentration/Diluted Soil Injection [1 ml PTM in 14 ml water (15ml total volume)/seedling] - Soil injection next to transplanted **container plug** just after planting..

11 = PTM™ Low Concentration/Diluted Soil Injection [1 ml PTM in 14 ml water (15ml total volume)/seedling] - (**Standard 2**) Soil injection next to transplanted **bareroot** just after planting..

12 = Containerized Check1 (untreated)

13 = Bareroot Check (untreated)

Containerized seedlings were individually treated using a small syringe on site just prior to planting (right). The seedlings were treated at different rates based on the restricted rate of 59 g AI/acre/year and the number of trees planted per acre (tpa). At 110 trees per acre (tpa) =0.537 g AI/seedling (a rate being considered by some forest industries for treatment of high-valued "crop" trees); at 435 tpa = 0.136 g AI/seedling (a tree density currently being used by Weyerhaeuser Co.); and 600 tpa = 0.1 g AI/seedling (a tree density used by several forest industries).

Ten recently-harvested tracts were selected in fall 2010 across the southeastern United States (TX, LA, AR, MS, GA, FL, and NC) based on uniformity of soil, drainage and topography (Figure 44).

TX – Rayonier (Leach), Weyerhaeuser (Fontenot), Hancock (Bounds)
LA - Campbell Group (Stansfield)
AR – ArborGen (Bryant)
MS – Cellfor (Muir)

GA – Rayonier (Wilson, Petre)
FL – Rayonier (Wilson, Petre)
NC – NC Forest Service (West), Weyerhaeuser (Edwards)

All study sites had been intensively site prepared, i.e., subsoil, bedding, and/or herbicide. A 1-acre (approximate) area within each site was selected. A triple Latin square design was established with single tree plots (13 rows X 13 treatments) serving as blocks, i.e., each treatment was randomly selected for placement along each row (bed). Thirty (39) rows were established on each site. Seedlings were planted at 8 foot spacing along each row. Individual tree locations were marked with different colored pin flags prior to tree planting. Herbicide to control broadleaf competitors was applied over the area in the spring to ensure that the seedlings remained exposed to tip moth attack throughout the year.

Damage and Tree Measurements
Tip moth damage was/will be 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/will be made as to the occurrence and extent of damage caused by other insects, i.e., coneworm, aphids, sawfly, etc. All study trees were measured for height & diameter (at ground level) at the beginning of the study (when seedlings were planted). Measurements also were/will be taken when tree growth has stopped in mid- to late November for at least the first 2 years of the study. Tree form will be evaluated at end of year 3. Form ranking of the seedling or tree will be categorized as follows: 0 = no forks; 1 = one fork; 2 = two to four forks; 3 = five or more forks. A fork is defined as a node with one or more laterals larger than one half the diameter of the main stem (Berisford and Kulman 1967).

Results: In 2011, tip moth populations were variable across the South; with relatively low damage levels on checks in TX (5% on container & 11% on bareroot) to ~30% on all seedling in GA (Figure 45, Table 37). PTM injected into container seedling plugs before planting reduced overall tip moth damage by 92% compared to untreated checks. This was 4% and 13% better than protection provided by PTM applied to container and bareroot seedlings , respectively, after planting (Figure 46) Nearly all PTM treatments (9 of 11) significantly improved height, diameter and volume (Table 38). Mean volume improvement for plugs treated prior to planting was 42% compared to checks. This was 12% higher than volume increase observed on postplant treated plugs. In addition, most PTM treatments (8 of 11) significantly improved survival compared to untreated checks. Mean survival of preplant treated plugs was 6.7% better than checks. This was double the improvement (3.4%) in survival observed on post plant treated seedlings.

Based on the above results, the duration of treatment efficacy will be further evaluated in 2012 for all treatments that reduced tip moth damage by > 75% in 2011. In addition, the study may be expanded to refine application rates and techniques for the promising treatment(s).

Acknowledgments: Thanks go to Arborgen, The Campbell Group, Hancock, NC Forest Service, Rayonier, and Weyerhaeuser for providing research site and Cellfor and Plum Creek for providing seedlings. We also thank Jim Bean, BASF, for providing financial support and PTM™ product for the project.

Reference:
Berisford, C.W., and H.M. Kulman. 1967. Infestation rate and damage by the Nantucket pine tip moth in six loblolly pine stand categories. For. Sci. 13: 428-438.

Fettig, C.J., J.T. Nowak, D.M. Grosman and C.W. Berisford. 2003. Nantucket pine tip moth phenology and timing of insecticide spray applications in the Western Gulf Region. USDA Forest Service So. Res. Stat. Res. Pap. SRS-32. 13pp.

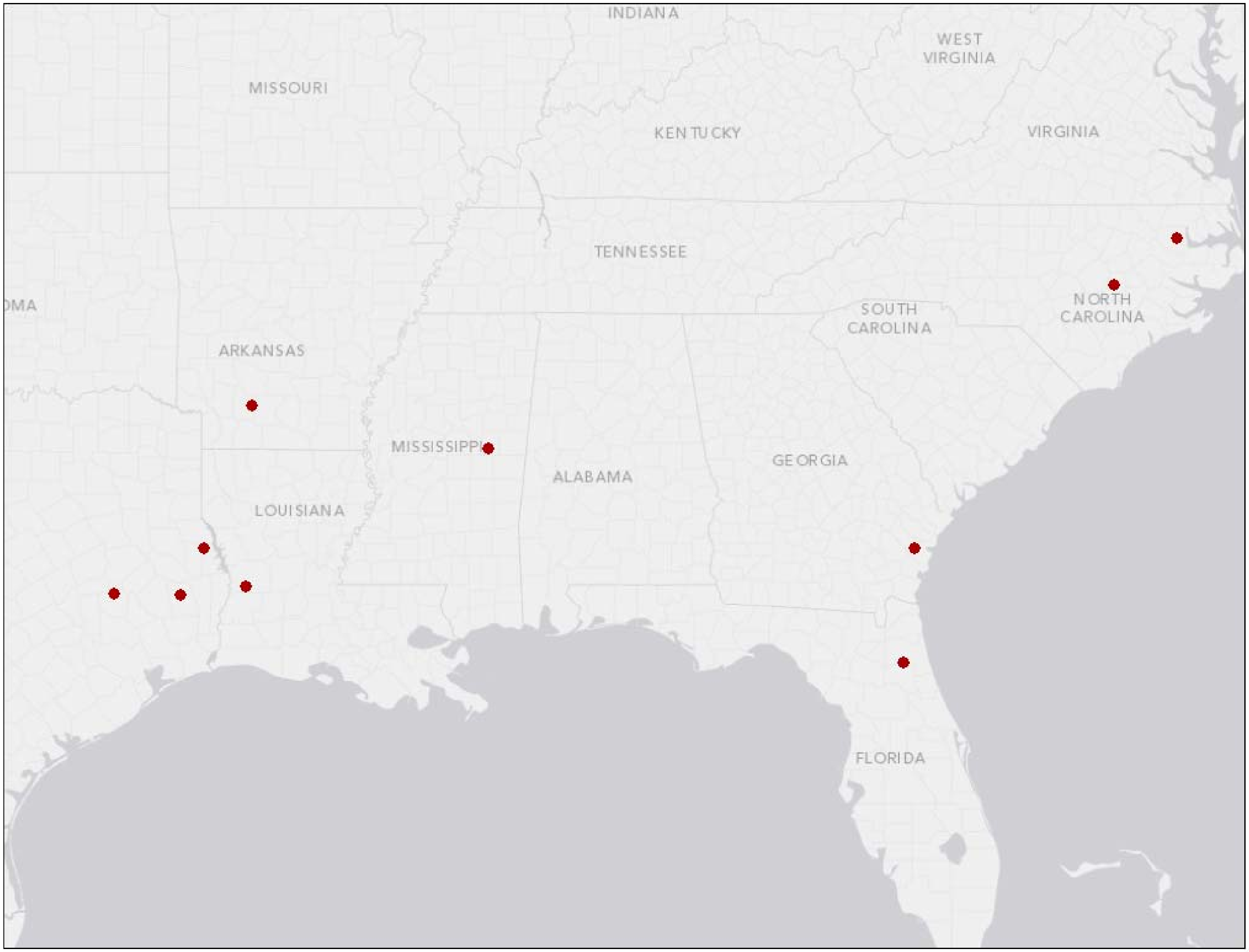


Figure 44. Locations of ten PTM container seedling research sites across the southeastern United States, 2011.

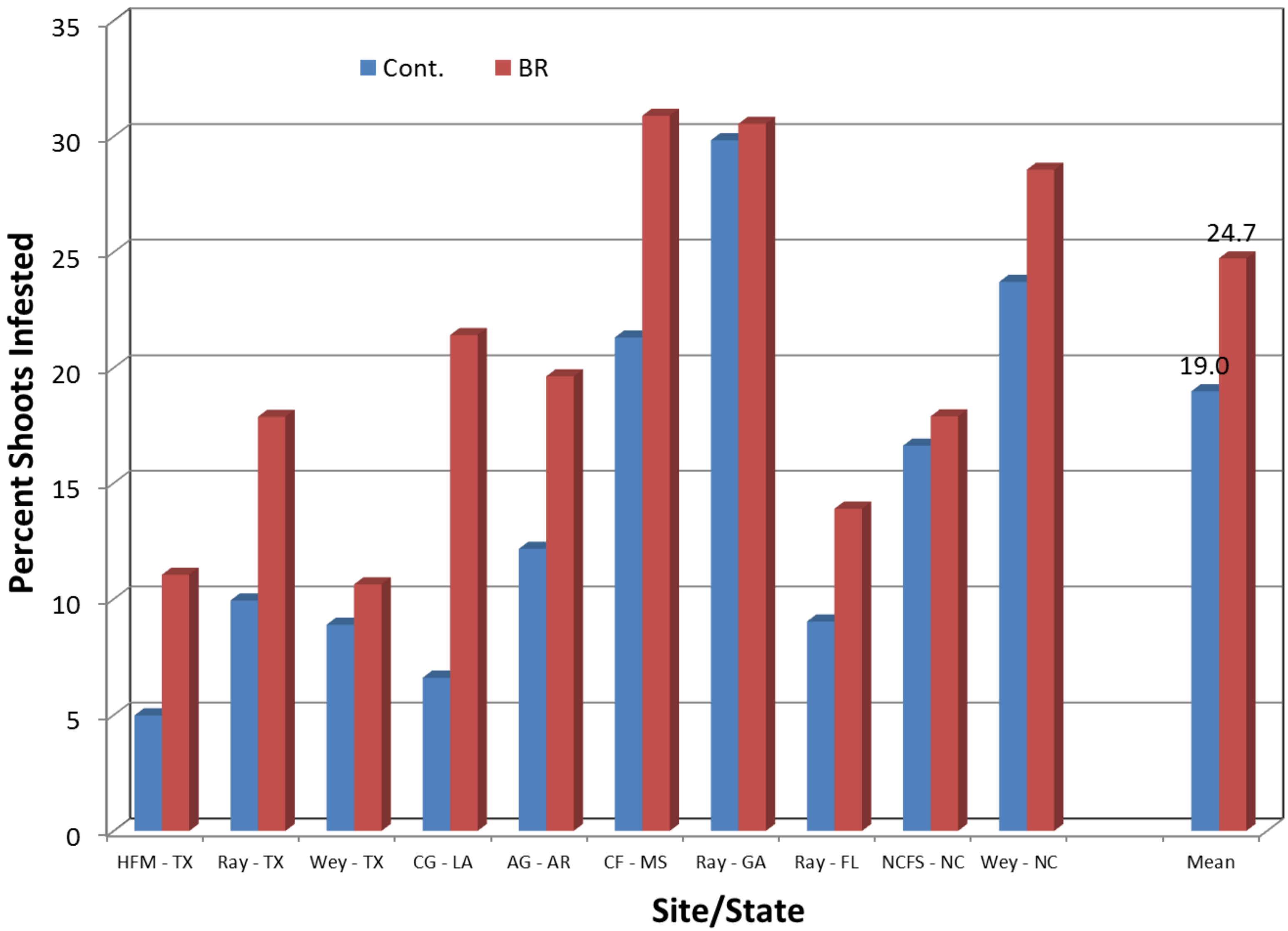
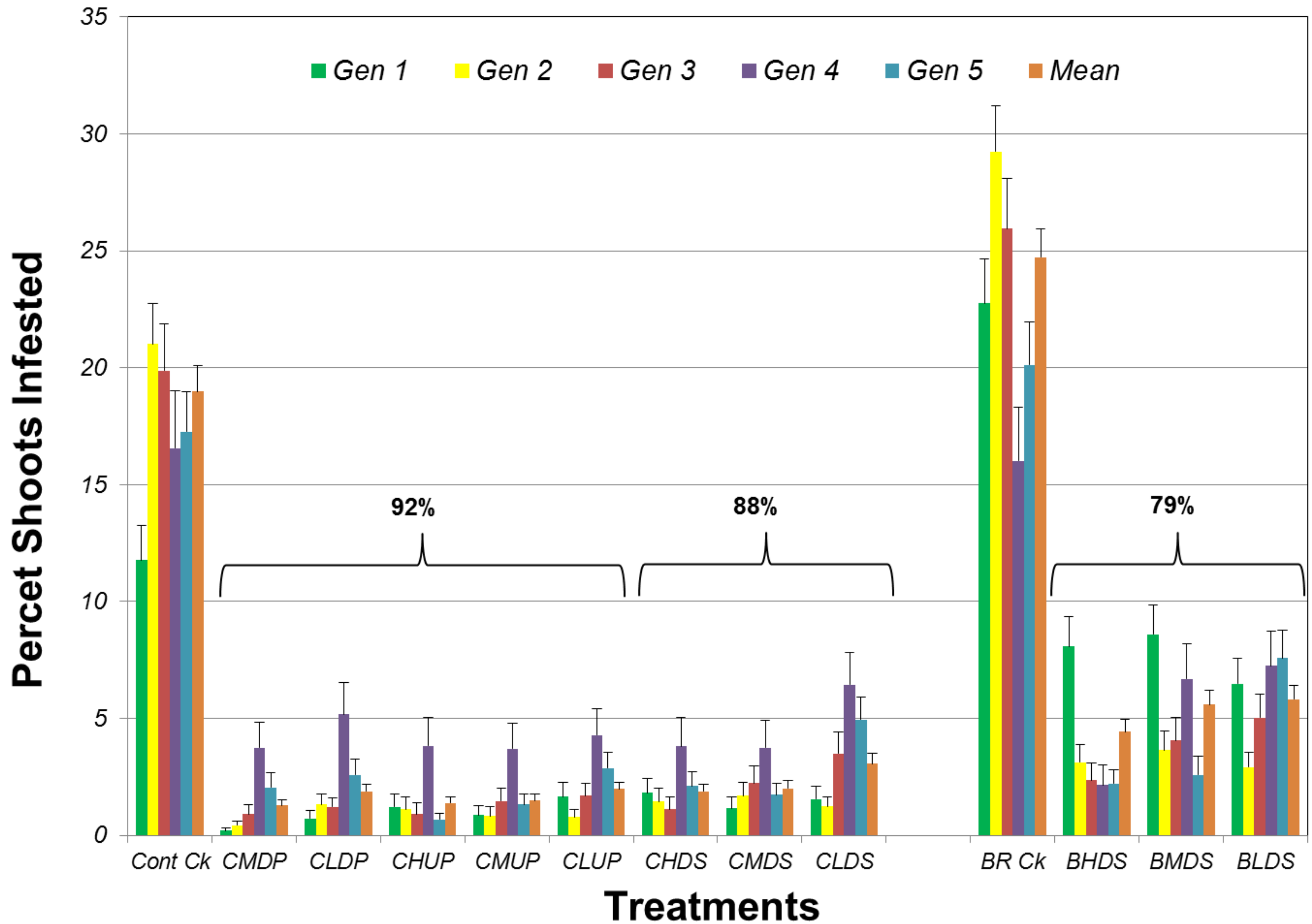


Figure 45. Mean tip moth infestation levels on first year containerized and bareroot loblolly pine on ten sites across the southeastern United States, 2011.



C= Containerized; B= Bareroot; L= Low rate; M= Medium rate; H= High rate; D= Dilute; U= Undilute; P= Plug injection; S= Soil injection

Figure 46. Effect of PTM™ plug and soil injection dose on tip moth infestation of containerized or bareroot loblolly pine on ten sites across the southeastern United States, 2011.

Table 37. Effect of PTM dose and technique on pine tip moth infestation of containerized and bareroot loblolly pine shoots (top whorl) on ten sites across the sotheastern United States, 2011.

	Treatment					(**Pct. Reduction Compared to Check**)																	
Year	Cont. or BR	Conc.	Dilute or Undilute	Inj. Loc.	N	Gen 1 (10 sites)			Gen 2 (10 Sites)			Gen 3 (8 Sites)			Gen 4 (6 Sites)			Gen 5 or Last (10 Sites)			Overall Mean		
2011	Cont.	Med	Dilute	Plug	390	0.2	**98**	*	0.4	**98**	*	0.9	**95**	*	3.8	**77**	*	2.1	**88**	*	1.3	**93**	*
	Cont.	Low	Dilute	Plug	390	0.7	**94**	*	1.3	**94**	*	1.2	**94**	*	5.2	**69**	*	2.6	**85**	*	1.9	**90**	*
	Cont.	High	Undilute	Plug	390	1.2	**89**	*	1.1	**95**	*	0.9	**95**	*	3.8	**77**	*	0.7	**96**	*	1.4	**93**	*
	Cont.	Med	Undilute	Plug	390	1.3	**89**	*	0.8	**96**	*	1.5	**93**	*	3.7	**78**	*	1.3	**92**	*	1.5	**92**	*
	Cont.	Low	Undilute	Plug	390	1.6	**86**	*	0.8	**96**	*	1.7	**92**	*	4.3	**74**	*	2.9	**83**	*	2.0	**90**	*
	Cont.	High	Dilute	Soil	390	1.8	**84**	*	1.5	**93**	*	1.1	**94**	*	3.8	**77**	*	2.1	**88**	*	1.9	**90**	*
	Cont.	Med	Dilute	Soil	390	1.2	**90**	*	1.7	**92**	*	2.2	**89**	*	3.8	**77**	*	1.7	**90**	*	2.0	**89**	*
	Cont.	Low	Dilute	Soil	390	1.6	**87**	*	1.2	**94**	*	3.5	**83**	*	6.4	**61**	*	5.0	**71**	*	3.0	**84**	*
	Cont.				390	11.6			21.1			19.9			16.5			17.3			19.0		
	BR	High	Dilute	Soil	390	8.5	**63**	*	2.9	**90**	*	2.4	**91**	*	2.2	**87**	*	2.2	**89**	*	4.4	**82**	*
	BR	Med	Dilute	Soil	390	8.6	**63**	*	3.6	**87**	*	4.0	**84**	*	6.7	**58**	*	3.3	**84**	*	5.6	**77**	*
	BR	Low	Dilute	Soil	390	6.5	**72**	*	3.0	**90**	*	5.0	**81**	*	7.2	**55**	*	7.6	**62**	*	5.8	**76**	*
	BR				390	22.8			29.0			25.9			16.0			20.1			24.7		

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

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

Table 38. Effect of PTM dose and technique on containerized and bareroot loblolly pine growth on ten sites across the southeastern United States, 2011.

	Treatment					Mean End of Season Loblolly Pine Seeding Growth Measurements (**Growth Difference (cm or cm3) Compared to Check)**						Mean Percent Tree Survival (**Percent Improvement Compared to Check**)	
Year	Cont. or BR	Conc.	Dilute or Undilute	Inj. Loc.	N	Height (cm)		Diameter (cm) [a]		Volume (cm^3)			
2011	Cont.	Med	Dilute	Plug	369	52.2 *	**7.0**	1.04 *	**0.12**	91.9 *	**28.2**	94 *	**7**
	Cont.	Low	Dilute	Plug	367	50.7 *	**5.5**	1.00 *	**0.09**	88.6 *	**24.9**	94 *	**6**
	Cont.	High	Undilute	Plug	371	50.0 *	**4.8**	0.98 *	**0.07**	86.1 *	**22.4**	95 *	**7**
	Cont.	Med	Undilute	Plug	360	52.8 *	**7.6**	1.03 *	**0.12**	95.5 *	**31.8**	92 *	**5**
	Cont.	Low	Undilute	Plug	374	51.9 *	**6.7**	1.02 *	**0.11**	91.7 *	**28.0**	96 *	**8**
	Cont.	High	Dilute	Soil	356	47.3	**2.1**	0.95	**0.03**	77.9	**14.2**	91 *	**4**
	Cont.	Med	Dilute	Soil	352	49.6 *	**4.4**	0.98 *	**0.07**	83.5 *	**19.8**	90	**2**
	Cont.	Low	Dilute	Soil	353	49.8 *	**4.6**	0.98 *	**0.06**	87.6 *	**23.9**	91	**3**
	Cont.				342	45.2		0.91		63.7		88	
	BR	High	Dilute	Soil	362	53.6	**3.2**	1.01	**0.04**	95.7	**24.1**	93	**3**
	BR	Med	Dilute	Soil	371	57.2 *	**6.8**	1.07 *	**0.10**	112.1 *	**40.4**	96 *	**5**
	BR	Low	Dilute	Soil	367	58.2 *	**7.8**	1.08 *	**0.11**	118.4 *	**46.7**	94 *	**4**
	BR				352	50.4		0.97		71.7		90	

[a] Groun Line Diameter.

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

PINE TIP MOTH TRIALS

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

Highlights:

- All SilvaShield™ tablet treatments significantly reduced tip moth damage at sustained reduction levels (90+%) through the second year.
- All PTM treatments also significantly reduced tip moth damage in the second year, but at reduced levels compared to year 1.
- None of the treatments significantly improved height growth parameters of treated seedlings.

Objectives:
The objectives of this research were to 1) determine the efficacy of PTM™ and SilvaShield™ in reducing pine tip moth infestation levels on loblolly pine seedlings; 2) evaluate these products applied at different rates and timing; and 3) determine the duration of protection provided by these insecticide applications.

Study Sites: In 2009, a recently-harvested tract, 121 acres in size and owned by The Campbell Group, was selected NW of Jasper, TX (Jasper Co.). The plot contained 15 treatments with 50 trees per treatment.

Insecticides:
Imidacloprid (SilvaShield™ (SS) 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:
Fifty seedlings for each treatment (A – O, see below) were hand planted (standard spacing 8' X 8') on a first-year plantation site. The site had received an intensive site preparation and the soil was disked. A randomized complete block design was used 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. Treatments A, D, F, H, K and M were applied as the seedling was planted. Just after seedling transplant, Treatments B, G, I, and N were applied (pushed into the soil 4" deep and 2 cm from each assigned seedling [SS] or poured into one 4"-deep probe hole near each seedling [PTM]. For treatments C, D, J and K, one tablet or solution was applied to each seedling in fall 2010. The remaining treatments (E, F, G, L, M and N) were applied in February 2011.

Treatment description:
A) PTM™ solution (1.4ml product in 13.6 ml water) applied into plant hole at planting (Dec. '09).
B) PTM™ solution (1.4ml product in 13.6 ml water) applied post plant at 1 point next to seedling (Dec. '09).
C) PTM™ solution (0.7ml product in 14.3 ml water) applied post plant at 2 points next to seedling (Sept. '10).
D) PTM™ solution (1.4ml product in 13.6 ml water) applied to plant hole at planting (Dec. '09) and (0.7ml product in 14.3 ml water) applied post plant at 2 points next to seedling (Sept. '10).
E) PTM™ solution (0.7ml product in 14.3 ml water) applied post plant at 2 points next to seedling (Feb. '11).
F) PTM™ solution (1.4ml product in 13.6 ml water) applied to plant hole at planting (Dec. '09) and (0.7ml product in 14.3 ml water) applied post plant at 2 points next to seedling (Feb. '11).
G) PTM™ solution (1.4ml product in 13.6 ml water) applied post plant at 1 point next to seedling (Dec. '09) and (0.7ml product in 14.3 ml water) applied post plant at 2 points next to seedling (Feb. '11).
H) SilvaShield™ (SS) (1 tablet) applied into plant hole at planting (Dec. '09).
I) SS (1 tablet) applied post plant next to seedling (Dec. '09).
J) SS (1 tablet) applied post plant next to seedling (Sept. '10).
K) SS (1 tablet) applied into plant hole at planting (Dec. '09) and SS (1 tablet) applied post plant next to seedling (Sept. '10).
L) SS (1 tablet) applied post plant next to seedling (Feb. '11).
M) SS (1 tablet) applied to plant hole at planting (Dec. '09) and SS (1 tablet) applied post plant next to seedling (Feb. '11).
N) SS (1 tablet) applied post plant next to seedling (Dec. '09) and SS (1 tablet) applied post plant next to seedling (Feb. '11).
O) Check –seedlings planted by hand without additional treatment.

Treatments and Layout

Code	Treatment	Color
A	PTM in plant hole at planting (Dec. '09)	red
B	PTM post plant at 1 pt next to seedling (Dec. '09)	blue
C	PTM post plant at 2 pt next to seedling (Sep. '10)	orange
D	PTM at planting + PTM post plant (2 pts, Sep. '10)	pink/blue
E	PTM post plant at 2 pt next to seedling (Feb. '11)	white
F	PTM at planting + PTM post plant (2 pts, Feb. '11)	red/white
G	PTM post plant (1 pt, Dec. '09) + PTM post plant (2 pts, Feb. '11)	yellow/blue
H	SS in plant hole at planting (Dec. '09)	yellow
I	SS post plant next to seedling (Dec. '09)	green
J	SS post plant next to seedling (Sep. '10)	pink
K	SS at planting + SS post plant (Sep. '10)	blue/white
L	SS post plant next to seedling (Feb. '10)	green/orange
M	SS at planting + SS post plant (Feb. '11)	yellow/green
N	SS post plant (Dec. '09) + SS post plant (Feb. '11)	blue/red
O	Check (lift and plant bare root seedlings)	green/white

Bed 1	Bed 2	Bed 3	Bed 4	Bed 5
J	G	L	I	K
E	H	E	O	E
F	J	C	H	I
L	E	H	G	O
A	C	J	E	H
N	B	M	M	A
K	L	B	B	F
O	F	F	K	M
B	M	A	A	N
D	I	K	C	C
G	A	D	N	G
C	N	I	F	J
I	D	G	L	D
M	K	O	D	B
H	O	N	J	L

Treatment Evaluation: Tip moth damage was evaluated 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.

<u>Times for Jasper Co., TX site:</u>

Generation 1: week of April 27
Generation 2: week of June 22
Generation 3: week of August 10
Generation 4: week of September 21
Generation 5: November 15 – December 31

Observations also were made as to the occurrence and extent of damage caused by other insects, i.e., aphids, weevils, coneworm, etc. Second-year trees were measured for ground level diameter and height in the fall (November). If warranted, three-year old trees will be measured for height and diameter (at DBH) and ranked for form. To rank for form, each tree will be categorized as follows: 0 = no forks; 1 = one fork; 2 = two to four forks; 3 = five or more forks. A fork is defined as a node with one or more laterals larger than one half the diameter of the main stem (Berisford and Kulman 1967).

Results:
In 2010, tip moth populations were moderate to high through most of the year with damage levels ranging from 12% of the shoots infested on check trees after generation 1 to 54% after the 5th generation (Table 39). All PTM™ and SS treatments with initial application made in December 2009 significantly reduced tip moth infestation of top whorl shoots compared to the check during all five generations. Overall reduction in damage compared to checks ranged from 79-97% for PTM™ treatments and 94-100 % for SS treatments. There was no difference between PTM™ and SS treatments applied at planting. However, SS treatments applied post plant generally provided better protection compared to post plant PTM™ treatments. Only SS treatments (3 of 5)

significantly improved tree height growth compared to check trees (Table 41). There were no differences in tree survival among the treatments.

In 2011, tip moth populations were generally higher through most of the 2nd year with damage levels ranging from 18% of the shoots infested on check trees after generation 2 to 75% after the 5th generation (Table 40). All PTM™ and SS treatments significantly reduced tip moth infestation of top whorl shoots compared to the check during all five generations. Overall reduction in damage compared to checks ranged from 31-87% for PTM™ treatments and 78-99 % for SS treatments. There was no difference between PTM™ and SS treatments applied at planting. However, SS treatments applied post plant provided markedly better protection compared to post plant PTM™ treatments. None of the treatments significantly improved tree height growth compared to check trees (Table 42). There were no differences in tree survival among the treatments.

Acknowledgments: Thanks go to The Campbell Group for providing research site and seedlings. We also thank Jim Bean, BASF, and Bruce Monke, Bayer Environmental Science, for providing PTM™ and Silvashield™ tablets, respectively, for the project.

Reference:

Berisford, C.W., and H.M. Kulman. 1967. Infestation rate and damage by the Nantucket pine tip moth in six loblolly pine stand categories. For. Sci. 13: 428-438.

Fettig, C.J., J.T. Nowak, D.M. Grosman and C.W. Berisford. 2003. Nantucket pine tip moth phenology and timing of insecticide spray applications in the Western Gulf Region. USDA Forest Service So. Res. Stat. Res. Pap. SRS-32. 13pp.

Table 39. Effect of PTM™ soil injection and SilvaShield™ tablet dose, timing and technique on pine tip moth infestation of loblolly pine shoots (top whorl) on one site (Campbell Group Nursery) in east Texas, 2010.

	Treatment				Mean Percent Top Whorl Shoots Infested by Tip Moth (**Pct. Reduction Compared to Check**)																	
Year	Product	Season	Tech.	N	Gen 1			Gen 2			Gen 3			Gen 4			Gen 5			Overall Mean		
2010	PTM	D '09	AP	50	0.4	**97**	*	1.5	**95**	*	0.0	**100**	*	0.0	**100**	*	2.4	**96**	*	0.9	**97**	*
	PTM	D '09 + S '10	AP	50	0.0	**100**	*	3.7	**89**	*	2.4	**88**	*	2.5	**95**	*	1.5	**97**	*	2.4	**93**	*
	PTM	D '09 + F '11	AP	50	1.3	**89**	*	2.7	**92**	*	0.7	**97**	*	1.1	**98**	*	0.0	**100**	*	0.9	**97**	*
	PTM	D '09	PP	50	3.4	**73**	*	5.8	**82**	*	5.7	**71**	*	5.4	**88**	*	5.6	**90**	*	5.2	**84**	*
	PTM	D '09 + F '11	PP	50	0.0	**100**	*	6.7	**79**	*	3.8	**81**	*	9.0	**81**	*	14.4	**73**	*	6.8	**79**	*
	PTM	S '10	PP	50	9.6	**23**		32.9	**-2**		12.4	**38**		15.0	**68**	*	41.4	**23**	*	23.1	**29**	*
	PTM	F '11	PP	50	7.4	**40**		42.4	**-32**		17.4	**12**		29.0	**39**	*	30.2	**44**	*	25.3	**22**	*
	SS	D '09	AP	50	0.0	**100**	*	0.4	**99**	*	1.4	**93**	*	8.2	**83**	*	4.3	**92**	*	2.9	**91**	*
	SS	D '09 + S '10	AP	50	0.0	**100**	*	0.7	**98**	*	0.0	**100**	*	0.0	**100**	*	0.0	**100**	*	0.1	**100**	*
	SS	D '09 + F '11	AP	50	0.0	**100**	*	0.0	**100**	*	0.0	**100**	*	1.0	**98**	*	0.0	**100**	*	0.2	**99**	*
	SS	D '09	PP	50	0.4	**97**	*	1.1	**97**	*	0.0	**100**	*	1.1	**98**	*	6.4	**88**	*	1.8	**94**	*
	SS	D '09 + F '11	PP	50	0.0	**100**	*	0.0	**100**	*	0.0	**100**	*	1.4	**97**	*	3.4	**94**	*	1.0	**97**	*
	SS	S '10	PP	50	7.6	**38**		33.7	**-5**		13.8	**30**		33.0	**30**	*	22.6	**58**	*	22.6	**31**	*
	SS	F '11	PP	50	7.3	**41**		34.6	**-8**		26.0	**-31**		39.8	**16**		47.0	**13**		30.9	**5**	
	Check			100	12.4			32.1			19.9			47.3			53.9			32.6		

PTM= fipronil; SS= SilvaShield, imidacloprid), D= December, S= September, F= February, AP= at plant, PP= post plant.

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

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

Table 40. Effect of PTM™ soil injection and SilvaShield™ tablet dose, timing and technique on pine tip moth infestation of loblolly pine shoots (top whorl) on one site (Campbell Group Nursery) in east Texas, 2011.

	Treatment				Mean Percent Top Whorl Shoots Infested by Tip Moth (**Pct. Reduction Compared to Check**)																	
Year	Product	Season	Tech.	N	Gen 1			Gen 2			Gen 3			Gen 4			Gen 5			Overall Mean		
2011	PTM	D '09	AP	47	11.1	**76**	*	3.3	**81**	*	6.6	**73**	*	4.6	**76**	*	20.0	**73**	*	9.2	**75**	*
	PTM	D '09 + S'10	AP	48	3.9	**91**	*	1.0	**94**	*	1.2	**95**	*	0.0	**100**	*	17.4	**77**	*	4.7	**87**	*
	PTM	D '09 +F '11	AP	48	7.9	**83**	*	2.6	**85**	*	2.1	**91**	*	2.5	**87**	*	8.0	**89**	*	4.7	**87**	*
	PTM	D '09	PP	42	37.2	**19**		6.4	**64**	*	11.2	**54**	*	9.1	**52**	*	45.8	**39**	*	22.0	**40**	*
	PTM	D '09 + F '11	PP	43	33.0	**28**	*	10.3	**42**	*	9.9	**59**	*	5.8	**69**	*	36.4	**51**	*	19.2	**47**	*
	PTM	S '10	PP	42	11.2	**76**	*	2.8	**84**	*	1.9	**92**	*	6.0	**68**	*	21.2	**72**	*	8.7	**76**	*
	PTM	F '11	PP	43	44.7	**3**		14.9	**16**		7.9	**67**	*	6.6	**65**	*	46.2	**38**	*	25.2	**31**	*
	SS	D '09	AP	47	7.0	**85**	*	1.8	**90**	*	0.7	**97**	*	0.0	**100**	*	4.7	**94**	*	2.8	**92**	*
	SS	D '09 + S'10	AP	46	4.0	**91**	*	0.0	**100**	*	0.0	**100**	*	0.5	**97**	*	0.0	**100**	*	0.9	**98**	*
	SS	D '09 +F '11	AP	47	0.7	**98**	*	0.0	**100**	*	0.7	**97**	*	0.0	**100**	*	0.4	**99**	*	0.4	**99**	*
	SS	D '09	PP	46	6.5	**86**	*	0.4	**98**	*	0.5	**98**	*	0.0	**100**	*	7.1	**91**	*	2.9	**92**	*
	SS	D '09 + F '11	PP	44	5.9	**87**	*	1.5	**92**	*	2.2	**91**	*	2.3	**88**	*	0.8	**99**	*	2.4	**93**	*
	SS	S '10	PP	43	7.7	**83**	*	2.3	**87**	*	0.0	**100**	*	0.0	**100**	*	6.2	**92**	*	3.2	**91**	*
	SS	F '11	PP	50	27.8	**39**	*	3.6	**80**	*	1.7	**93**	*	0.0	**100**	*	6.5	**91**	*	7.9	**78**	*
	Check			45	45.9			17.8			24.1			18.8			75.0			36.5		

PTM= fipronil; SS= SilvaShield, imidacloprid), D= December, S= September, F= February, AP= at plant, PP= post plant.
***** Means followed by an asterik are significantly different from checks at the 5% level based on Fisher's Protected LSD.
= treatment reduced damage by 75% or better compared to check.

Table 41. Effect of PTM™ soil injection and SilvaShield™ tablet dose, timing and technique on loblolly pine growth on one site (Campbell Group nursery) in east Texas, 2010.

Year	Treatment: Product	Treatment: Season	Treatment: Tech.	N	Mean End of Season Loblolly Pine Seeding Growth Measurements (**Growth Difference (cm or cm3) Compared to Check)**: Height (cm)			Diameter (cm) [a]		Volume (cm^3)		Mean Percent Tree Survival
2010	PTM	D '09	AP	50	66.9		**8.2**	0.94	**0.02**	70.7	**11.8**	98
	PTM	D '09 + S '10	AP	50	65.1		**6.4**	0.93	**0.02**	68.5	**9.5**	96
	PTM	D '09 + F '11	AP	50	65.1		**6.4**	0.88	**-0.04**	62.5	**3.6**	96
	PTM	D '09	PP	50	61.0		**2.3**	0.86	**-0.05**	63.1	**4.2**	90
	PTM	D '09 + F '11	PP	50	62.6		**3.9**	0.94	**0.03**	71.5	**12.6**	90
	PTM	S '10	PP	50	58.7		**-0.1**	0.95	**0.04**	67.7	**8.8**	86
	PTM	F '11	PP	50	57.3		**-1.4**	0.88	**-0.04**	58.5	**-0.4**	88
	SS	D '09	AP	50	70.5	*	**11.7**	0.96	**0.05**	75.5	**16.5**	96
	SS	D '09 + S '10	AP	50	62.3		**3.6**	0.91	**0.00**	59.4	**0.4**	94
	SS	D '09 + F '11	AP	50	63.1		**4.4**	0.91	**-0.01**	60.9	**2.0**	96
	SS	D '09	PP	50	69.4	*	**10.6**	0.97	**0.06**	81.7	**22.8**	94
	SS	D '09 + F '11	PP	50	67.1	*	**8.3**	0.89	**-0.02**	69.2	**10.3**	88
	SS	S '10	PP	50	53.4		**-5.4**	0.83	**-0.08**	46.4	**-12.5**	88
	SS	F '11	PP	50	61.4		**2.7**	0.95	**0.03**	65.5	**6.6**	100
	Check			50	58.7			0.91		58.9		90

PTM= fipronil; SS= SilvaShield, imidacloprid), D= December, S= September, F= February, AP= at plant, PP= post plant.

[a] Ground Line Diameter.

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

Table 42. Effect of PTM™ soil injection and SilvaShield™ tablet dose, timing and technique on loblolly pine growth on one site (Campbell Group nursery) in east Texas, 2011.

Year	Treatment: Product	Treatment: Season	Treatment: Tech.	N	Mean End of Season Loblolly Pine Seeding Growth Measurements (**Growth Difference (cm or cm3) Compared to Check)**: Height (cm)		Diameter (cm) [a]		Volume (cm^3)		Mean Percent Tree Survival
2011	PTM	D '09	AP	47	115.0	**4.4**	2.30	**0.1**	796.6	**135**	94
	PTM	D '09 + S '10	AP	48	114.5	**3.9**	2.17	**0.0**	754.7	**93**	96
	PTM	D '09 + F '11	AP	48	110.4	**-0.2**	2.10	**-0.1**	715.1	**53**	96
	PTM	D '09	PP	42	102.0	**-8.6**	2.10	**-0.1**	601.7	**-60**	84
	PTM	D '09 + F '11	PP	43	112.1	**1.5**	2.10	**-0.1**	696.1	**35**	86
	PTM	S '10	PP	43	103.1	**-7.5**	2.00	**-0.2**	603.2	**-58**	84
	PTM	F '11	PP	42	113.0	**2.4**	2.15	**0.0**	741.6	**80**	86
	SS	D '09	AP	47	123.1	**12.5**	2.27	**0.1**	778.4	**117**	94
	SS	D '09 + S'10	AP	47	123.1	**12.5**	1.94	**-0.2**	520.9	**-141**	94
	SS	D '09 + F '11	AP	46	123.1	**12.5**	1.93	**-0.2**	516.6	**-145**	92
	SS	D '09	PP	46	121.4	**10.8**	2.29	**0.1**	854.2	**193**	92
	SS	D '09 + F '11	PP	44	118.4	**7.8**	2.20	**0.0**	782.9	**121**	88
	SS	S '10	PP	43	99.3	**-11.3**	1.68	**-0.5**	437.9	**-224**	86
	SS	F '11	PP	50	123.7	**13.1**	2.33	**0.2**	845.4	**184**	100
	Check			45	110.6		2.17		661.6		90

PTM= fipronil; SS= SilvaShield, imidacloprid), D= December, S= September, F= February, AP= at plant, PP= post plant.

[a] Ground Line Diameter.

***** 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 tree growth parameters on all four sites measured after the fifth year.
- All treatments containing imidacloprid tablets, applied in 2009, significantly reduced tip moth damage levels through the first and second year, but not the third 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) 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 3) determine the duration of chemical activity.

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). The plots contained 3 - 5 treatments with 50 trees per treatment. In 2009, a trial was established on a newly-planted site at Cottingham Bridge in east 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:

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

2009 :

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, individual resident trees were removed and each was replaced with a single treatment tree. 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 2009, one tablet was 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 each 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. 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 (2007-2011)

In 2007 & 2008, all tablet treatments placed in the plant hole were highly effective in reducing tip moth damage throughout the year (Tables 43 & 44). Overall, damage was reduced by 81% (2007) and 50% (2008). Tablets pushed into the soil after the seedlings were planted and foliar sprays tended to be less effective.

In 2011, measurements were continued on 4 sites (2 TX and 2 AR). Tablet treatments significantly improved growth parameters compared to checks on all four sites measured (Table 45).

Input Comparison (Cottingham Bridge)

In 2009, tip moth populations were low during the first and second generations with averages of 5% and 4% of the shoots infested on check trees, respectively (Table 46). Populations rose to moderate levels (62%) by the fifth generation. 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 disappear by the fifth generation. Most treatments with tablets significantly improved tree growth parameters compared to those of check trees (Table 47).

In 2010, tip moth populations were much higher with mean percent shoots infested on checks ranging from 55% after the first generation to 96% at the end of the fourth generation (Table 46). Treatments containing tablets provided limited protection through the year, reducing damaged by 7 – 43% (15 – 29% overall). The addition of fertilizer or herbicide did not appear to have influence tip moth damage. All treatments with tablets significantly improved growth parameters compared to those of check trees (Table 47).

In 2011, tip moth populations declined somewhat with mean percent shoots infested on checks ranging from 23% after the second generation to 67% at the end of the fourth generation (Table 46). Most treatments containing tablets provided little or no protection through the year. The addition of fertilizer or herbicide did not appear to influence tip moth damage. All treatments with tablets significantly improved growth parameters compared to those of check trees (Table 47).

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Table 43. 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

= 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 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)

		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	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	

		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	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	

		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	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 45. Effect of Bayer tablets on height, diameter and volume index after the five growing seasons on four of the original six Western Gulf sites - 2011.

		Mean Parameter Growth (**Growth Difference (cm or cm³) Compared to Check**)									
		Height (cm)									
Treatment §	N	TX1		TX2		AR2		AR3		Mean		
20% FXT Ball PH	50	505.4	*	486.5	*	347.3	*	416.8	*	434.2	*	**59.3**
20% FXT Ball Adjacent	50	465.4		468.1	*	333.4	*	400.9	*	411.0	*	**36.2**
Mimic foliar spray	50	454.7		486.2	*	339.9	*	393.6	*	420.1	*	**45.2**
Check	50	441.0		426.7		287.3		360.9		374.9		
		Diameter (cm)										
Treatment §	N	TX1		TX2		AR2		AR3		Mean		
20% FXT Ball PH	50	6.71	*	6.97	*	6.10	*	5.48	*	6.28	*	**1.34**
20% FXT Ball Adjacent	50	6.34	*	6.82	*	5.35	*	5.29	*	5.89	*	**0.94**
Mimic foliar spray	50	5.89		6.99	*	5.86	*	5.22	*	6.01	*	**1.07**
Check	50	5.58		5.76		4.10		4.52		4.94		
		Volume Index (cm³)										
Treatment §	N	TX1		TX2		AR2		AR3		Mean		
20% FXT Ball PH	50	26499	*	25149	*	14832	*	14315	*	19712	*	**7892**
20% FXT Ball Adjacent	50	20544		24107	*	11102	*	12912	*	16612	*	**4792**
Mimic foliar spray	50	18243		25696	*	14152	*	12149	*	17637	*	**5817**
Check	50	16009		17736		5799		9093		11820		

§ 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 46. Effect of different silvicultural perscriptions on pine tip moth infestation of loblolly pine shoots (top whorl) on one site (Cottingham Bridge) in east Texas; 2009, 2010 and 2011.

			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		
2009	1 SS	50	6.6	**-34**		3.0	**26**		0.7	**93**	*	15.9	**62**	*	46.6	**25**	*	14.7	**41**	*
	DAP 1X	50	2.1	**57**		6.2	**-53**		10.4	**2**		42.3	**-2**		55.0	**12**		23.4	**5**	
	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		
2010	1 SS	50	48.6	**12**		49.1	**24**	*	53.2	**24**	*	72.9	**24**	*	71.0	**25**	*	59.0	**23**	*
	DAP 1X	50	61.0	**-10**		62.7	**3**		73.0	**-5**		94.7	**2**		93.1	**2**		77.4	**-1**	
	1 SS + DAP 1/2X	50	48.5	**13**		50.8	**21**		61.7	**11**		81.3	**16**	*	82.3	**13**	*	64.9	**15**	*
	HWC	50	48.3	**13**		68.8	**-7**		69.9	**0**		88.8	**8**		85.7	**10**		72.3	**6**	
	1 SS + HWC	50	38.7	**30**	*	52.1	**19**		58.4	**16**		77.0	**20**	*	86.3	**9**		62.5	**18**	*
	1 SS + DAP 1/2X + HWC	50	37.6	**32**	*	45.3	**30**	*	49.4	**29**	*	83.7	**13**	*	87.9	**7**		60.6	**21**	*
	1 SS + DAP 1X + HWC	50	44.6	**20**		48.8	**24**	*	39.7	**43**	*	65.6	**32**	*	73.9	**22**	*	54.6	**29**	*
	DAP 1X + HWC	50	52.4	**5**		69.1	**-7**		71.3	**-2**		96.9	**-1**		97.9	**-3**		77.6	**-1**	
	Check	50	55.4			64.3			69.6			96.3			95.0			76.6		
2011	1 SS	50	25.7	**23**		24.4	**-7**		33.5	**46**	*	23.9	**29**		45.3	**32**	*	30.6	**30**	*
	DAP 1X	50	42.9	**-28**		32.0	**-40**		50.6	**19**		40.8	**-21**		66.1	**1**		46.2	**-6**	
	1 SS + DAP 1/2X	50	43.6	**-30**		27.1	**-19**		49.5	**20**		40.6	**-21**		66.0	**1**		45.5	**-4**	
	HWC	50	51.6	**-54**	*	24.4	**-7**		60.7	**3**		48.3	**-44**		71.4	**-7**		51.3	**-17**	
	1 SS + HWC	50	31.7	**5**		28.4	**-24**		51.4	**17**		42.8	**-27**		58.0	**13**		42.5	**3**	
	1 SS + DAP 1/2X + HWC	50	33.2	**1**		26.2	**-15**		43.7	**30**	*	33.6	**0**		41.7	**37**	*	35.7	**18**	
	1 SS + DAP 1X + HWC	50	28.2	**16**		21.4	**7**		60.0	**4**		39.9	**-19**		59.4	**11**		42.0	**4**	
	DAP 1X + HWC	50	41.2	**-23**		37.1	**-62**	*	58.7	**6**		56.5	**-68**	*	78.4	**-18**		54.4	**-24**	
	Check	50	33.5			22.9			62.3			33.6			66.5			43.8		

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

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

Table 47. Effect of different silvicultural perscriptions on loblolly pine growth on one site (Cottingham Bridge) in east Texas; 2009, 2010 and 2011.

			Mean End of Season Loblolly Pine Seeding Growth Measurements (**Growth Difference (cm or cm^3) Compared to Check**)									
Year	Treatment	N	Height (cm)			Diameter (cm) [a]			Volume (cm^3)			Mean Percent Tree Survival
						@ 6 inches						
2009	1 SS	50	68.8		**7.1**	1.63		**0.17**	212.4		**33.0**	90
	DAP 1X	50	71.4	*	**9.7**	1.73	*	**0.26**	255.6	*	**76.2**	80
	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
2010	1 SS	50	148.5		**18.5**	3.54	*	**0.43**	2094.9	*	**513**	90
	DAP 1X	50	142.6		**12.6**	3.67	*	**0.55**	2189.1	*	**607**	78
	1 SS + DAP 1/2X	50	162.7	*	**32.7**	3.86	*	**0.74**	2596.0	*	**1014**	98
	HWC	50	125.2		**-4.8**	3.27		**0.16**	1637.7		**55**	84
	1 SS + HWC	50	159.7	*	**29.7**	3.89	*	**0.78**	2634.8	*	**1052**	92
	1 SS + DAP 1/2X + HWC	50	160.6	*	**30.6**	3.80	*	**0.69**	2517.0	*	**935**	94
	1 SS + DAP 1X + HWC	50	158.5	*	**28.5**	3.91	*	**0.80**	2674.5	*	**1092**	78
	DAP 1X + HWC	50	132.0		**2.0**	3.29		**0.18**	1796.1		**214**	94
	Check	50	130.0			3.11			1582.4			94
						@ DBH						
2011	1 SS	48	232.8	*	**26.3**	2.57	*	**0.54**	2041.0	*	**784**	96
	DAP 1X	37	229.5	*	**23.0**	2.54	*	**0.50**	1869.5	*	**612**	74
	1 SS + DAP 1/2X	48	253.7	*	**47.2**	3.00	*	**0.97**	2617.6	*	**1360**	96
	HWC	42	217.1		**10.6**	2.11		**0.08**	1333.6		**76**	84
	1 SS + HWC	46	248.5	*	**42.0**	2.92	*	**0.89**	2438.3	*	**1181**	92
	1 SS + DAP 1/2X + HWC	47	254.8	*	**48.4**	3.07	*	**1.04**	2803.9	*	**1547**	94
	1 SS + DAP 1X + HWC	38	248.3	*	**41.8**	2.97	*	**0.94**	2582.5	*	**1325**	76
	DAP 1X + HWC	47	208.7		**2.2**	2.17		**0.14**	1543.4		**286**	94
	Check	46	206.5			2.03			1257.1			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.

PINE TIP MOTH TRIALS

SilvaShield™ Operational Soil Injection Study - Western Gulf Region

Highlights:

- SilvaShield™ Forestry Tablets operationally applied by hand (Moffett 2008) significantly reduced tip moth damage in the first year (by 77%) and second year (by 69%) after application. After four growing seasons, the treatment significantly improved height, diameter, and volume growth by 21%, 31% and 82%, respectively.
- Operational treatment of second-year trees only reduced overall tip moth damage by 38% (first year after application) and 52% (second year after application) compared to untreated checks, but the treatment improved height, diameter, and volume growth by 5%, 9% and 19%, respectively, four years post treatment.
- SilvaShield™ operationally applied by hand into plant holes significantly reduced tip moth damage in the first year (by 85%), second year (by 39%), and third year (by 55%) after application. The treatment significantly improved height, diameter, and volume growth by 15%, 46% and 153%, respectively, three years post treatment.

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.

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 consisted of 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:

SilvaShield™ (one tablet) applied after planting next to each seedling to a depth of 8 inches (2008) or in plant hole (2009).
Check –seedlings planted by hand

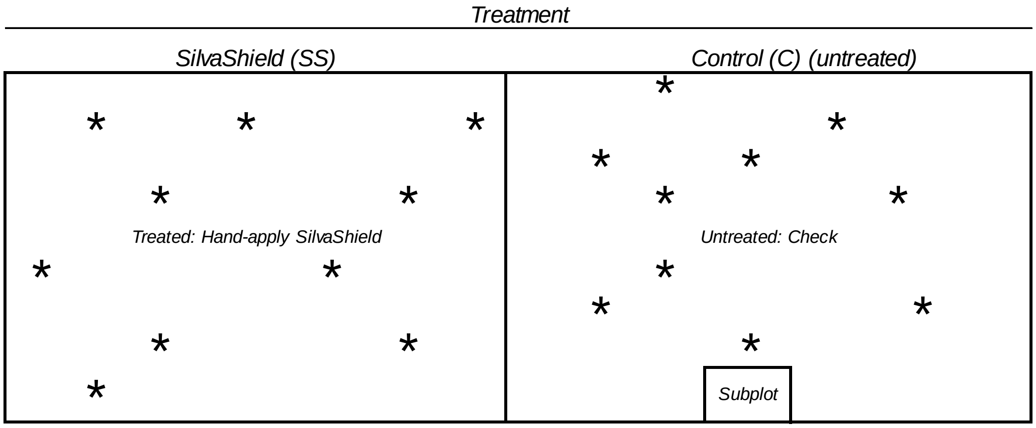
Two tracts about to be planted, and one one-year old tract, each 80 acres in size, were selected in Texas based on uniformity of soil, drainage, topography and potential susceptibility to tip moth infestation.

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 47). 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. 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 study sites were treated with herbicide after planting to minimize herbaceous and/or woody competition.

Tip moth damage was evaluated after each tip moth generation 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. Each tree was measured for diameter (at ground line) and height in the fall (November).

Efficacy was evaluated by comparing treatment differences for direct and indirect measures of insect-caused losses. Direct treatment effects consisted of a reduction in pine tip moth damage. Indirect treatment effects consisted of 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.



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

Figure 47. Generalized plot design

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 48). In contrast, the treatment provided very good protection during the second through fifth generations, reducing damaged by 74 – 85% (77% overall). During the second year, damage was reduced by 69%. The tablet treatment significantly improved all growth parameters (height, diameter, and volume) by 22%, 15%, and 54%, respectively, compared to those of check trees (Table 49). After four years, tablet–treated trees still had significantly improved growth parameters (height, diameter, and volume), by 21%, 31%, and 82%, respectively.

Tip moth populations were higher on the second-year site (Peavy) during the first generation in 2008 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 48). In contrast, the treatment provided good protection during the second through fifth generations, reducing damaged by 31 – 52% (38% overall). During the second year (third year after planting), damage was reduced by 52%. At five years post planting, the tablet-treated trees had significantly improved height, diameter, and volume index (by 5%, 9%, and 19%, respectively), compared to those of check trees (Table 50).

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 51). In contrast, the treatment provided very good protection during the second through fifth generations, reducing damaged by 65 – 90% (85% overall). During the second and third year, damaged was reduced by 39% and 55%, respectively. After three years, the tablet treatment has significantly improved tree height, diameter and volume growth parameters by 15%, 46%, and 153%, respectively, compared to those of check trees (Table 52).

Conclusions:
Data from new sites (Moffet and Rockland) indicate that SilvaShield™ tablets operationally applied by hand provided good protection against tip moth and improve growth during the second and third year after planting. 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 tree growth. The trials will be continued in 2012 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 48. 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 and 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.

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

Table 49. Effect of SilvaShield™ tablet on areawide loblolly pine growth on one site (Moffet) in the first year after planting in east Texas, 2008 - 2011.

Site	Year	Treatment	N	Height (cm)		Diameter (cm) [a]		Volume (cm^3)		Mean Percent Tree Survival
				Mean End of Season Loblolly Pine Seeding Growth Measurements (**Growth Difference (cm or cm^3) Compared to Check)**						
						at 6" above ground				
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
	2010	1 Tablet at 8"	100	219.1 *	**39.0**	4.08 *	**0.54**	4080.0 *	**1442.4**	100
		Check	100	180.1		3.54		2637.6		100
						at DBH				
	2011	1 Tablet at 8"	100	325.8 *	**55.9**	3.66 *	**0.86**	5110.5 *	**2309.2**	100
		Check	100	269.9		2.80		2801.3		100

[a] Diameter taken at 6" above ground.

Table 50. Effect of SilvaShield™ tablet on areawide loblolly pine growth on one sites (Peavy) treated in the second year after planting in east Texas, 2008 - 2011.

				Mean End of Season Loblolly Pine Seeding Growth Measurements (**Growth Difference (cm or cm^3) Compared to Check)**						
Site	Year	Treatment	N	Height (cm)		Diameter (cm) [a]		Volume (cm^3)		Mean Percent Tree Survival
						at 6" above ground				
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
						at DBH				
	2010	1 Tablet at 8"	100	419.2 *	**30.2**	5.48 *	**0.54**	13656.2 *	**2809.1**	100
		Check	100	389.0		4.94		10847.1		100
	2011	1 Tablet at 8"	100	511.2 *	**23.9**	7.07 *	**0.59**	26994.7 *	**4303.6**	100
		Check	100	487.3		6.47		22691.0		100

[a] Diameter taken at 6" above ground.

Table 51. Effect of SilvaShield™ tablet on areawide pine tip moth infestation of loblolly pine shoots (top whorl) on one site (Rockland) in east Texas, 2009, 2010 & 2011.

				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		
Rockland 2nd Yr	2010	1 Tablet in PH	100	8.8	**57**	*	9.8	**71**	*	13.5	**55**	*	42.1	**19**		48.4	**25**	*	24.5	**39**	*
		Check	100	20.6			34.0			30.1			51.8			64.7			40.2		
Rockland 3rd Year	2011	1 Tablet in PH	100	1.3	**-18**		1.2	**20**		3.4	**57**	*	2.3	**70**	*	17.8	**42**	*	4.2	**55**	*
		Check	100	1.1			1.5			7.9			7.7			30.8			9.3		

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

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

Table 52. Effect of SilvaShield™ tablet on areawide loblolly pine growth on one site (Rockland) in east Texas, 2009 and 2010.

Site	Year	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)			GLD (cm) [a]			Volume (cm^3)			
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	195.1	*	**23.9**	3.03	*	**0.49**	2361.2	*	**996.5**	100
		Check	100	171.2			2.54			1364.7			100
							DBH (cm)						
	2011	1 Tablet in PH	100	320.0	*	**41.3**	3.80		**1.20** *	6085.0	*	**3681.6**	100
		Check	100	278.7			2.60			2403.4			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 of Tested Systemic Insecticides

Fipronil: Over the past ten years (2002 – 2011), fipronil has proven to be highly effective in reducing tip moth damage to first-year pine seedlings. Further evaluations indicate that positive 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 with fipronil in the nursery, prior to lifting, is 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, at that time BASF and EPA were 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 applied at or after planting.

Two portable applicators, PTM Spot Gun™ ($140), and PTM Injection Probe™ ($420), have been successfully used to apply fipronil solution by hand. Note: A third applicator, the Kioritz™ soil injector has been discontinued. Soil injection trials established in 2005-2009 showed that soil injection treatments are consistently effective in reducing pine tip moth damage. A trial established in 2008 showed that post-plant applications of fipronil were 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 is 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. The FPMC was 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. At least one FPMC member has implemented this technique for operational treatments during the winter of 2011/2012. FPMC plans to monitor some of these sites for treatment efficacy in 2012.

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 ($\geq$99% reduction in damage), good results the second year ($\geq$52% reduction), and moderate results the third year ($\geq$ 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. BASF is now willing to consider a request to modify the PTM™ label to include use on containerized seedlings if FPMC can address concerns related to chemical leaching and worker exposure. A new trial established in 2011 indicates that the performance of plug injections of PTM™ was markedly better than post plant applications. In addition, the treatments contributed to improved seedling survival.

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 53 provides updated information about the PTM™ product (distributors, cost, etc.).

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 became 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 53 provides updated information about the SilvaShield™ 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 and 2010 indicate protection is provided through the second year but disappears in the third year. Operational applications at planting and post plant both show that these tablets are effective in reducing tip moth damage and improving tree growth.

Trials established in 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 will be monitored in 2012. An additional trial was installed in 2010 to directly compare the efficacy and duration of PTM™ and SilvaShield™. Second-year results continue to indicate that both products are highly and equally effective when applied at planting. However, SilvaShield™ generally performed better when applied post plant.

Table 53. 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*: $1,020 per case of 3 bags (contains a total of 3600 tablets); cost depends on quantity purchased.	RRS quote*: $435 per gallon (available in 2.5 gallon and 20 ounce containers); 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	**$127.50**	**$71.37**
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** Operational system available for contract work in Western Gulf area; contact Chris Dowden (phone:318-471-9529) **System for Whitfield planter** Not currently available;
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: **PTM Spot Gun** (1.2 gallon capacity) $140.00 thru RRS **PTM Injection Probe** (4.0 gallon capacity) ~$255.00 for probe assembly only ~$425.00 for gun + backpack sprayer thru aqumix.com
Recommended Quantity per Seedling	1 tablet	1.4 ml PTM + 13.6 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.

* Prices as of May 15, 2012