Forest Pest Management Cooperative

Research Accomplishments in 2012

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Forest Pest Management Cooperative Research Accomplishments in 2012: Executive Summary

The Western Gulf Forest Pest Management Cooperative (now Forest Pest Management Cooperative or FPMC) was established in 1996. This partnership between the Texas A&M Forest Service (TFS) and dues-paying members has provided research and technology transfer on major forest pests for more than 16 years under the leadership of Coordinator Dr. Donald M. Grosman. On December 31, 2012, Don resigned from TFS to join Arborjet, Inc. in Moburn, MS. However, he left the FPMC before the 2012 accomplishment report could be finalized.

Following a nation-wide search, Dr. Melissa Fischer was selected to fill the position of FPMC Coordinator, starting on September 1, 2013. Melissa comes to TFS and the FPMC with a Bachelor of Science degree in forestry and a Master's degree in silviculture /forest health, both from Northern Arizona University. She recently completed her Ph.D. in forest entomology from Virginia Tech. Her first challenge in her new position was to pull together the FPMC Research Accomplishment Report for studies conducted in 2012 and begin compiling results for CY 2013. Thanks, Dr. Fischer, for your contributions to this report.

Fortunately, when Dr. Grosman departed at the end of CY2012, he left detailed plans for research to be conducted in CY 2013, which have kept the small FPMC staff busy this year (2013). Thanks go to Bill Upton, in particular, along with other members of the FPMC staff, for keeping the field and laboratory studies on track in the absence of a Coordinator. Results of 2013 research will be compiled and analyzed for a separate report to be distributed to FPMC members early in 2014.

The attached report summarizes results of various research studies on control or prevention of seed orchard pests, pine bark beetles and oak wilt that were initiated in previous years, but were monitored for duration effects and/or growth impacts through CY2012. In addition, new studies on conifer mites, pine wood nematodes, and various evaluations of insecticides for pine tip moth were initiated in 2012. First-year results for these new studies also are reported herein.

Highlights of 2012 Research are listed below:

Seed Bug control in Pine Seed Orchards (Initiated in 2009, monitored through 2012)

- Abamectin and emamectin benzoate + two sprays showed the highest efficacy against seed bug damage in 2011, but by 2012, there was no evidence of suppression of seedbug damage in any of the treatments.
- Recommendations would be to use either abamectin or emamectin benzoate + two sprays for two years and re-treat on the third year.

Systemic Insecticide Timing, Dose Rate, and Volume for Single Tree Protection from Southern Ips Engraver Beetles (Initiated in 2011, monitored through 2012)

- The FPMC continued to evaluate the efficacy of a formulation of abamectin, for preventing attacks and brood production of Ips engraver beetles and wood borers on bolt sections of loblolly pine in East Texas.
- All three rates (0.4, 0.2 and 0.1 g AI/inch DBH) of Abacide 2 (2%AI) applied in the fall and spring were highly effective against Ips engraver beetles and wood borers 14 and 20 months after injection.
- All three rates (0.2, 0.1 and 0.05 g AI/inch DBH) of Abba Ultra (4%AI) applied in the spring were highly effective against Ips engraver beetles and wood borers 1, 4 and 7 months after injection.

Evaluation of Microinjection Systems for Application of Propiconazole to Manage Oak Wilt in Live Oak in Central Texas (Initiated in 2011, monitored through 2012)

- 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. 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 were evaluated for their ability to prevent development of oak wilt symptoms after inoculation with the oak wilt fungus *Ceratocystis fagacearum*. Nearly eighteen months after injection, disease symptoms were observed on 83% of the study trees that received no fungicide treatments (checks). In contrast, symptom expression was observed on 25 - 50% of fungicide-treated trees as of December 2012. Trees treated with Tree IV had the lowest incidence of oak wilt symptoms (25%). Evaluations will continue in 2013.

Incorporating Emamectin Benzoate into Control Strategies for the Southern Pine Beetle (Initiated in 2012)

- The FPMC initiated a trial in 2012 to evaluate the ability of emamectin benzoate (EB)-treated trap trees to manage southern pine beetle (SPB) populations at low levels in Alabama and Virginia.
- First year results indicate that baited EB-treated trees can absorb SPB in low population levels (<2.0 SPB/trap/day) areas (VA). However, trap trees cannot maintain attraction to SPB at higher population levels (3.0+ SPB/trap/day) areas (AL), resulting in "spill over" attacks and tree mortality outside treated plots.
- These results were used to develop a new protocol for 2013 trials.

Emamectin Benzoate and Propiconazole for Protection of Black Walnut from Walnut Twig Beetle and Thousand Canker Disease (Initiated in 2012)

- Treatments of emamectin benzoate, propiconazole, and emamectin benzoate + propiconazole were applied to black walnut trees in TN and TX in 2012 to determine their efficacy in protecting trees from attack by the walnut twig beetle (WTB) and the development of thousand canker disease.
- The studies are to be continued in 2013.

Occurrence and Seasonality of Pine Wood Nematode in Loblolly Pine Trees and Logs (Initiated in 2012)

- Pinewood nematodes are not present in live standing trees.
- One-third to nearly one-half of the adult *Monochamus* females carry PWN.
- Inoculation of PWN into loblolly pine can occur within hours of tree felling, particularly in the summer.
- Exposure of cut logs to direct sunlight, particularly in the summer, reduced PWN and blue stain occurrence in loblolly pine logs.
- Given the zero tolerance for presence of PWN in logs destined for export, just debarking logs does not appear to reduce risk of exporting infected logs.
- Emamectin benzoate (EB) is highly effective against PWN. Perhaps logs could be sprayed immediately after debarking to ensure clean logs for export. This option is being considered for feasibility by Syngenta Crop Science. Alternatively, EB could be injected into trees prior to harvest thus eliminating need to fumigate or debark logs prior to export.
- This study will be continued in 2013.

Evaluation of Bait Formulations for Attraction and Control of Texas Leaf-Cutting Ant (Initiated in 2012)

- There was no significant difference among the treatments in the weight difference of the baits or in the number of bait particles retrieved in 2012 preference trials of several new Syngenta leaf cutting ant bait formulations.
- Efficacy trials of these baits for control of leaf cutting ants are scheduled for 2013.

Evaluation of TREE-äge™ and Eco-Mite for Control of Conifer Mites on Loblolly Pine (Initiated in 2012)

- The TREE-äge treatment was statistically different (and lower) than the untreated controls ($p<0.05$), based on abundance of conifer mites in treated and untreated pines at the end of the 2012 season.
- The ECO-mite treatment was statistically different (and lower) than the untreated controls ($p<0.05$) on all dates following treatment.
- Trees will continue to be monitored through 2013 to determine the long-term efficacy of treatments against conifer mites.
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Pine Tip Moth Trials: Evaluation of Fipronil Treatments for Containerized Pine Seedlings (Initiated in 2007, monitored through 2012)

- In 2011, all treatments applied in 2007 continued to significantly improve height growth compared to check trees. However, diameter and volumes were only significantly greater for container 5X and bare-root injection. Volume growth improvements attributed to fipronil treatments ranged from 14-63%.

- In 2012, only container 5X and bare-root injection significantly improved height, diameter, and volume growth. Volume growth improvements attributed to fipronil treatments ranged from 0.1-40%.

<u>Pine Tip Moth Trials: Imidacloprid Tablet Trials: Western Gulf Region</u> (Initiated in 2007, monitored through 2012)

- In 2012, all Imidacloprid Tablet treatments applied once in 2007 continued to significantly improve growth parameters of treated trees compared to those of the control trees.

<u>Pine Tip Moth Trials: SilvaShieldTM Operational Soil Injection Study – Western Gulf Region</u> (Initiated in 2008, monitored through 2012)

- Data indicate that SilvaShield^{TM} Tablets operationally applied by hand provide good protection against tip moth and improve growth up to the fifth year after planting. Additional data indicate that Tablets applied to one-year-old trees are not quite as effective against tip moth, but the treatments can still significantly improve tree growth.

<u>Pine Tip Moth Trials: Comparison of PTM^{TM} and SilvaShield^{TM} for Control of Pine Tip Moth</u> (Initiated in 2010, monitored through 2012)

- In 2012, tip moth populations were high through most of the 3rd year, with damage levels ranging from 11% of the shoots infested after generation 1 to 90% after generation 5 (Table 37). Only the three SilvaShield (SS) treatments applied at planting showed a significant reduction in tip moth infestation of top whorl shoots compared to the control for all five generations.
- Analysis of variance found that SS "at plant" and "post plant" provided significantly better protection than PTM^{TM} both "at plant" and "post plant."
- Some of the treatments showed a significant improvement in tree height growth and diameter (measured as both GLD and DBH) compared to control trees, there was no difference in volume (Tables 40 [GLD] and 41 [DBH]).

<u>Pine Tip Moth Trials: Evaluation of Fipronil Treatments for Second-Year Pine Seedlings: East Texas</u> (Initiated in 2010, monitored through 2012)

- In 2011, tip moth populations were generally low (3-11%) through the first four generations but increased to 57% in the fifth generation. 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^{TM} 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, 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.

- In 2012, only tree growth was assessed. All treatments resulted in significant improvement in height, diameter (measured at DBH), and volume compared with the controls.

<u>Pine Tip Moth Trials: Evaluation of PTM™ Treatments for Containerized Pine Seedlings</u> (Initiated in 2011, monitored through 2012)

- In 2012, tip moth populations were variable, with low damage levels on checks in FL (5% on container & 10% on bare root) to 58% on bare root seedlings in LA.
- PTM applied to containers after planting reduced overall tip moth damage by 43% compared to untreated checks. This was only 5% and 7% better than protection provided by PTM injected into container seedling plugs before planting and PTM applied to bare root seedlings after planting, respectively.
- Almost all PTM treatments significantly improved height, diameter, and volume. Only the containerized high-dilution and bareroot high-dilution treatments applied to the soil after planting did not show significant improvement in diameter growth. The bare root high dilution treatment applied to the soil after planting did not show significant improvement in volume either.
- Mean volume improvement for plugs treated prior to planting was increased by 39% compared to checks. This was 16% higher than volume increase observed on post-plant treated seedlings.
- None of the PTM treatments significantly improved survival compared to untreated checks. Mean survival of pre-plant treated seedlings was 9.2% better than checks, and that of post-plant treated seedlings; 5.2%.

<u>Pine Tip Moth Trials: Evaluation of Plug Injection System for Application of PTMTM and Insignia®SC for Containerized Pine Seedlings</u> (Initiated in 2012)

- All PTM and/or Insignia treatments of containerized seedling plugs significantly reduced overall tip moth damage (mean reduction/ all treatments: 86.3%) compared to the untreated control. For bare root seedlings, all treatments that used PTM significantly reduced overall tip moth damage (mean reduction/ all treatments: 71.5%) compared to the untreated control, while the two bareroot treatments using Insignia only did not significantly reduce tip moth damage.
- Treatments 2 (Containerized: PTM, mid-concentration), 3 (Containerized: PTM and Insignia, mid-concentration), and 5 (Containerized: PTM, low-concentration & Insignia, mid-concentration) were found to have significantly lower mean percent infestations compared with the other treatments.
- Only treatments 2 (containerized: PTM, mid-concentration), 4 (containerized: PTM, low-concentration), and 8 (bare root: PTM mid-concentration) were found to result in significantly improved height, diameter, and volume compared with the controls. Percent tree survival was slightly increased compared with controls in the case of two containerized seedling treatments, while four of the bare root seedling treatments showed a decrease in percent tree survival compared with the control.

<u>Pine Tip Moth Trials: Evaluation of PTM™ and Insignia®SC Rate for Bare Root Pine Seedlings</u> (Initiated in 2012)

- All PTM and PTM + Insignia treatments significantly reduced overall percent tip moth infestation compared to the control (by 78% and 75% respectively) (Table 52, Figure 26). Insignia treatments alone resulted in an overall reduction in pine tip moth infestation by only 2%.
- None of the treatments resulted in a significant improvement in diameter. All three PTM treatments and the PTM + Insignia low concentration treatment resulted in a significant improvement in height.
- Volume was only significantly improved in the case of the low and high concentration PTM treatments.

Pine Tip Moth Trials: Machine Planter Evaluation in a Flex Stand Situation
(Initiated in 2012)

- Percent infestation of loblolly pine by pine tip moth was low at the two sites (LA) in 2012; the highest percentage occurred at the end of generation four on untreated trees at close to 30%. There was no significant difference between PTM treated trees and control trees in the percent of top whorl shoots infested by tip moth.
- There was a significant difference in height, volume, and growth of the PTM vs. untreated trees, but this is likely due to the fact that these trees are of improved genetic stock.

Potential Insecticides for Seed Bug Control in Pine Seed Orchards

(Initiated in 2009)

Highlights:

- Abamectin and emamectin benzoate + two sprays showed the highest efficacy against seed bug damage in 2011, but by 2012, there was no evidence of suppression of seedbug damage in any of the treatments.
- Recommendations would be to use either abamectin or emamectin benzoate + two sprays for two years and re-treat on the third year.

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.
2. Determine the duration of treatment efficacy.

Study Sites: ArborGen's Woodville Seed Orchard, Woodville Texas (Tyler Co.) and 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 (B 1 a and B 1 b)
- 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 affects 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 block 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. 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. Imidicloprid (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) - 0.4 g AI per inch DBH of tree in Fall 2009
5. Chlorantraniliprole (Acelepryn, DuPont) - 0.4 g AI per inch DBH of tree in Fall 2009
6. Azadiractin (TreeAzin®, BioForest Tech.) - 0.4 g AI per inch DBH of tree in Fall 2009
7. Acephate (Ace-jet™, Arborjet) - 0.4 g AI per inch DBH of tree in Spring 2010
8. Fipronil (BASF) - 0.4 g 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. Control

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, two applications of Asana® XL, were applied to foliage in April and July using a hydraulic sprayer at 10 gal/tree. The distance between test trees was ≥ 20 m to minimize the effects of drift.

Data Collection:

Seed bug damage to cones: 10 healthy second-year cones were picked at random from all healthy cones collected from each ramet in September 2010, 2011 and 2012. 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:

Evaluation of seed lots in the third year following treatment (2012) showed that none of the treatments reduced the percentage of damaged seed in cones compared to the controls (Table 1).

Conclusions:

In 2010, imidicloprid showed the highest significant efficacy against seed bug damage. In 2011, abamectin and emamectin benzoate + two sprays showed the highest efficacy against seed bug damage. By 2012, there was no evidence of suppression of seedbug damage in any of the treatments.

Recommendations would be to use either abamectin, or emamectin benzoate + two sprays for two years and re-treat on the third year.

Acknowledgments:

We greatly appreciate the assistance provided by Steve Smith, Weyerhaeuser, and Lance Nettles, ArborGen. We thank Arborjet, Inc., Mauget, Syngenta, Bioforest Technologies, BASF, and Dupont for the financial support, chemical donations, and/or loans of injection equipment.

Table 1. Seedbug damage (mean ± SE) from second-year cones of loblolly pine and slash pine protected with trunk injections of different systemic insecticides, Woodville, TX, 2010, 2011, & 2012.

			Mean Seed Bug Damage (%) to:			
Year	**Treatment**	**N**	**Early (2nd Yr Abort)**	**Late**	**Total**	**Mean No. Filled Seed per Cone**
	Abamectin	7	3.8 ± 2.0	27.7 ± 5.3	31.6 ± 5.3	90.7 ± 7.3
	Acephate	7	8.5 ± 6.2	27.7 ± 6.7	36.2 ± 6.9	82.8 ± 8.8
	Acelopryn	7	7.1 ± 2.7	35.6 ± 5.1	42.7 ± 4.6	73.0 ± 8.8
	Azadirachtin	7	10.9 ± 3.0	27.5 ± 5.7	38.4 ± 7.9	77.3 ± 10.4
	Dinotefuran	4	2.0 ± 0.7	17.1 ± 5.6*	19.1 ± 5.3*	114.2 ± 13.9*
2010	Emamectin benzoate	6	2.2 ± 0.5	25.2 ± 4.7	27.4 ± 4.5*	90.2 ± 7.3
	Emamectin benzoate + 2 Sprays	7	2.8 ± 0.6	25.9 ± 4.2	28.7 ± 4.3*	85.1 ± 5.0
	Fipronil	7	3.9 ± 1.3	33.4 ± 7.1	37.3 ± 7.4	81.4 ± 9.1
	Imidacloprid	***7***	***1.8 ± 0.4****	***20.5 ± 3.5****	***22.3 ± 3.4****	***99.0 ± 6.4****
	Control	7	7.4 ± 2.3	34.0 ± 3.8	41.3 ± 3.7	73.2 ± 4.9
	Abamectin	**6**	**1.4 ± 0.4***	**18.0 ± 4.2***	**19.4 ± 4.1***	**102.9 ± 4.7***
	Acephate	---	-----	-----	-----	-----
	Acelopryn	5	7.2 ± 3.2	19.2 ± 3.6*	26.4 ± 3.8	92.6 ± 9.5
	Azadirachtin	---	-----	-----	-----	-----
	Dinotefuran	3	7.3 ± 2.3	24.5 ± 10.4	31.9 ± 9.7	82.9 ± 13.2
2011	Emamectin benzoate	4	1.7 ± 0.7	21.3 ± 5.8	23.0 ± 5.3	104.1 ± 7.1*
	Emamectin benzoate + 2 Sprays	***7***	***1.1 ± 0.2****	***18.2 ± 3.9****	***19.2 ± 4.0****	***107.4 ± 6.7****
	Fipronil	7	4.0 ± 1.0	22.0 ± 2.7	26.0 ± 2.9	83.0 ± 5.2
	Imidacloprid	7	3.5 ± 1.0	19.8 ± 3.3*	23.3 ± 3.4*	101.7 ± 6.9*
	Control	7	5.1 ± 1.0	29.7 ± 3.8	34.9 ± 4.2	79.7 ± 7.1
	Abamectin	6	15.3 ± 3.4	37.43 ± 4.6	52.73 ± 4.4	33.80 ± 4.1
	Acephate	---	-----	-----	-----	-----
	Acelopryn	5	27.89 ± 7.7	27.24 ± 2.3	55.13 ± 7.2	16.4 ± 4.6
	Azadirachtin	---	-----	-----	-----	-----
2012	Dinotefuran	---	-----	-----	-----	-----

Emamectin benzoate	4	19.18 ± 5.9	31.94 ± 2.4	51.11 ± 7.0	27.70 ± 10.4
Emamectin benzoate + 2 Sprays	---	-----	-----	-----	-----
Fipronil	---	-----	-----	-----	-----
Imidacloprid	7	17.69 ± 6.8	36.62 ± 5.1	54.31 ± 6.5	25.47 ± 8.1
Control	6	19.60 ± 3.1	32.54 ± 4.0	52.13 ± 3.8	23.63 ± 5.6

* Asterisks represent means that are significantly different from the checks at the 5% level based on Fisher's Protected LSD

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

(Initiated in 2011)

Highlights:

- The FPMC continued to evaluate the efficacy of a formulation of abamectin, for preventing attacks and brood production of Ips engraver beetles and wood borers on bolt sections of loblolly pine in East Texas.
- All three rates (0.4, 0.2 and 0.1 g AI/inch DBH) of Abacide 2 (2%AI) applied in the fall and spring were highly effective against Ips engraver beetles and wood borers 14 and 20 months after injection.
- All three rates (0.2, 0.1 and 0.05 g AI/inch DBH) of Abba Ultra (4%AI) applied in the spring were highly effective against Ips engraver beetles and wood borers 1, 4 and 7 months 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 (2% AI)
- Abba Ultra (4% AI), JJ Mauget) – a mixture of avermectin B1a and B1b; fermentation products from soil bacterium *Streptomyces avermitilis*.

Research Approach:
Loblolly pine trees, 15 – 20 cm DBH, were selected. Thirty trees were each injected with one of two abamectin formulations: Abacide 2 (October 2010 or April 2011) at three different rates (0.1g, 0.2g, or 0.4g per 1 inch of tree diameter), or Abba Ultra (March 2012) at three different rates (0.05, 0.1g, or 0.2g 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 treatment were felled and one 1.5 m-long bolt was removed at 3 m height.

Treatments:

Trial 1: 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
3	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 2: Established March 2012

Trt #	Chemical	Formulation	Application Timing	Rate (g ai/inch dbh)	No. of Trees Treated	Felling Dates
1	Abamectin	Abba Ultra	Mar-12	0.2	30	Apr, Jul & Oct '12
2	Abamectin	Abba Ultra	Mar-12	0.1	30	Apr, Jul & Oct '12
3	Abamectin	Abba Ultra	Mar-12	0.05	30	Apr, Jul & Oct '12
4	Untreated				30	Apr, Jul & Oct '12

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 Fisher's Protected LSD test using the Statview statistical program.

Results:

Trial 1: Abacide 2

In 2012, the total number of attacks by male *Ips* engraver beetles did not differ among the abamectin treatments (Table 2). 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 treatments had significantly fewer nuptial chambers with egg galleries (Table 2). All abamectin treatments completely prevented brood development compared to check trees (Tables 3 and 4, Figure 1).

The attack level of wood borers (egg niches) on logs from most treated trees did not differ from that on check logs (Table 5). Only cerambycid attacks on mid-rate abamectin trees treated in the fall were higher than those on checks. A low level of cerambycid feeding (8%) occurred on untreated bolts during the 3-week period between tree felling and bolt evaluation (Table 5). All abamectin treatments completely prevented cerambycid larval development compared to the check.

Trial 2: Abba Ultra

Abba-Ultra is more viscous than Abacide 2. Thus, injection times were longer. Dilution of this formulation in water (1:1) improved uptake, but eliminates the benefit of using a higher concentration formulation.

The total number of attacks by male *Ips* engraver beetles did not differ among the abamectin treatments (Table 6). 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 treatments had significantly fewer nuptial chambers with egg galleries (Table 6). All abamectin treatments completely prevented brood development compared to check trees (Tables 7 and 8, Figure 2).

The attack level of wood borers (egg niches) on logs from most injected trees did not differ from that on check logs (Table 9). A low level of cerambycid feeding (9%) occurred on untreated bolts during the 3-week period between tree felling and bolt evaluation (Table 9). All abamectin treatments reduced the amount of wood borer larval feeding and development compared to the check.

Conclusions:

The trials continue to show that abamectin is highly effective for extended periods. No significant differences in the efficacy of Abacide 2 at the three rates were observed 20 months after injection. This trial will be continued into 2013.

Lower volumes of a higher concentration formulation (Abba Ultra) are also highly effective against engraver beetles and cerambycids 6 months after injection.

Acknowledgments: Many thanks go to Doug Long, Rayonier, and Bill Stansfield, The Campbell Group, for providing thinned stands for the project. We thank JJ Mauget, Inc. for the financial support and donation of chemical and Arborjet for loan of injection equipment.

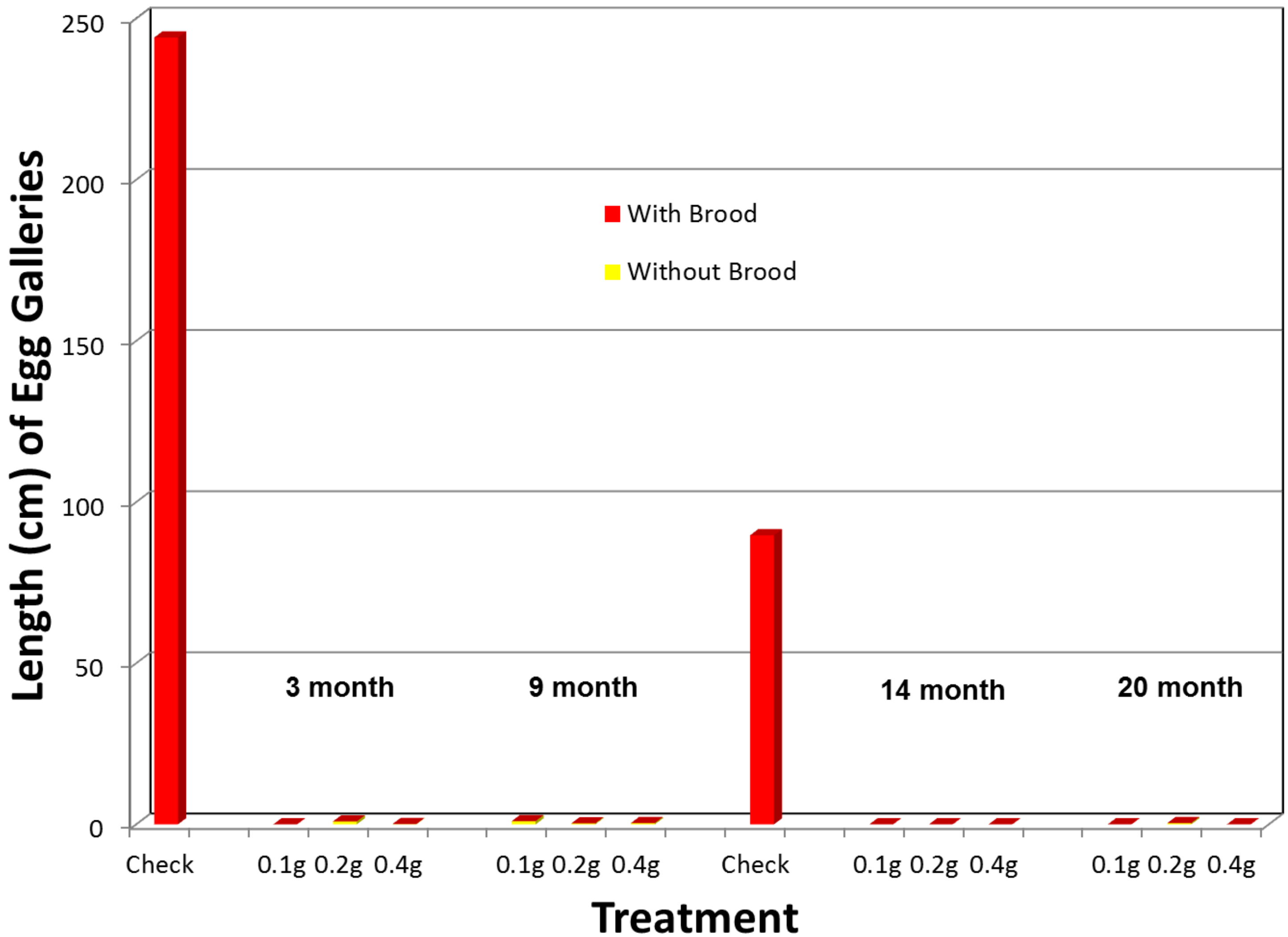

Figure 1. Mean length of egg galleries (with and without brood) constructed by *Ips* engraver beetles (per 1000 cm^2) in loblolly pine bolts cut 3 to 20 months after injection with three rates of abamectin (Abacide 2, 2%) using the Tree IV Injection System; Lufkin, TX: 2011 - 2012.

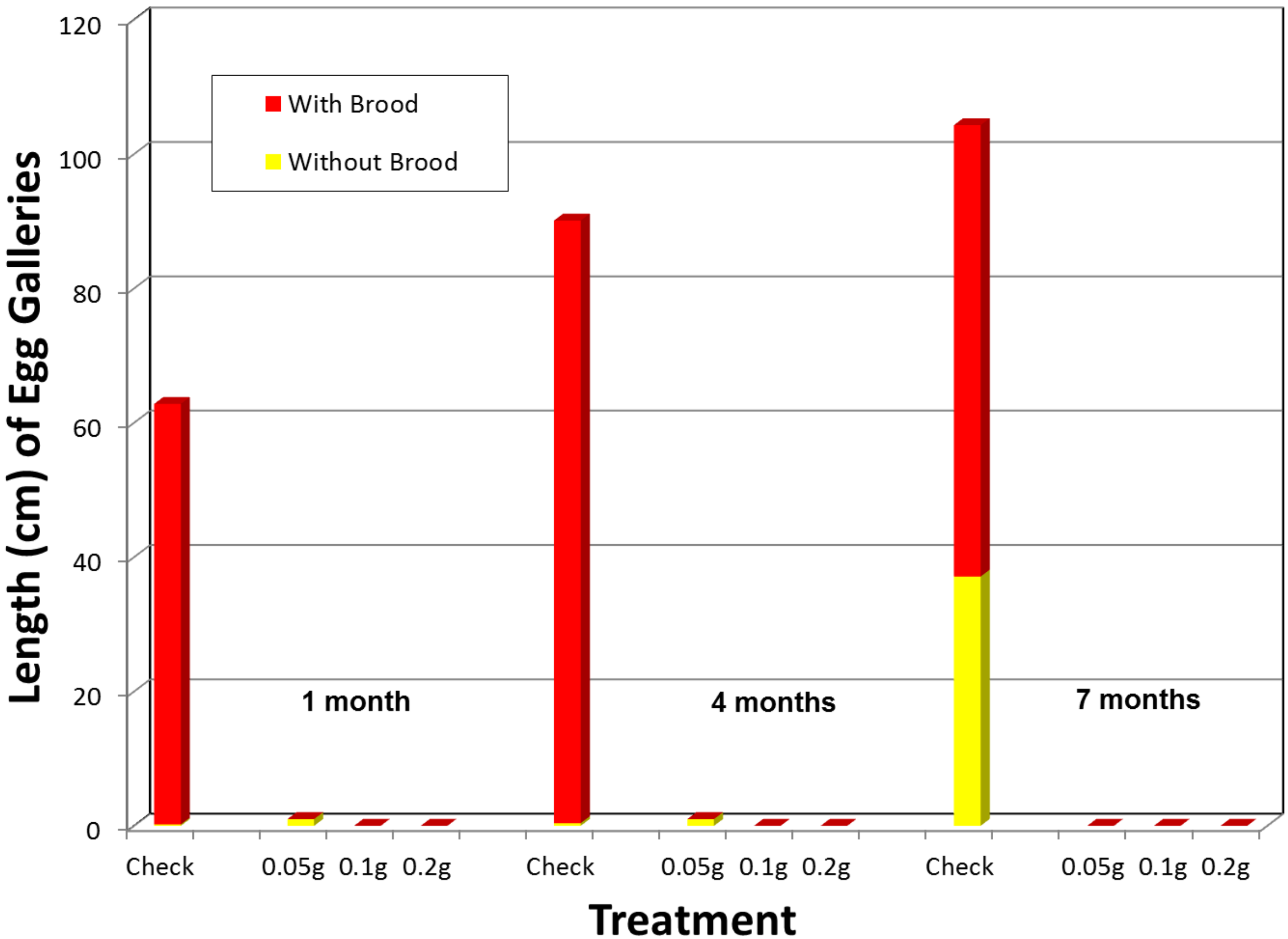

Figure 2. Mean length of egg galleries (with and without brood) constructed by *Ips* engraver beetles (per 1000 cm^2) in loblolly pine bolts cut 1 to 7 months after injection with three rates of abamectin (Abba Ultra, 4%) using the Tree IV Injection System; Lufkin, TX: 2011 - 2012.

Table 2: Attack success and gallery construction of *Ips* engraver beetles on loblolly pine bolts cut 3 to 20 months after trunk injection with Abacide 2 using the Tree IV injection system; Lufkin, Texas: 2011-2012.

Evaluation period	Season/Yr. Injected	Treatment	N	Mean # of nuptial chambers without egg galleries No.	Mean # of nuptial chambers without egg galleries % of total	Mean # of nuptial chambers with egg galleries No.	Mean # of nuptial chambers with egg galleries % of total	Mean total # of nuptial chambers
3 month post-injection (Aug. '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 (Aug. '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
14 month post-injection (Jul. '12)	Spring 2011	Aba 0.4 g AI	10	1.7 *	100	0.0 *	0	1.7
		Aba 0.2 g AI	10	2.2 *	100	0.0 *	0	2.2
		Aba 0.1 g AI	10	2.2 *	100	0.0 *	0	2.2
20 month post-injection (Jul. '12)	Fall 2010	Aba 0.4 g AI	10	2.5 *	100	0.0 *	0	2.5
		Aba 0.2 g AI	10	2.3 *	100	0.0 *	0	2.3
		Aba 0.1 g AI	10	2.2 *	100	0.0 *	0	2.2
		Check	10	0.0	0	2.1	100	2.1

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

Table 3: Mean number of egg galleries constructed by *Ips* engraver beetles (per 1000 cm^2) in loblolly pine bolts cut 3 to 20 months after trunk injection with abamectin using the Tree IV injection system; Lufkin, Texas: 2011-2012.

				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 (Aug. '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 (Aug. '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
14 month post-injection (Jul. '12)	Spring 2011	Aba 0.4 g AI	10	0.0	#####	0.0 *	#####	0.0 *
		Aba 0.2 g AI	10	0.0	#####	0.0 *	#####	0.0 *
		Aba 0.1 g AI	10	0.0	#####	0.0 *	#####	0.0 *
20 month post-injection (Jul. '12)	Fall 2010	Aba 0.4 g AI	10	0.0	#####	0.0 *	#####	0.0 *
		Aba 0.2 g AI	10	0.1	100	0.0 *	0	0.1 *
		Aba 0.1 g AI	10	0.0	#####	0.0 *	#####	0.0 *
		Check	10	0.1	2	6.0	98	6.1

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

Table 4: Mean length of egg galleries constructed by *Ips* engraver beetles (per 1000 cm^2) in loblolly pine bolts cut 3 to 20 months after trunk injection with abamectin using the Tree IV injection system; Lufkin, Texas: 2011-2012.

				Length of egg galleries				
				Without larvae		With larvae		
Evaluation period	Season/Yr. Injected	Treatment	N	cm	% of Total	cm	% of Total	Total length
3 month post-injection (Aug. '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 (Aug. '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
14 month post-injection (Jul. '12)	Spring 2011	Aba 0.4 g AI	10	0.0	#####	0.0 *	#####	0.0 *
		Aba 0.2 g AI	10	0.0	#####	0.0 *	#####	0.0 *
		Aba 0.1 g AI	10	0.0	#####	0.0 *	#####	0.0 *
20 month post-injection (Jul. '12)	Fall 2010	Aba 0.4 g AI	10	0.0	#####	0.0 *	#####	0.0 *
		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 *
		Check	10	0.4	0	89.7	100	90.1

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

Table 5: Extent of feeding by cerambycid larvae (per 1000 cm^2) in loblolly pine bolts cut 3 to 20 months after trunk injection with abamectin using the Tree IV injection systems; Lufkin, Texas: 2011-2012.

Evaluation period	Season/Yr. Injected	Treatment	N	No. of cerambycid egg niches on bark		Percent phloem area consumed by larvae	
3 month post-injection (Aug. '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 (Aug. '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	
14 month post-injection (Jul. '12)	Spring 2011	Aba 0.4 g AI	10	2.6		0.0	*
		Aba 0.2 g AI	10	2.7		0.0	*
		Aba 0.1 g AI	10	2.5		0.1	*
20 month post-injection (Jul. '12)	Fall 2010	Aba 0.4 g AI	10	2.4		0.0	*
		Aba 0.2 g AI	10	2.1	*	0.0	*
		Aba 0.1 g AI	10	2.4		0.0	*
		Check	10	3.4		7.6	

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

Table 6: Attack success and gallery construction of *Ips* engraver beetles on loblolly pine bolts cut 1 to 7 months after trunk injection with abamectin (Aba-Ultra) using the Tree IV injection system; Lufkin, Texas: 2012.

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	
1 month post-injection (Apr. '12)	Mar-12	Aba 0.2 g AI	10	2.2 *	98	0.0 *	0	2.2
		Aba 0.1 g AI	10	2.4 *	100	0.0 *	0	2.4
		Aba 0.05 g AI	10	2.7 *	93	0.2 *	7	2.9
		Check	10	0.1	5	2.1	95	2.2
4 month post-injection (Jul. '12)	Mar-12	Aba 0.2 g AI	10	1.9 *	100	0.0 *	0	1.9
		Aba 0.1 g AI	10	2.5 *	100	0.0 *	0	2.5
		Aba 0.05 g AI	10	2.6 *	100	0.0 *	0	2.6
		Check	10	0.0	0	2.1	100	2.1
7 month post-injection (Oct. '12)	Mar-12	Aba 0.2 g AI	10	3.7 *	100	0.0 *	0	3.7
		Aba 0.1 g AI	10	5.0 *	100	0.0 *	0	5.0
		Aba 0.05 g AI	10	4.4 *	100	0.0 *	0	4.4
		Check	10	0.0	0	4.7	100	4.7

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

Table 7: Mean number of egg galleries constructed by *Ips* engraver beetles (per 1000 cm^2) in loblolly pine bolts cut 1 to 7 months after trunk injection with abamectin using the Tree IV injection system; Lufkin, Texas: 2012.

				Number of egg galleries				
				Without larvae		With larvae		
Evaluation period	Season/Yr. Injected	Treatment	N	No.	% of total	No.	% of Total	Total #
1 month post-injection (Apr. '12)	Mar-12	Aba 0.2 g AI	10	0.0	#####	0.0 *	#####	0.0 *
		Aba 0.1 g AI	10	0.0	#####	0.0 *	#####	0.0 *
		Aba 0.05 g AI	10	0.5 *	100	0.0 *	0	0.5 *
		Check	10	0.1	1	8.0	99	8.1
4 month post-injection (Jul. '12)	Mar-12	Aba 0.2 g AI	10	0.0	#####	0.0 *	#####	0.0 *
		Aba 0.1 g AI	10	0.0	#####	0.0 *	#####	0.0 *
		Aba 0.05 g AI	10	0.2	100	0.0 *	0	0.2 *
		Check	10	0.1	2	6.3	98	6.4
7 month post-injection (Oct. '12)	Mar-12	Aba 0.2 g AI	10	0.0	#####	0.0 *	#####	0.0 *
		Aba 0.1 g AI	10	0.0	#####	0.0 *	#####	0.0 *
		Aba 0.05 g AI	10	0.0	#####	0.0 *	#####	0.0 *
		Check	10	5.8	46	6.8	54	12.6

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

Table 8: Mean length of egg galleries constructed by *Ips* engraver beetles (per 1000 cm^2) in loblolly pine bolts cut 1 to 7 months after trunk injection with abamectin using the Tree IV injection system; Lufkin, Texas: 2012.

				Length of egg galleries				
				Without larvae		With larvae		
Evaluation period	Season/Yr. Injected	Treatment	N	cm	% of Total	cm	% of Total	Total length
1 month post-injection (Apr. '12)	Mar-12	Aba 0.2 g AI	10	0.0	#####	0.0 *	#####	0.0 *
		Aba 0.1 g AI	10	0.0	#####	0.0 *	#####	0.0 *
		Aba 0.05 g AI	10	1.0	100	0.0 *	0	1.0 *
		Check	10	0.2	0	62.6	100	62.8
4 month post-injection (Jul. '12)	Mar-12	Aba 0.2 g AI	10	0.0	#####	0.0 *	#####	0.0 *
		Aba 0.1 g AI	10	0.0	#####	0.0 *	#####	0.0 *
		Aba 0.05 g AI	10	1.0	100	0.0 *	0	1.0 *
		Check	10	0.4	0	89.7	100	90.1
7 month post-injection (Oct. '12)	Mar-12	Aba 0.2 g AI	10	0.0	#####	0.0 *	#####	0.0 *
		Aba 0.1 g AI	10	0.0	#####	0.0 *	#####	0.0 *
		Aba 0.05 g AI	10	0.0	#####	0.0 *	#####	0.0 *
		Check	10	37.1	36	67.2	64	104.3

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

Table 9: Extent of feeding by cerambycid larvae (per 1000 cm^2) in loblolly pine bolts cut 1 to 6 months after trunk injection with abamectin using the Tree IV injection systems; Lufkin, Texas: 2012.

Evaluation period	Season/Yr. Injected	Treatment	N	No. of cerambycid egg niches on bark	Percent phloem area consumed by larvae	
1 month post-injection (Apr. '12)	Mar-12	Aba 0.2 g AI	10	1.5	0.0	
		Aba 0.1 g AI	10	2.4	0.0	
		Aba 0.05 g AI	10	2.2	0.1	
		Check	10	2.3	0.5	
4 month post-injection (Jul. '12)	Mar-12	Aba 0.2 g AI	10	2.3	0.0	*
		Aba 0.1 g AI	10	2.9	0.0	*
		Aba 0.05 g AI	10	2.3	0.2	*
		Check	10	3.4	7.6	
7 month post-injection (Oct. '12)	Mar-12	Aba 0.2 g AI	10	5.4	0.0	*
		Aba 0.1 g AI	10	4.7	0.0	*
		Aba 0.05 g AI	10	4.2	0.0	*
		Check	10	7.2	9.3	

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

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

(Initiated in 2011)

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. 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 were evaluated for their ability to prevent development of oak wilt symptoms after inoculation with the oak wilt fungus *Ceratocystis fagacearum*. Nearly eighteen months after injection, disease symptoms were observed on 83% of the study trees that received no fungicide treatments (checks). In contrast, symptom expression was observed on 25 - 50% of fungicide-treated trees as of December 2012. Trees treated with Tree IV had the lowest incidence of oak wilt symptoms (25%). Evaluations will continue in 2013.

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 during a 18 month period after injection.

Cooperators:

James N. Houser	Texas A&M Forest Service, Austin, TX
Dr. David Appel	Department of Plant Pathology, Texas A&M University, College Station, TX
Mr. Robert Edmonson	Texas Forest Service, Johnson City, TX
Mr. Gene Gehring	Urban Renewal, Arlington, TX
Mr. Joseph Doccola	Arborjet, Inc., Woburn, MA
Mr. Jim Redicker	Scenic Hills Nursery, Kerrville, TX
Ms. Marianne Waindle	JJ Mauget, Arcadia, CA
Mr. Chip Doolittle	ArborSystems, Omaha, NE
Mr. Shawn Bernick	Rainbow Treecare Scientific Advancements, Minnetonka, MN
Mr. Jerry Pulley	Tree Clinic, Austin, TX
Dr. David Cox	Syngenta Crop Protection, Madera, CA
Mr. Bruce Fairchild	Private landowner near Johnson City, TX
Dr. Robert Conner	Private landowner near Fredericksburg, TX
Mr. David Kuhlken	Private landowner near Stonewall, TX

Research Approach:

The following **s**ix injection/infusion systems were evaluated:

- 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 pt)
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 as of 18 months after oak wilt inoculation (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. 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 within the past year to stop the spread of oak wilt) 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 was be necessary to re-inoculate trees in May, 2012 and third time in June 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 were initially evaluated for crown condition every 4 weeks. The date of oak wilt symptom (veinal chlorosis and necrosis, leaf drop, thinning crown) appearance was recorded and then switched to once every 12 weeks thereafter for 80 weeks (18 months). Each oak crown was 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 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 or 3 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 or 3. The test will be invalidated if fewer than 60% of the control trees reach a crown rating of 2 or 3.

Results:

Field evaluations of injection systems were performed May 17, 18, and 19, 2011. Three (Tree IV, Pine 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 10). 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 or Portle) than to inject a diluted (Pine Infuser, Tree IV, Chemjet and Macro) solution. However, higher pressure systems (> 40 psi; Portle, Tree IV, and Pine Infuser) were able to push product into the tree faster than were lower pressure systems (Chemjet, Macro-Infusion and Mauget). 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), Pine Infuser (3.0 ml/minute), Chemjet (0.4 ml/minute), and Mauget (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 11 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 after 18 months). The criteria had a value ranging from 2 to 30 points.

The Tree IV system (Arborjet) accumulated the greatest number of points (74, Figure 3), 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), requires 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.

Arborjet's Tree IV

Chemjet

The Chemjet system (Chemjet Trading) was second with 67 points. It has several attractive features including that it is inexpensive, the system 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.

The Mauget capsules system was third with 66 points. Advantages include the system is prepackaged, low cost 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 may be more limited by weather restrictions (cold or dry conditions) than are other higher pressure systems.

Rainbow Treecare's Pine Infuser

Mauget's Capsules

The Pine Infuser (Rainbow Treecare) 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.

The Portle System (ArborSystem) was fifth with 51 points. Its attractive features are that the product is 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.

Rainbow Treecare's Macro-Infusion

ArborSystems' Direct-Inject Portle

The Macro-Infusion (Rainbow Treecare) system was sixth with 44 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 takes longer compared to other systems evaluated.

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 appeared to have 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 4). The positions of newly infected trees relative to the old oak wilt centers suggest that all trees were infected naturally. As of February 2012, the Tree IV system was the only one without symptomatic trees. However, this may be due more to position of treated trees relative to the oak wilt center than due to efficacy of the treatment. Three trees treated via the Macro-Infusion system exhibited oak wilt symptoms by February, but the mean level of defoliation at this time was relatively light (25%) compared to the higher levels (35 – 70%) of defoliation observed on symptomatic trees treated by other systems (Chemjet, Mauget, Pine Infuser, and Portle). This suggests that, so far, the Macro-Infusion treatment is better able to delay fungal infection compared to the other systems.

Additional evaluations were conducted through the remainder of 2012. By December, 2012, 83% of the untreated trees were exhibiting oak wilt symptoms, while symptoms were observed on 25% (Tree IV) to 50% (capsules) of the treated trees (Figure 4). Tree mortality (where trees have lost >97% of their foliage) was increasing through fall 2012. By December, mortality ranged from 17% (2 of 12 for Tree IV, Chemjet, capsules and macro) to 33% (4 of 12 for Pine Infuser) (Figure 5), but the treatments did not differ significantly.

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 seems to be faring better, regarding symptom manifestation, than the others. However, after 18 months post-treatment the Tree IV is comparable to Chemjet, capsules and Macro in the incidence of tree mortality. Based on the status of study trees observed in December 2012, further evaluation is warranted through 2013.

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.

Acknowledgments:
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, James Houser, Robert Edmonson, Bill Upton, Gene Gehring, Dale Amstutz, Jerry Pulley, and Jim Redicker is greatly appreciated. These trials were supported by funds from the International Society of Arboriculture – Texas Chapter.

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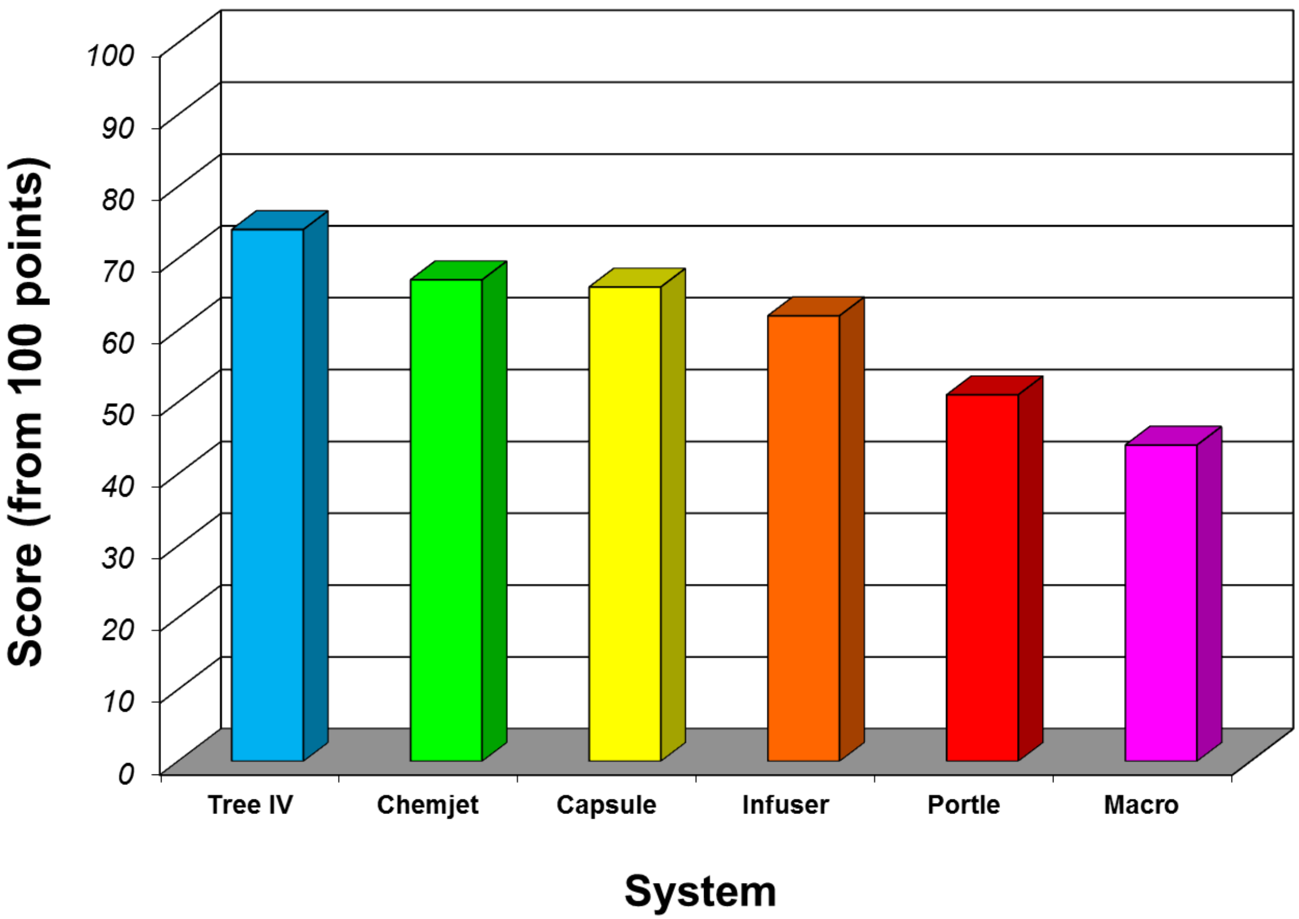

Figure 3. Total score (of 100 points) received by different injection systems.

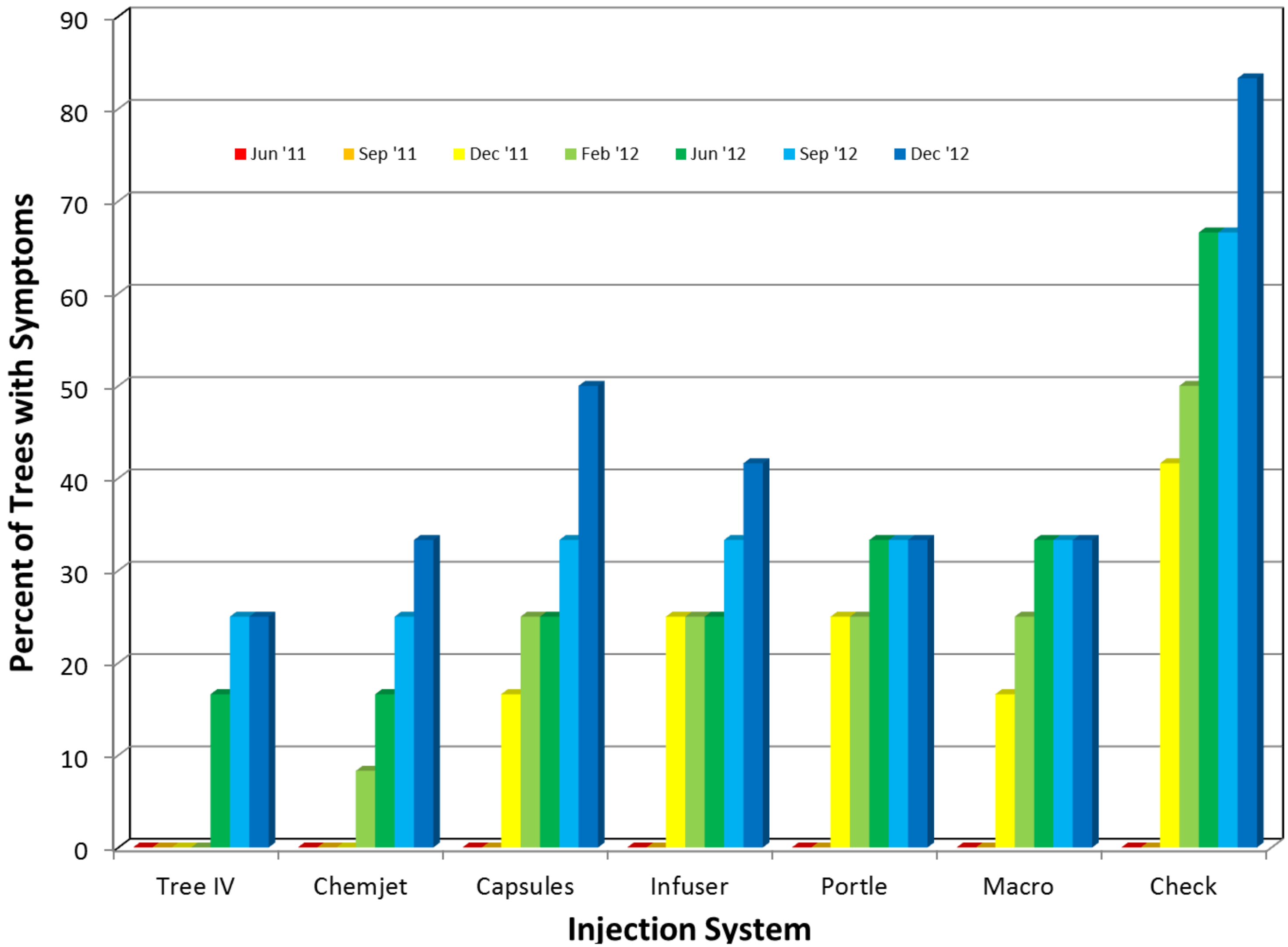

Figure 4. Effect of propiconazole treatments using different injection systems on the occurrence of oak wilt symptoms (veinal necrosis) on live oak in central Texas from June 2011 to December 2012.

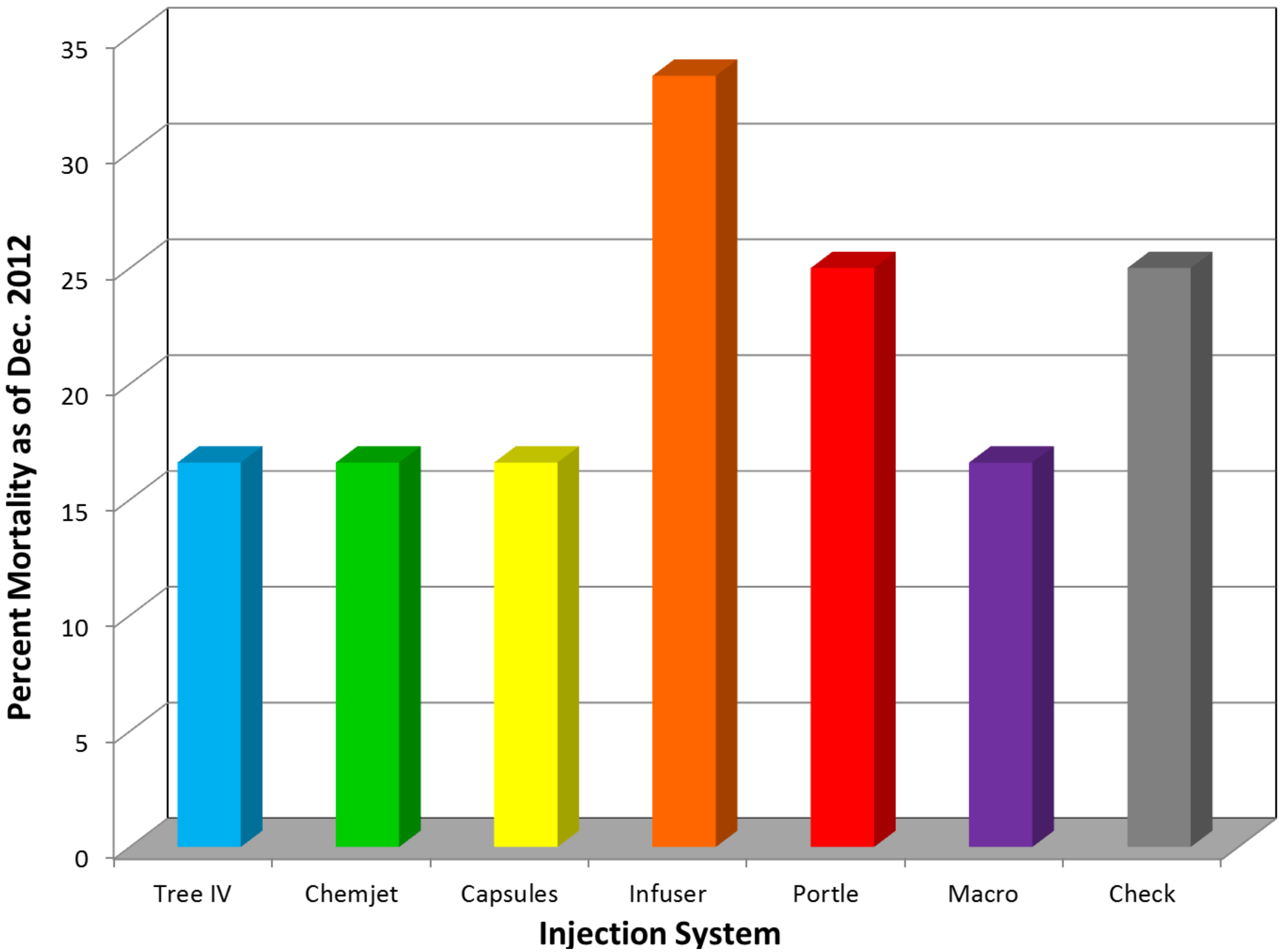

Figure 5. Effect of propiconazole treatments using different injection systems on the occurrence of live oak mortality in central Texas as of December 2012.

Table 10. 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 11: Comparison of characteristics of several injection systems that may be compatible with propiconazole (Alamo).

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 18, 2012 (17 month after injection) (30)	good	21	good	18	fair	12	fair	15	good	18	good	18
Total Score (out of 100 possible points)	**74**		**67**		**66**		**62**		**51**		**44**	

Excellent Good Fair Poor Bad

Incorporating Emamectin Benzoate into Control Strategies for the Southern Pine Beetle

(Initiated in 2012)

Highlights:

- The FPMC initiated a trial in 2012 to evaluate the ability of emamectin benzoate (EB)-treated trap trees to manage southern pine beetle (SPB) populations at low levels in Alabama and Virginia.
- First year results indicate that baited EB-treated trees can absorb SPB in low population levels (<2.0 SPB/trap/day) areas (VA). However, trap trees cannot maintain attraction to SPB at higher population levels (3.0+ SPB/trap/day) areas (AL), resulting in "spill over" attacks and tree mortality outside treated plots.
- These results were used to develop a new protocol for 2013 trials.

Objectives:

1) Evaluate the efficacy of trunk injections of emamectin benzoate for protection of southern yellow pines against SPB.
2) Develop and evaluate a new management strategy to monitor and respond to SPB populations to maintain them below the Allee threshold required for re-establishment and spread, using current knowledge of SPB seasonal behavior, available methods of SPB monitoring, and new technology for suppression.

Cooperators:

Ms. Cindy Ragland	Oakmulgee R.D, Talladega N.F., Brent, AL
Dr. Christopher Asaro	VA Dept. of Forestry, Charlottesville, VA
Dr. Stephen Clarke	USDA Forest Service – FHP R8, Lufkin, Texas
Mr. Joseph Doccola	Arborjet, Inc., Woburn, MA

Study Sites: The study was conducted in the Talladega National Forest, Oakmulgee Ranger District in Bibbs and Perry Co., Alabama and in the Prince Edward and Appomattox-Birmingham State Forests, Virginia with SPB attacking loblolly pine, *Pinus taeda*. Forest tracts (18-22) with loblolly pine predominate, similar in age (>30 years old) and density (>90square feet/acre basal area), were selected at the State or National Forest.

Insecticides:

Emamectin benzoate (TREE-äge™, Arborjet Inc.) – an avermectin derivative

Treatments:

- Baited (frontalin + Sirex lure + endo-brevicomin (EB)), untreated trap tree surrounded by 2-4 unbaited, emamectin benzoate-treated (5ml / inch DBH) trees (within 12 ft of baited trap tree),
- Baited (frontalin + Sirex lure + EB), emamectin benzoate-treated trees surrounded by 2-4 unbaited, emamectin benzoate-treated (5ml / inch DBH) trees (within 12 ft of baited trap tree).
- Baited (frontalin + Sirex lure + EB) trap tree only surrounded by 2-4 untreated trees (within 12 ft of baited trap tree).

Treatment Methods and Evaluation:

The AL and VA forests were selected based on previous year's low trap catch levels of SPB(<2 SPB/trap/day in spring surveys). Within each forest, loblolly stands with higher BA (>90 sq. ft./acre) were selected >1000 ft apart. Within each stand (within 150 ft of an access road to facilitate treatment), a center tree was selected and all trees within 15 ft of the center tree were flagged and tagged. One of three treatments was randomly assigned to each tract (Figure 6). Note: Where possible, poor quality (form, health, etc.) trees were selected as trap trees.

TREE-äge™ was injected at 5 ml per inch DBH in trees < 12" and 10 ml per inch DBH in trees ≥ 12". The Tree IV™ microinfusion system (Arborjet, Inc. Woburn, MA) was used to inject TREE-äge™ into 4 (trees <12" DBH) -8 (trees ≥12" DBH) points 0.3 m above the ground. The injected trees were allowed 4 weeks to translocate chemicals prior to being challenged by the application of synthetic pheromone baits.

All center trees were be baited with appropriate species-specific lures (Synergy Semiochemical, Delta, BC) for three 5 week periods in 2012. The surviving treated and check trees in each group will be rebaited again for the same length of time in 2013.

Table 12. Scheduled injection, baiting and evaluation dates for southern pine beetle trial.

	SPB (AL)
Project Leader(s)	Grosman & Cox
Injection Dates	April 2012
Baiting Period	May - August 2012 March - August 2013
Prelim Evaluation	June - November 2012 April - November 2013
Final Evaluation	December 2012 December 2013

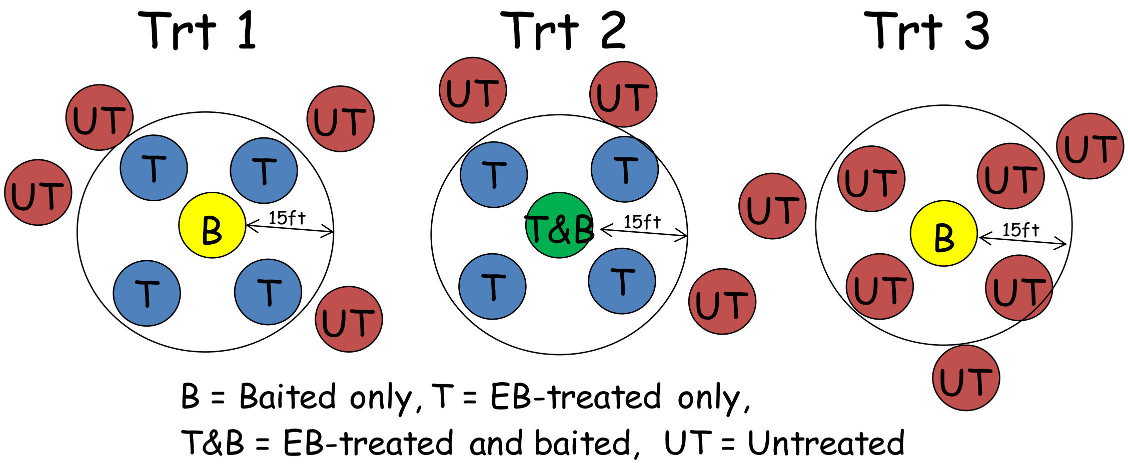

Figure 6: Schematic of potential study treatment layout. Three to six treatment replicates were installed at each state or national forest area.

Three-four Lindgren funnel traps baited with frontalin + Sirex lure + endo-brevicomin (displaced by 4 m) bait were deployed in each forest area (AL and VA

Treatment evaluation:

1) Monitored attack level (occurrence of pitch tubes) of SPB and health on study (baited, injected or untreated) trees at five (5) week intervals after the installation of baits.
2) At the end of the field season (September), each study tree (trap tree and treated and untreated within 30 ft of trap tree; N = 18-30 per block), was nondestructively sampled, using head lamps and hand lens, the number of SPB successful attacks (i.e., oxidized phloem material present in pitch tubes or points of attack containing phloem boring dust and/or dry frass) and unsuccessful attacks (i.e., pitch tubes without oxidized phloem material) in 20 X 25 cm (500 cm^2) sample windows at approximately 1.5, 4.0 and 6.5 m in height at northern and southern aspects.
3) All dead study trees were felled. Bark samples (10 X 10 cm = 100 cm^2) were collected at approximately 1.5, 4.0 and 6.5 m height at northern and southern aspects. SPB gallery length and density of emergence holes were measured.
4) The number of new SPB infestations that become established in treated areas were compared to untreated areas with similar host/climatic conditions.

A test of normality was performed and appropriate transformations used when data deviates significantly from a normal distribution (square root [attacks] and arcsine square root [% pitchouts]; Sokal and Rohlf 1995). *t*-Tests were performed on the density of SPB attacks, density of SPB successful attacks, and percent of SPB pitchouts (unsuccessful attacks) using alpha=0.05 (SigmaStat version 2.0; SPSS, Inc., Chicago, Illinois).

Results:

The two study areas (AL and VA) were selected based on generally low SPB population levels (>2.0 SPB/trap/day) detected in 2011. This trend held in VA where SPB numbers averaged 1.1 and 0.4

beetles/trap/day in the Appomattox-Buckingham and Prince Edwards SF, respectively (Table 13). SPB attacks were more successful and produced more brood (as indicated by the presence of emergence holes) on untreated trees compared to EB-treated trees (Table 14). All center baited trap trees were attacked for each treatment (Table 15). However, none of the treated trees (Trt 2) were killed while 50 - 67% of the untreated trees (Trt 1 – 3) were killed and there was some "spill over" attack to the outside of the plots. In contrast, SPB populations in AL were markedly higher, particularly in Comp 133 in May (28 SPB/trap/day). For the summer, May – August, SPB numbers averaged 3.2 beetles/trap/day. This resulted in higher attack levels on study trees (Table 14) and subsequently greater mortality of untreated trees within Treatment 1 and 3 plots and outside plots for all treatments (Table 15). Of 153 trees treated with EB (for the whole study), only one tree (0.07%) was killed as a result of SPB attack/ blue stain infection. In contrast, of 197 untreated trees that were attacked by SPB, 83 trees (42%) were killed.

Conclusions:

At low populations levels (i.e., VA), EB-treated trap trees (Trt 2) baited with lures were able to attract and kill (absorb) local populations of SPB without spill over to and mortality of neighboring trees. This should serve to prevent SPB populations from reaching the threshold at which populations explode into outbreak levels. In contrast, at higher population levels (i.e., AL), EB-treated trap trees (Trt 2) baited with lures do not appear to be as effective as untreated trap trees (Trt 1 and Trt 3) in attracting and maintaining SPB attack within the study plots. As a result there was greater "spill over" of beetle attacks on and subsequent mortality of untreated trees outside the plot (Table 15).

The above results may be explained by the knowledge that SPB attacking unprotected trees tend to be successful and release pheromones (frontalin, trans-verbenol) while the host releases kairomones (alpha- and beta-pinene, etc) that encourage the development of a mass attack of the host. In contrast, beetles attacking a EB-protected tree are immediately stopped and killed once they penetrate into the chemically-protected phloem layer. There may be minor amount of host volatiles released at the attack site, but pheromone release is prevented with the death of the attacking beetles. Thus, the attraction to the treated trap tree is not maintained. The lures on the trap tree continue to draw beetles into the area. Through random landing, untreated trees outside the plots are ultimately attacked and the attraction of SPB in the area can shift to outside trees.

Thus, the authors are of the opinion that in future trials EB-treated trap trees need to be isolated (> 10 feet) from neighboring trees to prevent spill over. The question is whether it is necessary to protect (treat) the neighboring trees. This will be tested in 2013.

Acknowledgments:

Many thanks go to our cooperators: Steve Clarke and Cindy Ragland, Jim Meeker for their efforts on the projects. We appreciate the chemical donations and injection equipment loans made by Syngenta Crop Protection and Arborjet, Inc, respectively and field assistance of Bill Upton and Larry Spivey. These trials were supported by funds from Syngenta Crop Protection and Forest Pest Management Cooperative.

Table 13. Southern pine beetle trap catches at Oakmulgee Ranger District, AL and Appomattox-Buckingham and Prince Edwards State Forests, VA in summer 2012.

Location: **Oakmulgee RD, AL**
Deployed: 05/14/12

Trap #	Collected	Trap Days	# SPB	SPB/day
AL 1	5/29	15	417	27.8
AL 2	5/29	15	4	0.3
AL 3	5/29	15	26	1.7
			SPB/Trap/Day:	9.9
AL 1	6/14	16	174	10.9
AL 2	6/14	16	2	0.1
AL 3	6/14	16	10	0.6
			SPB/Trap/Day:	3.9
AL 1	6/27	13	29	2.2
AL 2	6/27	13	0	0.0
AL 3	6/27	13	17	1.3
			SPB/Trap/Day:	1.2
AL 1	7/12	15	82	5.5
AL 2	7/12	15	0	0.0
AL 3	7/12	15	77	5.1
			SPB/Trap/Day:	3.5
AL 1	8/2	21	16	0.8
AL 2	8/2	21	0	0.0
AL 3	8/2	21	12	0.6
			SPB/Trap/Day:	0.4
AL 1	8/21	19	4	0.2
AL 2	8/21	19	0	0.0
AL 3	8/21	19	2	0.1
			SPB/Trap/Day:	0.1
			Mean SPB/Trap/Day:	3.2

Location: **Appomattox SF, VA**
Deployed: 05/29/12

Trap #	Collected	Trap Days	# SPB	SPB/day
VA 1	6/12	16	21	1.3
VA 2	6/12	16	12	0.8
			SPB/Trap/Day:	1.0
VA 1	6/26	14	2	0.1
VA 2	6/26	14	18	1.3
			SPB/Trap/Day:	0.7
VA 1	7/10	14	74	5.3
VA 2	7/10	14	1	0.1
			SPB/Trap/Day:	2.7
VA 1	8/1	22	3	0.1
VA 2	8/1	22	14	0.6
			SPB/Trap/Day:	0.4
VA 1	8/29	28	17	0.6
VA 2	8/29	28	60	2.1
			SPB/Trap/Day:	1.4
VA 1	9/25	27	8	0.3
VA 2	9/25	27	24	0.9
			SPB/Trap/Day:	0.6
			Mean SPB/Trap/Day:	1.1

Location: **Prince Edward SF, VA**
Deployed: 05/30/13

Trap #	Collected	Trap Days	# SPB	SPB/day
VA 3	6/12	15	9	0.6
VA 4	6/12	15	4	0.3
			SPB/Trap/Day:	0.4
VA 3	6/26	14	8	0.6
VA 4	6/26	14	27	1.9
			SPB/Trap/Day:	1.3
VA 3	7/11	15	4	0.3
VA 4	7/11	15	7	0.5
			SPB/Trap/Day:	0.4
VA 3	8/1	21	0	0.0
VA 4	8/1	21	4	0.2
			SPB/Trap/Day:	0.1
VA 3	8/29	28	1	0.0
VA 4	8/29	28	1	0.0
			SPB/Trap/Day:	0.0
VA 3	9/25	27	0	0.0
VA 4	9/25	27	1	0.0
			SPB/Trap/Day:	0.0
			Mean SPB/Trap/Day:	0.4

Table 14: Mean number of successful and unsuccessful attacks and emergence holes for southern pine beetle (SPB) per ft2 at different bole heights and black turpentine beetle (BTB) per tree.

Virginia - Prince Edwards and Appomattox-Buckingham SF as of September 26, 2012

Site Trt	Tree Trt	Height on bole	N	Suc SPB	Unsuc SPB	Emerg Holes	Suc BTB	Unsuc BTB	Emerg Holes
1	U	Low (1.5m)	6	2.323	0.310	9.600	0.833	5.333	0
Center untrt surrnded by trt trees	T	Low (1.5m)	26	0	0	0	0.077	1.038	0
	U	Med (4m)	6	0.017	1.261	0	0.554	2.482	0
	T	Med (4m)	26	0	0.893	0	0	0	0
	U	Hi (6.5m)	6	3.561	0.465	31.122	0	0	0
	T	Hi (6.5m)	26	0	0.107	0	0	0	0
2	U	Low (1.5m)							
All treated	T	Low (1.5m)	56	0.017	1.261	0	0.554	2.482	0
	U	Med (4m)							
	T	Med (4m)	56	0	3.451	0	0	0	0
	U	Hi (6.5m)							
	T	Hi (6.5m)	56	0	0.282	0	0	0	0
3	U	Low (1.5m)	36	0.929	0.645	2.116	0.889	1.833	2.000
Control: All untrted	T	Low (1.5m)							
	U	Med (4m)	36	2.116	3.226	4.697	0	0	0
	T	Med (4m)							
	U	Hi (6.5m)	36	0.981	0.697	4.464	0	0	0
	T	Hi (6.5m)							

Alabama - Oakmulgee RD as of September 25, 2012

Site Trt	Tree Trt	Height on bole		Suc SPB	Unsuc SPB	Emerg Holes	Suc BTB	Unsuc BTB	Emerg Holes
1	U	Low (1.5m)	1	3.716	0	9.290	2.000	1.000	0
Center untrt surrnded by trt trees	T	Low (1.5m)	34	0.109	0.683	0.519	0	2.588	0
	U	Med (4m)	1	13.006	0	10.219	0	0	0
	T	Med (4m)	34	0.328	3.634	0.000	0	0	0
	U	Hi (6.5m)	1	4.645	0	27.871	0	0	0
	T	Hi (6.5m)	34	0.738	2.077	0.109	0	0	0
2	U	Low (1.5m)							
All treated	T	Low (1.5m)	37	0.594	0.826	0.232	0	2.778	0
	U	Med (4m)							
	T	Med (4m)	37	0.619	4.671	0	0	0	0
	U	Hi (6.5m)							
	T	Hi (6.5m)	37	0.542	2.581	0	0	0	0
3	U	Low (1.5m)	29	1.121	0.288	1.890	2.138	6.655	1.828
Control: All untrted	T	Low (1.5m)							
	U	Med (4m)	29	6.215	1.185	4.773	0	0	0
	T	Med (4m)							
	U	Hi (6.5m)	29	2.289	0.995	6.337	0	0	0
	T	Hi (6.5m)							

Table 15: Number of trees attacked and killed by southern pine beetle (SPB) and black turpentine beetle (BTB) in Virginia and Alabama in 2012.

Virginia - Prince Edwards and Appomattox-Buckingham SF as of September 26, 2012

Site Trt	Rep	Tree Trt	N	# (%) Trees Inside Attacked by SPB	# (%) Trees Inside Killed by SPB	# Trees Outside Attacked by SPB	# Trees Outside Killed by SPB	# (%) Trees Inside Attacked by BTB	# Trees Outside Attacked by BTB
1	6	Center Untrt	6	6 (100)	3 (50)			2 (33)	
		Others Trt	26	9 (35)	0 (0)	7	0	4 (15)	?
2	6	Center Trt	6	6 (100)	0 (0)			3 (50)	
		Others Trt	28	3 (11)	0 (0)	0	0	2 (7)	?
3	6	Center Untrt	6	6 (100)	4 (67)			2 (33)	
		Others Untrt	30	19 (63)	3 (10)	11	0	7 (23)	?

Alabama - Oakmulgee RD as of September 25, 2012

Site Trt	Rep	Tree Trt	N	# (%) Trees Inside Attacked by SPB	# (%) Trees Inside Killed by SPB	# Trees Outside Attacked by SPB	# Trees Outside Killed by SPB	# (%) Trees Inside Attacked by BTB	# Trees Outside Attacked by BTB
1	6	Center Untrt	6	6 (100)	6 (100)			2 (33)	
		Others Trt	34	17 (50)	0 (0)	26	14 (6 cut)	15 (44)	8
2	6	Center Trt	6	6 (100)	1 (17)			1 (17)	
		Others Trt	31	18 (58)	1 (3)	40	20 (17 cut)	14 (45)	15
3	6	Center Untrt	6	6 (100)	6 (100)			5 (83)	
		Others Untrt	31	26 (84)	11 (35)	28	16 cut	18 (58)	8

Note: SPB-attacked trees outside AL plot areas were cut in advance of tree mortality to prevent uncontrolable expansion of infestation.

Emamectin Benzoate and Propiconazole for Protection of Black Walnut from Walnut Twig Beetle and Thousand Canker Disease

Initiated in 2012

Highlights:

- Treatments of emamectin benzoate, propiconazole, and emamectin benzoate + propiconazole were applied to black walnut trees in TN and TX in 2012 to determine their efficacy in protecting trees from attack by the walnut twig beetle (WTB) and the development of thousand canker disease.

Objectives:

1. To determine the efficacy of emamectin benzoate (TREE-äge™) and the fungicide propiconazole, alone or in combination, for protecting individual walnut trees from attack by walnut twig beetle and other insect pests.
2. To determine if emamectin benzoate, propiconazole or combination treatments can provide preventative and therapeutic control of thousand cankers disease.
3. To provide data on the distribution and concentration of emamectin benzoate in walnut xylem, phloem, and nuts at several points in time after injection.

Study sites: This study was established at three locations: TCD-confirmed location in Sevier Co., TN (about 35°59 N, 83°45 W, elev. 1136 ft) and uninfected locations in Cherokee Co., TX (about 31°45 N, 95°11 W, elev. 429 ft) and Nacogdoches Co., TX (about 31°41 N, 94°26 W, elev. 309 ft.).

Research Approach:

Treatments and Environmental Conditions

There are four treatments: emamectin benzoate (TREE-äge™) alone injected into trees (Treatment **1**); propiconazole (Alamo®) alone injected into trees (Treatment **2**); TREE-äge™+ Alamo® injected into tree (Treatment **3**); and an untreated control (Treatment **4**).

Each treatment was applied to 10-40 randomly-assigned trees per site. Test trees were located in areas with known insect activity, spaced >10 m apart, 13 to 38 cm dbh, and within 100 m of access roads to facilitate the treatment. Each insecticide, fungicide or insecticide + fungicide treatment (treatments 1-6) was injected with the Arborjet Tree IV™ or QUIK-jet™ microinfusion system (Arborjet, Inc. Woburn, MA) into 4-8 evenly spaced points 0.3 m above the ground. Injections occurred in early April (TX) or late-April (TN). The intent was to bait trees (treated and untreated) in TN with WTB pheromones (provided by Steve Seybold) beginning in June, 2012 and throughout the growing season. However, phytotoxic effects (burned leaves) caused by the treatments made it necessary to delay baiting. All treated trees in treatments 1-3 and the untreated control trees (treatment 4) will be baited in June, 2013. WTB populations were monitored throughout the season near the TN location with baited 4-unit Lindgren funnel traps placed at 10 feet on steel conduit poles. Trap catches were recovered every two weeks throughout the season.

In April, 2012 (at the time of treatment) and then every other month (June, August & October), the stem and crown of each tree were ranked as to the extent of insect damage. In addition, three small branches (12" length) will be collected from the low, mid and upper crown of several study tree. The branches will be evaluated for the presence of and ranked on the level of WTB (TN) and other insect damage (TX and TN).

Treatment Efficacy

A photograph of the crown of each study tree in TN was taken at the time of treatment. Trees were/will be evaluated for crown condition every other month for 18 months. The date of appearance of TCD symptoms will be recorded. Each walnut crown will be given a rating of 0 (healthy), 1 (wilt symptoms comprising < 20% of the crown), 2 (wilt symptoms comprising 20-80% of the crown), 3 (wilt symptoms comprising >80% of the crown) (Mayfield et al. 2008), or 4 (dead tree). At the June and August rating periods, trees with a crown rating of 2 will have wood samples taken from the stem and branches to determine the presence of WTB galleries and *G. morbidia*.

At the termination of the experiment, final crown ratings will be made. An analysis of variance will be used to test for differences among injection treatments. 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 insecticide-, fungicide- or combination-treated trees and the untreated control group (Mayfield et al. 2008). The null hypothesis will be rejected if more than 20% of the 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.

<u>Residue Analyses</u>
Residue levels of emamectin benzoate and propiconazole are being determined in xylem (i.e., to ascertain whether the insecticide was moving within the tree), phloem (i.e., the target tissue where bark beetles feed, etc.) and nuts (that may be consumed). Branch and nut samples were collected June 26, 2012 (treatments 1 - 4), and nuts only September 16, 2012 (treatments 1 - 4) from 3-15 randomly selected trees per treatment (*see* below). Additional tissue samples will be collected in June 2013 (treatments 1-4) and September 2013 (treatments 1-4). If sufficient concentrations exist in phloem collected in September 2013, we may continue sampling in 2014 if additional funding can be obtained.

Residue analyses protocol
Propiconazole residues were extracted with ethylacetate, cleaned up by Gel Permeation Chromatography and analyzed by gas chromatography (GLC) utilizing an N-P detector. Positive pesticide residues were confirmed by GC-Mass Spectroscopy. The GC columns utilized were SPB-5 and SPB-35 megabore capillary columns. The column oven was temperature programmed from 135-275 °C at 5 degrees/min. A fortified sample and reagent blank was included with each set of analyses. In the past, the average propiconazole residue recovery has been 72.4% and the method is well recognized. Emamectin benzoate residues will also analyzed, but the exact methodology that will be used has not yet been determined [i.e., we are currently reviewing the efficiency and effectiveness of recently developed methods employed by Syngenta Corp. (unpublished).

Results:

The state of health of the chemically treated trees at the three sites used in this study fell between 0.13 (excellent) and 3.67 (fair) following treatments (Tables 1-3). Psyllid damage ranged between 0.57 (isolated) to 2.80 (light, almost moderate) at the two Texas sites.

In TN, all three treatments showed the presence of WTB attacks, egg galleries, and cankers; but exit holes were not found (Table 19). Four months after treatment, the control trees had a better tree condition rating (1.92: excellent) compared with the treated trees (2.0, 2.42, 2.53: good) (Table 20).

Tissue analysis found that emamectin benzoate was present in the xylem at almost 13ppb (Table 21). It was present at very low concentrations in the phloem (~0.1ppb) and almost negligible in the nut meat (<0.0001ppb) (Table 21).

Conclusions:
Due to the delay in baiting, data collection will continue through 2013 and into the year 2014.

Acknowledgments:
Co-investigators in this study included Paul Merten, US Forest Service/FHP, Asheville, NC, Dr. Steve Seybold, USFS/SWRS, Davis, CA, and Dr. David Cox, Syngenta, Modera, CA. Many thanks go to our cooperators: Mr. Bill France of Seymour, TN, Mr. Phil Power of Rusk TX, and Mr. Harold Read of Martinsville, TX for providing research sites. Field and lab assistance was provided by William Upton, Larry Spivey, Billi Kavanagh, and Charlie Jackson. Tissue analysis was conducted by Syngenta.

Table 16: Occurrence and severity of damage caused by insects or injections of sytemic chemicals on Black Walnuts; Power's property, Rusk (Cherokee Co.), TX - 2012

		Psyllid	Tree Condition		
Treatment*	N	20-Jul	13-Apr	10-May	20-Jul
Emamectin benzoate	15	0.67	1.67	1.33	1.80
EB + Propiconizole	15	0.57	3.67	2.30	2.30
Check	14	1.46	1.00	1.00	1.18

Tree Condition: 1 = Excellent, 2 = Good, 3 = Fair, 4 = Poor, 5 = Near Death or Dead

Psyllid Rank: 1 = Isolated; 2 = light; 3 = moderate; 4 = heavy; 5 = extensive

Table 17: Occurrence and severity of damage caused by insects and/or injections of sytemic chemicals on Black Walnuts; Read's property, Martinsville (Nacogdoches Co.), TX - 2012

		Defoliator	Psyllid		Condition		
Treatment*	N	8-Jun	8-Jun	20-Jul	13-Apr	10-May	20-Jul
Emamectin benzoate	10	0.75	1.00	1.90	1.25	1.05	1.05
Check	10	1.90	1.95	2.80	1.00	0.37	0.37

Defoliator and Psyllid Rank: 1 = Isolated; 2 = light; 3 = moderate; 4 = heavy; 5 = extensive

Tree Condition: 1 = Excellent, 2 = Good, 3 = Fair, 4 = Poor, 5 = Near Death or Dead

Table 18: Occurrence and severity of damage caused by injections of sytemic chemicals on Black Walnuts; Bill France property, Seymour (Sevier Co.), TN - 2012

Treatment*	N	Phytotoxic Symptoms Ranking	Leaf Deformity	Bark Separation
Emamectin benzoate	40	1.09	0.40	0.13
Propiconazole	39	1.06	1.79	0.21
EB + Propiconizole	40	2.33	1.58	0.15
Check	19	0.00	0.37	0.00

Phytotoxicity ranking : 0= no signs; 1 = 20% of crown w burn; 2 = 40%; 3= 60%; 4 = 80%; 5 = 100%
Leaves affected by chemical: 0 = None; 1 =light, 2 = moderate; 3 = severe

Table 19. Occurrence and severity of damage caused by Walnut Twig Beetle/ Thousand Cankers Disease on Black Walnut branches; Seymour(Sevier Co.), TN - 2012

Treatment	N	% Branches with WTB	Branch Surface Area	Number, Length or Area per 100 cm^2 of branch Surface Aea							
				# WTB Attacks	# Egg Galleries	Lgth of Egg Gal (cm)	Adults Present? (N=0, Y=1)	Brood Present? (N=0, Y=1)	Canker Present? (N=0, Y=1)	Canker Area (cm^2)	# Exit Holes
Emamectin benzoate	6	83.3	180.9	1.9	1.2	2.2	0.0	0.0	0.4	3.1	0.0
EB + Propiconizole	7	42.8	186.7	3.6	1.8	2.8	0.0	0.0	0.6	2.8	0.0
Check	8	62.5	178.3	1.1	0.6	0.8	0.0	0.0	0.2	1.4	0.0

Table 20: Condition of Black Walnuts 4 months after treatment, Bill France property, Seymore Co., TN - August 2012

				# Dead Branches				
Treatment*	N	Branch Flagging (BF)	Thinning Crown (TC)	< 1"	1-3"	> 3"	% Dieback	Tree Condition *
Emamectin benzoate	40	0.58	1.25	3.63	1.78	0.38	11.25	2.00
Propiconazole	39	1.31	1.74	3.33	1.54	0.49	13.46	2.42
EB + Propiconizole	40	1.21	2.15	3.35	2.28	0.43	13.50	2.53
Check	19	0.58	0.89	2.58	1.79	0.32	8.95	1.92

BF & TC Rank: 1 = Isolated; 2 = light; 3 = moderate; 4 = heavy; 5 = extensive

Condition: 1 = Excellent, 2 = Good, 3 = Fair, 4 = Poor, 5 = Near Death or Dead

Table 21. Mean Concentration (PPM) of emamectin benzoate (EB) in black walnut xylem, phloem and nut meat tissue mid-summer folowing spring injection 2012.

	Xylem	Phloem	Nut Meat
Emamectin benzoate	12.9710	0.0575	<0.001
EB + Propiconazole	6.4611	0.0995	<0.001
Check	<0.0059	<0.0012	<0.001

Note: LOQ (Limit of qantitation) set at 1 ppb (0.001 ppm); 1 of 4 check samples from xylem and ploem had 0.002 ppm while others below LOQ

Occurrence and Seasonality of Pine Wood Nematode in Loblolly Pine Trees and Logs

(Initiated in 2012)

Objectives:

1. Determine if pine wood nematode (PWN) occurs in standing loblolly pine
2. Seasonal timing of PWN infection on standing trees and/or felled logs
3. Extent to which debarking logs eliminates PWN risk
4. Time limit after felling in which PWN infection risk is sufficiently low to be acceptable

Cooperators:

Hugh McManus	Hancock Forest Management, Shreveport, LA
Wilson Edwards	Weyerhaeuser Company, New Bern, NC

Research Approach:

Parameters:
- Tree Species: loblolly pine
- Sites: Two (2) per period provided by Hancock Forest Management
- Seasonal periods:
  - Spring (April – June)
  - Summer (July – September)
- Tree (upper crown, lower crown, lower bole) @ 0 hrs. after felling
- Felled Log:
  - On-site Time: 24hrs, 2d, 4d and 6d before transport to debarking facility;
  - Debark Time: logs debarked within 24h, 2d, or 4d of arrival at facility.

During the spring and summer season, two sites were selected in east Texas, between Wells and Rusk (Nacogdoches and Cherokee counties).

At each site, six (6) “healthy appearing” trees of export size (28 - 40.6 cm (=11 - 16”) DBH, 25-YO) were felled. Immediately (within an hour of felling), wood samples were taken from the main stem of the upper crown, lower crown, and lower bole. Each full log (18-20cm top, >10 m long) was cut into nine (spring) or eleven (summer) **-** 1.0 m sections. Each of the 9 or 11 log sections was randomly assigned a treatment (Figure 7 or 8). The spring treatments included:

A = **1** day on site before move (rotate); debarked **1** day after move – **2** day exposure
B = **1** day on site before move (rotate); debarked **3** days after move – **4** day “
C = **1** day on site before move (rotate); debarked **6** days after move – **7** day “
D = **3** days on site before move (rotate); debarked **1** day after move – **4** day “
E = **3** days on site before move (rotate); debarked **3** days after move – **6** day “
F = **3** days on site before move (rotate); debarked **6** days after move – **9** day “
G = **6** days on site before move (rotate); debarked **1** day after move – **7** day “
H = **6** days on site before move (rotate); debarked **3** days after move – **9** day “
I = **6** days on site before move (rotate); debarked **6** days after move – **12** day “

The summer treatments included:

A = log immediately wrapped in screen mesh; no debarking **– 0 day exposure**
B = log debarked within 3 hours of felling – **0** day "
C = log debarked within 24 hours of felling – **1** day "
D = **1** day on site before move (rotate); debarked **1** day after move – **2** day "
E = **1** day on site before move (to office); debarked **1** days after move – **2** day "
F = **1** day on site before move (rotate); debarked **3** days after move – **4** day "
G = **1** day on site before move (to office); debarked **3** day after move – **4** day "
H = **3** days on site before move (rotate); debarked **1** days after move – **4** day "
I = **3** days on site before move (to office); debarked **1** days after move – **4** day "
J = **3** days on site before move (rotate); debarked **3** days after move – **6** day "
K = **3** days on site before move (office); debarked **3** days after move – **6** day "

Groups of 18 log sections were held at the harvest site for different intervals [0h, 24h, 3d, or 6d, (Figure 7 and 8)]. Individual log sections were placed about 1 m apart on discarded, dry pine bolts to maximize surface area available for colonization as well as to discourage predation by ground and litter-inhabiting organisms. A bait blend (ethanol, (-) a-pinene, ipsenol, ipsdienol, and monochamol) was deployed in the harvest area to attract cerambycid beetles. At the end of each on-site interval, 18 logs were transported (rotated to simulate movement) to debarking site. Groups of 6 logs were debarked (with chainsaw and planer) at different intervals (0h, 24h, 2d, 3d, 6d, or 12d) after arrival (rotation). All logs were sampled for PWN 21d after debarking. Note: In the summer, some treatment (A,B, C, D, F, H, and J) logs were rotated only and left on site in the direct sunlight, while the remainder (E, G, I, and K) were transported to the TFS office and placed in the shade under mature pines.

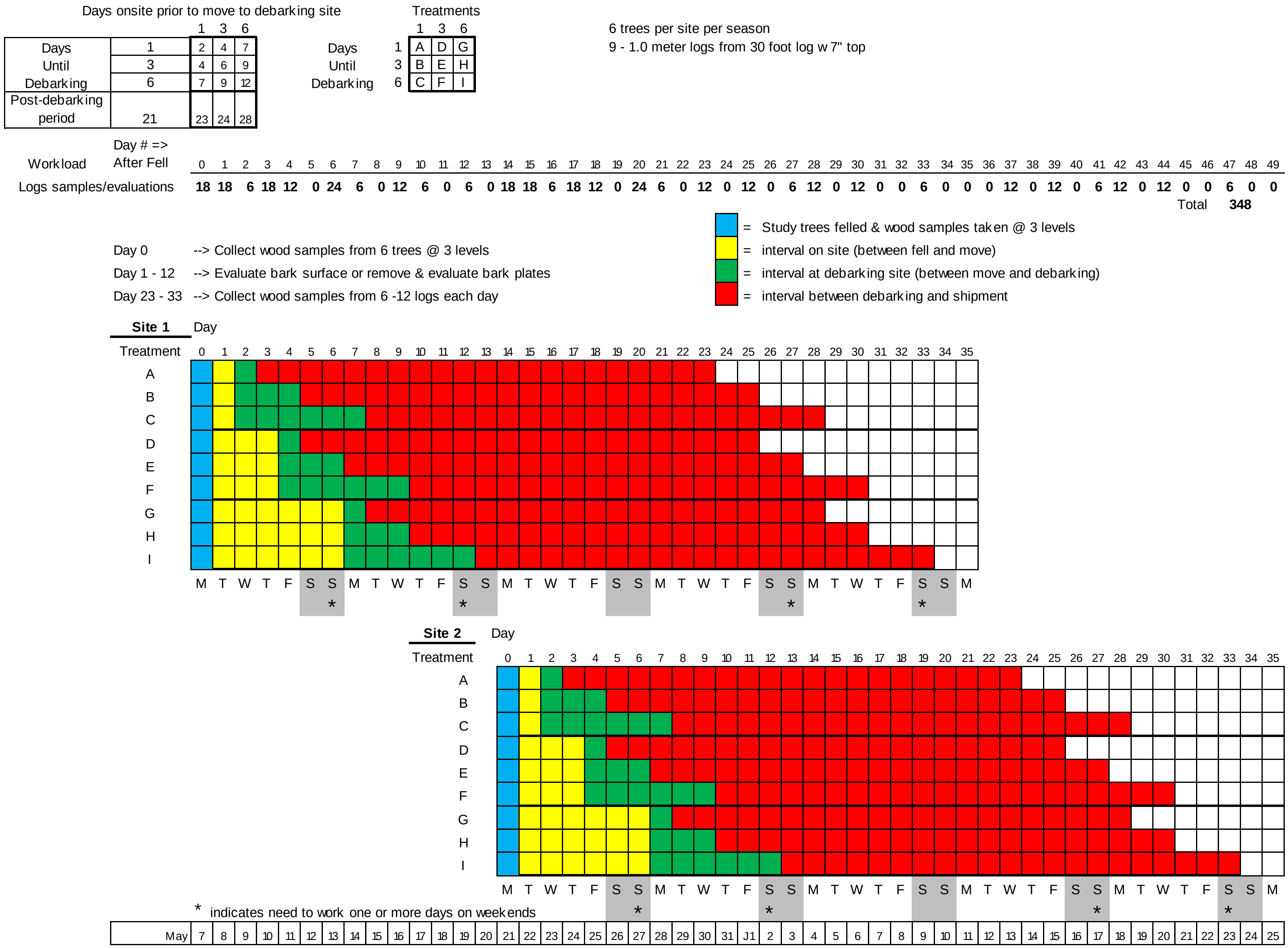

Figure 7. Sampling scheme for pinewood nematode at each of two east Texas sites in spring 2012

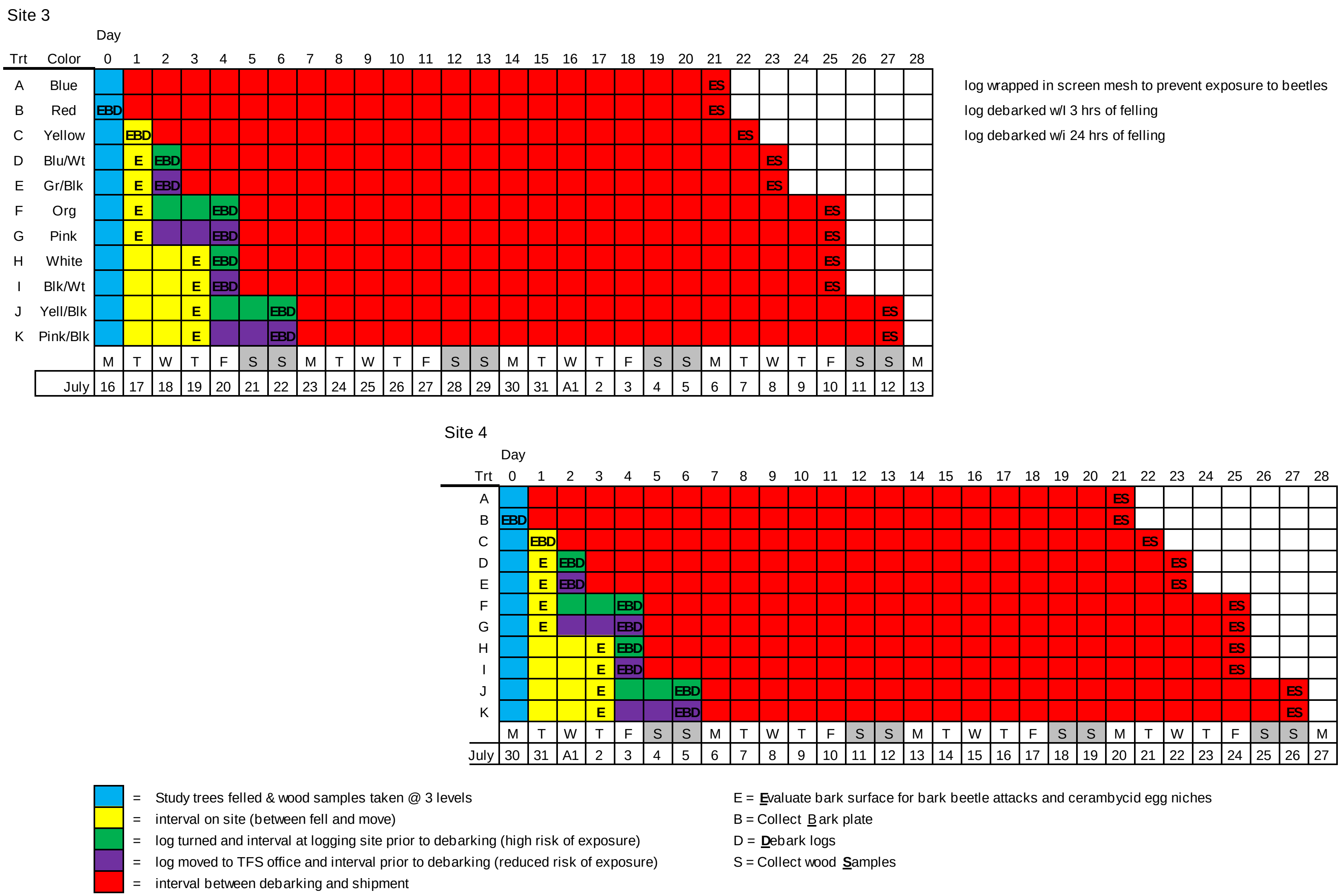

Figure 8. Sampling scheme for pinewood nematode at each of two east Texas sites in summer 2012.

Monitoring Monochamus species and PWN occurrence in beetles
Modified funnel traps were deployed (beginning in April) at 2-3 nearby harvest sites. Traps were baited with kairomone blend (ethanol, (-)alpha-pinene, ipsenol, ipsdienol, & monochamol) placed inside the funnels and using a wet cup (Miller et al. 2011, Dave Wakarchuk, personal communication). Traps were monitored for six months at 1-2 week intervals. Collected cerambycids were identified to species. Female *Monochamus* specimens were dissected to determine presence/absence of PWN (Linit 1988, Linit et al. 1983).

Inspecting logs for wood borer and bark beetle colonization
At each time interval (end of onsite period, 21 days after felling and just before debarking), borders of two 10 X 50 cm strips (total = 1000 cm^2) were marked on the bark surface and the number of cerambycid egg niches and bark beetle attacks were counted within each strip.

Just prior to debarking, two 10 X 50 cm strips (total = 1000 cm^2) of bark were removed from each log and the following assessments were made:

1. Number of unsuccessful *Ips* attacks - penetration to phloem, but no egg galleries.
2. Number of successful Ips attacks - construction of nuptial chamber and at least one egg gallery extending from it.
3. Number and lengths of Ips egg galleries with brood galleries radiating from them.
4. Cerambycid activity, estimated by overlaying a 100 cm2 grid over a portion of each bark strip and counting the number of squares overlapping the area where cerambycid larvae have fed.
5. Number of oval cerambycid larvae entrance holes into sapwood.
6. Presence and percent area covered with blue stain.

Sampling logs for pinewood nematodes 21 days after debarking
Each log was sampled at five locations: at two points approximately one-third distance from the ends and 3 times at the end of the log, 1.5 cm below the cambium, in a triangular pattern (holes may overlap on small logs). A wire brush was used to remove dirt and debris from the sample locations. At log ends, the first 5 cm from the sample locations was discarded due to possible contamination. A clean container was placed beneath the work site to catch shavings throughout the process. Using a 5.4 cm (1 1/2 in) drill bit, the log was slowly drilled to the center. The drill bit was reversed and removed from the hole every 4 - 5 cm (1.5 – 2.0 inches) to collect the shavings. For large diameter trees a utensil was required to remove the final shavings.

The shavings from a given log were pooled into a bucket, mixed well, placed in a sealable plastic bag and kept at room temperature. In the lab, half of the material was used for nematode extraction (the remaining half served as a backup, in case there was need to repeat the test).

Extraction of nematodes from wood shavings:
The following extraction method (pie-pan) was used to extract PWN. This method is only good for extracting live, motile nematodes.

- Each sample was assigned a lab ID number.
- Approximately 80 g of wood shavings were wrapped in double-folded large Kimwipes™. The wrapped shavings were placed into a baking tin. Water was added to the containers until the wood shavings were completely submerged. The shavings were allowed to incubate for 24 hours at room temperature to allow nematodes to move out.
- After incubation, the supernatant water was decanted from the containers, after gently removing the wood-containing baskets.

- The nematode suspension in the container was left to settle for about 10 minutes at a slant, approximately 45 degrees. The supernatant water was decanted again.
- Approximately 100 ml of the nematode solution was decanted into beakers and allowed to settle for 60 minutes.
- Supernatant water was then collected to approximately 20ml.
- The sample was poured into a counting dish. Nematodes were identified and counted under an inverted microscope (Mamiya & Kiyohara, 1972 and Mamiya, 1984 as references for identification).
- Samples were saved by adding 10 drops of 4% Formalin to the water sample for further testing and future reference.

Identification of nematodes:

Nematode samples were sent to Dr. James Starr, Texas A&M University, for identification. Nematodes extracted from the wood samples were identified based on morphological characteristics.

The nematodes were identified and counted under the microscope. Liquid samples containing live nematodes were heat treated gently for about 5 seconds on a hot-plate (sufficient to kill the nematodes) and placed in temporary water mounts for all measurements and microphotographs to assure quality and accuracy. For suspect specimens, nematodes were heat killed and fixed in 4% formalin for long term preservation. The nematodes were processed with glycerin by a modification of a glycerin-ethanol series of Seinhorst's rapid method (1959) and permanently mounted on 25 × 75-mm microscope slides. Specimens were examined with a compound microscope with interference contrast at up to 1,000× magnification.

The amount of blue stain fungi that had colonized logs was evaluated. Using a chainsaw, "cookies" were cut from the log at 2", 8" and 19" from the end of each log. The cross-sectional area covered by blue stain was determined and recorded.

Data Analysis

The number of cerambycid egg niches, bark beetle attacks, nematodes present per log treatment, position on tree, and interval after felling and debarking, were used to measure the degree of risk of PWN export. Risk of export was then analyzed statistically using Statview software (SAS Institute, Inc. 1999) to contrast and determine the difference between treatments at each observation. Percentage and measurement data were transformed by the arcsine % and log transformations, respectively, prior to analysis.

Results:

No pine wood nematodes were found in wood samples collected immediately after tree felling in both the spring and summer (Table 22). This is a strong indication that nematodes are not present in live, standing loblolly pine trees.

Trap catches of *Monochamus* beetles averaged 6.7 females per trap per day over a 37 day period in the spring. Earlier studies conducted in East Texas showed that *Monochamus* spp. do not fly in January, February or early March (Billings, R. F., unpublished data). We found that just over 35% of females carried PWN with an average of 55 PWN per female. In contrast, we collected fewer females per day (3.6) during a 23 day period during the summer. However, 49% carried PWN with an average of 72 PWN per female.

The number of cerambycid egg niches observed on study logs increased slowly over the first few days of exposure during the spring; not exceeding 10 niches per m^2 until at least the 6^{th} day after felling (Figures 9A & B). Then the number increased quickly until there were more than 40 niches per m^2 on day 12. In contrast, there were 20 -30 niches after only 6 days of exposure during the summer (Figures 10A & B). This indicates that cerambycids are more abundant during the summer months (July – August).

Similarly, the numbers of *Ip*s engraver beetle attacks were relatively low in the spring; ranging from 1.5 – 4.0 attacks/ m^2 after 6 days of exposure to 8-22 attacks after 12 days (Figures 11A & B). Number of attacks increased in the summer, ranging from 5 – 22 attacks after only 6 days of exposure (Figures 12A & B).

Table 22: Number of nematodes per sample collected from "live, healthy" loblolly pine; just after felling.

Tree	Level	Site 1	Site 2	Site 3	Site 4
1	Upper Crown	0	0	0	0
	Lower Crown	0	0	0	0
	Lower Bole	0	0	0	0
2	Upper Crown	0	0	0	0
	Lower Crown	0	0	0	0
	Lower Bole	0	0	0	0
3	Upper Crown	0	0	0	0
	Lower Crown	0	0	0	0
	Lower Bole	0	0	0	0
4	Upper Crown	0	0	0	0
	Lower Crown	0	0	0	0
	Lower Bole	0	0	0	0
5	Upper Crown	0	0	0	0
	Lower Crown	0	0	0	0
	Lower Bole	0	0	0	0
6	Upper Crown	0	0	0	0
	Lower Crown	0	0	0	0
	Lower Bole	0	0	0	0
Date collected		7-May	21-May	16-Jul	30-Jul

Pinewood nematodes were found in 1 of 6 logs (site 1) and 2 of 6 logs (site 2) that had been exposed to wood borers and bark beetles for only two days prior to debarking during the spring (Figures 13A & B). The number of positives (for PWN) increased with cumulative time of exposure. This indicates it takes very little time for wood borers to infect a log. It also provides supporting data that PWN do not occur in trees prior to felling.

In response to the spring results, the intervals of exposure were reduced for some treatments to 0 and 1 day prior to debarking. No PWN were found in logs wrapped in screening or debarked immediately after felling (0 days exposure) on site 4 (Figure 14B). However, at least one log out of six was infected with PWN regardless of exposure length on site 3 (Figure 14A). Again, the number of positive incidences of PWN tended to increase with an increase in duration of exposure. It is not known for sure how the one Treatment B log became infected when it was debarked immediately after felling. Perhaps, female wood borers were attracted to the log and some of them may have attempted to oviposit eggs even when there was no bark. This action may have resulted in some inoculation of PWN. The number of logs infected by PWN during the summer generally increased with time of exposure, but there were some differences between treatment logs that were kept on the logging site and those brought to the TFS office. It would appear that in most cases, PWN were more prevalent in logs moved to the shade (TFS office) than those left at the logging site in direct sunlight.

The mean area covered by blue stain fungi in the logs after exposure to beetles during the spring and summer is shown in Figures 15A and B and 16A and B, respectively. For sites 1 and 2, in particular, the amount of blue stain fluctuated from 10-30% among the treatments - increasing somewhat during the first few days, but then declined. In contrast, there were wide fluctuations in the amount of blue stain among treatments during the summer. However, it is interesting to note that those log treatments (A, B, C, D, F, H and J) that were kept at the logging site (in direct sunlight) had lower levels of blue stain (2 – 21%) compared to those treatment logs (E, G, I and K) moved to the TFS office (under the shade of mature pines) – (21 – 55%). This indicates that growth and spread of blue stain within loblolly pine logs may be inhibited by high temperatures resulting from the exposure of cut logs to direct sunlight.

Conclusions:

1) Pinewood nematodes are not present in live standing trees.
2) One-third to nearly one-half of the adult *Monochamus* females carry PWN.
3) Inoculation of PWN into loblolly pine can occur within hours of tree felling, particularly in the summer.
4) Exposure of cut logs to direct sunlight, particularly in the summer, reduced PWN and blue stain occurrence in loblolly pine logs.
5) Given the zero tolerance for presence of PWN in logs destined for export, just debarking logs does not appear to reduce risk of exporting infected logs.
6) Emamectin benzoate (EB) is highly effective against PWN. Perhaps logs could be sprayed immediately after debarking to ensure clean logs for export. This option is being considered for feasibility by Syngenta Crop Science. Alternatively, EB could be injected into trees prior to harvest thus eliminating need to fumigate or debark logs prior to export.

Acknowledgments:
Many thanks to our cooperators from Hancock and Weyerhaeuser, specifically Hugh McManus and Trevor Terry who aided in coordinating this research and provided sites for the trials. William Upton, Larry Spivey, Charlie Jackson, and Billi Kavanagh provided assistance in the field and lab.

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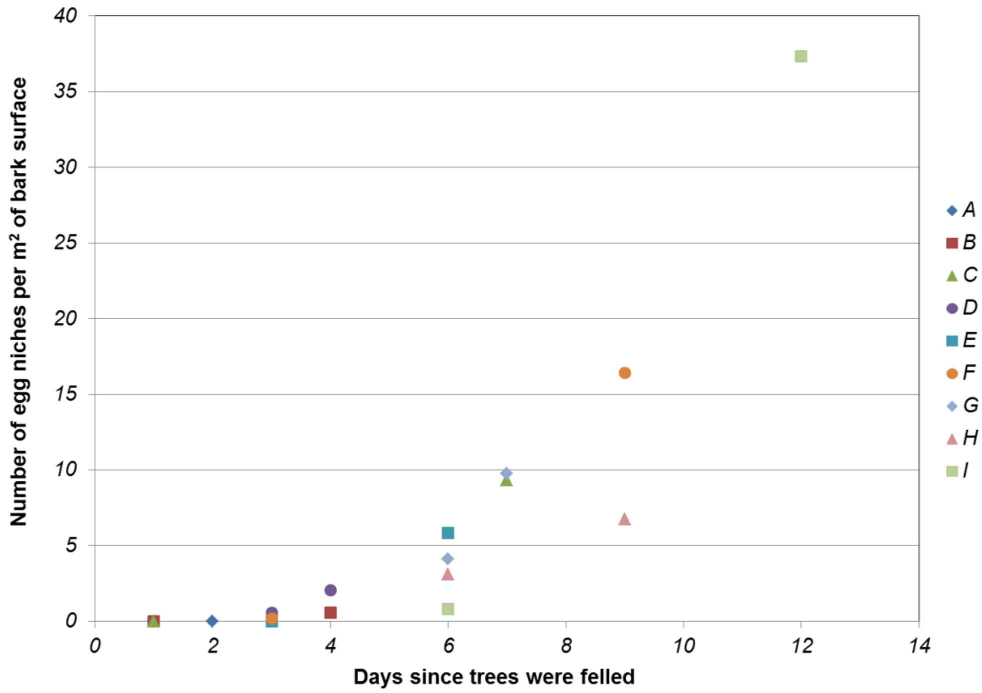
A



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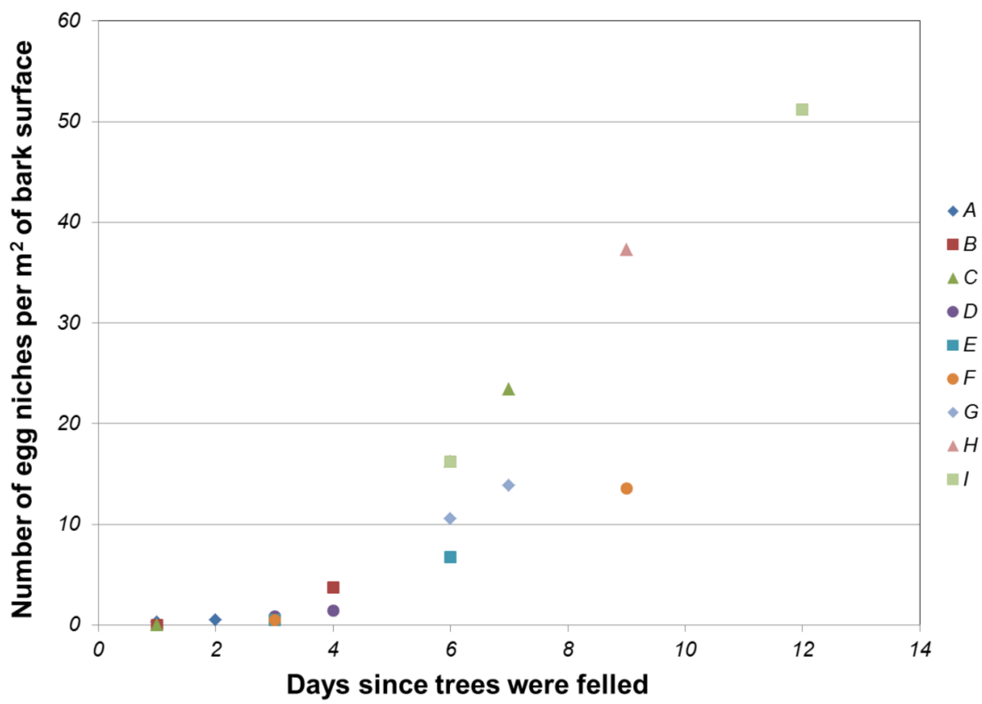
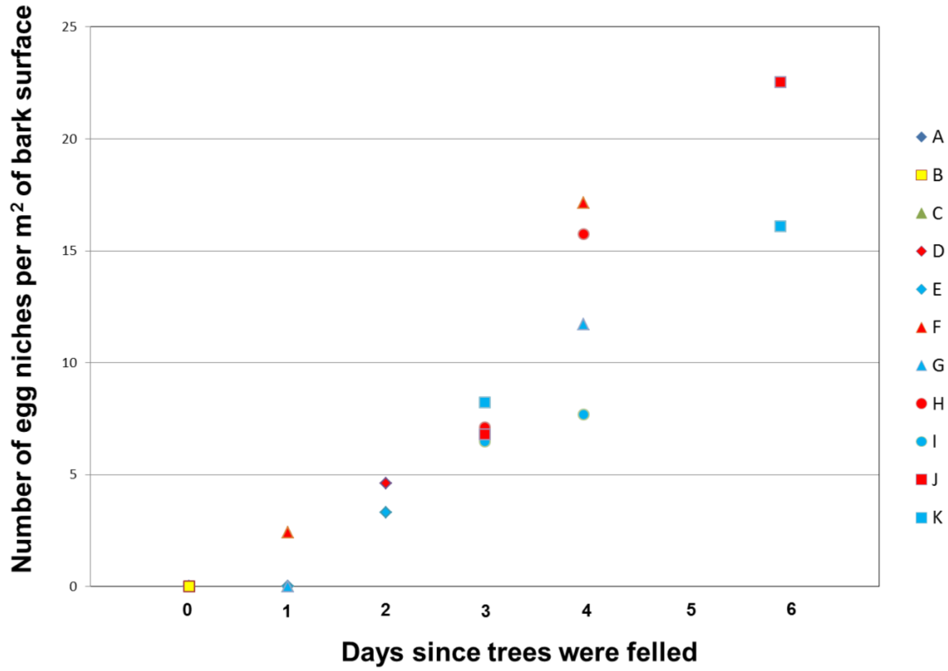


Figure 9. Number of cerambycid egg niches observed on the bark surface of loblolly pine logs during spring 2012 at sites 1 (A) and 2 (B).

A



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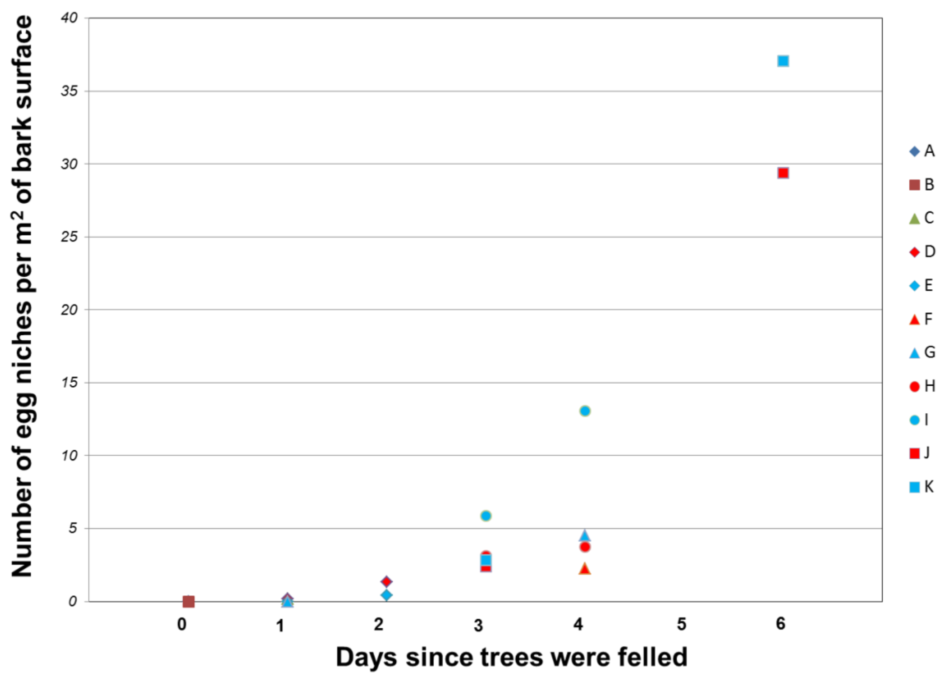
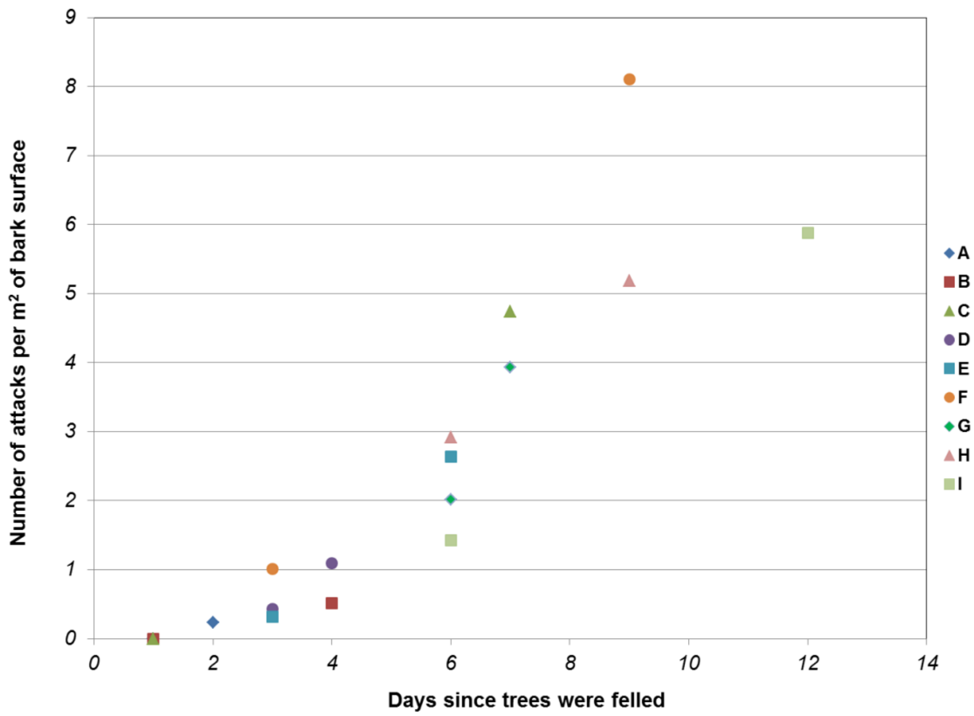


Figure 10. Number of cerambycid egg niches observed on the bark surface of loblolly pine logs during spring 2012 at sites 3 (A) and 4 (B).

A



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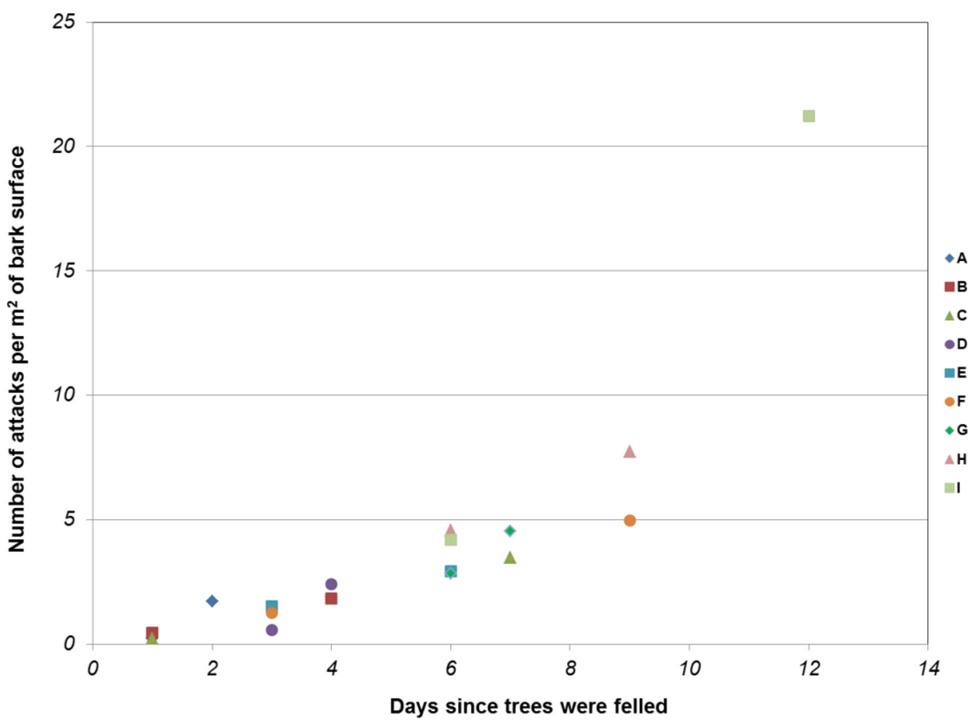
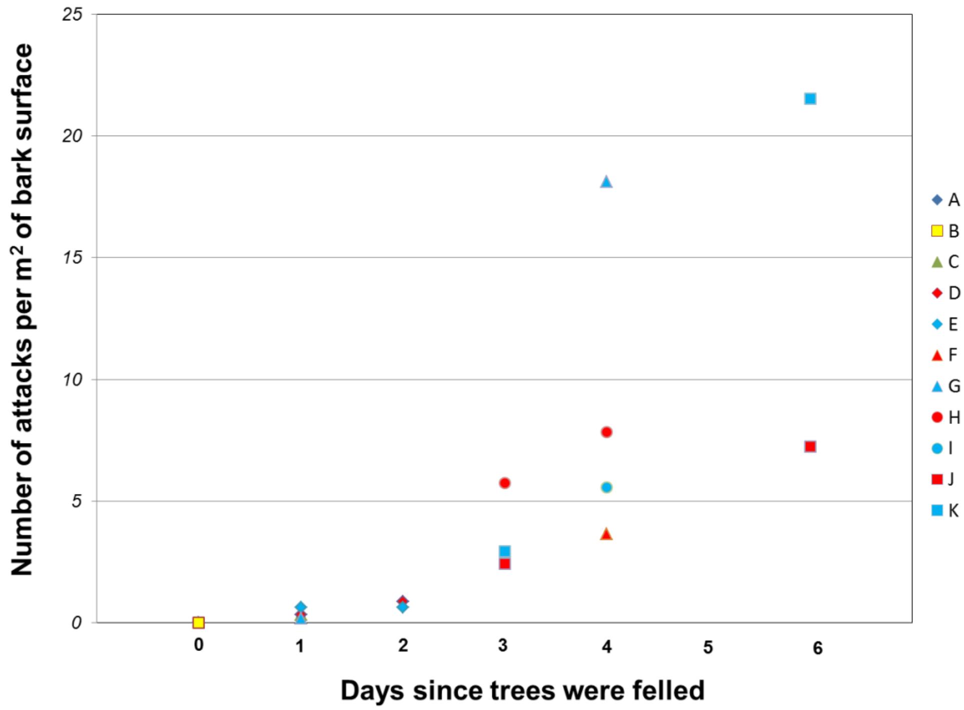


Figure 11: Number of *Ips* engraver beetle attacks observed on the bark surface of loblolly pine logs during spring 2012 at sites 1 (A) and 2 (B).

A



B

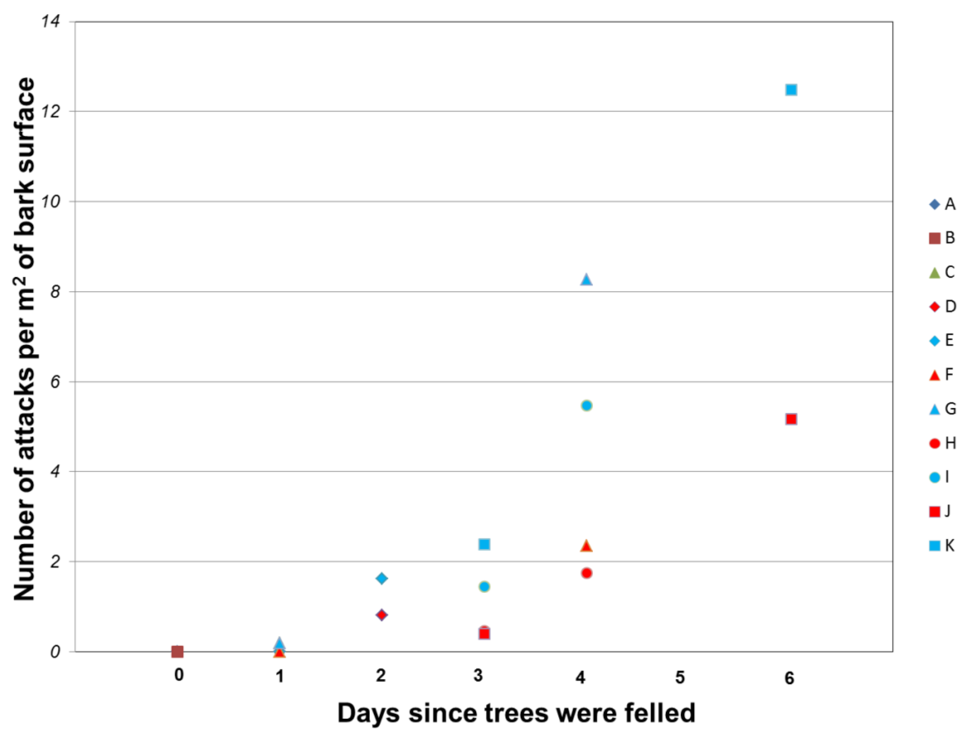
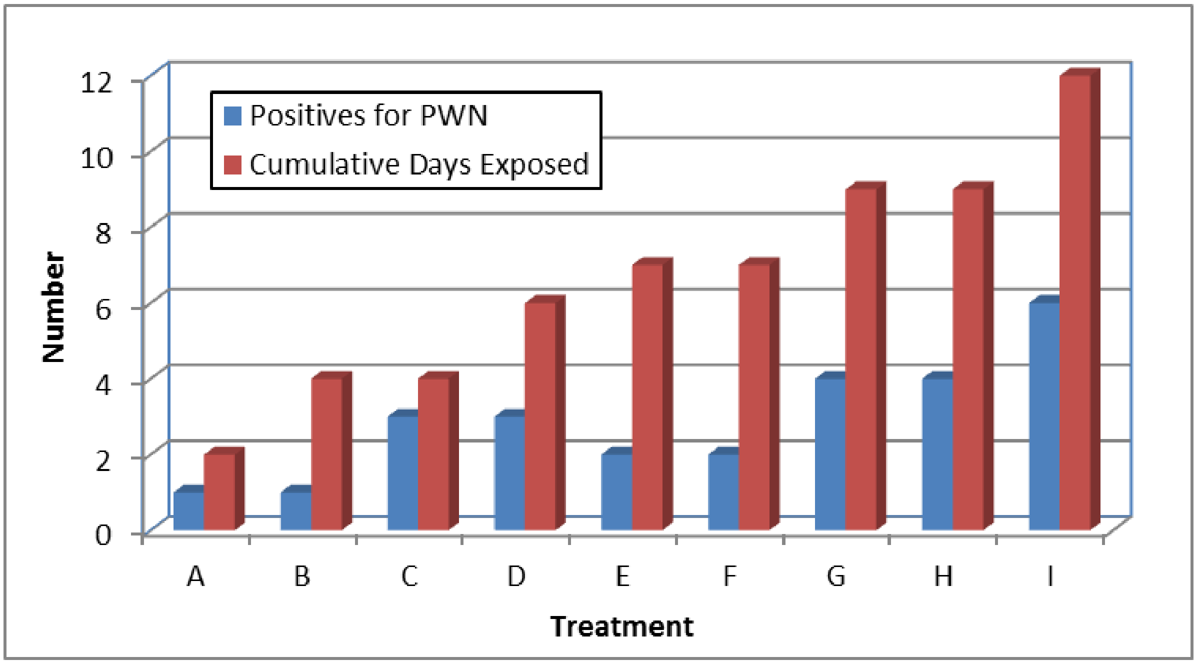


Figure 12: Number of *Ips* engraver beetle attacks observed on the bark surface of loblolly pine logs during summer 2012 at sites 3 (A) and 4 (B).

A



B

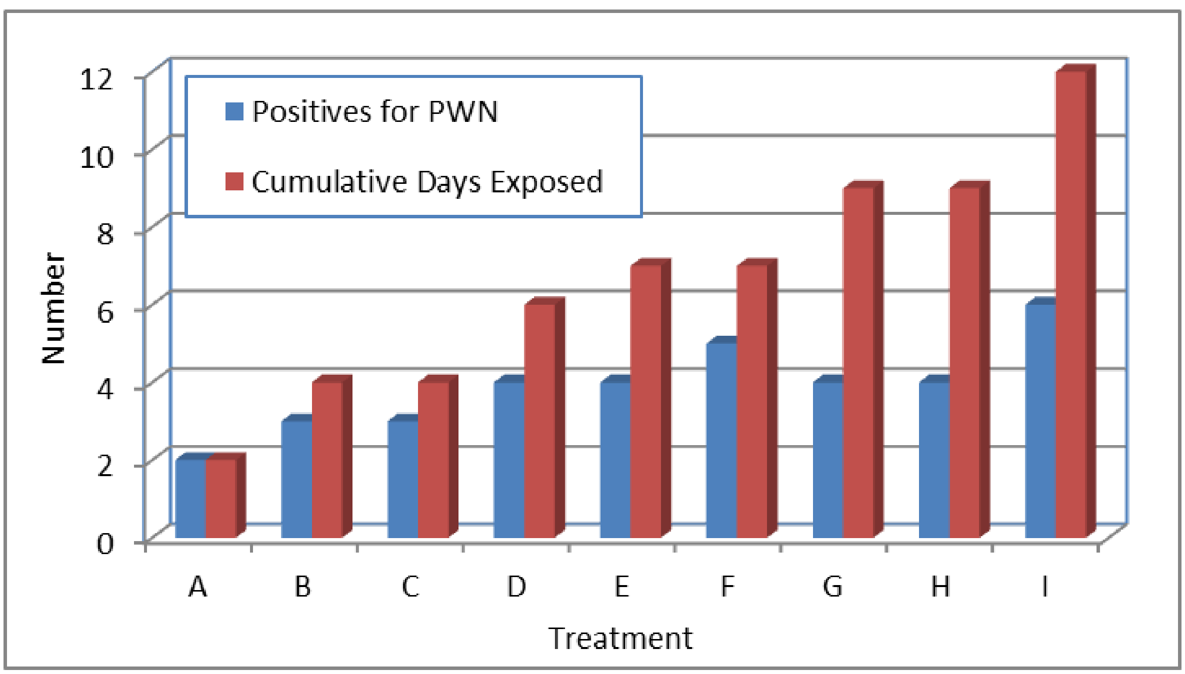
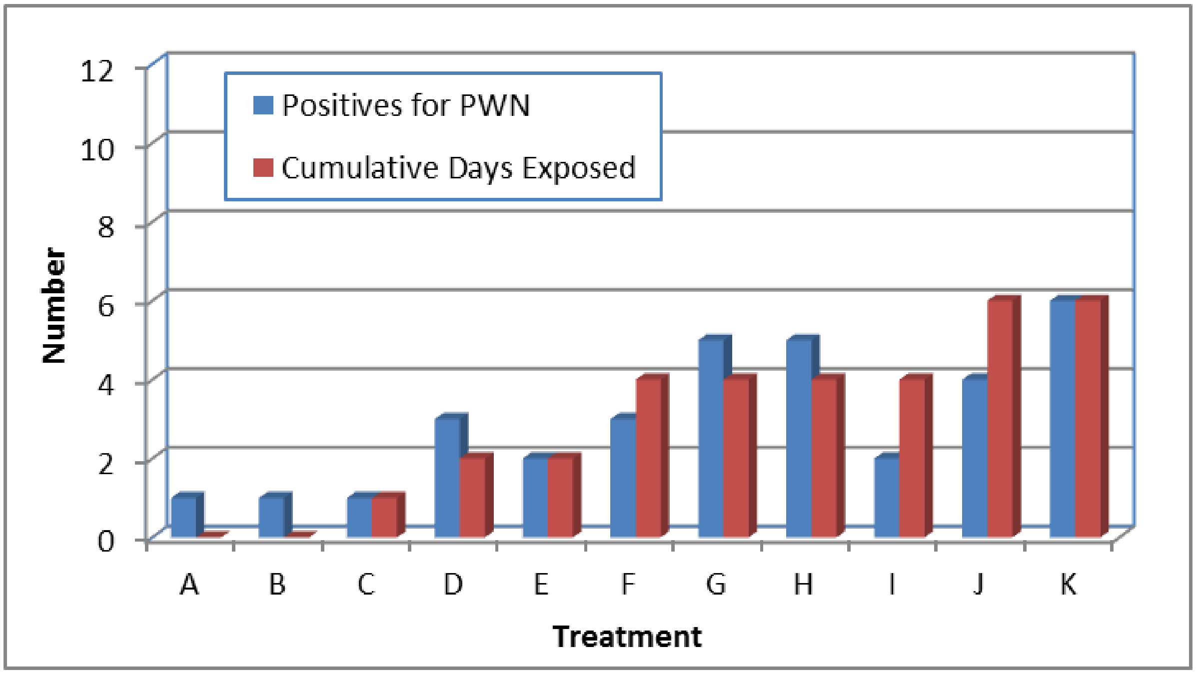


Figure 13: Occurrence of pinewood nematode in loblolly pine logs after different intervals of exposure to cerambycids and engraver beetles on sites 1 (A) and 2 (B) during the spring 2012.

A



B

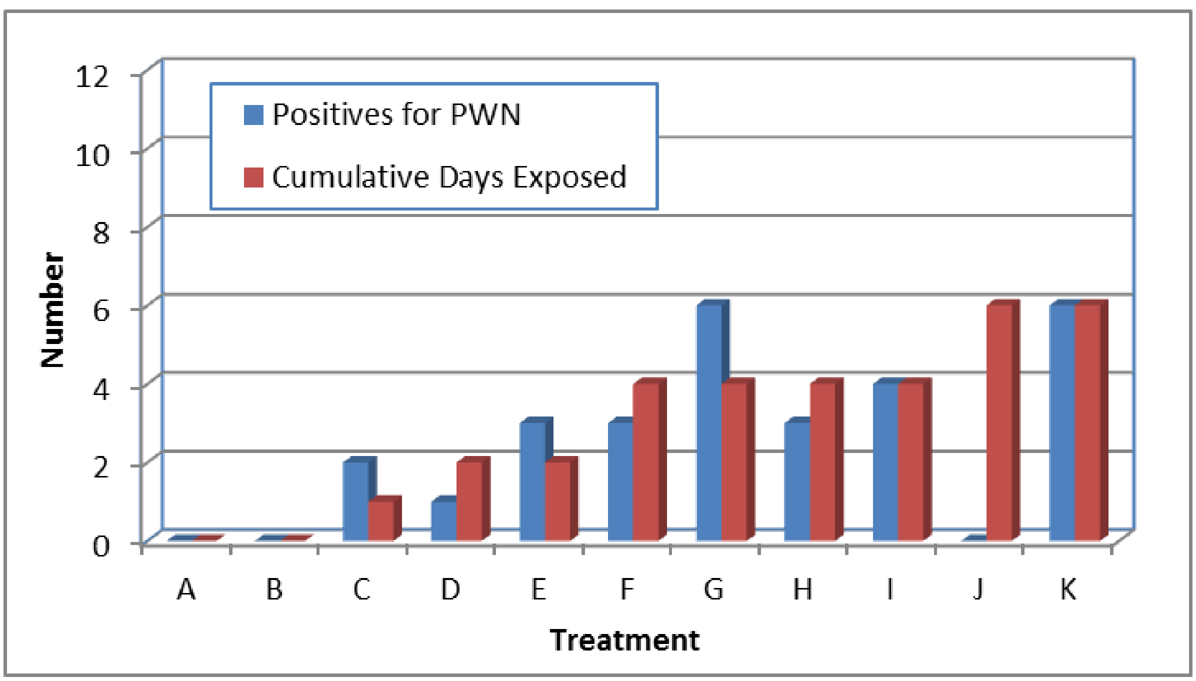
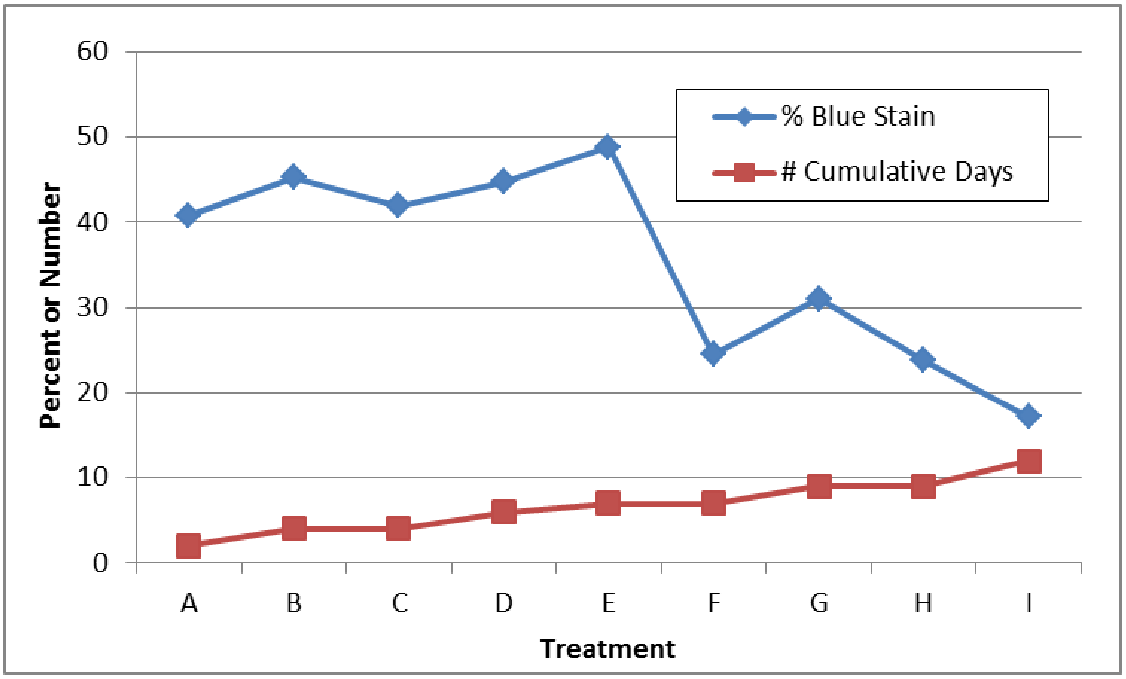


Figure 14: Occurrence of pinewood nematode in loblolly pine logs after different intervals of exposure to cerambycid and engraver beetles on sites 3 (A) and 4 (B) during the summer 2012.

A



B

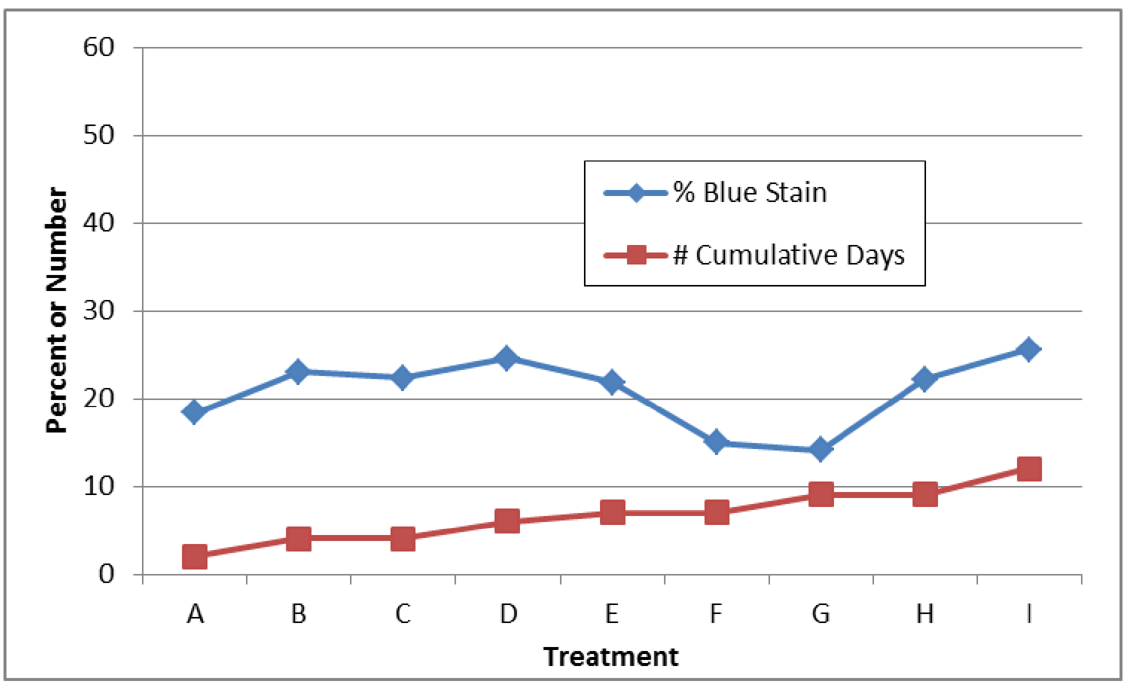
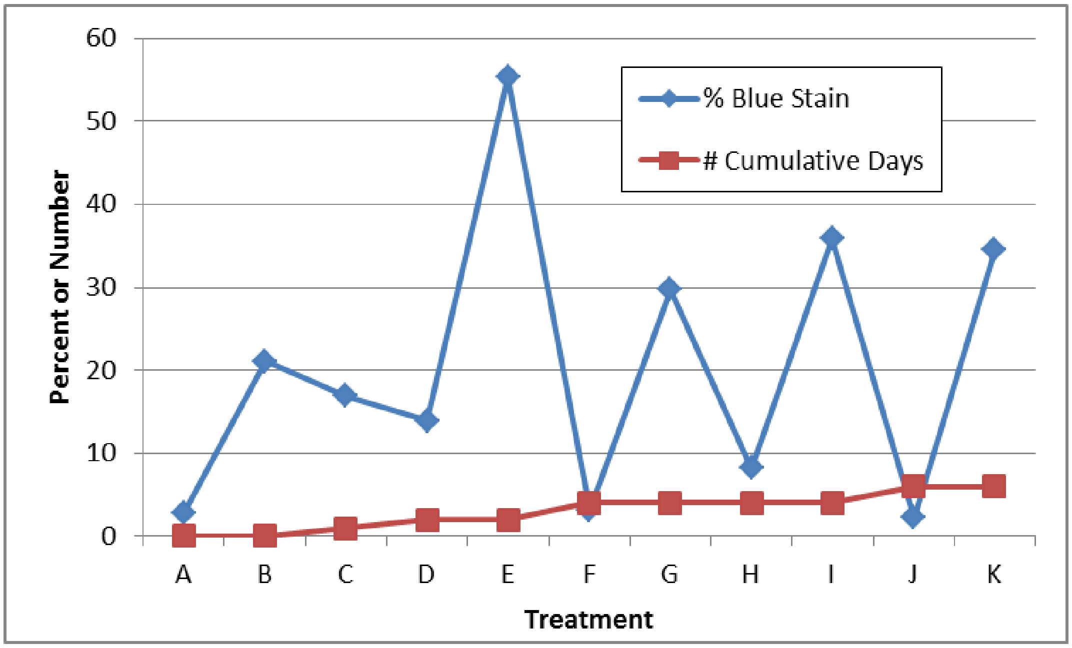


Figure 15: Cross-sectional area of loblolly pine logs covered by blue stain fungi after different intervals of exposure to cerambycids and engraver beetles on sites 1 (A) and 2 (B) during the spring 2012.

A



B

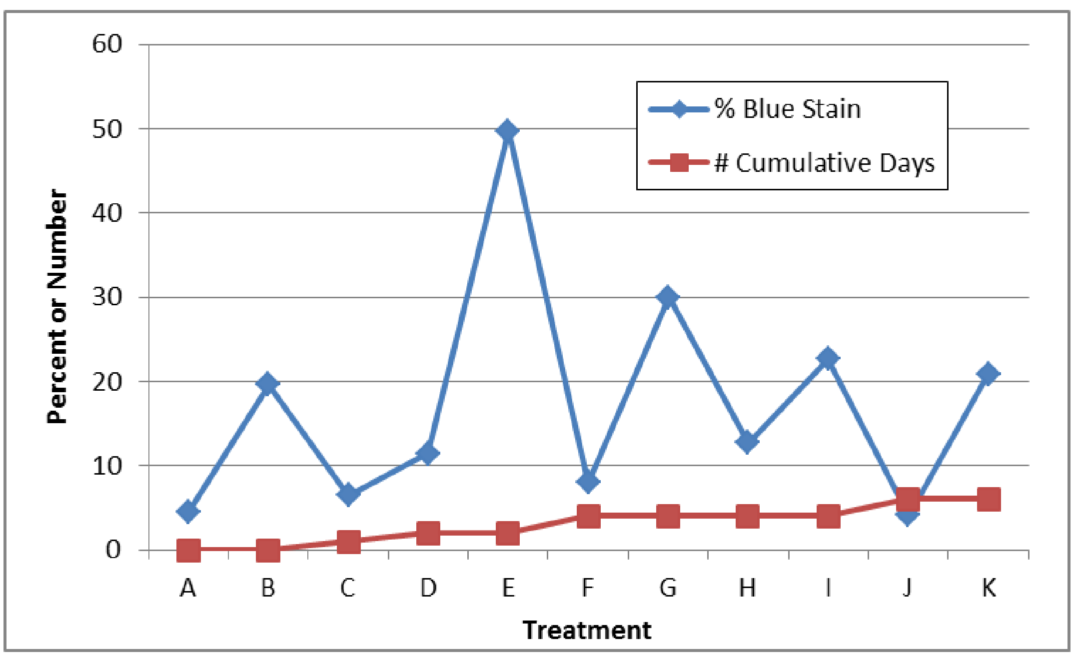


Figure 16: Cross-sectional area of loblolly pine logs covered by blue stain fungi after different intervals of exposure to cerambycids and engraver beetles on sites 3 (A) and 4 (B) during the summer 2012.

Evaluation of Bait Formulations for Attraction and Control of Texas Leaf-Cutting Ant

(Initiated in 2012)

Objectives:

1. Determine the attractiveness of toxic bait formulations to the Texas leaf-cutting ant
2. Determine the efficacy of baits for control of Texas leaf-cutting ants
3. Determine the effect of different rates of application of active ingredients on ant preference and treatment efficacy

Research Approach:

New bait formulations for control of Texas leaf-cutting ants were developed by Syngenta.

Preference Trial:

Pre-weighed bait (5g) was placed in Petri dishes at two different locations, Tonkowa & Colmesneil TX, on October 25 and 29, 2012, respectively. There were five colonies per location for a total of 10 colonies per bait treatment.

Preference trial 1 included the following baits: A. Amdro, B. Brazilian, C. Control, D. A20387A, and E. A2038B. Baits were placed in the mid-morning and ant foraging was allowed for approximately six hours before baits were retrieved and reweighed to determine amount of bait removed by ants.

After this initial trial, an additional preference test was conducted on October 30, 2012. This trial included the baits A. Amdro, E. A20387B, and F: Blitz. There were four replicates per treatment. Baits were placed in the mid-morning and foraging was again allowed for approximately 6 hours.

Data on the weight of baits (initial weight – post weight) and the number of bait particles retrieved were analyzed using the Wilcoxon signed ranks test to determine significant differences among the treatments.

Results:

There was no significant difference among the treatments in the weight difference of the baits or in the number of bait particles retrieved for preference trial 1 (χ^2 = 0.8358, DF = 4, P = 0.9336; χ^2= 5.3253, DF = 4, p = 0.2555, respectively) or two (χ^2 = 0.4208, DF = 2, P = 0.8103; χ^2= 0.6154, DF = 2, P = 0.7351, respectively).

Conclusion:

Additional testing will be completed in early 2013 using experimental baits developed by Syngenta Crop Science.

Acknowledgments:

Special thanks to Hancock Forest Management for providing access to leaf-cutting ant colonies and to Syngenta Crop Science for donating the chemicals.

Evaluation of TREE-äge™ for Control of Conifer Mites on Loblolly Pine

(Initiated in 2012)

Objectives:

1) Evaluate the potential efficacy of tree injection of TREE-age™ (emamectin benzoate) for control of secondary conifer mites on young loblolly pine trees.

Research approach:

Locations, Treatments, and Environmental Conditions

This study was conducted at The Campbell Group's Seed Orchard, Jasper, TX (about 30°57 N, 94°09 W, elev. 105 ft). An initial survey was conducted in early September, 2012, of the general health of four-year-old loblolly pines in a polymix trial containing several families. Each pine was evaluated for tip moth damage and presence of conifer mites. Ten (10) trees were randomly selected for treatment. An additional ten trees served as untreated checks.

There were two treatments: TREE-age™ (emamectin benzoate) tree injection (treatment **1**); and untreated control (treatment **2**).

The TREE-age treatment was applied to 10 randomly-assigned trees. Test trees were located in areas with abundant pine tip moth activity, and spaced >4 m apart. The injection treatment (treatment 1) was injected at the labeled rate (2.5 ml TREE-age per inch ground line diameter) after dilution in 1 part water with the Arborjet Tree IV™ microinfusion system (Arborjet, Inc. Woburn, MA) into a three points (use #3 Arborplugs) at staggered heights up to 6 inches above the ground. Injections were made in early September 2012.

In September, 2012, (at the time of initial treatment) and then periodically at 7 - 28 days, two lower branches were shaken over a white sheet of paper. The conifer mites found on the paper were counted and identified.

Precipitation and temperature data were obtained from the nearest weather station during the course of this study.

Results

The baseline number of mites observed on 18-September, 2012 (prior to injection) across treatments was 3.3 ± 0.34 per tree sample. No statistical differences among treatments were observed. Mite numbers on untreated checks were quite variable, ranging from 1.7 to 23.4 mites per sample. No signs of phytotoxicity were observed on injected trees. On 4-October, 14 days after treatment, reduction in mite numbers was observed. The lowest number of mites was in the TREE-äge™ treatment, however the means were not statistically different from the untreated trees ($p=0.05$) due to the variability observed in the untreated control. On 12-October, the TREE-äge™ treatment had a mean of 0.8 ± 0.29 mites per tree. This treatment was statistically different from the untreated trees ($p<0.05$), and on 19-October, the means for the TREE-äge**™** was 0.5 ± 0.307. The TREE-äge treatment was statistically different (and lower) than the untreated controls ($p<0.05$).

Conclusion:
Trees will continue to be monitored through 2013 to determine the long-term efficacy of treatments against conifer mites.

Acknowledgments:
We appreciate the field assistance of Billi Kavanagh, William Upton and Larry Spivey, Texas A&M Forest Service, and mite identification provided by Dr. Alex Mangini, US Forest Service, Forest Health Protection, Pineville, LA.

Evaluation of ECO-mite™ for Control of Conifer Mites on Loblolly Pine

(Initiated in 2012)

Objective:

1. Evaluate the potential efficacy of spray applications of ECO-mite™ and NO Spider Mite™ for control of secondary conifer mites on young loblolly pine trees.

Research approach:

Locations, Treatments, and Environmental Conditions

This study was conducted at The Campbell Group's Seed Orchard, Jasper, TX (about 30°57 N, 94°09 W, elev. 105 ft). An initial survey was conducted in early September 2012 of the general health of four-year-old loblolly pines in a polymix trial containing several families. Each pine was evaluated for tip moth damage and presence of conifer mites. Ten (10) trees were randomly selected for treatment. An additional ten trees served as untreated checks.

There were three treatments: ECO-mite foliar spray (treatment **1**); No Spider Mite foliar spray (treatment **2**); and untreated control (treatment **3**).

The ECO-mite and No Spider Mite treatments were each applied to 10 randomly-assigned trees. Test trees were located in areas with abundant pine tip moth activity, and spaced >4 m apart. Foliar sprays were made initially on 21-September, 2012 and again on 5-October, 2012 using a backsprayer and applied until the foliage was wet.

In September, 2012 (3 days prior to initial treatment) and then periodically at 7 - 28 days, two lower branches were shaken over a white sheet of paper. The conifer mites found on the paper were counted and identified.

Precipitation and temperature data were obtained from the nearest weather station during the course of this study

Results

The baseline number of mites observed on 18-September, 2012 (prior to foliar spray) across treatments was 3.3 ± 0.34 per tree sample. No statistical differences among treatments were observed (Figure 17). Mite numbers on untreated checks were quite variable, ranging from 1.7 to 23.4 mites per sample. No signs of phytotoxicity were observed on injected trees. On 4-October, 14 days after treatment, reduction in mite numbers was observed. The lowest number of mites was in the ECO-mite™ treatment. However, the means were not statistically different from those for untreated trees ($p=0.05$) due to the variability observed in the untreated control. On 12-October, the ECO-mite™ treatment had a mean of 0.3 mites per tree. This treatment was statistically different from the untreated trees ($p<0.05$). On 25-October, 1-November, 20-November, and 29 November the means for the ECO-mite**™** were 1.5, 0.9, 3.0, and 1.1, respectively. The ECO-mite treatment was statistically different (and lower) than the untreated controls ($p<0.05$) on all dates.

Acknowledgments:

We appreciate the field assistance of Billi Kavanagh, William Upton and Larry Spivey, Texas A&M Forest Service, and mite identification provided by Dr. Alex Mangini, USDA Forest Service, Forest Health Protection, Pineville, LA.

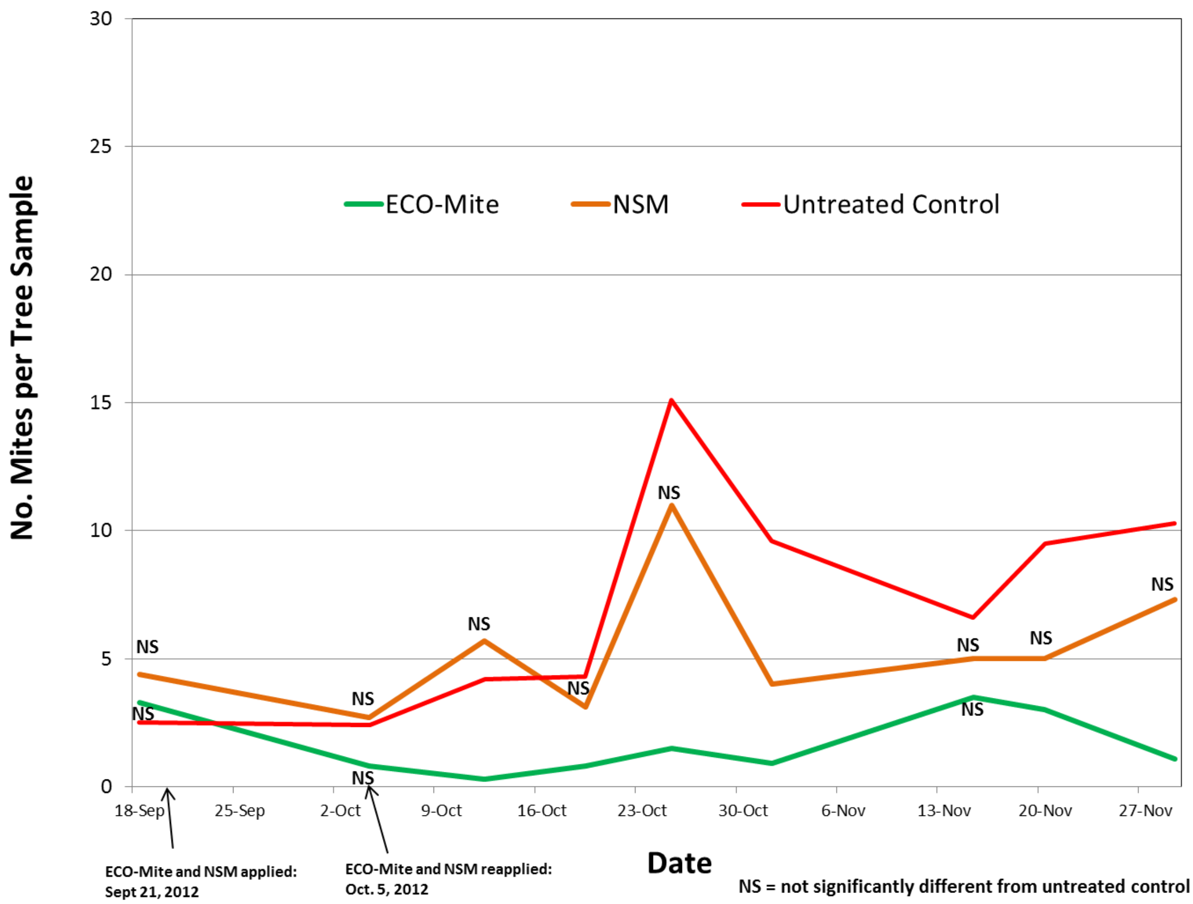


Figure 17. Mean number of pine spider mites (*Oligonychus milleri*) detected on ECO-mite, No Spider Mite (NSM) and untreated- loblolly pine near Jasper, Texas from September and November 2012.

Pine Tip Moth Trials: Evaluation of Fipronil Treatments for Containerized Pine Seedlings

Initiated in 2007

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
3. Determine the duration of chemical activity

Study Sites: Two first-year pine plantations owned by Campbell Group 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 – 15mL/seedling)
3. Containerized Control (untreated)
4. Bare-root Fipronil (12mL/seedling)
5. Bare-root Control (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 = 0.118g 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 were calculated; and 3). Separately, the terminal was identified as infested or not. Observations also were made as to the occurrence and extent of damage caused by other insects, i.e., aphids, weevils, 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; ≤ 2% of the shoots were infested on control trees (Table 23). 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 (Table 24)

In 2008, tip moth population pressure was much greater than in 2007, with an average of > 90% of the top-whorl shoots infested on check trees during the 4th and 5th generations and a mean of > 57% shoots infested over the entire growing season (5 generations) (Table 23). 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 24). Volume growth improvements attributed to fipronil treatments ranged from 64-94% (Figure 18).

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 23). 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 24). Volume growth improvements attributed to fipronil treatments ranged from 22-70% (Figure 18).

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 23). 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 24). Volume growth improvements attributed to fipronil treatments ranged from 36-69% (Figure 18).

In 2011, all treatments significantly improved height growth compared to check trees (Table 24). However, diameter and volumes were only significantly greater for container 5X and bare-root injection. Volume growth improvements attributed to fipronil treatments ranged from 14-63% (Figure 18).

In 2012, only container 5X and bare-root injection significantly improved height, diameter, and volume growth (Table 24). Volume growth improvements attributed to fipronil treatments ranged from 0.1-40%.

Acknowledgments:

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

Table 23. 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)**	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

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

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

Table 24. 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.

			Mean End of Season Tree Measurements (**Growth Difference (cm or cm^3) Compared to Check**)														
Year	Treatment	N	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		
2012	Containerized FIP 3 ml	100	545.8	661.3	603.5		**-4.05**	8.104	9.853	8.979		**0.076**	40434	66606	53520		**80**
	Containerized FIP 15 ml	100	640	667.4	653.7	*	**46.07**	9.654	10.15	9.902	*	**0.999**	65013	73970	69492	*	**16052**
	Containerized Check	100	544.7	670.5	607.6			8.082	9.725	8.903			41027	65853	53440		
	BR FIP SI 12 ml	50	544	650.1	602.1	*	**77**	8.354	9.786	9.07	*	**1.3**	45245	71661	58453	*	**16806**
	BR Check	50	431.5	618.6	525.1			8.104	9.646	7.77			18567	64727	41647		

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

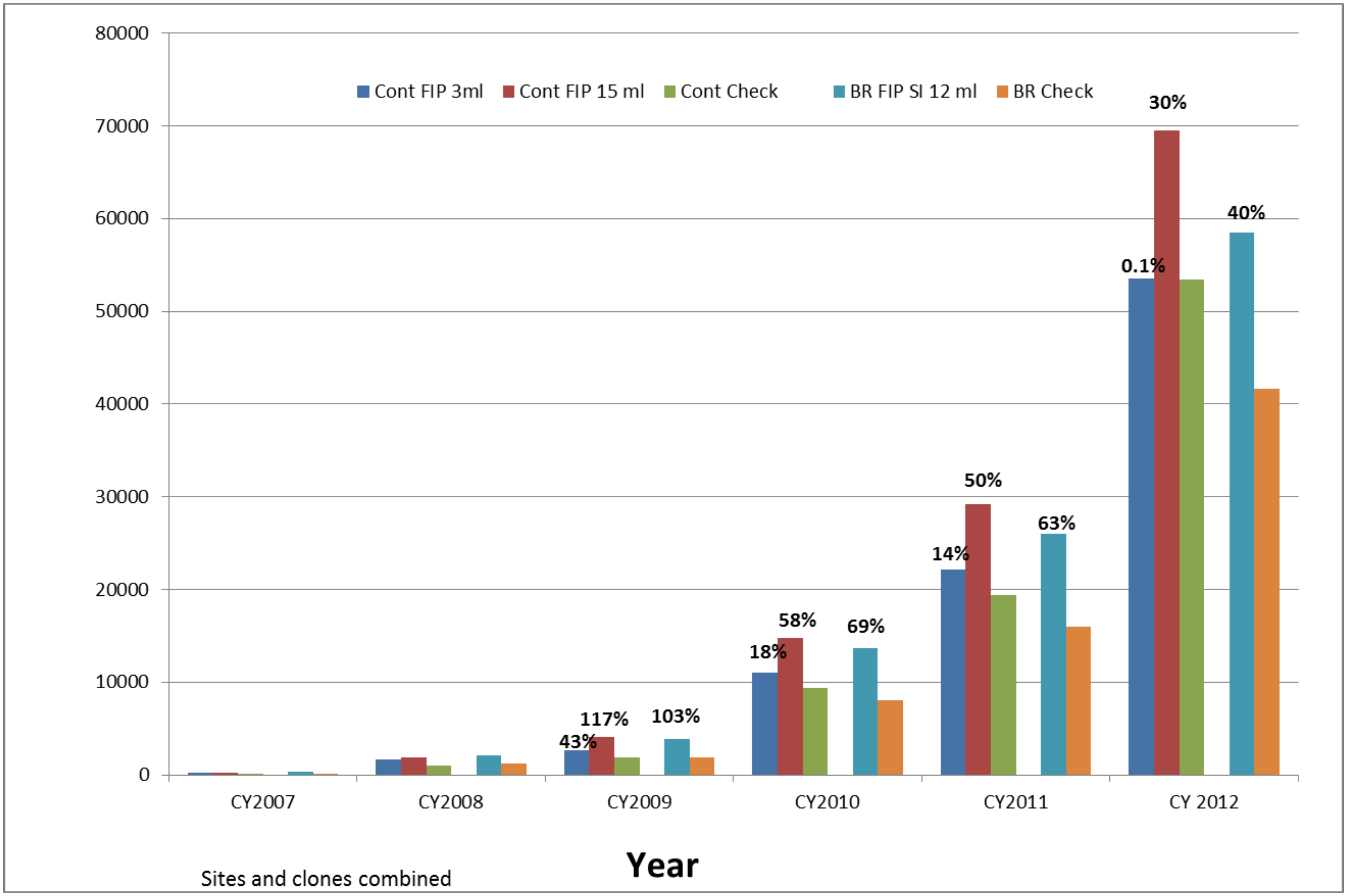


Figure 18. Effects of fipronil soil treatment on volume (cm3) growth of containerized and bareroot loblolly seedlings on two Texas sites: 2007-2012.

Pine Tip Moth Trials: Imidacloprid Tablet Trials: Western Gulf Region

Initiated in 2007

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
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 neonicotinoid 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 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® (0.6mL/L water) 5X / season
4. Bare-root Control: Treat with Terrasorb™ and plant bare-root

2009

1. Control (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 Tablet) + 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 both research years (2007 & 2009), a single family of loblolly pine bare-root seedlings was selected at the Texas Forest Service Indian Mounds 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 and 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 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. 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 25 and 26). 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 2012, measurements were continued on 2 sites in TX. Only treatment one (20% Merit® FXT Std. Tablet – 1 Tablet in plant hole) continued to show significant improvement of all growth parameters compared to checks on both sites (Table 27).

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 28). Populations rose to moderate levels (62%) by the fifth generation. As a result of low tip moth pressure, none of the 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 damage 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 29).

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 28). Treatments containing Tablets provided limited protection through the year, reducing damage by 7-43% (15 – 29%

overall). 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 the check trees (Table 29).

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 28). 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 29).

In 2012, all treatments with Tablets continued to significantly improve growth parameters compared to those of the control trees (Table 29).

Acknowledgments:

Thanks go to The Campbell Group, Weyerhaeuser Co., Potlatch Forest Holding, Plum Creek Timber Co., and Rayonier for providing research sites. We thank ArborGen for donating seedlings. We also thank Nate Royalty and Bruce Monke, Bayer Environmental Science, for providing support funds and imidacloprid tablets and other formulations for the project.

Table 25. 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)

Treatment §	N	Generation 1								Generation 2							
		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	

Treatment §	N	Generation 3								Generation 4							
		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	

Treatment §	N	Generation 5 (Last)								Mean							
		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 asterisk are significantly different from checks at the 5% level based on Fisher's Protected LSD.

Table 26. 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

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

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

Table 27. Effect of Bayer Tablets on height, diameter and volume index after the five growing seasons on two of the original six Western Gulf sites - 2012.

		Mean Parameter Growth (**Growth Difference (cm or cm^3) Compared to Check**)						
		Height (cm)						
Treatment §	N	TX1		TX2		Mean		
20% FXT Ball PH	50	661.9	*	642.0	*	651.0	*	**70.0**
20% FXT Ball Adjacent	50	613.9		617.1	*	615.5	*	**34.6**
Mimic foliar spray	50	618.4		636.7	*	628.4	*	**47.4**
Check	50	586.7		575.2		580.9		
		Diameter (cm)						
Treatment §		TX1		TX2		Mean		
20% FXT Ball PH	50	9.06	*	9.63	*	9.37	*	**1.20**
20% FXT Ball Adjacent	50	8.66		9.77	*	9.21	*	**1.04**
Mimic foliar spray	50	8.10		9.60	*	8.92	*	**0.75**
Check	50	7.84		8.51		8.17		
		Volume Index (cm^3)						
Treatment §		TX1		TX2		Mean		
20% FXT Ball PH	50	60783	*	61756	*	61319	*	**17214**
20% FXT Ball Adjacent	50	49953		63622	*	56787	*	**12681**
Mimic foliar spray	50	44629		61973	*	54075	*	**9969**
Check	50	40396		47820		44106		

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

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

Table 28. 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 asterisk 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 29. Effect of different silvicultural prescriptions 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] @ 6 inches			Volume (cm^3)			Mean Percent Tree Survival
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
2012	1 SS	45	358.4	*	**33.0**	5.00	*	**0.7**	10533.0	*	**2942.7**	90
	DAP 1X	37	358.1		**32.6**	5.08		**0.8**	10480.5		**2890.1**	74
	1 SS + DAP 1/2X	48	384.8	*	**59.3**	5.47	*	**1.2**	12401.1	*	**4810.8**	96
	HWC	41	336.7		**11.3**	4.44		**0.2**	7901.1		**310.8**	82
	1 SS + HWC	46	374.6	*	**49.1**	5.55	*	**1.3**	12737.4	*	**5147.1**	92
	1 SS + DAP 1/2X + HWC	47	389.6	*	**64.1**	5.51	*	**1.3**	12805.1	*	**5214.8**	94
	1 SS + DAP 1X + HWC	38	381.6	*	**56.1**	5.50	*	**1.2**	12670.3	*	**5080.0**	76
	DAP 1X + HWC	47	331.7	*	**6.2**	4.52	*	**0.3**	9036.9	*	**1446.6**	94
	Check	46	325.5			4.26			7590.3			92

***** Means followed by an asterisk 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

Initiated in 2008

Objectives:

1. To 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
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 a highly systemic neonicotinoid with activity against Lepidoptera.
- The fertilizer consisted of an 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). Control: seedlings planted by hand.

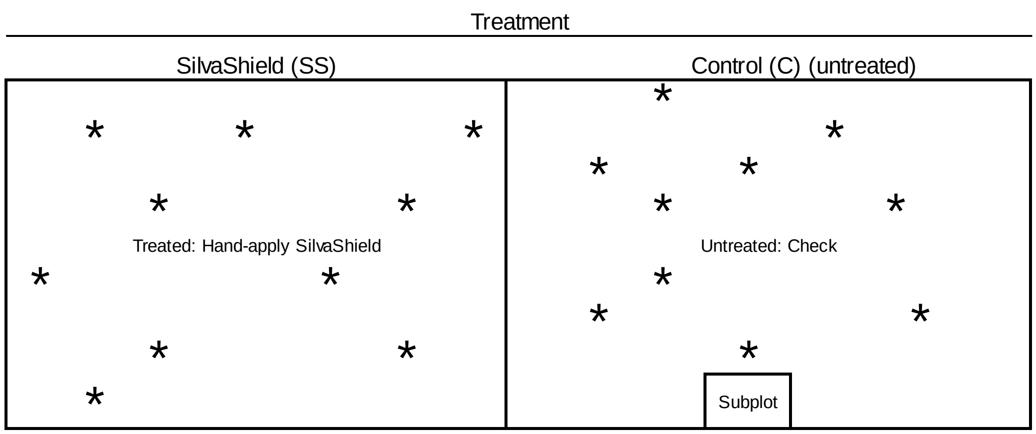
Two tracts about to be planted, and one one-year old tract, each 80 acres in size, were selected in Texas based on uniformity of soil, drainage, topography and potential susceptibility to tip moth infestation.

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 19). 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 areas. 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.

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 19. 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 reduce tip moth infestation levels compared to the check during this generation (Table 30). In contrast, the treatment provided very good protection during the second through fifth generations, reducing damage 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 31). After four years, Tablet-treated trees still had significantly improved growth parameters (height, diameter, and volume), by 21%, 31%, and 82% respectively. After five years, Tablet-treated trees continued to significantly improve growth parameters (height, diameter, and volume), by 10%, 13%, and 28%, 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 30). In contrast, the treatment provided good protection during the second through fifth generations, reducing damage by 31-52% (38% overall mean). 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 32). In the sixth year post planting, the Tablet-treated trees showed only a significant improvement in height at 4% compared with check trees (Table 32). There was no significant improvement in diameter or volume.

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 reduce tip moth infestation levels compared to the check during this generation (Table 33). In contrast, the treatment provided very good protection during the second through fifth generations, reducing damage by 65-90% (85% overall). During the second and third year, damage was reduced by 39% and 55% respectively. After three years, the Tablet treatment had significantly improved tree height, diameter, and volume growth parameters by 15%, 46%, and 153%, respectively, compared to those of check trees (Table 34). After four years, the Tablet treatment had significantly improved tree height, diameter, and volume growth parameters by 16%, 34%, and 102%, respectively, compared to control trees (Table 34).

Conclusions:

Data indicate that SilvaShield™ Tablets operationally applied by hand provide good protection against tip moth and improve growth up to the fifth year after planting. Additional data indicate that Tablets applied to one-year-old trees are not quite as effective against tip moth, but the treatments can still significantly improve tree growth.

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Table 30. 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 asterisk are significantly different from checks at the 5% level based on Fisher's Protected LSD.
[grey shading] = treatment reduced damage by 75% or better compared to check.

Table 31. 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	Mean End of Season Loblolly Pine Seeding Growth Measurements (**Growth Difference (cm or cm^3) Compared to Check)**									Mean Percent Tree Survival
				Height (cm)			Diameter (cm) [a]			Volume (cm^3)			
							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
	2012	1 Tablet at 8"	100	448.8	*	**42.0**	5.98	*	**0.69**	17408.3	*	**3807.1**	100
		Check	100	406.7			5.29			13601.2			100

[a] Diameter taken at 6" above ground.

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

Table 32. 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.

Site	Year	Treatment	N	Mean End of Season Loblolly Pine Seeding Growth Measurements (**Growth Difference (cm or cm^3) Compared to Check)** Height (cm)			Diameter (cm) [a]			Volume (cm^3)			Mean Percent Tree Survival
							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
	2012	1 Tablet at 8"	100	645.4	*	**22.9**	9.40		**0.41**	60592.2		**5754.4**	100
		Check	100	622.5			8.99			54837.8			100

[a] Diameter taken at 6" above ground.
***** Means followed by an asterisk are significantly different from checks at the 5% level based on Fisher's Protected LSD.

Table 33. 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 asterisk are significantly different from checks at the 5% level based on Fisher's Protected LSD.
[grey shading] = treatment reduced damage by 75% or better compared to check.

Table 34. Effect of SilvaShield Tablet on areawide loblolly pine growth on one site (Rockland) in east Texas, 2008 & 2009.

Site	Year	Treatment	N	Mean End of Season Loblolly Pine Seeding Growth Measurements (**Growth Difference (cm or cm^3) Compared to Check)** Height (cm)			**GLD (cm)** [a]			Volume (cm^3)			Mean Percent Tree Survival
Rockland 1st Yr	2009	1 Tablet in PH	100	75.3	*	**7.7**	1.19		**0.10**	146.8	*	**45.9**	100
		Check	100	67.7			1.09			100.9			100
2nd Yr	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
3rd Yr	2011	1 Tablet in PH	100	320.0	*	**41.3**	5.70	*	**1.3**	12310.1	*	**6129.5**	100
		Check	100	278.7			4.40			6180.6			100

Site	Year	Treatment	N	Height (cm)			**DBH (cm)** [a]			Volume (cm^3)			Mean Percent Tree Survival
Rockland 3rd Yr	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
Rockland 4th Yr	2012	1 Tablet in PH	100	498.1	*	**70.0**	7.96	*	**2.03**	34979.9	*	**17652.3**	100
		Check	100	428.1			5.93			17327.6			100

[a] Diameter taken at 6" above ground.

***** Means followed by an asterisk 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

Initiated in 2010

Objectives:

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
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 neonicotinoid 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. Control: 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)	w hite
F	PTM at planting + PTM post plant (2 pts, Feb. '11)	red/w hite
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/w hite
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/w hite

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.

Times for Jasper Co., TX site:

- 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 35). 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 38).

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 36). 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 39). There were no differences in tree survival among the treatments.

In 2012, tip moth populations were high through most of the 3rd year, with damage levels ranging from 11% of the shoots infested after generation 1, to 90% after generation 5 (Table 37). Only the three SS treatments applied at planting showed a significant reduction in tip moth infestation of top whorl shoots compared to the control for all five generations (Table 37). Analysis of variance found that SS "at plant" and "post plant" provided significantly better protection than PTM™ both "at plant" and "post plant" (SS AP vs. PTM AP: $p < .0001$; SS PP vs. PTM PP: $p < .0001$). Some of the treatments showed a significant improvement in tree height growth and diameter (measured as both GLD and DBH) compared to control trees, there was no difference in volume (Tables 40 [GLD] and 41 [DBH]).

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.

References:

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.

Table 35. 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 asterisk 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 36. 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 asterisk 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 37. 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, 2012.

	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		
2012	PTM	W '09	AP	47	3.01	**73**	*	1.7	**62**		20.4	**29**	*	44.3	**26**	*	68.3	**24**	*	27.5	**27**	*
	PTM	W '09 + S'10	AP	48	3.3	**70**	*	4.1	**12**		13.3	**53**		22.8	**62**		43.8	**51**	*	17.5	**54**	*
	PTM	W '09 +F '11	AP	48	0.94	**91**	*	4.1	**11**		28.5	**0**		43.8	**27**		73.7	**18**	*	29	**23**	*
	PTM	W '09	PP	42	14.8	**-34**		3.7	**20**		28.5	**0**		61.2	**-3**		78.1	**13**		37.3	**1**	
	PTM	W '09 + F '11	PP	43	3.88	**65**	*	4.8	**-4**		30.7	**-8**		47.8	**20**		65.8	**27**	*	30.6	**19**	*
	PTM	S '10	PP	42	0.79	**93**	*	3.1	**32**		37.0	**-30**		59.1	**1**		75.2	**16**		36	**4**	
	PTM	F '11	PP	43	3.88	**65**	*	4.7	**-2**		25.5	**10**		46.6	**22**		68.3	**24**		28.9	**23**	*
	SS	W '09	AP	47	3.55	**68**	*	0.4	**92**	*	3.5	**88**	*	10.7	**82**	*	32.4	**64**	*	10.1	**73**	*
	SS	W '09 + S'10	AP	46	3.8	**65**	*	1.1	**77**		3.3	**89**	*	10.9	**82**	*	23.0	**74**	*	8.19	**78**	*
	SS	W '09 +F '11	AP	46	3.26	**70**	*	0.0	**100**	*	3.4	**88**	*	11.1	**81**	*	14.9	**83**	*	6.55	**83**	*
	SS	W '09	PP	46	3.33	**70**	*	4.3	**8**		27.0	**5**		34.1	**43**		58.2	**35**	*	25.4	**33**	*
	SS	W '09 + F '11	PP	44	6.86	**38**		0.6	**88**		8.5	**70**	*****	19.9	**67**	*****	36.1	**60**	*	14.4	**62**	*
	SS	S '10	PP	43	4.65	**58**	*	0.5	**90**		7.6	**73**	*****	16.4	**73**	*****	39.3	**56**	*	13.7	**64**	*
	SS	F '11	PP	50	4.83	**56**	*	2.4	**48**		9.7	**66**	*****	12.2	**80**	*****	48.1	**46**	*	15.4	**59**	*
	Check			45	11			4.63			28.5			59.6			89.8			37.7		

***** Means followed by an asterisk 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™ soil injection and SilvaShield™ tablet dose, timing and technique on loblolly pine growth on one site (Campbell Group nursery) in east Texas, 2010.

	Treatment				Mean End of Season Loblolly Pine Seeding Growth Measurements (**Growth Difference (cm or cm3) Compared to Check)**						Mean Percent Tree
Year	Product	Season	Tech.	N	Height (cm)		Diameter (cm) [a]		Volume (cm^3)		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 asterisk are significantly different from checks at the 5% level based on Fisher's Protected LSD.

Table 39. 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.

	Treatment				Mean End of Season Loblolly Pine Seeding Growth Measurements (**Growth Difference (cm or cm3) Compared to Check)**						Mean Percent Tree
Year	Product	Season	Tech.	N	Height (cm)		Diameter (cm) [a]		Volume (cm^3)		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 asterisk are significantly different from checks at the 5% level based on Fisher's Protected LSD.

Table 40. Effect of PTM™ soil injection and SilvaShield™ Tablet dose, timing, and technique on loblolly pine growth (diameter measured at ground level [GLD]) on one site (Campbell Group nursery) in east Texas, 2012.

	Treatment				Mean End of Season Loblolly Pine Seeding Growth Measurements **(Growth Difference (cm or cm^3) Compared to Check)**							
Year	Product	Season	Tech.	N	Height (cm)			GLD (cm)			Volume (cm^3)	
2012	PTM	D '09	AP	47	282.7		**21.7**	5.85		**0.4**	10760.8	**2093**
	PTM	D '09 + S '10	AP	48	281.33	*	**20.3**	5.794		**0.3**	11727.1	**3060**
	PTM	D '09 +F '11	AP	48	290.84		**29.8**	5.80		**0.4**	10895.6	**2228**
	PTM	D '09	PP	42	258.3		**-2.8**	5.20	*	**-0.3**	8200.4	**-467**
	PTM	D '09 + F '11	PP	43	278.5		**17.5**	5.37		**-0.1**	9440.2	**773**
	PTM	S '10	PP	42	284.5		**23.5**	5.73		**0.3**	10945.0	**2278**
	PTM	F '11	PP	43	258.2		**-2.9**	5.12		**-0.3**	8392.0	**-276**
	SS	D '09	AP	47	288.5	*	**27.4**	5.45		**0.0**	9289.0	**621**
	SS	D '09 + S'10	AP	46	289.9	*	**28.8**	5.45		**0.0**	9408.7	**741**
	SS	D '09 +F '11	AP	46	275.7		**14.6**	5.14		**-0.3**	8194.0	**-473**
	SS	D '09	PP	46	286.1	*	**25.1**	5.60		**0.2**	9959.9	**1292**
	SS	D '09 + F '11	PP	44	283.1		**22.0**	5.51		**0.1**	9778.1	**1111**
	SS	S '10	PP	43	254.3		**-6.8**	4.65	*	**-0.8**	6676.8	**-1991**
	SS	F '11	PP	50	287.0	*	**26.0**	5.80		**0.4**	10753.9	**2086**
	Check			45	261.1			5.45			8667.5	

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

Table 41. Effect of PTM™ soil injection and SilvaShield™ Tablet dose, timing, and technique on loblolly pine growth (diameter measured at breast height [DBH]) on one site (Campbell Group nursery) in east Texas, 2012.

	Treatment				Mean End of Season Loblolly Pine Seeding Growth Measurements **(Growth Difference (cm or cm³) Compared to Check)**							
Year	Product	Season	Tech.	N	Height (cm)			DBH (cm)			Volume (cm³)	
2012	PTM	D '09	AP	47	282.7		**21.7**	5.85		**0.4**	3395.3	**835**
	PTM	D '09 + S '10	AP	48	281.333	*	**20.3**	5.79		**0.3**	3787.4	**1227**
	PTM	D '09 +F '11	AP	48	290.84		**29.8**	5.80	*	**0.4**	3795.8	**1236**
	PTM	D '09	PP	42	258.3		**-2.8**	5.20		**-0.3**	2483.2	**-77**
	PTM	D '09 + F '11	PP	43	278.5		**17.5**	5.37		**-0.1**	3083.3	**523**
	PTM	S '10	PP	42	284.5		**23.5**	5.73	*	**0.3**	3963.9	**1404**
	PTM	F '11	PP	43	258.2		**-2.9**	5.12		**-0.3**	2426.0	**-134**
	SS	D '09	AP	47	288.5	*	**27.4**	5.45	*	**0.0**	3271.9	**712**
	SS	D '09 + S'10	AP	46	289.9	*	**28.8**	5.45		**0.0**	3064.8	**505**
	SS	D '09 +F '11	AP	46	275.7		**14.6**	5.14		**-0.3**	2446.2	**-114**
	SS	D '09	PP	46	286.1	*	**25.1**	5.60		**0.2**	3375.4	**815**
	SS	D '09 + F '11	PP	44	283.1		**22.0**	5.51		**0.1**	3674.9	**1115**
	SS	S '10	PP	43	254.3		**-6.8**	4.65		**-0.8**	2257.8	**-302**
	SS	F '11	PP	50	287.0	*	**26.0**	5.80	*	**0.4**	3556.8	**997**
	Check			45	261.1			5.45			2559.9	

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

Pine Tip Moth Trials: Evaluation of Fipronil Treatments for Second-Year Pine Seedlings: East Texas

(Initiated in 2010)

Objectives:

1. Evaluate the efficacy of PTM^{TM} Insecticide (fipronil) applied to second-year pine seedlings for reducing pine tip moth infestation levels
2. Evaluate PTM^{TM} efficacy using different soil injection techniques
3. Determine the duration of PTM^{TM} activity

Study Sites:

A one-year-old plantation (planted in 2008) off CR3260 near Colmesneil, Texas, was selected. The plots contained 11 treatments and 550 trees (5 rows X 110 trees).

Insecticides:

- Fipronil: PTM^{TM} Insecticide (0.9 lbs. AI/Gal), BASF Corp.
- Imidacloprid: SilvaShield^{TM} Forestry Tablet (20% AI), Bayer Crop Science

Research Approach:

Treatments:

Trial 1:

1. Check (untreated): resident seedling

Fall 2009

2. PTM^{TM} (1.4 mL/tree LO Vol): double injection (7.5mL ea.) into soil 4” deep
3. PTM^{TM} (1.4mL/ tree HI Vol): double injection (15mL ea.) into soil 4” deep
4. PTM^{TM} (2.8mL/ tree LO Vol): double injection (7.5mL ea.) into soil 4” deep
5. PTM^{TM} (2.8mL/ tree HI Vol): double injection (15mL ea.) into soil 4” deep
6. SilvaShield^{TM} Tablet: 2 Tablets (1 on ea. Side) into soil 4” deep

Spring 2010

7. PTM™ (1.4mL/ tree LO Vol): double injection (7.5mL ea.) into soil 4" deep
8. PTM™ (1.4mL/ tree HI Vol): double injection (15mL ea.) into soil 4" deep
9. PTM™ (2.8mL/ tree LO Vol): double injection (7.5mL ea.) into soil 4" deep
10. PTM™ (2.8mL/ tree HI Vol): double injection (15mL 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 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.

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 15cm or 6in) 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 42). 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 43), 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 generations but increased to 57% in the fifth generation (Table 42). 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 43), 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.

In 2012, only tree growth was assessed. All treatments resulted in significant improvement in height, diameter (measured at DBH), and volume compared with the controls (Table 44).

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 42. 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 asterisk are significantly different from checks at the 5% level based on Fisher's Protected LSD.

Table 43. 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.

				Mean Second Year Growth (**Growth Difference (cm or cm^3) Compared to Check**)								
Year	Treatment	Timing	N	Height (cm)			GLD (cm)			Volume (cm^3)		
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 asterisk are significantly different from checks at the 5% level based on Fisher's Protected LSD.

Table 44. Effect of fipronil application timing, rate and volume on loblolly pine growth 9 - 38 months after treatment on one site (CR 3260) in East Texas - 2012

				Mean End of Season Loblolly Pine Seeding Growth Measurements (**Growth Difference (cm or cm^3) Compared to Check)**								
Year	Treatment	Timing	N	Height (cm)			DBH (cm)			Volume (cm^3)		
2012	PTM (1.4 ml) - 15 ml Dilution	Oct '09	50	472.1	*	**59.3**	7.15	*	**1.2**	25564	*	**8620.0**
	PTM (1.4 ml) - 30 ml Dilution	Oct '09	50	473.1	*	**60.3**	7.21	*	**1.2**	26223	*	**9278.6**
	PTM (2.8 ml) - 15 ml Dilution	Oct '09	50	461.3	*	**48.5**	6.97	*	**1.0**	24088	*	**7143.9**
	PTM (2.8 ml) - 30 ml Dilution	Oct '09	50	484.2	*	**71.4**	7.35	*	**1.4**	28004	*	**11059.0**
	Silvashield (2 Tablets)	Oct '09	49	454.5	*	**41.7**	6.72	*	**0.7**	21467	*	**4522.3**
	PTM (1.4 ml) - 15 ml Dilution	March '10	50	453.9	*	**41.1**	6.89	*	**0.9**	22909	*	**5964.8**
	PTM (1.4 ml) - 30 ml Dilution	March '10	50	454.2	*	**41.4**	6.90	*	**0.9**	23174	*	**6229.9**
	PTM (2.8 ml) - 15 ml Dilution	March '10	50	451.9	*	**39.1**	6.66	*	**0.7**	21622	*	**4677.8**
	PTM (2.8 ml) - 30 ml Dilution	March '10	50	438.2	*	**25.4**	6.62	*	**0.6**	21494	*	**4549.1**
	Silvashield (2 Tablets)	March '10	50	458.4	*	**45.6**	6.79	*	**0.8**	23339	*	**6394.9**
	Check		50	412.8			5.97			16944		

***** Means followed by an asterisk 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 2011)

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 bareroots seedlings for reducing pine tip moth infestation levels
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 [5.6mL PTM undiluted/ seedling (110 TPA rate)]: Injection into container seedling plug just prior to shipping
2. PTM™: High concentration/ diluted soil injection [5.6mL PTM in 9.4mL water (15mL total volume)/seedling]: Soil injection next to transplanted container plug just after planting
3. PTM™: High concentration/ diluted soil injection [5.6mL PTM in 9.4mL water (15mL total volume)/ seedling]: Soil injection next to transplanted bareroot just after planting
4. PTM™: Mid-concentration/ undiluted plug injection [1.4mL PTM undiluted/ seedling (435 TPA rate)]: Injection into container seedling plug just prior to shipping
5. PTM™: Mid-Concentration/ diluted plug injection [1.4mL PTM in 1.7mL water (3mL total volume)/seedling]: Injection into container seedling plug just prior to shipping
6. PTM™: Mid-concentration/ diluted soil injection [1.4mL PTM in 13.6mL water (15mL total volume)/seedling]: Soil injection next to transplanted container plug just after planting
7. PTM™: Mid-concentration/ diluted soil injection [1.4mL PTM in 13.6mL water (15mL total volume)/seedling]: (Standard 1) Soil injection next to transplanted bareroot just after planting.
8. PTM™: Low-concentration/undiluted plug injection [1mL PTM undiluted/seedling (600 TPA rate)]: Injection into container seedling plug just prior to shipping
9. PTM™: Low-concentration/ diluted plug injection [1mL PTM in 2mL water (3mL total volume/seedling)]: Injection into container seedling plug just prior to shipping
10. PTM™: Low-concentration/ diluted soil injection [1mL PTM in 14mL water (15mL total volume)/seedling]: Soil injection next to transplanted container plug just after planting
11. PTM™: Low-concentration/diluted soil injection [1mL PTM in 14mL water (15mL total volume)/seedling]: (Standard 2) Soil injection next to transplanted bareroot just after planting
12. Containerized Control (untreated)
13. Bareroot Control (untreated)

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

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

- 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-nine (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/will be 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 the 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 seedlings in GA (Figure 20, Table

45). 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 21). Nearly all PTM treatments (9 of 11) significantly improved height, diameter, and volume (Table 46). Mean volume improvement for plugs treated prior to planting was 42% compared to checks. This was 12% higher than volume increase observed on post-plant treated seedlings. In addition, most PTM treatments (8 of 11) significantly improved survival compared to untreated checks. Mean survival of pre-plant treated seedlings was 6.7% better than checks. This was double the improvement (3.4%) in survival observed on post-plant treated seedlings.

In 2012, tip moth populations were again variable, with low damage levels on checks in FL (5% on container & 10% on bareroot) to 58% on bareroot seedlings in LA (Figure 22, Table 47). PTM applied to containers after planting reduced overall tip moth damage by 43% compared to untreated checks. This was only 5% and 7% better than protection provided by PTM injected into container seedling plugs before planting and PTM applied to bareroot seedlings after planting, respectively (Figure 23). Almost all PTM treatments significantly improved height, diameter, and volume (Table 48). Only the containerized high-dilution and bareroot high-dilution treatments applied to the soil after planting did not show significant improvement in diameter growth. The bareroot high dilution treatment applied to the soil after planting did not show significant improvement in volume either (Table 48). Mean volume improvement for plugs treated prior to planting was increased by 39% compared to checks. This was 16% higher than volume increase observed on post-plant treated seedlings. None of the PTM treatments significantly improved survival compared to untreated checks. Mean survival of pre-plant treated seedlings was 9.2% better than checks, and that of post-plant treated seedlings; 5.2%.

Acknowledgments:

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

References:

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.

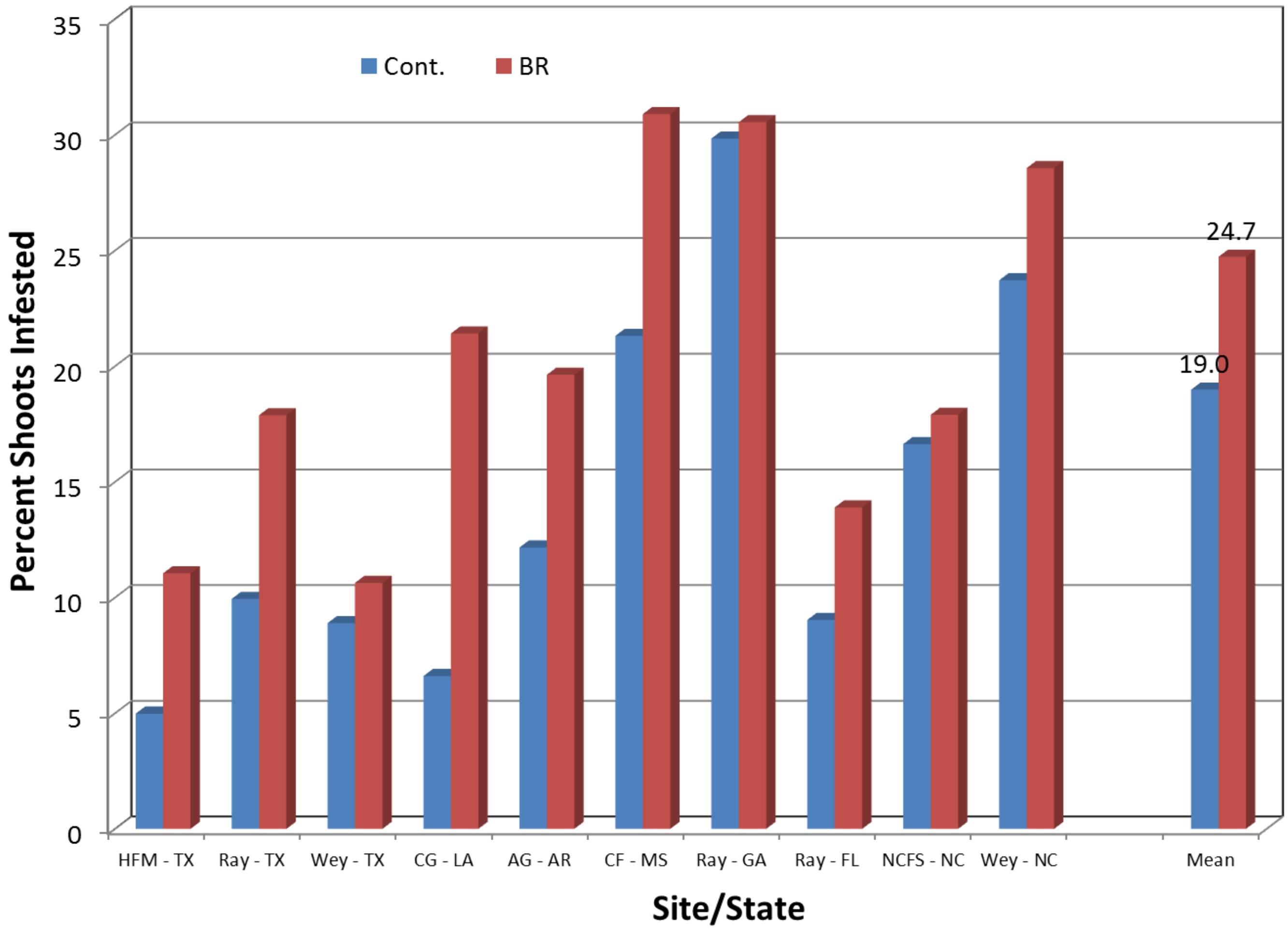

Figure 20. Mean tip moth infestation levels on first year containerized and bareroot loblolly pine on ten sites across the southeastern United States, 2011.

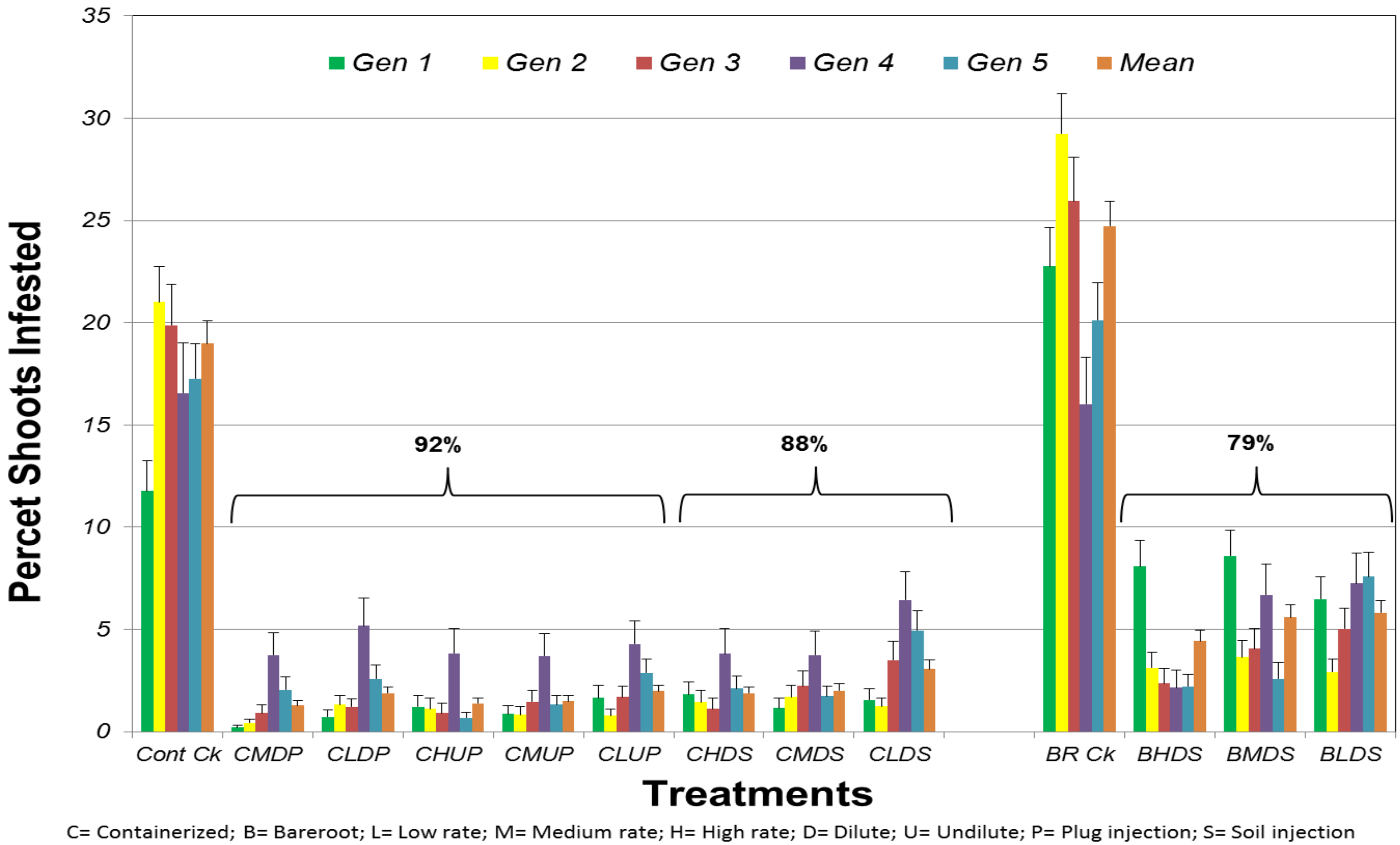

Figure 21. Effect of PTM™ plug and soil injection dose on tip moth infestation of containerized or bareroot loblolly pine on ten sites across the southeastern United States, 2011.

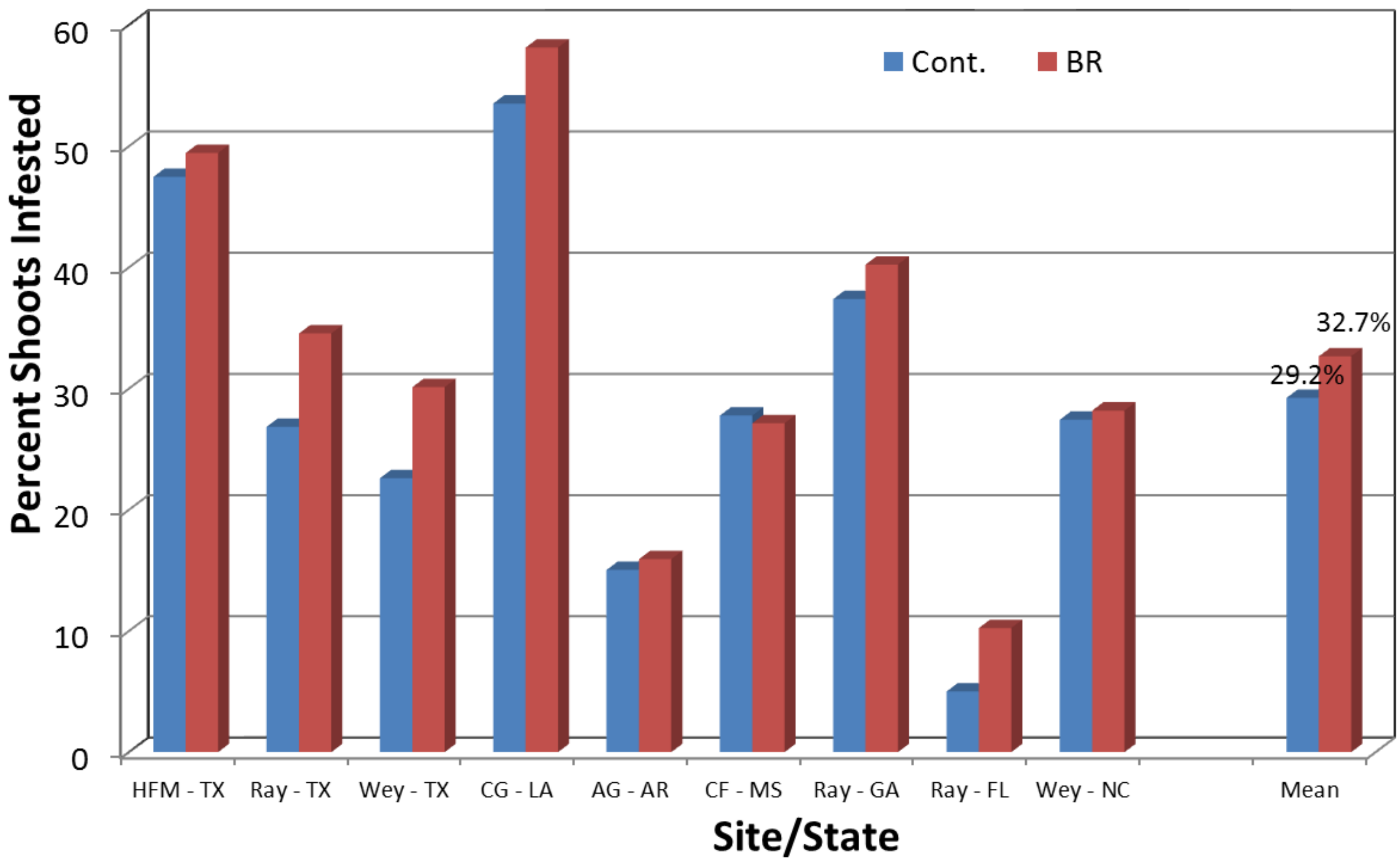

Figure 22. Mean tip moth infestation levels on first year containerized and bareroot loblolly pine on ten sites across the southeastern United States, 2011.

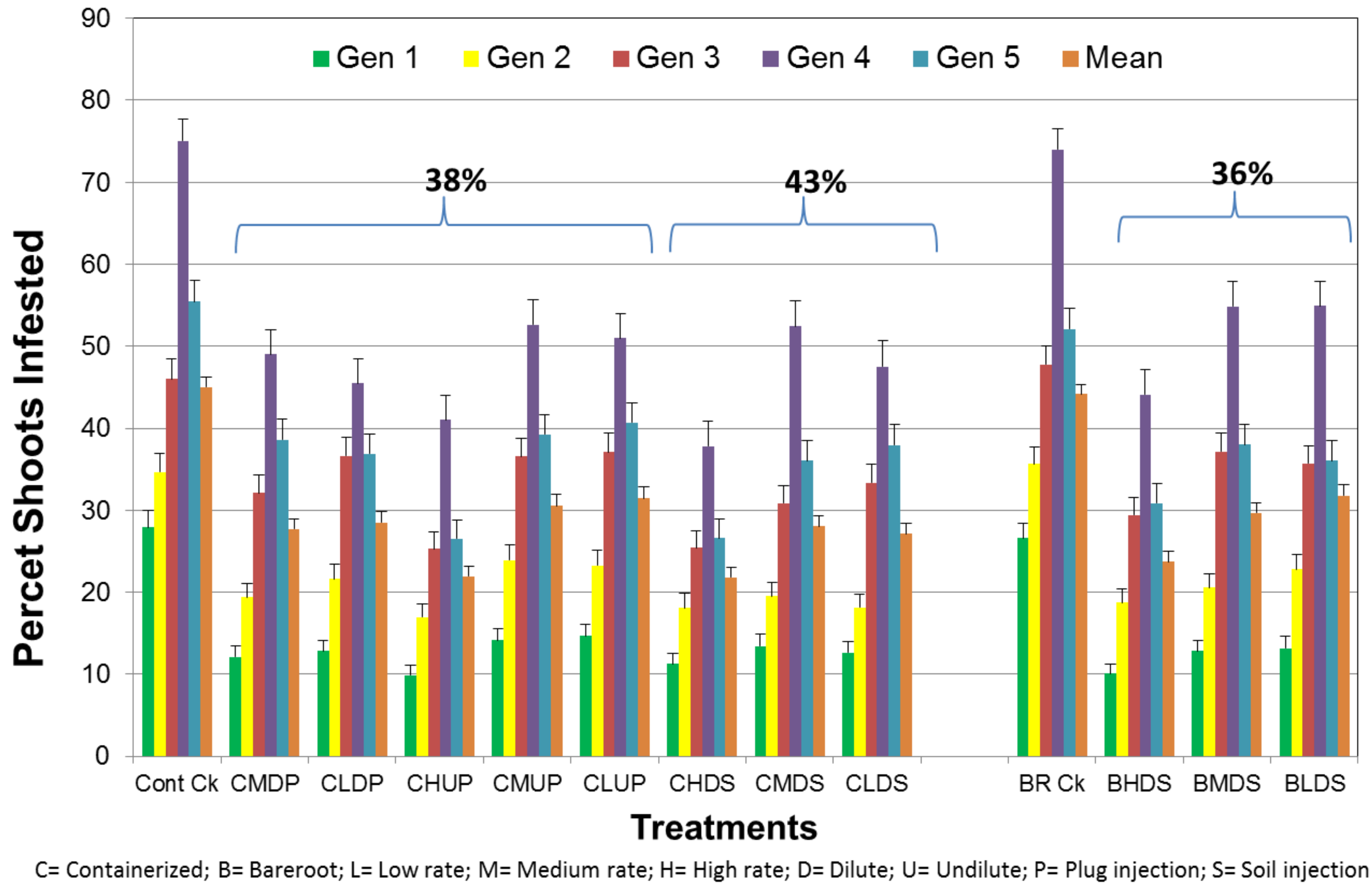

Figure 23. Effect of PTM™ plug and soil injection dose on tip moth infestation of containerized or bareroot loblolly pine on ten sites across the southeastern United States, 2012.

Table 45. 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					Mean Percent Top Whorl Shoots Infested by Tip Moth																	
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 46. 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] Ground Line Diameter.

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

Table 47. Effect of PTM dose and technique on pine tip moth infestation of containerized and bareroot loblolly pine shoots (top whorl) on nine sites across the southeastern United States, 2012 (Est. 2011).

	Treatment					Mean Percent Top Whorl Shoots Infested by Tip Moth (**Pct. Reduction Compared to Check**)																	
Year	Cont. or BR	Conc.	or Undilute	Inj. Loc.	N	Gen 1 (10 sites)			Gen 2 (9 Sites)			Gen 3 (8 Sites)			Gen 4 (6 Sites)			Gen 5 or Last (9 Sites)			Overall Mean		
2012	Cont.	Med	Dilute	Plug	390	12.0	**57**	*	19.4	**44**	*	32.1	**30**	*	49.0	**35**	*	38.6	**30**	*	27.7	**38**	*
	Cont.	Low	Dilute	Plug	390	12.5	**55**	*	21.6	**38**	*	36.6	**20**	*	45.5	**39**	*	36.9	**33**	*	28.5	**37**	*
	Cont.	High	Undilute	Plug	390	10.4	**62**	*	17.0	**51**	*	25.3	**45**	*	41.0	**45**	*	26.5	**52**	*	22.0	**51**	*
	Cont.	Med	Undilute	Plug	390	14.2	**49**	*	23.9	**31**	*	36.5	**21**	*	52.6	**30**	*	39.2	**29**	*	30.6	**32**	*
	Cont.	Low	Undilute	Plug	390	11.0	**60**	*	23.3	**33**	*	39.1	**15**	*	51.0	**32**	*	40.7	**27**	*	31.5	**30**	*
	Cont.	High	Dilute	Soil	390	11.0	**60**	*	18.0	**48**	*	25.4	**45**	*	37.8	**50**	*	26.6	**52**	*	21.8	**52**	*
	Cont.	Med	Dilute	Soil	390	13.8	**50**	*	19.4	**44**	*	30.9	**33**	*	52.4	**30**	*	36.0	**35**	*	28.0	**38**	*
	Cont.	Low	Dilute	Soil	390	13.6	**51**	*	18.1	**48**	*	33.3	**28**	*	47.5	**37**	*	38.0	**32**	*	27.1	**40**	*
	Cont.				390	27.7			34.7			46.0			75.1			55.5			45.0		
	BR	High	Dilute	Soil	390	10.0	**61**	*	18.7	**48**	*	29.4	**38**	*	44.1	**40**	*	30.9	**41**	*	23.7	**46**	*
	BR	Med	Dilute	Soil	390	13.5	**48**	*	20.5	**42**	*	37.2	**22**	*	54.8	**26**	*	38.0	**27**	*	29.7	**33**	*
	BR	Low	Dilute	Soil	390	16.2	**37**	*	22.8	**36**	*	35.7	**25**	*	54.9	**26**	*	41.4	**21**	*	31.8	**28**	*
	BR				390	25.9			35.6			47.7			74.0			52.1			44.2		

***** Means followed by an asterisk 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 48. Effect of PTM dose and technique on containerized and bareroot loblolly pine growth on nine sites across the southeastern United States, 2012 (Est 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)					
2012	Cont.	Med	Dilute	Plug	327	128.3	*	**19.8**	2.96	*	**0.44**	1882.9		**544.0**	*	93	**9**
	Cont.	Low	Dilute	Plug	327	125.0	*	**16.5**	2.86	*	**0.34**	1843.3		**504.4**	*	93	**9**
	Cont.	High	Undilute	Plug	326	127.7	*	**19.3**	2.88	*	**0.36**	1884.0		**545.1**	*	93	**9**
	Cont.	Med	Undilute	Plug	321	127.6	*	**19.1**	2.95	*	**0.43**	2015.4		**676.5**	*	91	**7**
	Cont.	Low	Undilute	Plug	335	124.3	*	**15.8**	2.84	*	**0.32**	1694.9		**355.9**	*	95	**11**
	Cont.	High	Dilute	Soil	314	117.7	*	**9.2**	2.70		**0.18**	1634.6		**295.6**	*	89	**5**
	Cont.	Med	Dilute	Soil	311	120.8	*	**12.3**	2.70	*	**0.18**	1631.4		**292.4**	*	89	**5**
	Cont.	Low	Dilute	Soil	309	119.7	*	**11.2**	2.71	*	**0.19**	1669.3		**330.3**	*	88	**4**
	Cont.				295	108.5			2.52			1339.0				84	
	BR	High	Dilute	Soil	321	129.3	*	**7.9**	2.86		**0.12**	1882.9		**261.0**		91	**4**
	BR	Med	Dilute	Soil	327	136.4	*	**15.0**	3.05	*	**0.31**	2266.5	*	**644.6**	*	93	**6**
	BR	Low	Dilute	Soil	330	136.6	*	**15.2**	3.06	*	**0.32**	2246.8	*	**624.9**	*	94	**7**
	BR				306	121.4			2.74			1621.9				87	

[a] Ground Line Diameter.

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

Pine Tip Moth Trials: Evaluation of Plug Injection System for Application of PTM^{TM} and Insignia®SC for Containerized Pine Seedlings

(Initiated in 2012)

With support from the Forest Pest Management Cooperative, a novel system for injecting insecticides into containerized seedlings at the nursery was developed by Stewart Boots, S&K Designs in 2011.

Objectives:

1. Evaluate the new plug injection system for application of PTM^{TM} (fipronil) to containerized seedlings in the nursery
2. Evaluate efficacy of PTM^{TM} (fipronil) and Insignia®SC (pyraclostrobin) alone or combined and applied to containerized and bare-root seedlings for reducing pine tip moth infestation levels and improving seedling health
3. Determine the duration of chemical activity

Research Approach:

One family of loblolly pine containerized and bare-root seedlings were provided by IFCo and Plum Creek.

Treatments:

1. Insignia®SC: Mid-concentration / undiluted plug injection [4.9mL Insignia undiluted/seedling (435 TPA rate)]: Injection into container seedling plug just prior to shipping.
2. PTM^{TM}: Mid-concentration/ undiluted plug injection [1.4mL PTM undiluted/ seedling (435 TPA rate)]: Injection into container seedling plug just prior to shipping
3. PTM^{TM} + Insignia®SC: Mid-concentration/ undiluted plug injection [1.4mL PTM + 4.9mL Insignia (6.3mL total volume)/ seedling]: Injection into container seedling plug just prior to shipping.
4. PTM^{TM}: Low concentration/ undiluted plug injection [1mL PTM undiluted/ seedling (600 TPA rate)]: Injection into container seedling plug just prior to shipping
5. PTM^{TM}: (Low) + Insignia®SC (Mid) Concentration/ Diluted plug injection [1mL PTM + 4.9mL Insignia (5.9mL total volume)/ seedling]: Injection into container seedling plug just prior to shipping
6. Insignia®SC: high concentration/ diluted soil injection [13mL Insignia in 17mL water (30mL total volume)/ seedling]: Soil injection at two points next to transplanted bareroot just after planting
7. Insignia®SC: Mid-concentration/ diluted soil injection [4.9mL Insignia in 25.1mL water (30mL total volume)/ seedling]: Soil injection at two points next to transplanted bareroot just after planting
8. PTM^{TM}: Mid-concentration/ diluted soil injection [1.4mL PTM in 28.6mL water (30mL total volume)/ seedling]: Soil injection at two points next to transplanted bareroot just after planting

9. PTM™ + Insignia®SC: Mid-concentration/ diluted soil injection [1.4mL PTM + 4.9mL Insignia in 23.7mL water (30mL total volume)/ seedling]: Soil injection at two points next to transplanted bareroot just after planting
10. PTM™: Low-concentration/ diluted soil injection [1mL PTM in 29mL water (30mL total volume)/ seedling]: Soil injection next to transplanted bareroot just after planting
11. PTM™: (Low) + Insignia®SC (Mid) Concentration/ diluted soil injection [1mL PTM + 4.9mL Insignia in 25.5mL water (30mL total volume)/ seedling]: Soil injection next to transplanted bareroot just after planting
12. Containerized Control (untreated)
13. Bareroot Control (untreated)

Containerized seedlings were individually treated at the nursery prior to planting using a plug injection system developed by Stewart Boots, S&K Designs. The seedlings were treated with PTM™ and/or Insignia®SC at different rates based on the restricted rate of 59g AI/acre/year (PTM™) or 530g AI/acre/year (Headline®) and the number of trees planted per acre (TPA). For example, fipronil was applied at 110 trees per acre (TPA) = 0.537g AI/seedling (a rate being considered by some forest industries for treatment of high-valued "crop" trees); at 435 TPA = 0.136g AI/seedling (a tree density currently being used by Weyerhaeuser Co.); and 600 TPA = 0.1g AI/seedling (a tree density used by several forest industries).

Five recently harvested tracts were selected in fall 2011 across the southeastern United States (in TX, AR, AL, GA, and NC) based on uniformity of soil, drainage, and topography.

- TX: Campbell Group (Stansfield)
- AR: Plum Creek (Fristoe)
- AL: Rayonier (Leach)
- GA: International Forestry Co. (Bell)
- NC: Weyerhaeuser (Edwards)

All stands were 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-nine rows were established on each site. Seedlings were planted at 8-foot spacing along each row. Individual tree locations were marked with different color pin flags prior to tree planting.

The plot corners were marked with PVC pipe and metal tags. If necessary, herbicide was applied over the area in the spring to ensure that the seedlings would remain exposed to tip moth attack throughout the year.

Damage and Tree Measurements

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 were calculated; and 3). Separately, the terminal was identified as infested or not. Observations were also made as to the occurrence and extent of damage caused by other insects, i.e., coneworm, aphids, sawfly, etc. Measurements of tree health were collected periodically and/or at the end of each growing season. Tree health measurements included tree height and diameter; crown diameter, density and color (vigor): number and length of shoots in top whorl, and tree survival. All study trees were measured for height and diameter at ground line at the beginning of the study (when seedlings were planted). Measurements were taken when tree growth stopped in mid- to late November.

Results:

In 2012, pine tip moth populations were variable across the South, with low damage levels in AL and GA (average of 4.2% and 4.7% on containerized seedlings, respectively) and higher damage levels in AR (43.8% on bare root seedlings) (Figure 24). ALL PTM and/or Insignia treatments of containerized seedling plugs significantly reduced overall tip moth damage (mean reduction/ all treatments: 86.3%) compared to the untreated control (Figure 25, Table 49). For bareroot seedlings, all treatments that used PTM significantly reduced overall tip moth damage(mean reduction/ all treatments: 71.5%) compared to the untreated control, while the two bareroot treatments using Insignia only did not significantly reduce tip moth damage (Figure 25, Table 49).

There was a significant difference in mean percent pine tip moth infestation among the treatments (ANOVA, $p < 0.0001$; Table 50). Treatments 2 (Containerized: PTM, mid-concentration), 3 (Containerized: PTM and Insignia, mid-concentration), and 5 (Containerized: PTM, low-concentration & Insignia, mid-concentration) were found to have significantly lower mean percent infestations compared with the other treatments (Table 50).

Only treatments 2 (containerized: PTM, mid-concentration), 4 (containerized: PTM, low-concentration), and 8 (bareroot: PTM mid-concentration) were found to result in significantly improved height, diameter, and volume compared with the controls (Table 51). Percent tree survival was slightly increased compared with controls in the case of two containerized seedling treatments, while four of the bareroot seedling treatments showed a decrease in percent tree survival compared with the control (Table 51).

Acknowledgments:

Thanks go to ArborGen LLC and BASF for providing Insignia and PTM product. Thanks to: The Campbell Group, International Forestry Co., Plum Creek, Rayonier, and Weyerhaeuser for providing research sites. IFco and Plum Creek provided seedlings.

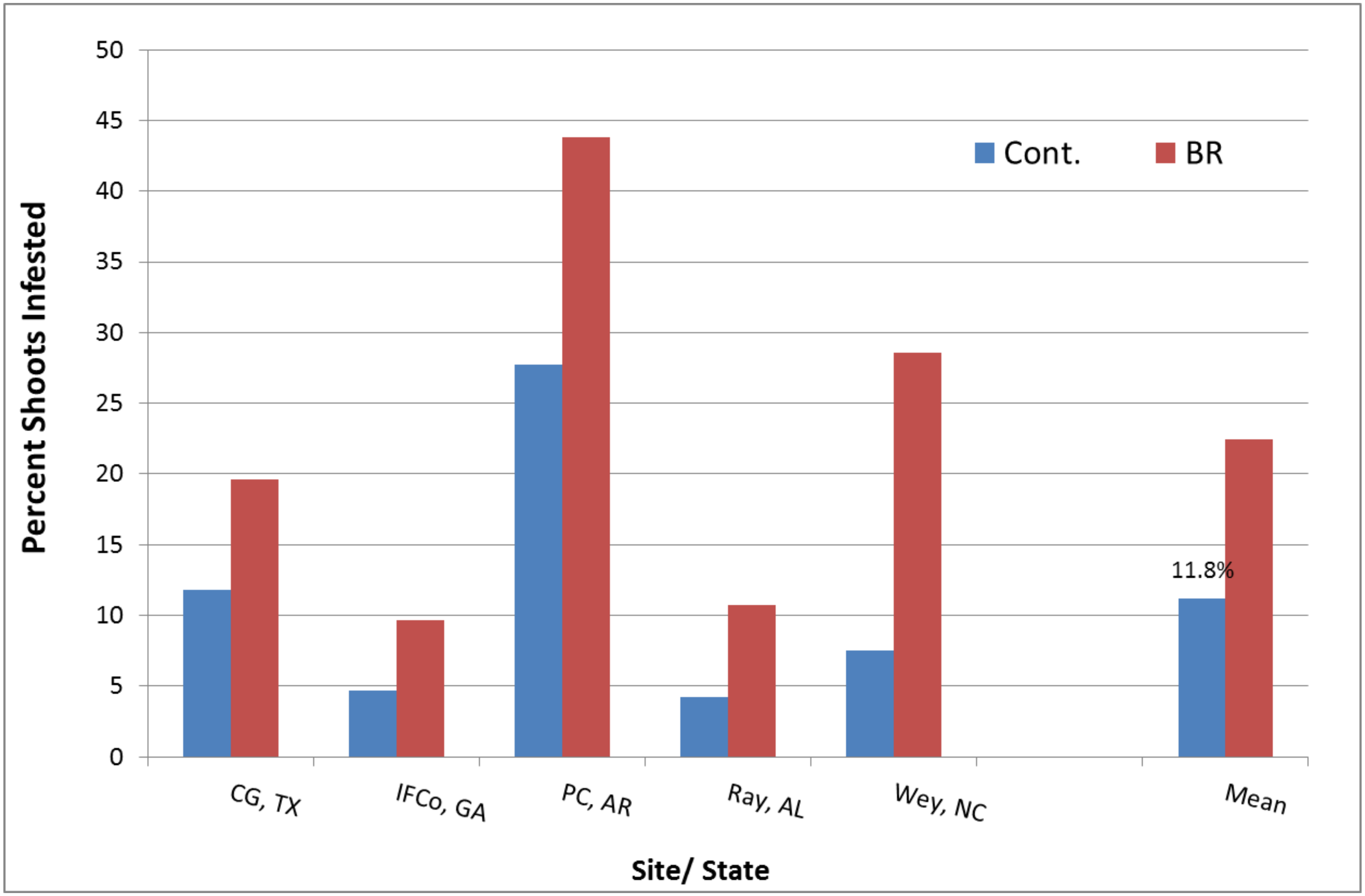

Figure 24. Mean tip moth infestation levels on first year containerized and bareroot loblolly pine on five sites across the southeastern U.S., 2012.

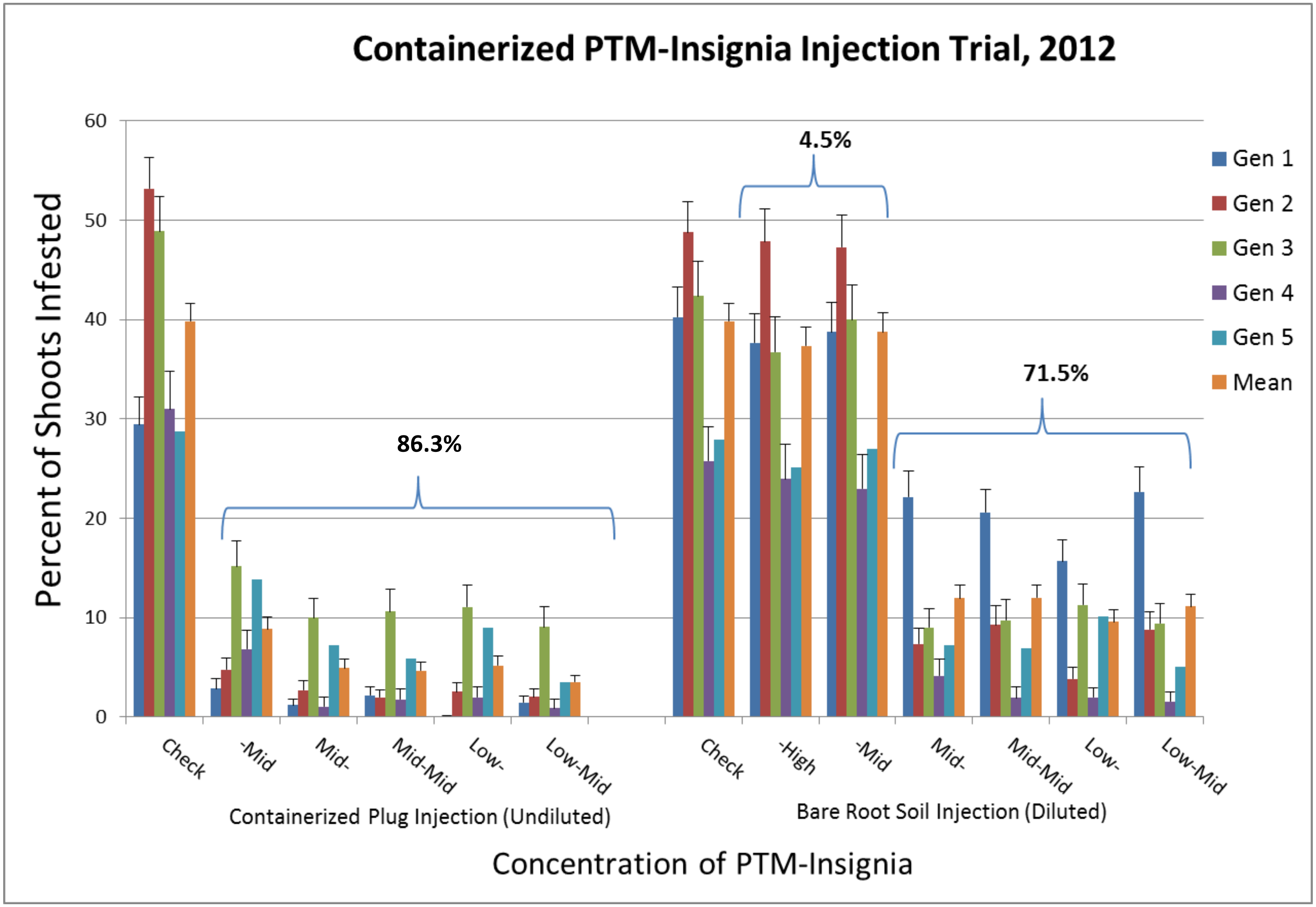

Figure 25. Effect of PTM and/or Insignia SC dose and technique on pine tip moth infestation of containerized or bareroot loblolly pine on five sites across the southeastern United States, 2012.

Table 49. Effect of PTM and/or Insignia SC dose and technique on pine tip moth infestation of containerized and bareroot loblolly pine shoots (top whorl) on five sites across the southeastern United States, 2012.

Year	Cont. or BR	Conc. PTM	Conc. Insignia	Dilute or Undilute	Inj. Loc.	N	Gen 1 (5 sites)			Gen 2 (5 Sites)			Gen 3 (4 Sites)			Gen 4 (3 Sites)			Gen 5 or Last (5 Sites)			Overall Mean		
2012	Cont.		Mid	U	Plug	189	2.9	**90**	*	4.8	**91**	*	15.2	**69**	*	6.9	**78**	*	13.8	**52**	*	8.9	**78**	*
	Cont.	Mid		U	Plug	195	1.2	**96**	*	2.7	**95**	*	10.0	**80**	*	1.1	**97**	*	7.2	**75**	*	5.0	**88**	*
	Cont.	Mid	Mid	U	Plug	190	2.2	**93**	*	2.0	**96**	*	10.6	**78**	*	7.8	**75**	*	5.9	**79**	*	4.7	**88**	*
	Cont.	Low		U	Plug	192	0.1	**100**	*	2.5	**95**	*	11.1	**77**	*	2.0	**94**	*	9.0	**69**	*	5.2	**87**	*
	Cont.	Low	Mid	U	Plug	189	1.5	**95**	*	2.0	**96**	*	9.1	**81**	*	0.9	**97**	*	3.5	**88**	*	3.5	**91**	*
	Cont					190	29.4			53.2			48.9			31.0			28.8			39.8		
	BR		High	D	Soil	178	37.7	**6**		47.9	**2**		36.7	**13**		24.0	**7**		25.1	**10**		37.4	**6**	
	BR		Mid	D	Soil	183	38.8	**4**		47.3	**3**		40.0	**6**		23.0	**11**		27.0	**3**		38.7	**3**	
	BR	Mid		D	Soil	185	22.2	**45**	*	7.4	**85**	*	9.0	**79**	*	4.2	**84**	*	7.3	**74**	*	12.0	**70**	*
	BR	Mid	Mid	D	Soil	182	20.6	**49**	*	9.3	**81**	*	9.7	**77**	*	1.9	**92**	*	6.9	**75**	*	12.0	**70**	*
	BR	Low		D	Soil	190	15.7	**61**	*	3.8	**92**	*	11.3	**73**	*	2.0	**92**	*	10.1	**64**	*	9.6	**76**	*
	BR	Low	Mid	D	Soil	191	22.6	**44**	*	8.8	**82**	*	9.4	**78**	*	1.6	**94**	*	5.0	**82**	*	11.1	**72**	*
	BR					188	40.3			48.8			42.4			25.8			27.9			39.9		

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

Table 50. Mean percent pine tip moth infestation of containerized and bareroot loblolly pine seedlings treated with varying concentrations of PTM and Insignia. Levels not connected by the same letter are significantly different (Student's T).

Treatment #	Containerized (Cont.) or Bareroot (BR)	PTM Concentration	Insignia Concentration					Mean % Infestation
13	BR	X	X	A				39.85
12	Cont.	X	X	A				39.81
7	BR	X	Mid	A				38.74
6	BR	X	High	A				37.38
9	BR	Mid	Mid		B			11.99
8	BR	Mid	X		B			11.97
11	BR	Low	Mid		B			11.12
10	BR	Low	X		B			9.59
1	Cont.	X	Mid		B	C		8.86
4	Cont.	Low	X			C	D	5.20
2	Cont.	Mid	X				D	4.95
3	Cont.	Mid	Mid				D	4.67
5	Cont.	Low	Mid				D	3.53

Table 51. Effect of PTM and/or Insignia SC dose and technique on containerized and bareroot loblolly pine growth on five sites across the southeastern U.S., 2012.

	Treatment						Mean End of Season Loblolly Pine Seeding Growth Measurements (**Growth Difference (cm or cm3) Compared to Check)**						Tree Survival (**Percent Improvement Compared to Check**)	
Year	Cont. or BR	Conc. PTM	Conc. Insignia	Dilute or Undilute	Inj. Loc.	N	Height (cm)		Diameter (cm) [a]		Volume (cm^3)			
2012	Cont.		Mid	U	Plug	189	75.28	**2.64**	1.44	**-0**	229.61	**6.07**	97	**0**
	Cont.	Mid		U	Plug	195	86.66 *	**14**	1.73 *	**0.28**	389.76 *	**166**	100	**3**
	Cont.	Mid	Mid	U	Plug	190	77.95 *	**5.31**	1.45	**0**	245.52	**22**	97	**0**
	Cont.	Low		U	Plug	192	86.10 *	**13.5**	1.70 *	**0.25**	364.41 *	**141**	98	**1**
	Cont.	Low	Mid	U	Plug	189	75.96	**3.33**	1.40	**-0**	222.97	**-0.6**	97	**0**
	Cont					190	72.64		1.45		223.54		97	
	BR		High	D	Soil	178	67.00	**-7**	1.38	**-0.1**	184.03	**-98**	91	**-5**
	BR		Mid	D	Soil	183	69.66	**-4.4**	1.40	**-0.1**	203.24	**-79**	94	**-3**
	BR	Mid		D	Soil	185	85.03 *	**11**	1.66 *	**0.14**	347.25 *	**65.1**	95	**-1**
	BR	Mid	Mid	D	Soil	182	77.39 *	**3.34**	1.48	**-0**	251.94	**-30**	93	**-3**
	BR	Low		D	Soil	190	93.62 *	**19.6**	1.83 *	**0.31**	444.07	**162**	97	**1**
	BR	Low	Mid	D	Soil	191	85.00	**11**	1.60 *	**0.09**	318.14 *	**36**	98	**2**
	BR					188	74.05		1.51		282.1		96	

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

Pine Tip Moth Trials: Evaluation of PTM™ and Insignia®SC Rate for Bareroot Pine Seedlings

Initiated in 2012

Objectives:

1. Evaluate the efficacy of PTM™ (fipronil) and Insignia®SC (pyraclostrobin) alone or combined applied to bareroot seedlings at different rates for reducing pine tip moth infestation levels and improving seedling health
2. Determine the duration of chemical activity

Study site: Hancock Forest Management's Rocky Mt. Cemetery site in Etoile, TX

Research approach:

Bareroot seedlings were provided by Hancock Forest Management.

Treatments:

1. PTM™: high concentration/ diluted soil injection [5.6mL PTM (110 TPA rate) in 24.4mL water (30mL total volume)/ seedling]: soil injection at two points next to transplanted bareroot just after planting
2. PTM™: mid-concentration/ diluted soil injection [1.4mL PTM (435 TPA rate) in 28.6mL water (30mL total volume)/ seedling]: soil injection at two points next to transplanted bareroot just after planting.
3. PTM™: low-concentration/ diluted soil injection [1.0mL PTM (600 TPA rate) in 29.0mL water (30mL total volume/ seedling]: soil injection at two points next to transplanted bareroot just after planting.
4. Insignia®SC: high concentration/ undiluted soil injection [51.6mL Insignia (110 TPA rate) undiluted/ seedling]: soil injection at four points next to transplanted bareroot just after planting.
5. Insignia®SC: mid-concentration/ diluted soil injection [13.1mL Insignia (435 TPA rate) in 11.9mL water (30mL total volume)/seedling]: Soil injection at two points next to transplanted bareroot just after planting.
6. Insignia®SC: low-concentration/ diluted soil injection [9.5mL Insignia (600 TPA rate) in 20.5mL water (30mL total volume)/ seedling]: soil injection at two points next to transplanted bareroot just after planting.
7. PTM™ + Insignia®SC: high concentration/ undiluted soil injection [5.6mL PTM + 51.6mL Insignia (57.2mL total volume)/ seedling]: soil injection at four points next to transplanted bareroot just after planting.

8. PTM™ + Insignia®SC: mid-concentration/ diluted soil injection [1.4mL PTM + 13.1mL Insignia in 15.5mL water (30mL total volume)/seedling]: soil injection at two points next to transplanted bareroot just after planting.
9. PTM™ + Insignia®SC: low-concentration/ diluted soil injection [1.0mL PTM + 9.5mL Insignia in 19.5mL water (30mL total volume)/ seedling]: soil injection at two points next to transplanted bareroot just after planting.
10. Bareroot control (untreated)

Bareroot seedlings were individually treated after planting using a PTM injection probe system developed by Sammy Keziah (formerly with Enviroquip). The seedlings were treated with PTM™ and/or Insignia®SC at different rates based on the restricted rate of 59g AI/acre/year (PTM™) or 1,416g AI/acre/year (Insignia®) and the number of trees planted per acre (TPA). For example, fipronil was applied to 110 TPA = 0.537g AI/seedling (a rate being considered by some forest industries for treatment of high-valued crop trees); at 435 TPA = 0.136g AI/ seedling (a tree density currently being used by Weyerhaeuser Co.); and 600 TPA = 0.1g AI/seedling (a tree density used by several forest industries).

One recently hand planted tract was selected in January 2012 in TX based on uniformity of soil, drainage, and topography. The harvested tract was intensively site prepared, i.e., subsoil, bedding and/ or herbicide were used. A half-acre (approximate) area was selected. A triple Latin square design was established with single tree plots (10 rows X 10 treatments) serving as blocks, i.e., each treatment was randomly selected for placement along each row (bed). Thirty rows were established on each site. Seedlings were planted at 6 foot spacing's along each row. Individual tree locations were marked with different color pin flags prior to tree planting. The plot corners were marked with PVC pipe and metal tags.

Damage and Tree Measurements:

Tip moth damage was evaluated after each tip moth generation (3-4 weeks after peak moth flight) by 1). Identifying if the tree is infested or not, 2). If infested, the proportion of tips infested on the top whorl and terminal were calculated; and 3). Separately, the terminal was identified as infested or not. Observations were made as to the occurrence and extent of damage caused by other insects, i.e., coneworm, aphids, sawfly, etc. Measurements of tree health were collected at the end of each growing season. Tree health measurements included height and diameter; crown diameter, density and color (vigor); number and length of shoots in the top whorl, and tree survival. All study trees were measured for height and diameter at ground line at the beginning of the study. Measurements were also taken when tree growth stopped in mid- to late November.

Results:

All PTM and PTM + Insignia treatments significantly reduced overall percent tip moth infestation compared to the control (by 78% and 75% respectively) (Table 52, Figure 26). Insignia treatments alone resulted in an overall reduction in pine tip moth infestation by only 2% (Table 52, Figure 26).

None of the treatments resulted in a significant improvement in diameter (Table 53). All three PTM treatments and the PTM + Insignia low concentration treatment resulted in a significant improvement in height. Volume was only significantly improved in the case of the low and high concentration PTM treatments (Table 53).

Acknowledgments:

Many thanks to Hancock Forest Management for providing a research site and seedlings for this study. Thanks also to Ken Smith and Mike Curry for their contributions.

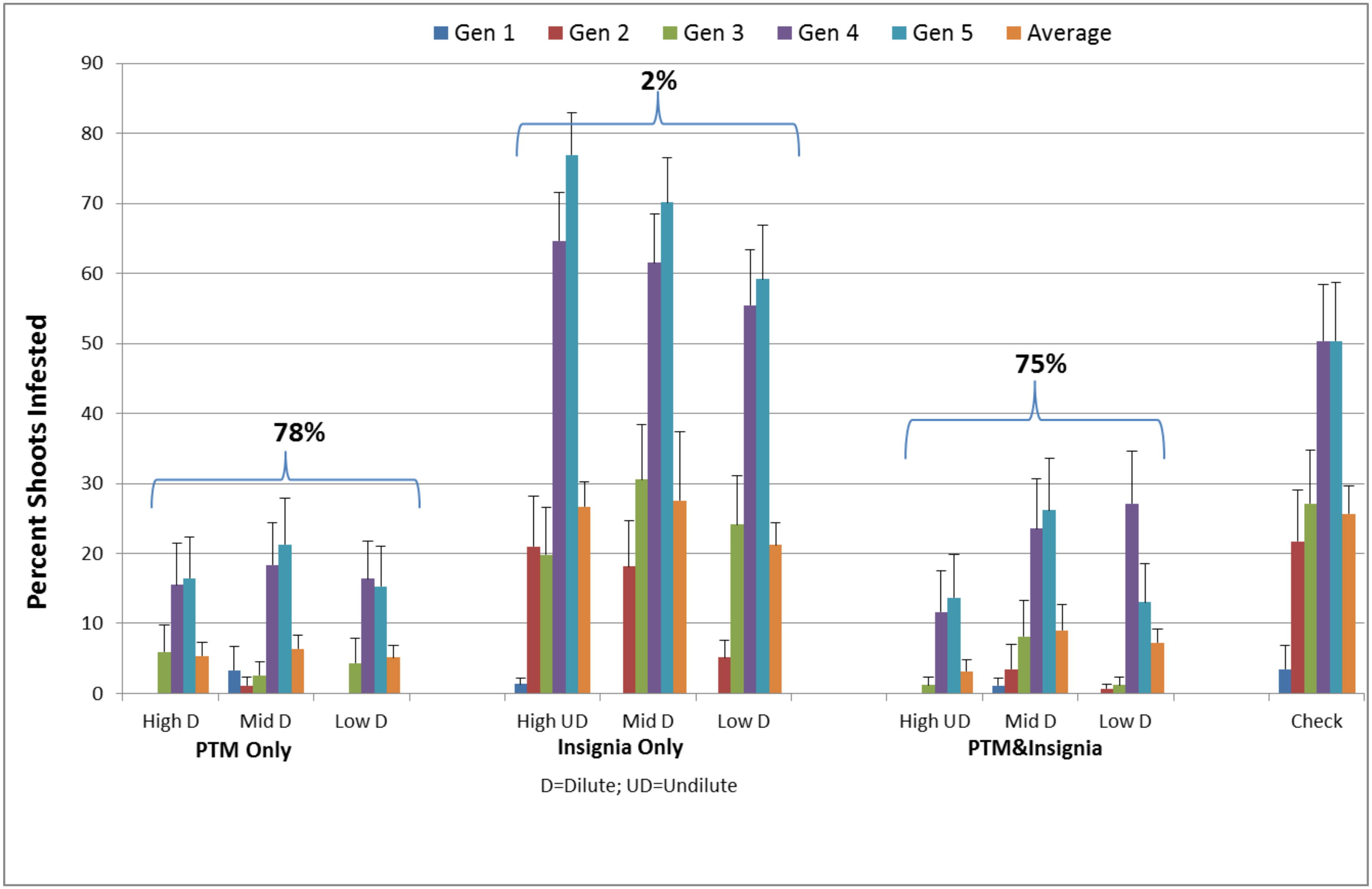

Figure 26. Effect of PTM™ and/or Insignia®SC soil injection dose on tip moth infestation of bareroot loblolly pine at one site in East Texas, 2012

Table 52. Effect of PTM and/or Insignia SC does and technique on pine tip moth infestation of containerized and bareroot loblolly pine shoots (top whorl) on five sites across the southeastern United States, 2012.

							Mean Percent Top Whorl Shoots Infested by Tip Moth (**Pct. Reduction Compared to Check**)																	
Year	Treatment #	Conc. PTM	Conc. Insignia	Dilute or Undilute	# of inj. Pts.	N	Gen 1			Gen 2			Gen 3			Gen 4			Gen 5 or Last			Overall Mean		
2012	1	High	X	dilute	2	30	0.0	**100**		0.0	**100**	*	6.0	**78**	*	15.5	**69**	*	16.4	**67**	*	5.4	**79**	*
	2	Mid	X	dilute	2	30	3.33	**3**		1.1	**95**	*	2.6	**90**	*	18.4	**63**	*	21.3	**58**	*	6.4	**75**	*
	3	Low	X	dilute	2	30	0.0	**100**		0.0	**100**	*	4.2	**85**	*	16.4	**67**	*	15.3	**70**	*	5.1	**80**	*
	4	X	High	Undilute	4	30	1.3	**61**		21.0	**3**		19.8	**27**		64.7	**-28**		76.9	**-53**	*	26.7	**-4**	
	5	X	Mid	Dilute	2	30	0.0	**100**		18.1	**17**		30.6	**-13**		61.5	**-22**		70.1	**-39**	*	27.5	**-7**	
	6	X	Low	Dilue	2	30	0.0	**100**		5.1	**76**	*	24.1	**11**		55.5	**-10**		59.2	**-18**		21.2	**18**	
	7	High	High	Undilute	4	30	0.0	**100**		0.0	**100**	*	1.2	**96**	*	11.6	**77**	*	13.7	**73**	*	3.2	**88**	*
	8	Mid	Mid	Dilute	2	30	1.1	**68**		3.4	**84**	*	7.9	**71**	*	23.5	**53**	*	26.2	**48**	*	9.0	**65**	*
	9	Low	Low	Dilute	2	30	0.0	**100**		0.7	**97**	*	1.2	**96**	*	27.1	**46**	*	13.0	**74**	*	7.2	**72**	*
	10	X	X	X	X	30	3.4			21.7			27.1			50.4			50.4			25.7		

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

Table 53. Effect of PTM™ and/or Insignia SC™ dose on bareroot loblolly pine growth on one site in East Texas, 2012.

Treatment					Mean End of Season Loblolly Pine Seeding Growth Measurements (**Growth Difference (cm or cm3) Compared to Check)**							
Year	Treatment	Conc.	Dilute or Undilute	N	Height (cm)			Diameter (cm) [a]		Volume (cm^3)		
2012	PTM Only	High	Dilute	29	63.8	*	**14.9**	1.32	**0.2**	130.5	*	**46.1**
	PTM Only	Mid	Dilute	29	58.0	*	**9.1**	1.18	**0.0**	93.0		**8.7**
	PTM Only	Low	Dilute	30	61.8	*	**13.0**	1.29	**0.1**	123.9	*	**39.5**
	Insignia Only	High	Undilute	29	54.4		**5.6**	1.13	**0.0**	84.1		**-0.3**
	Insignia Only	Mid	Dilute	29	50.2		**1.4**	1.11	**-0.1**	72.2		**-12.2**
	Insignia Only	Low	Dilute	29	53.4		**4.6**	1.12	**-0.1**	78.3		**-6.1**
	PTM&Insignia	High	Undilute	28	57.0		**8.2**	1.12	**0.0**	97.6		**13.2**
	PTM&Insignia	Mid	Dilute	28	58.0		**9.1**	1.21	**0.0**	115.7		**31.3**
	PTM&Insignia	Low	Dilute	28	61.5	*	**12.7**	1.29	**0.1**	127.2		**42.8**
	Untreated			28	48.8			1.17		84.4		

[a] Ground Line Diameter.

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

Pine Tip Moth Trials: Machine Planter Evaluation in a Flex Stand Situation

(Initiated in 2012)

Objectives:

1. Evaluate the efficacy of PTM applied to genetically-improved trees located every fourth tree along a row with trees of standard root stock
2. Determine the duration of PTM activity.

Study site: Weyerhaeuser's Natchitoches and Creston, LA sites

Research approach:

Two recently-planted sites were selected in Natchitoches and Creston, Louisiana. The stand consisted of 75% trees of standard rootstock (biomass trees) and 25% improved genetic stock (crop trees) (i.e. a flex stand). Trees were planted by machine at a rate of three biomass trees followed by one crop tree. All crop trees were treated at the 435 TPA rate or 1.4mL PTM/tree. This was done by the person feeding the coulter wheel. Once the crop tree was in the furrow, the operator pushed a button to dispense PTM into the furrow before it was closed.

At each site, 10 subplots were randomly selected. Each subplot consisted of 10 crop trees and 10 biomass trees selected along a single row.

Damage and Tree Measurements:

Study trees were evaluated for damage from pine tip moth after each generation of tip moth had occurred. Height and ground line diameter measurements were taken immediately after plot establishment and again at the end of the year.

Results:

Percent infestation of loblolly pine by pine tip moth was low at the two sites (LA) in 2012; the highest percentage occurred at the end of generation four on untreated trees at close to 30% (Figure 27). There was no significant difference between PTM treated trees and control trees in the percent of top whorl shoots infested by tip moth (Table 54). There was a significant difference in height, volume, and growth of the PTM vs. untreated trees (Table 55), but this is likely due to the fact that these trees are of improved genetic stock.

Acknowledgments:

Many thanks to Weyerhaeuser for providing research sites for this project. Additional thanks to Tony Fontenot, Land Manager and to Chris Dowden of Chris Dowden Forestry who applied PTM using his privately owned machine planter.

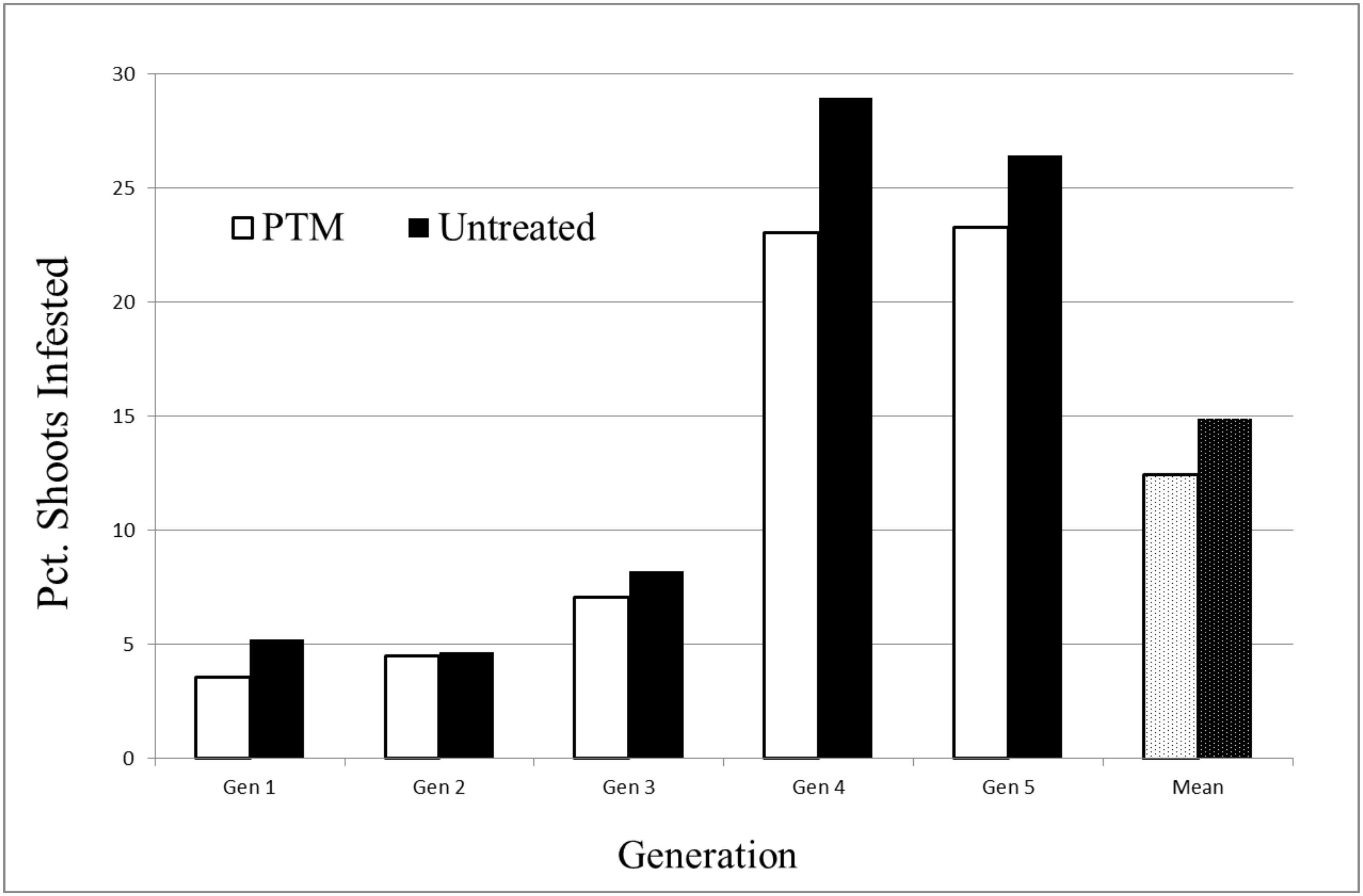

Figure 27. Mean tip moth infestation levels on PTM treated loblolly crop trees vs. untreated loblolly biomass trees at two sites in western Louisiana in 2012.

Table 54. Effect of PTM application technique on areawide pine tip moth infestation of loblolly pine shoots (top whorl) on two sites in West Louisiana, 2012.

				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	
Flex Stand	2012	PTM	186	3.6	**32**	4.5	**3**	7.1	**14**	23.1	**20**	23.3	**12**	12.5	**16**
		Untreated	177	5.2		4.7		8.2		29.0		26.5		14.9	

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

Table 55. Effect of PTM application technique on loblolly pine growth approx. 1 year after treatment on two sites in West Louisiana - 2012.

				Mean End of Season Tree Measurements (**Growth Difference (cm or cm^3) Compared to Check**)										
Site	Year	Treatment	N	Height (cm)			DBH (cm)		Volume (cm^3)			Growth(cm^3)**		
Flex Stand	2012	PTM	186	57.3	*	**9.7**	0.96	**0.1**	71.83	*	**22.0**	69.849	*	**23.0**
		Untreated	177	47.6			0.90		49.87			46.866		

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

**Winter 2012 vol. - at plant (2011) volume

Systemic Injections for Protection of Southeastern Pines from Southern Pine Beetle and BlueStain Fungi

Highlights:

- The FPMC initiated a trial in 2009 to evaluate the efficacy of emamectin benzoate alone or combined with a fungicide mix for preventing mortality of conifers by southern pine beetle (SPB)(Coleoptera: Curculionidae, Scolytinae) in Alabama.
- Fourth year results indicate that treatments containing emamectin benzoate were again effective in reducing/preventing tree mortality by southern pine beetle. The addition of the fungicide mix appears to have improved survival of SPB-attacked trees.

Objectives:

1) Evaluate the efficacy of systemic injections of emamectin benzoate alone or combined with fungicide for preventing mortality of conifers by *Dendroctonus* bark beetles found in the southeastern United States and blue stain fungi
2) Evaluate effect of injection timing on treatment efficacy
3) Determine the duration of treatment efficacy

Cooperators:

Dr. Steve Clarke	USDA Forest Service – FHP R8, Lufkin, Texas
Ms. Cindy Ragland	Oakmulgee R.D, Talladega N.F., Brent, AL
Dr. David Cox	Syngenta, Modesta, CA
Mr. Joseph Doccola	Arborjet, Inc., Woburn, MA

Study Sites: The study is being conducted in the Talladega National Forest, Oakmulgee Ranger District in Bibbs and Perry Co., Alabama with SPB attacking loblolly pine, *Pinus taeda*.

Insecticides:

- Emamectin benzoate (TREE-age™, Arborjet Inc.) – an avermectin derivative
- Propiconazole (Alamo™, Syngenta) – a triazole fungicide (preventative)
- Thiabendazole (Arborjet Inc.) – a systemic benzimidazole fungicide (broad spectrum)

Treatments:

Trial 1

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

Table 56. Scheduled injection, baiting and evaluation dates for southern pine beetle trial.

	SPB (AL)
Project Leader(s)	Grosman & Clarke
Injection Dates	April 2009
Baiting Period	May - July 2009 March - June 2010 March - July 2011 March - August 20112
Prelim Evaluation	June - November 2009 April - November 2010 April - November 2011 April - November 2012
Final Evaluation	December 2009 December 2010 December 2011 December 2012

Treatment Methods and Evaluation:

Thirty (30) groups of 4 trees each wee selected along National Forest roads. Tree groups were located in areas with recent beetle activity, spaced >110m apart, and within 75m of an access road to facilitate treatment. Test trees were 23 to 52 cm dbh. Treatments were randomly assigned to trees within each group. Dead check trees were replaced with another untreated checks at the beginning of each evaluation year.

Each systemic insecticide treatment was injected with the Tree IV™ microinfusion system (Arborjet, Inc. Woburn, MA) into 4-8 points 0.3 m above the ground. The injected trees were allowed 1 month to translocate chemicals prior to being challenged by the application of synthetic pheromone baits.

All test trees and the first set of untreated check trees in AL were be baited with appropriate species-specific lures (Phero Tech Inc., Delta, BC or Synergy Semiochemical, Delta, BC) for 12 weeks in 2009. The surviving treated and check trees in each group were rebaited again for the same length of time in 2010, 2011, and 2012.

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

Treatments will be considered to have sufficient beetle pressure if ≥60% of the untreated control trees dies from beetle attack during each year. Insecticide treatments 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 (Shea et al., 1984).

Results:

In 2009, he study trees were baited with the three-component bait (frontalin, turpentine and endo-brevicomin) from the start (May). The results showed nearly 41% (12 of 29) the check trees exhibited fading crowns by December 2009 (Figure 1). In contrast, 3% each of the EB and EB plus fungicide-treated trees had faded. The fungicide only tree mortality (46%) did not differ substantially from check mortality. All dead trees were cut down to determine the cause of tree mortality. As in the past, mortality of check trees was caused by a combination of SPB activity and blue-stain fungi infection (Table 58). SPB was not successful in trees injected with EB. Although other treatment trees also had blue stain fungi, the cross sectional area covered by fungi in fungicide only trees was somewhat reduced compared to checks.

In 2010, the study trees were baited with the three-component bait for two 6 week periods starting in April. The results showed 41% (12 of 29) of the check trees exhibited fading crowns by the end of December 2010 (Figure 1). In contrast, 4% and 7% of the EB and EB plus fungicide-treated trees had faded, respectively. The fungicide only tree mortality (25%) did not differ substantially from check mortality. All dead trees were cut down to determine the cause of tree mortality. As in the past, mortality of check trees was caused by a combination of SPB activity and blue-stain fungi infection (Table 58). SPB was not successful in trees injected with EB.

In 2011, 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 1). In contrast, 16%, 8%, and 4% of the EB-, fungicide-, and EB plus fungicide-treated trees had faded, respectively. All dead trees were cut down to determine the cause of tree mortality. As in the past, mortality of check trees was caused by a combination of SPB activity and blue-stain fungi infection (Table 58). SPB was not successful in trees injected with EB.

In 2012, the study trees were again baited with the three-component bait for three 6 week periods starting in April. The results showed 58% (15 of 26) of the check trees exhibited fading crowns by the end of November 2012 (Table 57, Figure 28). In contrast, 43%, 40%, and 21% of the EB-, fungicide-, and EB plus fungicide-treated trees had faded, respectively. All dead trees were cut down to determine the cause of tree mortality. As in the past, mortality of check trees was caused by a combination of SPB activity and blue-stain fungi infection (Table 58). SPB was not successful in trees injected with EB.

Conclusions:

Shea's Protocol for check mortality threshold (>60%) was not met for any year of the study. However, the results of trials presented above indicate that emamectin benzoate alone injection treatments can provide good protection against southern pine beetle for two seasons. It appears that the addition of a fungicide mix (Propiconazole + Thiabendazole) may reduce the success of blue stain fungi colonization. It appears that the combination treatment does improved protection compared to EB alone to the extent that combined mortality is still below the 20% threshold even after 3 full years.

Acknowledgments:

Many thanks go to our cooperators: Steve Clarke and Cindy Ragland, Jim Meeker for their efforts on the projects. We appreciate the chemical donations and injection equipment loans made by Arborjet, Inc, BASF, and Syngenta and field assistance of Bill Upton, Larry Spivey, Wood Johnson, and Roger Menard. These trials were supported by funds from the FPMC, Southern Pine Beetle Initiative, and Syngenta Crop Protection.

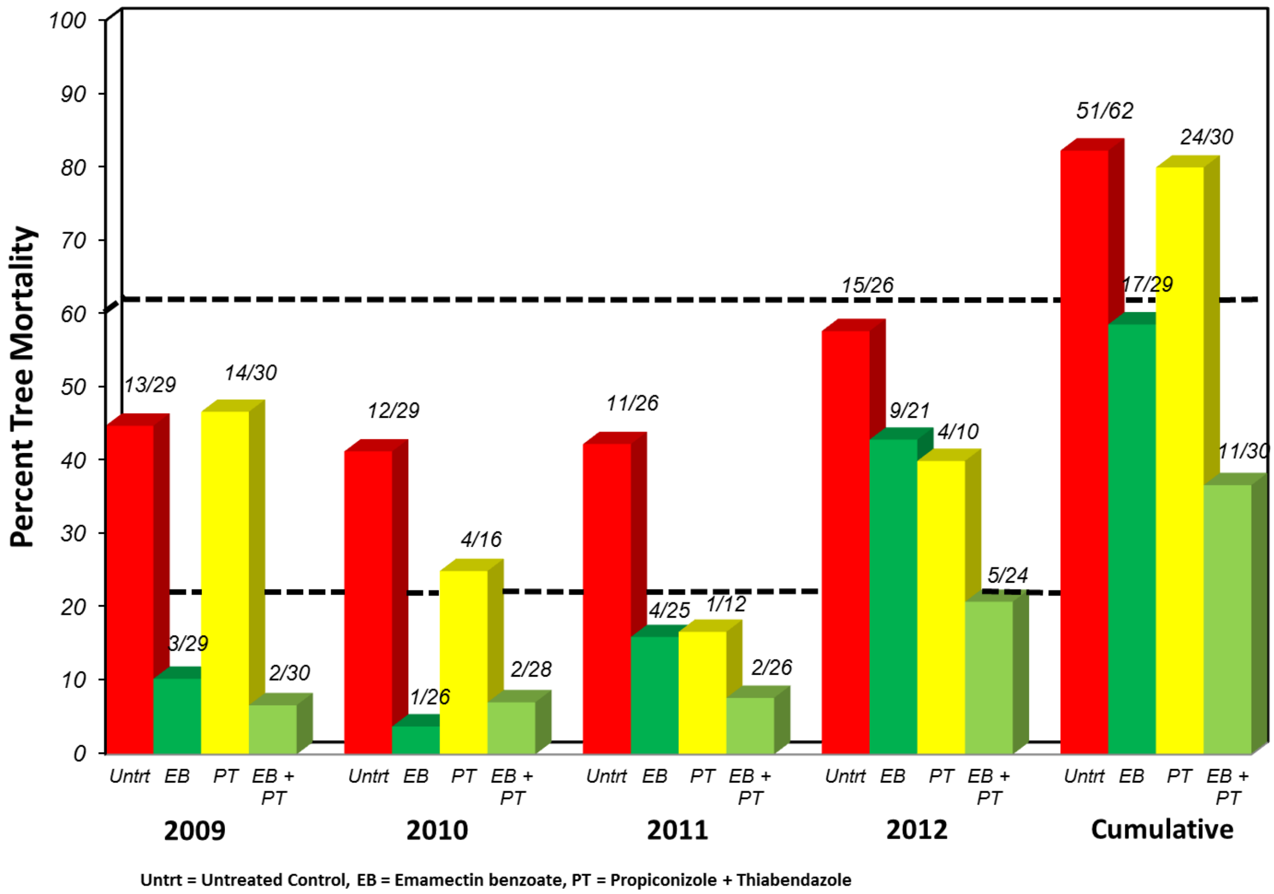

Figure 28. Effects of emamectin benzoate injection treatments on loblolly pine mortality caused by southern pine beetle in 2009, 2010, 2011 and 2012 (as of November 28), Talladega National Forest, AL. The dashed line at 60% cumulative mortality is the level of control tree mortality necessary for a valid test; the dashed line at 20% cumulative mortality is the maximum allowable mortality of treatments to be considered efficacious.

Table 57. Evaluation of systemic injections for protecting loblolly pine from southern pine beetle attack, AL, 2009-2012.

Treatment	**Date**				
	2009	**2010**	**2011**	**2012**	**Cumulative**
Emamectin benzoate (EB, 0.4 g/in dbh)	3/29[b]	1/26	4/25	9/21	17/29
Propiconazole + Thiabendazole (PT, 0.2-0.4 g/in dbh)	14/30	4/16	2/12	4/10	24/30
EB + PT (0.2-0.4 g/in dbh)	2/30	2/28	2/26	5/24	17/29
Untreated control	13/29[b]	12/29	11/26	15/26	51/62

[a] Shea et al. (1984) protocols dictate treatments are considered efficacious when <7 trees (cumulative, at any point in time) die as a result of bark beetle attack when at least 60% mortality is observed in the untreated control. This experimental design serves as the standard for bole spray evaluations and provides a very conservative test of efficacy.

[b] Two tree lost due to fire damage and Ips engraver beetle attack.

Table 58. Effects of Emamectin Benzoate and Fungicide Injection Treatments on Mean (+ SE) of Success of Bark Beetle, Cerambycids and Blue Stain Colonization, 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.

Forest Pest Management Budget Summary: FY 2012 - 2014

CY 2012 FPMC Budget

The budget for calendar year 2012 totaled $300,069 (Table A). Eighty-five percent was devoted to staff salaries and wages for seasonal workers and the remaining 15% to operating expenses. Membership dues for seven full members ($10,000 each) and four associate members ($3,500 each), plus $12,000 of FPMC surplus and $1,500 for WGFTIP seed analysis yielded a total of $97,500. One Associate Member (CelFor, Inc) left the coop at the end of CY2011. The remaining $202,569 was provided by Texas A&M Forest Service and FY 2012 grants from US Forest Service (FSIAP), Hancock, Weyerhaeuser, Syngenta and BASF (Table E). Expenditures for CY 2012 totaled 291,031 (Table B). These expenses were covered by the FPMC (33%), TFS (31%), and grants (36%).

CY 2013 FPMC Budget

The budget for CY2013 is given in Table C by source of funding. A total of $296,211 was available to fund the FPM, 86% for salaries, wages and fringe benefits and 14% for operating expenses (Table D). Of this total, $80,500 was provided by membership dues, $1,500 by WGFTIP seed analysis and $16,500 represented surplus funds from CY 2012, $132,766 from grants, and the remainder ($81,445) from the Texas A&M Forest Service (Table G). New grants in 2013 were received from the following sources: Arborjet, Hancock, Syngenta, USFS (FSIAP), and Weyerhaeuser (Table F). One Associate Member (North Carolina Forest Service) left the coop at the end of CY 2012. Expenditures will be computed at the end of the calendar year.

CY 2014 Proposed FPMC Budget

A total budget of $292,751 is proposed for CY 2014 (Table D). Of this total, 84% would be devoted to salaries and wages and the remainder to operating expenses. One new Associate Member (Arborjet, Inc.) joined the coop in late 2013. Assuming the memberships remains at seven full members and 4 Associate Members, revenues in the amount of $84,000 will be generated by dues, $1,500 by WGFTIP seed analysis, $122,251 from existing grants and ca. $85,000 from Texas A&M Forest Service in CY 2014 (Table E). Additional funds may be generated by new members or new grants.

Table A. FPMC Budget by Source of Funding - CY 2012

	Source				Total**	% of Total
	FPMC		TFS and Others*			
A. Salaries and Wages						
FPMC Coordinator (Grosman) (100%)	$ 16,834	(26%)	$ 47,913	(74%)	$ 64,747	
Research Specialist (Kavanagh) (100%)	24,795	(75%)	8,265	(25%)	33,060	
Staff Forester (Upton) (95%)	23,812	(30%)	24,319	(48%)	48,131	
Staff Assistant (Spivey) (100%)	5,040	(20%)	20,159		25,199	
3 Seasonal Technician (4.5 mo.)			29,970	(100%)	29,970	
Total Salaries and Wages	$ 70,481		$ 130,626		$ 201,107	
B. Fringe Benefits (30% of Salaries & 8.5 % of Wages)	$ 21,144		$ 32,243		$ 53,387	
	91,625		162,869		254,494	85%
C. Operating Expenses						
Supplies	$ 5,000		$ 9,975		$ 14,975	
Vehicle Use and Maintainance	0		15,500		15,500	
Travel	0		7,100		7,100	
Telecommunications (15% of PCS)	0		1,500		1,500	
Utilities (15% of PCS)	0		1,500		1,500	
Other Services (rentals, publications, postage, etc.)	875		4,125		5,000	
Total Operating Expenses	$ 5,875		$ 39,700		$ 45,575	15%
Grand Total	$ 97,500	**	$ 202,569		$ 300,069	
% of Total	32%		68%		100%	100%

* includes industry or federal grants.

** member dues at $10,000/yr for seven members; $3,500/yr for four members, $12,000 FPMC surplus, and $1,500 for WGTIP seed analysis. = $97,500

Table B. FPMC Expenditures by Source of Funding - CY 2012

	Source				% of
	FPMC	TFS	Fed./Ind. Grants *	Total	Total
A. Salaries and Wages					
Principal Investigator (Grosman) (100%)	$ 16,847 (26%)	$ 47,900 (74%)	$ 0	$ 64,747	
Research Specialist (Kavanagh) (100%)	22,770 (69%)	0	10,350 (31%)	33,120	
Staff Forester (Upton) (78%)	18,692 (43%)	3,495 (8%)	20,961 (49%)	43,148	
Staff Assistant (Spivey) (100%)	6,710 (27%)	16,890 (67%)	1,599 (6%)	25,199	
Seasonal Workers	0	0	17,478 (100%)	17,478	
Total Salaries and Wages	$ 65,019	$ 68,285	$ 50,388	$ 183,692	
B. Fringe Benefits	$ 19,506	$ 20,485	$ 11,359	$ 51,350	
	84,525	88,770	61,747	235,042	83%
C. Operating Expenses					
Total Operating Expenses	$ 12,975	$ 0	$ 33,252	$ 46,227	17%
Indirect Costs (26%)			9,762	9,762	
Grand Total	$ 97,500	$ 88,770	$ 104,761	$ 291,031	
% of Total	33%	31%	36%	100%	100%

* Grant/Gift funds remaining from 2011; grants awarded to TFS from the Southern Pine Beetle Initiative; BASF, Mauget, and Syngenta in CY2012.

Table C. FPMC Budget by Source of Funding - CY 2013

	Source				% of
	FPMC*	TFS and Others**	Total		Total
A. Salaries and Wages					
FPMC Coordinator (100%)	$ 16,834 (26%)	$ 47,913 (74%)	$ 64,747	**	
Research Specialist (Kavanagh) (100%)	24,795 (75%)	8,265 (25%)	33,060	**	
Staff Forester (Upton) (95%)	23,812 (30%)	24,319 (48%)	48,131	**	
Staff Assistant (Spivey) (100%)	5,040 (20%)	20,160 (80%)	25,200	**	
3 Seasonal Technician (4.5 mo.)		29,970	29,970		
Total Salaries and Wages	$ 70,481	$ 130,627	$ 201,108		
B. Fringe Benefits (30% of Salaries & 8.5% of Wages)	$ 21,144	$ 32,744	$ 53,888		
	91,625	163,371	254,996		86%
C. Operating Expenses					
Supplies	$ 3,500	$ 9,975	$ 13,475		
Vehicle Use and Maintainance	0	10,500	10,500		
Travel	3,000	6,512	9,512		
Telecommunications (15% of PCS)	0	1,500	1,500		
Utilities (15% of PCS)	0	1,500	1,500		
Other Services (rentals, publications, postage, etc.)	375	4,353	4,728		
Total Operating Expenses	$ 6,875	$ 34,340	$ 41,215		14%
Grand Total	$ 98,500 **	$ 197,711	$ 296,211		
% of Total	33%	67%	100%		100%

* member dues at $10,000/yr for seven members; $3,500/yr for three members, $16,500 FPMC surplus, and $1,500 for WGTIP seed analysis. = $98,500

** includes industry and federal grants.

Table D. Proposed FPMC Budget by Source of Funding - CY 2014

	Source							% of
	FPMC*		TFS and Others**			Total		Total
A. Salaries and Wages								
FPMC Coordinator (100%)	$	30,000 (50%)	$	30,000 (50%)	$	60,000		
Research Specialist (vacant) (100%)		24,000 (75%)		8,000 (25%)		32,000		
Staff Forester (Upton) (95%)		23,547 (47%)		24,048 (48%)		47,595		
Staff Assistant (Spivey) (1000%)		10,000 (48%%)		15,200		25,200		
3 Seasonal Technician (4.5 mo.)				29,970		29,970		
Total Salaries and Wages	$	87,547	$	107,218	$	194,765		
B. Fringe Benefits (30% of Salaries &	$	26,264	$	25,722	$	51,986		
8.5 % of Wages)		$113,811		$132,940		$246,751		84%
C. Operating Expenses								
Supplies	$	3,500	$	3,000	$	5,500		
Equipment (Mule and trailer)				10,000		10,000		
Vehicle Use and Maintainance		3,000		10,000		13,000		
Travel		3,000		6,000		9,000		
Telecommunications (15% of PCS)		0		1,500		1,500		
Utilities (15% of PCS)		0		1,500		1,500		
Other Services		1,395		4,105		5,500		
(rentals, publications, postage, etc.)								
Total Operating Expenses	$	10,895	$	36,105	$	46,000		16%
Grand Total	$	124,706 **	$	169,045	$	292,751		
% of Total		42%		58%		100%		100%

* member dues at $10,000/yr for seven members; $3,500/yr for four members, $39,206 FPMC surplus, and $1,500 for WGTIP seed analysis. = $124,706

** includes industry and federal grants.

Table E: List of Funding Sources and Expenditures by Calendar Year

		Membership Dues								
CalenderYear	No. Full / Assoc. Members **	Full / Assoc. / Year	Total Revenue	Reserve	Grants/Gifts	TFS	Total	Dues % of Total	TFS % of Total	
1996	3 / 1	$6K / ----	$18,000			$54,800	$72,800	25%	75%	
1997	4 / 1	$6K / $2K	$26,000		$16,600	$36,571	$79,171	33%	46%	
1998	5 / 0	$6K / $2K	$31,000		$18,300	$55,560	$104,860	30%	53%	
1999	5 / 0	$7K / $2.5K	$35,000		$31,000	$43,285	$109,285	32%	40%	
2000	7 / 1	$7K / $2.5K	$51,000		$24,488	$44,621	$120,109	42%	37%	***
2001	6 / 1	$7K / $2.5K	$44,500		$19,356	$77,600	$141,456	31%	55%	
2002	6 / 1	$8K / $2.5K	$50,500		$20,356	$69,512	$140,368	36%	50%	
2003	7 / 1	$8K / $2.5K	$58,500		$20,468	$62,206	$141,174	41%	44%	
2004	7 / 1	$8K / $2.5K	$58,500		$75,195	$68,301	$201,996	29%	34%	
2005	7 / 1	$8K / $2.5K	$58,500		$66,054	$76,517	$201,071	29%	38%	
2006	7 / 1	$8K / $2.5K	$58,500		$129,000	$82,847	$270,347	22%	31%	
2007	7 / 2	$9K / $3K	$69,000		$74,755	$85,156	$228,911	30%	37%	
2008	8 / 2	$9K / $3K	$79,000		$67,000	$86,553	$232,553	34%	37%	
2009	8 / 2	$10K / $3.5K	$87,000		$61,960	$84,000	$232,960	37%	36%	***
2010	8 / 5	$10K / $3.5K	$92,500		$63,818	$84,000	$240,318	38%	35%	***
2011	7 / 5	$10K / $3.5K	$92,500		$98,021	$67,811	$258,332	36%	26%	***
2012	7 / 5	$10K/$3.5K	$85,500		$131,158	$83,411	$300,069	28%	28%	***
2013*	7 / 3	$10K/$3.5K	$82,000		$132,766	$81,445	$296,211	28%	27%	
2014*	7 / 4*	$10K/$3.5K	$85,500		$122,251	$85,000	$292,751	29%	29%	***
Mean			$61,211		$65,141	$69,958	$192,881	32%	44%	

* estimated
** Not including TFS
*** Years TFS not paying more than members.
Reserve = $39,206 on 09/01/2013

Table F: FY 2013 Budget, Expenses and Balances: FPMC (as of September 1, 2013)

Budget #	FY	Name	Source	Budgeted	Expenditures	Balance Available
462101	2013	FPMC	Membership Dues	$80,500	$60,507	$19,993
			Seed Analysis	$1,500		$1,500
			Reserve			$17, 713
Older Grants			FPMC Total			$39,206
462300	2000	Mountain Pine Beetle	Mauget	$10,074	$5,773	$4,301
462301	2001	Ips Engraver Beetles	Mauget	$35,000	$4,481	$30,519
462601	2001	Oak Wilt	ISAT	$15,954	$10,663	$5,291
			Total	$61,028	$20,917	$40,111
2012 Grants						
432222	2012	Walnut twig beetle	FSIAP	$28,300	$19,908	$8,392
462802	2012	Pine Wood Nematode	Hancock/Weyerh.	$11,510	$13,886	-$2,376
462232	2012	SPB Allee	Syngenta	$24,165	$24,165	$0
462412	2012	Pine Tip Moth	BASF	$19,436	$17,192	$2,244
			Total	$83,411	$75,151	$8,260
2013 Grants						
462263	2013	SPB Allee	Syngenta	$24,000	$24,000	$0
462233	2013	Texas leafcutting ant	Syngenta	$11,932	$2,116	$9,816
462243	2013	Pine Tip Moth	Syngenta	$5,000	$3,719	$1,281
462253	2013	Black Turpentine Beetle	Syngenta	$5,000	$5,000	$0
462703	2013	Hypoxylon Canker	Arborjet	$5,000	$189	$4,811
462713	2013	Conifer Mites	Arborjet	$5,000	$2,763	$2,237
462803	2013	Pine Wood Nematode	Hancock/Weyerh.	$14,588	$2,778	$6,356
462223	2013	Walnut Twig Beetle	FSIAP	$30,000	$0	$30,000
			Total	$100,520	$40,565	$54,501
			Total for Grants	$244,959	$136,633	$102,872
			Total Grants + FPMC	$325,459	$197,140	$142,078
2014 Grants						
462724	FY2014	Sweetgum Injections	Arborjet	$5,000	$0	$5,000