Forest Pest Management Cooperative

2011 Research Project Proposals

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Table of Contents

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With the approval of the Executive Committee representatives, the Forest Pest Management Cooperative (FPMC) will address three primary research areas (trunk injection of systemic insecticides for native and invasive insects, tip moth impact/hazard rating/control, and leaf-cutting ant control) in 2011. Results obtained this past year warrant further evaluations in these areas.

The following trials were completed/discontinued in 2010:

Fire Ant Control Evaluation
Potential Insecticides for Seed Bug Control – Florida
Evaluation of Artic and OnyxPro for Protection Against Weevils
Evaluation of Fipronil for Containerized Seedlings – Preliminary Trial

Proposed objectives and methods for the systemic injection, tip moth, and leaf-cutting ant studies in 2011 are presented below. Studies to test the efficacy of various pesticides for protection of trees against 1) pine bark beetles, 2) hardwood pests, 3) seed bugs in pine seed orchards, and 4) invasive insects will be continued.

As a result of the outbreaks of Nantucket pine tip moth in the Western Gulf Region and other areas of the South and the perceived damage being caused by this insect, the FPMC initiated two projects in 2001 and will look to complete the projects in the next year or two. The first, a cooperative study with Mr. Trevor Walker and Dr. Dean Coble, Stephen F. Austin State University, is the evaluation of pine tip moth impact and development of hazard-rating models to assess the susceptibility of sites to this pest across the South. The second project consists of evaluating the potential of different systemic insecticides, applied to pine seedlings at or post planting, for reducing pine tip moth damage. As a result of the promising results shown by fipronil in the seedling treatment (2002 – 2010), evaluation of PTM™ treatments and application techniques will be continued in 2011. In addition, a new trial will be established in 2011 to evaluate efficacy of containerized seedling plugs treated with different rates of PTM™ at ten different sites across the South. The Bayer trials (2003 – 2010) showed that imidacloprid/fertilizer spikes and SilvaShield™ Forestry Tablets provide good protection of pine seedlings against tip moth. New trials established in 2010 to directly compare efficacy and duration of SilvaShield™ versus PTM™ Insecticide and evaluate the impact of SilvaShield™ relative to other management practices (fertilization and weed control) will be continued in 2011.

PTM™ soil injection treatment was registered in 2009 to treat leaf-cutting ant colonies. In addition, a new formulation of bait (modified Amdro®) was evaluated in 2009 and 2010 for attractiveness and efficacy against leaf-cutting ants. One last efficacy trial will be established in 2011 to further test these new control options.

The following trials are expected to be completed in 2011:

Leaf-cutting Ant Control Evaluation
Potential Insecticides for Seed Bug Control – Arkansas
Evaluation of Systemics for Protection Against Ips Engraver Beetles – Trials 1 & 2

Evaluation of Systemics for Protection Against SPB – Alabama
Evaluation of Systemics for Protection Against Chalcid Wasp
Evaluation of Fipronil for Second-Year Pines – Trial 1 and 2
Imidacloprid Tablets for Control of Tip Moth (Moffet, Peavy, CR3260)

Continuation or initiation of other projects presented below will be dependent upon approval by the FPMC Executive Committee. Extension of each project into 2012 will depend on the degree of success achieved in 2011 and remaining gaps in knowledge.

TEXAS LEAF-CUTTING ANT

Leaf-cutting Ant Control Evaluation - East Texas
(Initiated in 2009)

Justification: Currently, there is no safe and effective control option available for control of Texas leaf-cutting ants. Volcano™ (sulfluramid/citrus pulp bait) and methyl bromide were phased out in 2003 and 2005, respectively. In 2003, Grant Laboratories, CA, began marketing their Grant's Total Ant Killer bait. Trials conducted by the FPMC early in 2004, found that a single application only halted the activity of 25% of the treated colonies – about equal to the efficacy of the old Amdro® bait used in the mid-1990s. In late 2004, Ambrands (formerly American Cyanamid) began marketing a new Amdro® Ant Block bait. Additional trials conducted in early spring 2005 and later in 2006 found that a single application of this bait did not halt the activity of most treated colonies, but did reduce all colonies by 60% compared to untreated colonies. Grosman hypothesized that the poor efficacy of Amdro is at least in part due to the small particle size of the bait. Using a laboratory pellet mill, a modified (larger) Amdro® bait was created and tested in 2009. The modified baits (produced by FPMC and later by Schirm USA) were all significantly more effective in halting leaf-cutting ant compared to the standard Amdro Ant Block treatment. The new bait has been refined to optimize ant retrieval. Trials were initiated in 2010 to confirm efficacy of the baits. As bait efficacy tends to change with season (Grosman, personal observation), there is a need to determine to what extent the optimal application rate varies with season.

PTM™ SC Insecticide (fipronil) was registered with EPA in December 2009 for soil injection to control leaf-cutting ants. Trials conducted in winter, spring and fall showed excellent control. However, a trial during the summer resulted in less favorable control. A trial will be initiated this winter to evaluate different application techniques to improve efficacy of PTM™ (fipronil).

Objective: Evaluate the efficacies of a modified Amdro® Ant Block bait and PTM™ soil injection for control of the Texas leaf-cutting ant.

Cooperators:

Forest Pest Management Cooperative members
Private landowners

K. Dickinson & J. Gunning	Central Garden Control Group, N. Richland Hills, TX
Mr. Jim Bean	BASF Corporation, Research Triangle Park, NC

Study Sites: Active Texas leaf-cutting ant colonies (~40) will be selected in East Texas on lands owned by investment organizations and private landowners.

Insecticide:

- Hydramethylnon – undetectable, slow-acting poison
  - Amdro® Ant Block bait - concentration (0.88% a.i.); defatted corn grit carrier with soybean oil; packing (tight); color (yellow); size < 2 mm dia.
  - Modified Amdro® bait - concentration (0.88% a.i.); defatted corn grit carrier with soybean oil; packing (tight); color (yellow); size 2.5 mm X 10 mm length and 0.04 g.
- Fipronil – undetectable, slow-acting poison in liquid formulation
  - PTM™ Insecticide - concentration (2 % a.i. v/v).

Research Approach:

Efficacy Trial

Experiments will be conducted in East Texas; within 75 miles of Lufkin. In this area, Texas leaf-cutting ant colonies will be selected depending on the season. Those colonies larger than 30 m by 30 m, smaller than 3m by 3 m, adjacent to each other (within 100 m), and/or lacking a distinct central nest area will be excluded from this study. Treatments will then be randomly assigned to the selected ant nests with 2-11 replicates per treatment.

The central nest area (CNA) is defined as the above-ground portion of the nest, characterized by a concentration of entrance/exit mounds, surrounded by loose soil excavated by the ants (Cameron 1989). Scattered, peripheral entrance/exit and foraging mounds are not included in the central nest area. Application rates will be based on label rates and/or the area (length X width) of the central nest. Two trials, one in the fall and one in late winter, are planned for 2010 - 2011; the treatments will likely include:

Trial 1 and 2:

1) Large Amdro® bait - bait will be spread uniformly over the CNA at 10.0 g/m^2.
2) Small Amdro® Ant Block (standard) - bait will be spread uniformly over the CNA at 3/4 lb per colony.
3) PTM™ SC Insecticide – soil injection within the CNA at 40.0 ml/entrance hole.
4) Untreated colony (Check)

Bait treatments will be made with a cyclone spreader to evenly spread amounts over the CNA. PTM™ solutions will be applied using the PTM Spot Gun™. The lance will be inserted into each entrance hole so that the tip will be 3 inches below ground.

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

Application Dates:

Trial 1: Fall 2010: Treatments applied to 10 colonies in November.

Trial 2: Late Winter 2011: Treatments applied to 10 colonies in January.

Project Support: The trial is being supported by FPMC funds.

Research Time Line:

January 2011

- Reevaluate ant activity for Fall Trial at 8 weeks post treatment.
- Conduct statistical analyses of data.
- Prepare and submit reports to FPMC and BASF.
- Obtain new modified Amdro® baits from Schirm.
- Locate 40 leaf-cutting ant colonies.
- Randomly assign and treat colonies with baits.
- Reevaluate ant activity for Winter Trial 2 weeks post treatment.

February - May, 2011

- Reevaluate ant activity for Fall trial 16 weeks post treatment.
- Reevaluate ant activity for Winter Trial 4, 8 & 16 weeks post treatment.
- Conduct statistical analyses of data.
- Prepare and submit reports to FPMC, Central Garden & Pet and BASF.

Reference:

Cameron, R.S. 1990. Potential baits for control of the Texas leaf-cutting ant, *Atta texana* (Hymenoptera: Formicidae), p. 628-637. *In* R.K. Vander Meer, K. Jaffe, and A. Cedeno [eds] Applied Myrmecology: A World Perspective.

SYSTEMIC INSECTICIDE INJECTION TRIALS

Potential Insecticides for Seed Bug Control in Pine Seed Orchards – TX & AR (Initiated in 2010)

Justification: Repeatedly, cone and seed insects severely reduce potential seed yields in southern pine seed orchards that produce genetically-improved seed for regeneration programs. One of the most important insect pest groups is the seed bugs, *Leptoglossus corculus* (Say) and *Tetyra bipunctata* (Herrich-Schaffer) in the South and *L. occidentalis* Foote in the West, that suck the contents from developing seeds in conelets and cones (Ebel et al. 1980). Without a comprehensive insect-control program, this insect group commonly destroys 30% of the potential seed crop; 50% losses are not uncommon (Fatzinger et al. 1980).

The FPMC Systemic Insecticide Duration and Rate Studies have demonstrated that trunk injection of emamectin benzoate (Arise®, Denim® and TREE-age™) alone were effective in reducing coneworm damage by 80% for 6 years, but seed bug damage was reduced by only 34% for 2 years (Grosman et al. 2002, FPMC Annual Report 2001, 2002, and 2003). Trials with thiamethoxam, a neonicotinoid insecticide, applied alone or combined with emamectin benzoate did not improve efficacy against seed bugs.

The FPMC tested imidacloprid, another neonictinoid insecticide, in our seed orchard trials at low (2ml, Pointer® w/ Wedgle Tip injector in 1997) and high (30 ml, Admire® w/ STIT injector in 1999-2000) volumes. Generally, low volume injections were ineffective against coneworms and seed bugs. High volume injections of imidacloprid did significantly reduce coneworm damage (45%), but were not nearly as effective as emamectin benzoate (94%) in the first year after injection. In contrast, imidacloprid was more effective against seed bugs (82% reduction) than was emamectin benzoate (34% reduction). However, there was considerable variability in the efficacy against both groups of pests and efficacy against both coneworms and seed bugs declined markedly in the second year. One problem with imidacloprid is that it has a low solubility in water (0.4g/L). Thus, mixing currently-registered products (Merit® and Admire®) in water to create an injectable solution at an effective concentration that is easily injected is difficult. For these reasons, we elected to discontinue our evaluation of imidacloprid after 2000. However, recently Arborjet has developed a new formulation of 5% injectable imidacloprid (Ima-jet™). This formulation may be more effective against seed bugs. It was tested in 2007 and 2008, at Weyerhaeuser's Magnolia Orchard. Only imidacloprid high rate (0.4g/ inch DBH alone or combined with emamectin benzoate (0.4 g/ inch DBH) significantly reduced seed bug damage during the second year after injection.

New formulations of other systemic insecticides recently have been/are being developed: abamectin, azadiractin, chlorantraniliprole, dinotefuran, and fipronil. It is of interest to determine if any of these chemicals have activity against seed bugs and coneworms.

With the potential loss of currently-registered foliar insecticides, there is an obvious need for an effective alternative to control cone and seed insects in southern pine seed orchards. A chemical alternative that provides long-term protection (> 1 year) and could by applied via a closed system to individual trees would be preferred by orchard managers because it could be easily applied, economical, and generally pose little hazard to the applicator. Trials conducted thus far indicate that injections of emamectin benzoate and fipronil into loblolly pine can significantly reduce coneworm-caused damage, but generally have little or no effect against seed bugs.

Objectives: The objectives of this research proposal are to: 1) to evaluate the potential efficacy of systemic injections of new formulations of systemic insecticides (abamectin, azadiractin, chlorantraniliprole, dinotefuran, emamectin benzoate, fipronil, imidacloprid, and indoxacarb) in reducing seed crop losses due seed bugs in pine seed orchards; and 2) determine the duration of treatment efficacy.

Cooperators:

Dr. Tom Byram	Western Gulf Tree Improvement Program
Mr. Steve Smith	Weyerhaeuser Company, Magnolia, AR
Mr. Joseph Doccola	Arborjet, Inc., Worchester, MA
Mr. Joe Meating	BioForest Technologies Inc., Sault Ste. Marie, ON
Mr. Jim Bean	BASF, Research Triangle Park, NC
Mr. T.V. Smith	DuPont, Allen, TX
Ms. Marianne Waindle	JJ Mauget, Arcadia, CA

Research Approach: A first phase of the study was initiated in fall 2009 in a loblolly pine block (Weyerhaeuser's Magnolia Seed Orchard, Arkansas). A second phase of the study was initiated in fall 2009 in a loblolly pine block (ArborGen's Woodville Seed Orchard, Texas). A block in each orchard was selected that had not been sprayed with insecticide for 1 or more years prior to initiation of this experiment. In September 2009, 6 ramets from each of 6 clones were selected in Arkansas and 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). The treatments include:

Treatments:

AR Orchard (Loblolly pine)

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

TX Orchard (Loblolly pine)

1) Imidacloprid (Ima-jet®, Arborjet) (0.4 g AI / inch DBH) in Fall 2009
2) Emamectin benzoate (TREE-age, Arborjet) (0.4 g AI / inch DBH) in Fall 2009
3) Dinotefuran (Valent/Mauget) 0.4 g AI / inch DBH) in Spring 2010
4) Abamectin (Abacide2, Mauget) (0.4g AI / inch DBH) in Fall 2009
5) Chlorantraniliprole (Acelepyrn, DuPont) 0.4g AI / inch DBH) in Fall 2009
6) Fipronil (BASF) 0.4g AI / inch DBH) in Fall 2009
7) Emamectin benzoate (TREE-age, Arborjet) (0.4 g AI / inch DBH) in Fall 2009 plus two Asana foliar sprays (1 in spring and 1 in late summer).
8) Check

Injection treatments were applied in October 2009 and April 2010 (AR & TX) using the Arborjet Tree IV™ microinfusion system (Arborjet, Inc. Woburn, MA). Each treatment was injected into four or more cardinal points (depending on tree diameter) about 0.3 m above the ground.

Spray treatments (Asana® XL in TX) were/will be applied to foliage beginning in April and August 2010 and 2011 using a hydraulic sprayer from a bucket truck (if necessary) at 10 gal/tree. The distance between test trees will be ≥20 m to minimize the effects of drift.

Conelet and cone survival will be evaluated in 2010 and possibly 2011 by tagging 6 to 10 branches on each tree (50 conelets and 50 cones, if possible) in early April. Counts of surviving conelets and cones from these branches will be made in August (Florida and Texas) or September (Arkansas) of each year. Conelet and cone survival generally reflects protection from seed bugs and coneworms, respectively. In July and September, 50 conelets will be randomly sampled from each tree and evaluated for seed bug damage. Reduction of coneworm attacks will be evaluated by collecting all cones present on the south half of each tree in August (Texas) or September (Arkansas) 2011. From the samples, counts will be made of healthy- and coneworm-attacked cones. Each year, a subsample of 10 healthy cones/tree will be selected; seed lots from these cones will be radiographed to determine seed yield/cone and filled-seed yield/cone to measure the extent of seed bug and seedworm damage. Data will be analyzed by GLM and the Fisher's Protected LSD test using the Statview statistical program.

Project Support: Both trials are supported by FPMC funds. Syngenta, Mauget and Arborjet, Inc., BASF, Valent, and Bioforest Technologies are providing chemicals or injection equipment for the project.

Research Time Line:

January - April 2011

- Treat TX study trees with standard (Asana®XL) foliar treatment (April)
- Flag 6-10 branches/tree and record number of conelets and cones on all treatment and check trees (April).

May - August, 2011

- Treat TX study trees with standard (Asana®XL) foliar treatment (August)

September - December 2011

- Evaluate conelet and cone survival on flagged branches (early September).
- Collect all cones and 50 conelet sample from sample trees for evaluation of coneworm and seed bug damage levels, respectively (late September).
- Cleaning and radiographic analysis of seed lots (October – December).
- Conduct statistical analyses of data.
- Prepare and submit report to FPMC, Syngenta, Arborjet, and Mauget

References:

DeBarr, G.L. 1978. Southwide test of carbofuran for seed bug control in pine seed orchards. USDA For. Serv. Res. Pap. SE-185. 24 p.

Ebel, B.H., T.H. Flavell, L.E. Drake, H.O. Yates III, and G.L. DeBarr. 1980. Seed and cone insects of southern pines. USDA For. Serv. Gen. Tech Rep. SE-8. 44 p.

Fatzinger, C.W., G.D. Hertel, E.P. Merkel, W.D. Pepper, and R.S. Cameron. 1980. Identification and sequential occurrence of mortality factors affecting seed yields of southern pine seed orchards. USDA For. Serv. Res. Pap. SE-216. 43 p.

Grosman, D.M., W.W. Upton, F.A. McCook, and R.F. Billings. 2002. Systemic insecticide injections for control of cone and seed insects in loblolly pine seed orchards – 2 year results. So. J. Appl. For. 26: 146-152.

SYSTEMIC INSECTICIDE INJECTION TRIALS

Systemic Insecticide Treatment Timing, Rate and Duration for Protection of Loblolly Pine from Bark Beetles. (Initiated in 2008)

Justification: In 2005, a trial was conducted to evaluate the efficacy of new formulations of fipronil for protection of loblolly pine against *Ips* engraver beetles. The results showed that injections of fipronil (BAS 350 UB) applied at 0.2 g/inch diameter were highly effective in preventing the successful colonization of treated bolts 1, 3 and 5 months after tree injection (see 2005 Accomplishment Report).

In 2006, a second trial was initiated to evaluate the effects of application rate (0.01, 0.1 and 0.4g/inch diameter) of fipronil on efficacy against *Ips* engraver beetles. Generally, efficacy of fipronil treatments improved with increasing chemical rate. However, efficacy of the highest rate was reduced by the second year. It is of interest to determine if fipronil duration can be improved at higher rates (0.8 g/inch diameter).

A preliminary trial in 2008 showed that abamectin was highly effective in preventing the successful colonization of *Ips* engraver beetles and wood borers in loblolly pine bolts 5 months after injection. Additional treatments were applied in 2008 and 2010 to evaluate different rates applied in different seasons.

Azadiractin is a natural product with known systemic activity in trees. It is of interest to determine if azadiractin is active against pine bark beetles using different application techniques.

Objectives: 1) Determine the efficacy of systemic injections of abamectin, fipronil and azadiractin for preventing colonization of loblolly pine by *Ips* engraver beetles, 2) determine the minimum application rate that yields efficacy, 3) determine the optimal timing of each application, and 4) determine the duration of treatment efficacy.

Cooperators

Mr. Ragan Bounds	Hancock Forest Management, Colmesneil, TX
Mr. Bill Stansfield	The Campbell Group, Diboll, TX
Ms. Marianne Waindle	JJ Mauget, Arcadia, CA
Mr. Joseph Doccola	Arborjet, Inc., Worchester, MA

Treatments:

Trial 1: Established April 2008

Trt #	Chemical	Formulation	Application Timing	Rate (g ai/inch dbh)	No. of Trees Treated	Felling Dates
1	Abamectin	Abacide	Apr-08	0.4	40	Sept '08, July '09, '10 & '11
2	Abamectin	Abacide	Apr-08	0.8	40	Sept '08, July '09, '10 & '11
3	Abamectin	Abacide	Oct-08	0.4	30	Jul '09, '10 & '11
4	Abamectin	Abacide	Oct-08	0.8	30	Jul '09, '10 & '11
5	Fipronil	BAS 350 PW	Oct-08	0.4	30	Jul '09, '10 & '11
6	Fipronil	BAS 350 PW	Oct-08	0.8	30	Jul '09, '10 & '11
7	Untreated				40	Sept '08, July '09, '10 & '11
					240	

Trial 2: Established October 2010

Trt #	Chemical	Formulation	Application Timing	Rate (g ai/inch dbh)	No. of Trees Treated	Felling Dates
1	Abamectin	Abacide	Oct-10	0.1	30	July '11, '12 & '13
2	Abamectin	Abacide	Oct-10	0.2	30	July '11, '12 & '13
3	Abamectin	Abacide	Oct-10	0.4	30	July '11, '12 & '13
4	Abamectin	Abacide	Apr-11	0.1	30	July '11, '12 & '13
5	Abamectin	Abacide	Apr-11	0.2	30	July '11, '12 & '13
6	Abamectin	Abacide	Apr-11	0.4	30	July '11, '12 & '13
7	Untreated				30	July '11, '12 & '13
					210	

Trial 3: Established April 2011

Trt #	Chemical	Formulation	Application Technique	Application Timing	No. of Trees Treated	Felling Dates
1	Azadirachtin	AzaSol	Injection	Apr-11	15	May, July & Sept '11
2	Azadirachtin	AzaSol	Bark Spray	Apr-11	15	May, July & Sept '11
3	Azadirachtin	AzaSol	Drench	Apr-11	15	May, July & Sept '11
4	Azadirachtin	AzaSol	Spray & Drench	Apr-11	15	May, July & Sept '11
5	Dinotefuran	Safari	Bark Spray	Apr-11	15	May, July & Sept '11
6	Untreated				15	May, July & Sept '11
					90	

Research Approach and Evaluation:

These studies were/will be established in a loblolly pine plantation (about 20 years old) that was recently thinned near Diboll (Angelina Co.), TX. Test trees (90 - 240) ranging from 15 to 23cm dbh, were/will be selected. The above abamectin treatments (Trial 1) were applied to 40 trees in April 2008 and 30 more trees were treated with abamectin or fipronil treatments in October 2008. Additional trees (Trial 2) were/will be treated in October 2010 and April 2011.

For Trial 3, AzaSol (6 g Azadirachtin/100 g w/w SP) treatments will be applied by three methods: tree injection, bark spray and soil drench. AzaSol is a water soluble powder mixed at application in neutral, slightly acidic pH (5.5 – 6.5) or de-ionized water. Tree injection solution will be prepared by mixing 30 grams of AzaSol in 180 mLs water and agitating until completely dissolved. The dilution (4 mls) will be injected using the Arborjet Tree IV™ microinfusion system (Arborjet, Inc. Woburn, MA) into four cardinal points 0.3 m above the ground. For bark sprays, 15 grams of Azasol will be mixed in 56.8 L of water until dissolved; spray the bole thoroughly (to 3 meter height) applying 3.8 L of solution per tree. For the drench treatment, 120 g AzaSol will be mixed in 56.8 L water until completely dissolved. The organic matter will be removed from the base of the tree to a radius of 90 cm; this is the application area. The dilution (3.8 L) will be used to drench the soil within the application area for each tree. TRT 4 is a combination of bark spray and soil drench treatments (repeat mixing and application instructions). For TRT 5, 15 grams Safari will be mixed in 56.8 L of water until dissolved; the bole will be sprayed thoroughly (to 3 meter height) applying 3.8 L of solution per tree. TRT 6 is the untreated check tree. The treated trees will be allowed at least 1 month to translocate chemicals prior to being challenged by bark beetles.

In May, July and/or September 2011, 5 - 10 trees of each treatment will be felled. One or more1.5 m-long bolt will be removed from the 3, 5 or 8m height of the bole. The bolts will be transported to a nearby plantation that had been recently thinned and contains fresh slash material. Bolts will be randomly placed 1 m from other bolts on discarded, dry pine bolts to maximize surface area available for colonization as well as to discourage predation by ground and litter-inhabiting organisms. To encourage bark beetle attacks, packets of *Ips* pheromones (racemic ipsdienol [98%, bubble cap] _ lanerione [99%, Eppendorf tube] combination, racemic ipsenol[_98%, bubble cap] or *cis*-verbenol [92%, bubble cap]; Phero Tech, Inc., Delta, British Columbia, Canada) will be attached separately to 10 1-m stakes evenly spaced in the study area.

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

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

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

Project Support: JJ Mauget and Arborjet have provided funding toward the project and donated chemical product. Arborjet, Inc. also has agreed to loan the FPMC injection equipment for the project.

Research Time Line:

CY 2011

April - June, 2011

- Inject study trees (Trials 2 & 3) (April)
- Fell first (trial 3) series of trees, transport bolts to thinned stand, lay out bolts and install lures (May)
- Remove bolts and record attacks and gallery lengths (June)

July - August, 2011

- Fell fourth (trial 1), first (trial 2), and second (trial 3) series of trees, transport bolts to thinned stand, lay out bolts and install lures (July)
- Remove bolts and record attacks and gallery lengths (August)

September - December, 2011

- Fell third (trial 3) series of trees, transport bolts to thinned stand, lay out bolts and install lures (September)
- Remove bolts and record attacks and gallery lengths (October)
- Conduct statistical analyses of data.
- Prepare and submit report to FPMC Executive Committee and JJ Mauget.
- Present results at annual Entomological Society of America meeting.

CY 2012

July - August, 2012

- Fell second (trial 2) series of trees, transport bolts to thinned stand, lay out bolts and install lures (July)
- Remove bolts and record attacks and gallery lengths (August)

September - December, 2012

- Conduct statistical analyses of data.
- Prepare and submit report to FPMC Executive Committee and JJ Mauget.

CY 2013

July - August, 2013

- Fell third (trial 2) series of trees, transport bolts to thinned stand, lay out bolts and install lures (July)
- Remove bolts and record attacks and gallery lengths (August)

September - December, 2013

- Conduct statistical analyses of data.
- Prepare and submit report to FPMC Executive Committee and JJ Mauget.

SYSTEMIC INSECTICIDE INJECTION TRIALS

Systemic Injections for Protection of Southern and Western Pines from Bark Beetles and Bluestain Fungi (Initiated in 2009)

Justification: The southern pine beetle (SPB), *Dendroctonus frontalis*, and mountain pine beetle (MPB), *D. ponderosae*, are responsible for extensive pine mortality throughout southeastern and western North America, respectively. These species have a significant impact on timber, recreation, water, and wildlife resources as well as residential property values. The value of individual trees located in residential, recreational, or administrative sites, the cost of removal, and the loss of aesthetics may justify protecting these trees when local bark beetle populations are high. Protection of individual trees from bark beetles has historically involved insecticide applications to the tree bole using hydraulic sprayers. However, this control option can be expensive, time-consuming, of high risk for worker exposure and drift, and detrimental to natural enemies (Billings 1980). The use of a newly-developed injection technology to deliver systemic insecticides could reduce or eliminate many of the limitations associated with hydraulic spray applications.

In 2004, two field trials conducted by the FPMC demonstrated that injections of emamectin benzoate into loblolly pine were highly effective for preventing colonization of treated bolts by *Ips* engraver beetles, and the mortality of standing trees (Grosman and Upton, 2006). In 2005, a trial was initiated in the Chickasawhay Ranger District in the DeSoto National Forest to evaluate the efficacy of emamectin benzoate and fipronil against SPB. Unfortunately, the SPB population declined in the study area to the extent that few baited trees died as a result of beetle attack. However, the level of attack on injected trees was markedly lower than on check trees, suggesting that the treatments had an effect on SPB attack success. In 2006 and 2007, injection trials were established in the Oakmulgee R.D. and Bankhead R.D., AL, respectively. Both trials demonstrated that emamectin benzoate could significantly reduce tree mortality compared to untreated checks (Grosman et al, 2009). However, mortality of injected trees was attributed to numerous inoculations of blue stain fungi by the unsuccessful SPB. Recently, tree-injected propiconazole and thiobendazole have been found to reduce the size of blue stain lesions (Klepzig, unpublished data). Emamectin benzoate and the fungicide mix (propiconazole + thiobendazole) alone or combined needs to be tested for efficacy against SPB and MPB and their symbiotic bluestain fungi.

Objectives: 1) Evaluate the efficacy of trunk injections of emamectin benzoate or abamectin and fungicide (propiconazole, propiconazole + thiobendazole, or tebuconazole) for protection of loblolly pines against SPB and blue stain fungi or lodgepole pine against MPB and bluestain fungi, and 2) to determine duration of treatment efficacy.

Cooperators

Dr. Steve Clarke,	USDA Forest Service – FHP R8, Lufkin, Texas
Ms. Cindy Ragland,	USDA Forest Service – Talladega National Forest, AL
Dr. Christopher J. Fettig,	USDA Forest Service – PSW Research Station, Davis, CA
A. Stephen Munson	USDA Forest Service – Ogden, UT
Mr. Joseph Doccola	Arborjet, Inc., Worchester, MA
Ms. Marianne Waindle	JJ Mauget, Arcadia, CA

Research Approach: These trials are being conducted at two sites: 1) Talladega National Forest, Oakmulgee Ranger District in Bibbs and Perry Co., Alabama with southern pine beetle attacking loblolly pine; and 2) Uinta-Wasatch-Cache National Forest, Mountain View-Evanston Ranger District, Utah, with mountain pine beetle (MPB) attacking lodgepole pine. The treatments at each site included:

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

Trial 2

1) Emamectin benzoate (0.4g AI per inch; Tree-age, Arborjet Inc.) injection at 10 ml per inch DBH in June 2009,
2) Emamectin benzoate (0.4g AI per inch; Tree-age, Arborjet Inc.) injection at 10 ml per inch DBH in September 2009,
3) Emamectin benzoate + Propiconazole injection at 20 ml per inch DBH in June 2009,
4) Emamectin benzoate + Propiconazole injection at 20 ml per inch DBH in September 2009,
5) Abamectin (0.4g AI per inch; Abacide2, Mauget Inc.) injection at 20 ml per inch DBH in September 2009,
6) Abamectin (0.4g AI per inch; ; Abacide2, Mauget Inc.) injection at 20 ml per inch DBH + Tebuconazole (0.4g AI per inch; Tebuject 16, Mauget Inc.) injection at 6 ml per inch DBH in September 2009,
7) Untreated (control) - used to assess beetle pressure during each summer (2009 - 2010)

Test trees were located in areas with recent beetle activity and isolated from other sample trees. Trees selected were 23 to 52cm dbh, and within 75m of an access road to facilitate treatment. The spacing between adjacent treated trees was >100m to ensure that a sufficient number of beetles would be in the vicinity of each tree to rigorously test the efficacy of these treatments.

Each systemic insecticide treatment was injected with the Arborjet Tree IV™ microinfusion system (Arborjet, Inc. Woburn, MA) into 4 cardinal points 0.3 m above the ground on each of 30 - 35 trees. The treatments were applied in April 2009 (AL & UT) and September 2009 (UT) (Table 1). The injected trees were generally allowed one or more months (depending on water availability) to translocate chemicals prior to being challenged by the application of synthetic pheromone baits.

All test trees and the the set of untreated check trees were/will be baited with appropriate species-specific bark beetle lures (Synergy Semiochemicals, Delta, BC) for 6 weeks in April (AL) and June (UT). The surviving treated trees in each treatment (if there are no more than 6 killed by the bark beetle challenge), and the second set of check trees were baited again for the same length of time in 2010 (AL). Similarly, the treated trees and third set of check trees will be baited in 2011.

Table 1. Scheduled injection, baiting and evaluation dates for three *Dendroctonus b* ark beetle trials.

	SPB (AL)	MPB (UT)
Project Leader(s)	Grosman & Clarke	Fettig
Injection Dates	Apr-09	Apr-09 Sep-09
Baiting Period	May - Jun 2009 Apr - Jun 2010 Apr - Jun 2011	Jul - Aug 2009 Jul - Aug 2010 Jul - Aug 2011
Prelim Evaluation	Jun - Nov 2009 May - Nov 2010 May - Nov 2011	Oct 2009 Oct 2010 Oct 2011
Final Evaluation	Dec. 2009 Dec. 2010 Dec. 2011	Jun 2010 Jun 2011 Jun 2012

SPB = Southern pine beetle; MPB = Mountain pine beetle

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

Treatments will be considered to have sufficient beetle pressure if at least 60% of the untreated control trees die from beetle attack. Insecticide treatments will be considered efficacious if less than seven treated trees die as a result of bark beetle attack. 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 $\geq$ 90%). These parameters provide a conservative binomial test ($\alpha = 0.05$) to reject Ho when more than six trees die. The power of this test, that is the probability of having made the correct decision in rejecting Ho, is .84 when the true protection rate is 70% (Shea et al. 1984).

Project Support: The SPB trial is being funded by a grant from the Southern Pine Beetle Initiative. The WPB trial is being funded by a grant from the Pesticide Impact Assessment Program and Mauget. Syngenta, Mauget and Arborjet, Inc. are providing chemicals or injection equipment for the project.

Research Time Line:

CY 2011

March, 2011

- Bait AL trees (March)

April - September, 2011

- Monitor for tree mortality in AL (April - September)
- Evaluate logs from dead trees for beetle and bluestain fungi success (April - September)
- Bait UT trees (July)
- Monitor for tree mortality in UT (September)

November - December, 2011

- Conduct statistical analyses of data.
- Prepare and submit report to FPMC Executive Committee, PIAP, Mauget and Arborjet.
- Present results at annual Entomological Society of America meeting.

References:

Billings, R. F. 1980. Direct control. Chapter 10 in The southern pine beetle.: R.C. Thatcher, J.L. Searcy, J.E. Coster, and G.O. Hertel, eds. U.S. Dept. Agric. For. Serv. Tech. Bull. 1631. pp. 179-192.

Dalusky, M.J., C.W. Berisford and P.B. Bush. 1990. Efficacy of three injected chemical systems for control of the southern pine beetle. Georgia For. Comm. Ga. For. Res. Paper 83, 8 p.

Duthie-Holt, M.A., J.H. Borden and L.J. Rankin. 1999. Translocation and efficacy of neem-based insecticide in lodgepole pine using *Ips pini* (Coleoptera: Scolytidae) as an indicator species. J. Econ. Entomol. 92: 180-186.

Grosman, D.M. and W.W. Upton. 2006. Efficacy of systemic insecticides for protection of single trees against southern pine engraver beetles (Coleoptera: Curculionidae, Scolytinae) and wood borers (Coleoptera: Cerambycidae). J. Econ. Entomol. 99: 124-132.

Grosman, D.M., S.R. Clarke, and W.W. Upton. 2009. Efficacy of two systemic insecticides injected into loblolly pine for protection against southern pine bark beetles (Coleoptera: Curculionidae). J. Econ. Entomol. In Print.

Haverty, M.I., P.J. Shea and J.M. Wenz. 1997. Metasystox-R, applied in Mauget injectors, ineffective in protecting individual ponderosa pine from western pine beetle. U.S. Dep. Agric. For. Serv. Pac. Southwest Res. Stn. Res. Note. PSW-420, 7 p.

Shea, P.J., M.I. Haverty and R.W. Hall. 1984. Effectiveness of fenitrothion and permethrin for protecting ponderosa pine from attack by western pine beetle. Journal of the Georgia Entomological Society 19: 427-433.

SYSTEMIC INSECTICIDE INJECTION TRIALS

Evaluation of Emamectin Benzoate (TREE-age™) for Protection of Trees Against Invasive Insect Pests (Initiated from 2009)

Justification: Injection trials conducted by the Forest Pest Management Cooperative, Arborjet Inc. (Woburn, MA) and others from 1999 – 2008 have shown that emamectin benzoate (EB, TREE-äge™), injected into conifers and hardwoods, is highly effective against coneworm, bark beetles, wood borers, forest tent caterpillar and winter moth. Syngenta had submitted TREE-äge for registration by EPA in January 2008. TREE-äge™ was registered in December 2010 for use on conifers and hardwoods. It is of interest to know if the TREE-äge™ formulation is effective in preventing/reducing damage by new (invasive) pests, such as an unnamed chalcid wasp affecting Afghan pine in West Texas and the soapberry borer, a close relative of the emerald ash borer, affecting western soapberry in Central Texas.

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

Cooperators

Mr. Oscar Mestas	Urban Forester, Texas Forest Service, El Paso, TX
Mr. Randy Myers	Urban Forester, Midland, TX
Mr. Tom French	Private landowner, Rosharon, TX
Ms. Dennis Moore	City Forester, Allen, TX
Mr. Chad Krajca	District Park Supervisor, Mesquite, TX
Ms. Kim Knopp	Park Ranger, Yegua Creek Park, Brenham, TX
Mr. John London	Park Ranger, Fanthrop Inn State Historical Site, Anderson, TX
Ms. Kathy Cantu	Private Landowner, Belton, TX
Keith Martin	County Arborist, Southlake and Colleyville, TX
Patrick Haigh	TXDOT Superintendent and private landowner, Rockwall, Mesquite, and Forney, TX
Dr. and Mrs. Aaron Tucker	Private landowners, Rockport, TX
Dr. David Cox	Syngenta, Modesta, CA
Mr. Joseph Doccola	Arborjet, Inc., Worchester, MA

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

1) Skyline Park, El Paso, TX with chalcid wasps attacking Afghan pine,
2) Municipal property, Midland, TX with chalcid wasps attacking Afghan pine,
3) Private and municipal property in or near Rosharon, Allen, Mesquite, Anderson, Belton, Colleyville, Southlake, Forney, Rockwall, and Rockport, TX with soapberry borer (SBB) attacking western soapberry,

Research Approach:

Trial 1 (Chalcid)

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

This study is being conducted in an El Paso and Midland, TX. A number of Afghan pines (age and size unknown) at each location have been under attack by an insect (chacid wasp?) for several years. Test trees (10 - 15) were selected in early December 2008 in El Paso and in early March 2009 in Midland. Five (5)trees were injected with a standard rate (10 ml per inch diameter) of TREE-age™ in the spring (late March) at each location. Five (5) trees were treated with imidacloprid via soil injection in El Paso only. Five trees serve as untreated controls at each location.

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

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

In April (just after treatment) and late September 2009, 2010 and 2011, 3-4' long branches were/will be collected from three heights (low, middle and top crown) on each study tree. In the laboratory, 2 inch sections were/will be clipped off from each branch (12 inch total per branch). The diameter at each section was/will be measured. The bark was/will be peeled and the number of live and dead larvae, live and dead adults, current and last year's adult emergence holes were/will be recorded. The number of chalcids (larvae or adult) per 100 cm^2 of branch were/will be calculated.

Trial 2 (Soapberry Borer)

1) Emamectin benzoate (0.4g AI per inch; TREE-äge™, Arborjet Inc.) trunk injection at 10 ml per inch DBH in June 2009, May – September 2010, and April 2011
2) Untreated (control)

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

All study trees will be evaluated in June and November, 2011 for relative health. Additional evaluations may be made in 2012 and 2013. The following criteria will be used to evaluate tree condition at each visit:

Health Condition:

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

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

Project Support: The chalcid trial is supported by TFS and FPMC funds. The soapberry borer trial is being funded by a grants from Syngenta and XXXXX to Dr. Ron Billings. Syngenta, Mauget and Arborjet, Inc. are providing chemicals or injection equipment for the project.

Research Time Line:

CY 2011

April, 2011

- Inject remaining soapberry trees

June - October, 2011

- Evaluate soapberry trees for damage and mortality (June - October)
- Collect and evaluate Afghan pine branches (September)

November - December, 2011

- Conduct statistical analyses of data.
- Prepare and submit report to FPMC Executive Committee and Arborjet
- Present results at annual Entomological Society of America meeting.

CY 2012

June - October, 2010

- Evaluate soapberry trees for damage and mortality (June - October)
- Collect and evaluate Afghan pine branches (September)

November - December, 2010

- Conduct statistical analyses of data.
- Prepare and submit report to FPMC Executive Committee and Arborjet.

SYSTEMIC INSECTICIDE INJECTION TRIALS

Evaluation of TREE-äge™ and IMA-jet™ for Protection of Athel Trees Against Saltcedar Beetles (Initiated in 2010)

Justification: The saltcedar beetle (Coleoptera: Chrysomelidae), introduced as a biological control agent for the exotic salt cedar, *Tamarix* spp. has been defoliating a related species, athel, *T. aphylla*, a popular shade tree along the Rio Grande River in Texas. Imidacloprid and emamectin benzoate are known to be active against chrysomelid leaf beetles. It is of interest to know if the Tree-age® and Ima-jet® formulations are effective in preventing/reducing damage by the saltcedar beetle on non-target athel trees.

Objectives: 1) Determine the efficacy of TREE-age™ and IMA-jet™ for protection of individual athel trees from damage and/or mortality attributed to the saltcedar beetle; and 2) determine the duration of treatment protection.

Cooperators

Mr. Joe Sirotnak	National Park Service, Big Bend National Park, TX
Mr. Brad Newton	City Manager, Presidio, TX
Mr. Carlos Nieto	Private landowner, Presidio, TX
Mr. Slack	Private landowner, Presidio, TX
Mr. Aranda	Private landowner, Presidio, TX
Mr. David Lewis	Private landowner, Presidio, TX
Mr. Alfred Muniz	Private landowner, Ruidosa, TX
Ms. Diane Hankins	Private landowner, Ruidosa, TX
Mr, Tom Griffith	Private landowner, Ruidosa, TX

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

1) Private and municipal trees in and around Presidio and Ruidosa, TX,
2) Big Bend National Park

Research Approach:

Established April 2011

Trt #	Chemical	Formulation	Application Technique	Application Timing	No. of Trees Treated	Evaluation Dates
1	Emamectin benzoate	TREE-age	QUIK-jet Inj	Nov-10	11	May & Sept '11
2	Imidacloprid	IMA-jet	QUIK-jet Inj	Nov-10	12	May & Sept '11
3	Emamectin benzoate	TREE-age	QUIK-jet Inj	Feb-11	16	May & Sept '11
4	Imidacloprid	IMA-jet	QUIK-jet Inj	Feb-11	16	May & Sept '11
5	Untreated				24	May & Sept '11
					79	

Treatments

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

3) Untreated (control)

This study is being conducted along the Rio Grande River in Presidio, Ruidosa and Big Bend National Park, TX. A number of athel (age and size unknown) at each location came under attack by the saltcedar beetle in 2010 as populations of this introduced beneficial insect have increased. Test trees (10 - 15) were selected in early November 2010 and late February 2011. Each study tree was injected with a standard rate (4 or 5 ml per inch diameter) of IMA-jet or TREE-age™, respectively, in the fall and spring in each location. Five trees serve as untreated controls at each location.

Both Ima-jet and TREE-äge™ treatments were injected with the Arborjet's QUIKjet™ microinfusion system (Arborjet, Inc. Woburn, MA) into 4-10 cardinal points 0.3 m above the ground. First, a 3/8" diameter hole was drilled horizontally at each point. An Arbor –plug was installed into each hole. The QUIKjet needle was inserted into the plug. Using hand pressure (60 psi), the products was pushed into the chamber behind the plug and then out into the xylem tissue. The injected trees were allowed three or seven months to translocate chemicals prior to being evaluated for efficacy.

Tree health and survival was evaluated in at the time of treatment application and monitoring will continue in May and September 2011 and, if warranted, 2012 and 2013 using the following ranking criteria.

Health Condition:

1=Excellent	Full crown, good foliage
2=Good	Mostly full crown
3=Fair	Thinning crown;
4=Poor	Moderately thin crown;
5=Near Death	Mostly dead crown;
6=Dead	No leaves, many areas of flaking bark

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

Project Support: The athel injection trial is being funded by a federal invasive plant grant from the US Forest Service, Forest Health Protection, Region 8. Arborjet, Inc. is providing chemicals and injection equipment for the project.

Research Time Line:

CY 2010

November, 2010

- Select and inject study trees (November)

CY 2011

February, 2011

- Select and inject study trees (February)

May - October, 2011

- Evaluate tree condition (May and October)

November - December, 2011

- Conduct statistical analyses of data.
- Prepare and submit report to FPMC Executive Committee and Arborjet.
- Present results at annual Entomological Society of America meeting.

SYSTEMIC INJECTION TRIALS

Evaluation of Microinjection Systems for Application of Propiconazole in Live Oak (Initiated in 2011)

Justification: Several cultural control techniques (minimize fungal inoculum, timing of branch pruning, painting wounds and pruning cuts on oaks, prompt removal of infected red oaks, and root disruption/trenching around expanding infection centers, among others) are available for management of oak wilt, caused by the plant pathogen, *Ceratocystis fagacearum* (Koch et al. 2010). However, these techniques are often impractical for treatment of high value individual trees or small groups at risk to infection. Currently, the only effective treatment available for protecting high-value oaks is high volume treatments of the systemic fungicide propiconazole (Alamo®) diluted in water injected at the lower stem or root flare of trees (Appel and Kurdyla 1992, Appel 1995). Applications of propiconazole have been made almost exclusively through the use of macroinjection systems to deliver 20 ml Alamo® diluted in 1 liter water per inch tree DBH. The intent is to saturate the xylem tissue of the root collar with fungicide to prevent movement of the pathogen into the above ground area of the trees. The treatment is often effective in preventing tree death for about 2 years (Blaedow et al. 2010), but is very labor intensive to perform. Arborists are interested to know if propiconazole can be applied at more concentrated levels to live oak using available microinjection/infusion systems and whether these applications are effective in preventing/reducing fungal infection and spread within the host.

Objectives:

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

Cooperators

Mr. James Houser	Texas Forest Service
Dr. David Appel	Texas A&M University, College Station, TX
Mr. Joe Doccola	Arborjet, Inc., Woburn, MA
Mr. Chip Doolittle	ArborSystems, Omaha, NE 68127
Ms. Marianne Waindle	JJ Mauget, Arcadia, CA 91006
Mr. Shawn Bernick	Rainbow Treecare Scientific Advancements, Minnetonka, MN
Mr. Jim Rediker	Scenic Hills Nursery, Kerrville, TX
Mr. Gene Gehring	Urban Renewal, Inc.
Dr. David Cox	Syngenta Crop Protection, Modera, CA

Study Sites: The study will be conducted in central Texas at site(s) yet to be determined.

Research Approach:

Five (5) microinjection systems and one (1) macroinjection system will be evaluated:

Mauget System (Mauget; contact: Marianne Waindle) low volume (6-10 ml/inj pt); low pressure (10 psi)

Pine Infuser System (Rainbow Treecare Scientific Advancements; contact: Shawn Bernick); moderate volume (50 ml/inj pt ?); moderate pressure (50-70 psi ?)
Portle System (ArborSystems; contact: Chip Doolittle) – moderate volume (10 – 20+ ml/inj pt); high pressure (500+ psi)
Tree IV System (Arborjet, Inc.; contact: Joe Doccola) – high volume (20 – 125+ ml/inj pt); moderate pressure (60 psi)
Chemjet System (Scenic Hills Nursery; contact: Jim Rediker) – moderate volume (20 ml/inj pt); low pressure (10 psi ?)
Macro Injection System (Standard) (Rainbow Treecare Scientific Advancements; contact: Shawn Bernick) - high volume (30 ml/inj pt); low pressure (20 - 30 psi)

Information about the systems will be requested from each manufacturer/distributor. In particular, information will be requested on:

1) system cost
2) need for peripheral parts (plugs, needles)
3) system capacity (volume of product)
4) recommended procedures for installation and injection of trees
5) Is system reusable?
6) Does chemical product need to be prepackaged or mixed?

Each system will be ranked on the following criteria with potential points in parentheses:

1) System cost (10 pts)
2) Need for peripheral parts (plugs, needles, battery chargers) (5 pts)
3) System capacity (volume of product) (3 pts)
4) Is system disposable or reusable? (2 pts)
5) Does chemical come prepackaged; can you inject product undiluted or is it necessary to dilute with water? (5 pts)
6) Time and ease to fill system with chemical product (5 pts)
7) Time and ease to install system on tree (5 pts)
8) Number of injection points required per tree (5 pts)
9) Can the system be left alone on tree or does the applicator need to manually operate the system continuously? (5 pts)
10) Time and ease to inject X amount of product. (10 pts)
11) Cumulative time applicator spends at each tree. (10 pts)
12) Potential for chemical exposure. (10 pts)
13) Time and ease to clean system. (10 pts)
14) Weather restrictions (moisture, temperature) (5 pts)
15) Effectiveness of treatment 1 month after treatment (10 pts)
16) Effectiveness of treatment at 6, 12 and 18 months (10 pts each period)

Treatment Methods and Evaluation**:**

This study will be conducted within the range of live oak and oak wilt in central Texas (location(s) to be determined). Non-symptomatic test trees (75), ranging from 15 to 46cm (6 – 18 in) dbh (diameter at breast height), will be selected. In late April 2011, ten (10) trees per delivery system will be injected with Alamo® (Syngenta) at the label rate (20 ml/inch tree dbh) using each of the six systems described above. Fifteen trees will serve as untreated controls. The application procedure used to inject the propiconazole formulation will be based on the recommendations of each system manufacturer. The injected trees will be allowed at least 1 month to translocate chemicals prior to being challenged with fungal inoculations. Note: A 4-foot deep trench will be installed completely around the study trees prior to inoculation to reduce the likelihood of underground spread.

Inoculations will be performed using standard procedures (Camilli et al. 2009, Peacock and Fulbright 2009). One wild-type strain of *Ceratocystis fagacearum* will be recovered from infected trees in fall 2010 from an active oak wilt center in Central Texas. Inoculum is to be produced by growing the isolate for 1 week on unamended APDA(?) at room temperature. In April 2011, a drag plane will be used to thin and smooth the outer bark of each tree at breast height and a cork borer will be used to make a 5 mm diameter and 3 mm deep hole in the outer sapwood. A mycangium-bearing agar plug (5 mm diameter) will be cut from the source colony plates and placed top side inward into the hole in the sapwood. The inoculum plug will be covered with moist paper towels and secured with duct tape.

Trees will be evaluated for oak wilt symptoms after 4 weeks and then every 8 weeks thereafter for 80 weeks (18 months). Each oak crown will be given a rating of 0 (healthy), 1 (wilt symptoms comprising up to one-third of the crown), 2 (wilt symptoms comprising greater than one-third of the crown) (Mayfield et al. 2008), or 3 (dead tree). At each rating period, trees with a crown rating of 2 may be felled and wood samples taken from the stem and branches to determine the presence of *Ceratocystis fagacearum*.

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

Once the trial is complete, infected trees and any new oak wilt centers will be destroyed to prevent further spread into other areas.

Project Support: This trial is being funded by a grant from the International Society of Aboriculture - Texas. Syngenta Crop Protection and Mauget are providing chemical, Dr. Appel is providing fungal inoculum, and Arborjet, Rainbow Treecare Scientific, Mauget, ArborSystems, Scenic Hills Nursery, and Urban Renewal are providing injection equipment for the project.

Research Time Line:

CY 2011

<u>April, 2011</u>

- Select 7 sets of study trees (6 treatments and a check)
- Inject each set of trees with one of six injection systems (excluding check trees)

May - December, 2011

- Inoculate trees with fungal plugs (May)
- Monitor for tree decline (June - October)
- Sample infected trees to confirm presence of *Ceratocystis fagacearum*.
- Present preliminary results of system evaluation at annual International Society of Arboriculture (September)
- Conduct statistical analyses of data (November)
- Prepare and submit report to FPMC Executive Committee, Syngenta and System manufacturers (December).

CY 2012 (if warranted, based on 2011 results)

April - December, 2012

- Monitor for tree decline (April - October)
- Sample infected trees to confirm presence of *Ceratocystis fagacearum*.
- Conduct statistical analyses of data (November)
- Prepare and submit report to FPMC Executive Committee, Syngenta and System manufacturers (December).
- Present final results at annual International Society of Arboriculture and Entomological Society of America meeting.
- Destroy all infested trees and treat new oak wilt centers created by this study.

References:

Appel, D.N. 1995a. The oak wilt enigma: perspectives from the Texas epidemic. Ann. Rev. of Phytopathology. 33: 103-118.

Appel, D.N. 1995b. Chemical control of oak wilt. In: Appel, D.N. and R.F. Billings (eds.) The Proceedings of the National Oak Wilt Symposium. Information Development Inc., Houston, TX pp. 81-88.

Blaedow, R.A., J. Juzwik and B. Barber. 2010. Propiconazole distribution and effects on *Ceratocystis fagacearum* survival in roots of treated red oaks. Phytopathology 100: 979-985.

Camilli, K., D.N. Appel, and W.T. Watson. 2009. Studies on pruning cuts and wound dressings for oak wilt control, pp. 115-128. *In* R.F. Billings and D. N. Appel (eds.). Proceedings National Oak Wilt Symposium, June 4-7, 2007, Austin, TX. Texas Forest Service Publ. 166.

Koch, K.A., G.L. Quiram, and R.C. Venette. 2010. A review of oak wilt management: A summary of treatment options. Urban Forestry & Urban Greening. 9: 1-8.

Mayfield III, A.E., E.L. Benard, J.A. Smith, S.C. Bernick, J.M. Eickwort, and T.J. Dreaden. 2008. Effect of propiconazole on laurel wilt disease development in redbay trees and on the pathogen in vitro. Arboriculture & Urban Forestry. 34: 317-324.

Peacock, K.L. and D.W. Fulbright. 2009. Effective longevity of propiconazole following injection into Quercus rubra, pp. 175-184. *In* R.F. Billings and D. N. Appel (eds.). Proceedings National Oak Wilt Symposium, June 4-7, 2007, Austin, TX. Texas Forest Service Publ. 166.

PINE TIP MOTH

Impact Study
(Initiated in 2001)

Justification: Pine tip moths, *Rhyacionia* spp., can cause significant damage in young pine plantations in the southern United States. Tip moth larval feeding causes bud and shoot mortality that results in tree deformation, reduced height and diameter growth, and occasionally tree mortality (Yates III 1960). The Nantucket pine tip moth (NPTM), *R. frustrana*, is the most common and economically important tip moth species in the South (Berisford 1988). It may have three to five generations annually (Powell and Miller 1976).

The impact of tip moth attack on tree growth has not been clearly established. Beal (1967) showed that pine trees protected from tip moth attack grew significantly faster than unprotected trees during the first 6 years after planting on some sites, but not on others. At age 16, differences in height and volume growth between treated and untreated plots were still present, but had decreased considerably (Williston and Barras 1977). In contrast, volume differences between protected and unprotected trees were still increasing after 12 years in Georgia and North Carolina (Berisford et al., unpublished data). Ten years after planting on northeast Florida sandhills, unprotected loblolly pine trees were 2.8 m shorter in height, 3.81 cm smaller in dbh, and had about one forth as much wood as protected pines (Burns 1975). Cade and Hedden (1987) found that loblolly pine protected from tip moth attack for 3 years in Arkansas had ca 13 m^2/ha more volume than unprotected trees at age 12.

During the first year (2001) of the FPMC Tip Moth Impact Study, the unprotected seedlings in 16 study sites averaged 22% of shoots infested over five generations (Figure 1). The exclusion of tip moth from Mimic®-treated seedlings improved tree height, diameter, and volume by 28%, 12% and 45%, respectively, compared to untreated trees. During the second year (2002), tip moth population showed a general decline in the Western Gulf Region with the percent of shoots infested on unprotected seedlings in 7 first-year (planted in 2002) and 15 second-year (planted in 2001) sites averaging 7% and 21%, respectively. The higher damage levels in second-year sites significantly impacted the growth of unprotected trees. After two years, the height, diameter, and volume of Mimic®-treated trees were improved by 11%, 12%, and 38%, respectively, compared to check trees. During the next four year (2003 - 2006) tip moth populations remained low with the percent of shoots infested on first year seedlings ranging from 10% to 14%, while infestation on second-year trees ranged from 12% to 16%. Even at relatively low populations, protection with Mimic®- improved tree height (7-16%), diameter (2-20%), and volume (17-58%), respectively, compared to untreated trees.

In 2007 - 2010, we have observed substantial higher tip moth populations and damage compared to 2003 – 2006 (Figure 1). High levels are expected for 2011 as well.

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

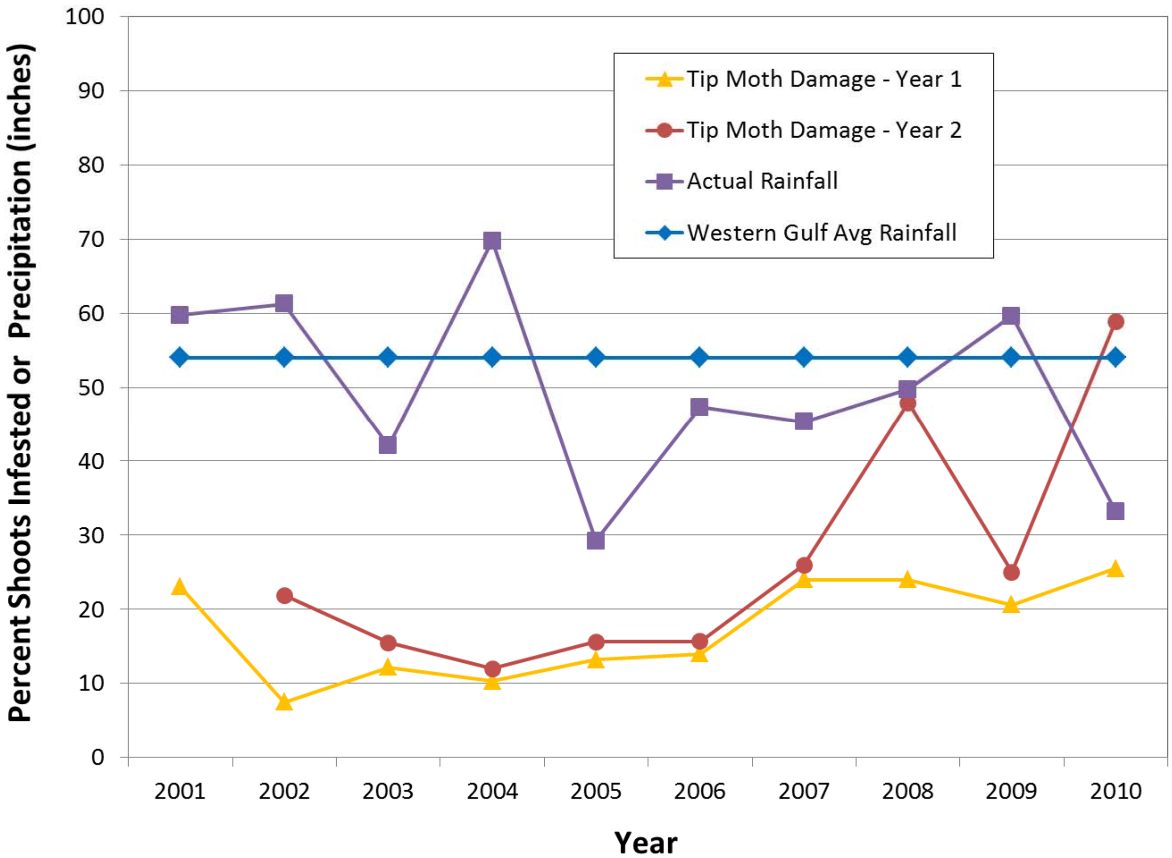


Figure 1: Average tip moth damage levels on first- and second-year loblolly pine in relation to rainfall totals in the Western Gulf: 2001 – 2010.

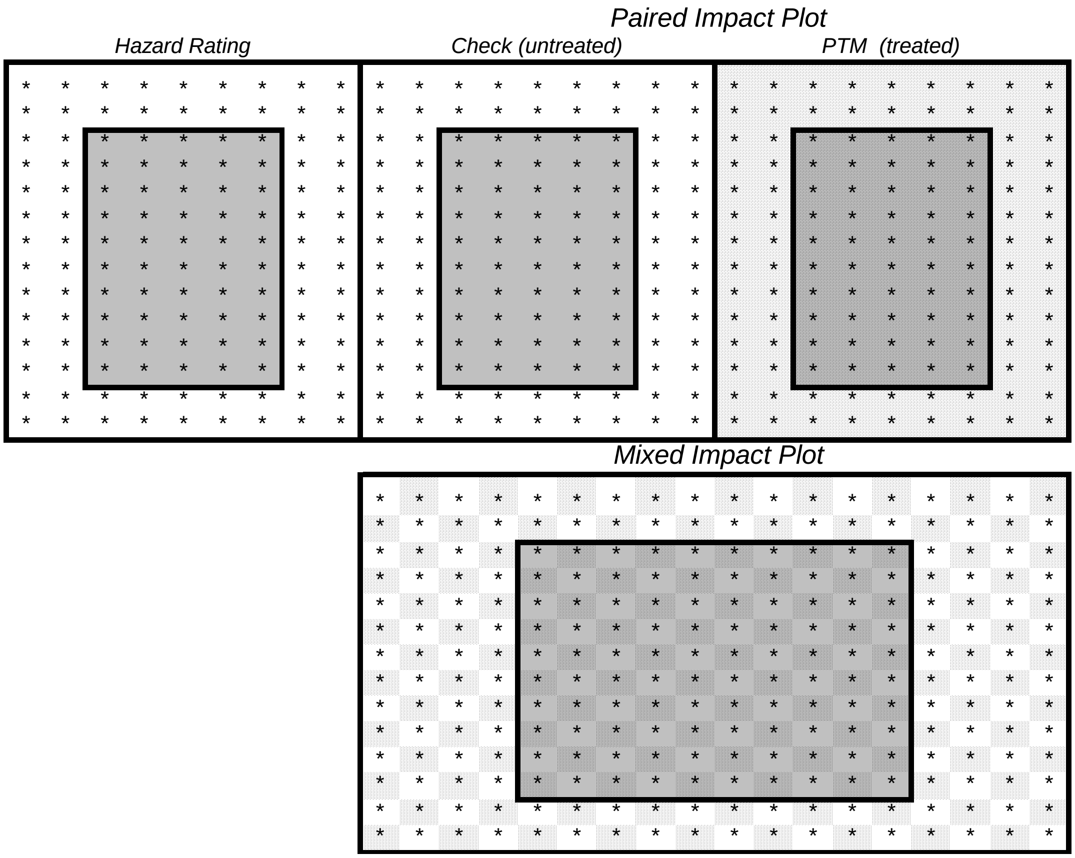
Cooperators

Forest Pest Management Cooperative members

Mr. Trevor Walker	Stephen F. Austin State University, Nacogdoches, TX
Dr. Dean Coble	Stephen F. Austin State University, Nacogdoches, TX

Research Approach: Most participating companies/organizations have established one or more impact sites from 2001 to 2008. We (TFS) will establish five new sites during each of the next two years (2011 & 2012). All sites were/will be planted with improved 1-0 bare-root loblolly pine seedlings. The study uses a randomized block design with 1-2 replications (blocks) per site. Two treatments (plots) were/will be established in each block. Each plot will contain 126 trees (9 rows X 14 columns (see below) spacing depending on landowner). The treatments include:

1) a hazard rating (standard company practices, i.e., site prep., herbicide, and fertilizer)
2) a check (standard and additional herbaceous control)
3) tip moth control applied at recommended time (in this case immediately after planting) and standard company practices plus additional herbaceous control.



PTM™ Insecticide was/will be applied to plant holes using a PTM™ Spot Gun™ per label rates (5.2 ml / 60 ml of water) at planting.

Tip moth damage was/will be evaluated on 1st- and 2nd-year sites after the 1st, 2nd, 3rd and 4th (for sites north of the LA/AR border) and 5th (on sites south of the border) tip moth generations by 1) identifying if the tree is infested or not, 2) if infested, the proportion of tips infested on the top whorl and terminal will be calculated, and 3) separately, the terminal will be identified as infested or not.

Tree height and diameter (at 15cm or 6 in) will be measured at the end of the growing season on first- and second-year sites (established in 2011 and 2010, respectively); tree height, diameter (at breast height (DBH)), and form were/will be measured after year 3 (2009 planting), 5 (2007 planting), 8 (2004) and 10 (2002).

Tree form was/will be determined using the method of Berisford and Kulman (1967). Four form classes, based on the number of forks present per tree, was/will be recorded as follows: 0 = no forks, 1 = one fork, 2 = two to four forks, and 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. Height and diameter measurements will be used to calculate volume index (height X diameter^2).

Mr. Trevor Walker, graduate student in the College of Agriculture and Forestry at Stephen F. Austin State University, has is running a cost/benefit analysis on the impact data. This may identify the threshold at which tip moth damage (% shots infested) would justify application of PTM™ or SilvaShield™ for protection of pine seedlings.

Data Analysis: Mr. Walker has provided the following outline for data analysis:

A) Dominant height equation modifier:

Relate tree growth impact to infestation level (Hedden paper):

Predictor variables - Years since treatment, identify others in Hazard-rating part of study

B) Economic simulation:

Determine *willingness to pay* (Asaro 2006) for treatment:

Assume:

Real price increase and consumer price index

Fluctuate levels of, or numerically solve - Price per unit of forest product, Alternative rate of return.

Project Support: The remainder of the trial will be supported by FPMC funds.

Research Time Line:

CY 2011

<u>January - February 2011</u>

- Locate and establish new plots.
- Treat seedlings as they are planted with PTM™ SC Insecticide.

<u>March - September 2011</u>

- Treat plots on second-year sites with foliar sprays based on optimal spray timing recommended for each site location for 1st, 2nd, 3rd and 4th generations.
- Evaluate tip moth damage after 1st, 2nd, and 3rd generations in treated and check plots on second-year sites; photograph damage.

<u>October - November 2011</u>

- Evaluate tip moth damage after 4th and 5th (if present) generations on second-year sites; take growth measurements on 2nd, 3rd and 5th-year trees; evaluate tree form on three- and five-year old sites; photograph damage.

<u>December 2011 - January 2012</u>

- Conduct statistical analyses of all data; prepare and distribute final report to members (Grosman).

CY 2012

<u>January - February 2012</u>

- Locate and establish new plots.
- Treat seedlings as they are planted with PTM™ SC Insecticide.

<u>March - September 2012</u>

- Evaluate tip moth damage after 1st, 2nd, and 3rd generations in treated and check plots on second-year sites; photograph damage.

<u>October - November 2012</u>

- Evaluate tip moth damage after 4th and 5th (if present) generations on second-year sites; take growth measurements on 2nd, 3rd and 5th-year trees; evaluate tree form on three- and five-year old sites; photograph damage.

December 2012 - January 2013

- Conduct statistical analyses of all data; prepare and distribute final report to members (Grosman).

References:

Beal, R.H. 1967. Heavy tip moth attacks reduce early growth of loblolly and shortleaf pines. USDA For. Serv. Res. Note 50-54. So. For. Exp. Stat., New Orleans, LA. 3 p.

Berisford, C.W. 1988. The Nantucket pine tip moth. p. 141-161. *In* Berryman, R.R., Ed. Dynamics of forest insect populations. Plenum Publishing Corp.

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.

Burns, R,M. 1975. Tip moth control pays off. Forest Farmer 34(13): 13.

Cade, S.C., and R.L. Hedden. 1987. Growth impact of pine tip moth on loblolly pine plantations in the Ouachita Mountains in Arkansas. So. J. Appl. For. 11: 128-133.

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

Powell, J.A., and W.E. Miller. 1976. Nearctic pine tip moths of the genus *Rhyacionia*: Biosystematic review (Lepidoptera: Tortricidae, Olethreutidae). USDA Agric. Handbook No. 514. 51 p.

Williston, H.L., and S.J. Barras. 1977. Impact of tip moth injury on growth and yield of 16-yr-old loblolly and shortleaf pine. USDA For. Serv. Res. Note 50-221. So. For. Exp. Stat., New Orleans, LA. 5 p.

Yates III, H.O. 1960. The Nantucket pine tip moth. A literature review. US For. Serv. SE For. Exp. Stat., Stat. Pap. No. 115. Asheville, NC. 19 p.

PINE TIP MOTH

Hazard Rating Study
(Initiated in 2001)

Justification: Pine tip moths, *Rhyacionia* spp., can cause significant damage in young pine plantations in the southern United States. Tip moth larval feeding causes bud and shoot mortality that results in tree deformation, reduced height and diameter growth, and occasionally tree mortality (Yates III 1960). The Nantucket pine tip moth (NPTM), *R. frustrana*, is the most common and economically important tip moth species in the South (Berisford 1988). It may have three to five generations annually (Powell and Miller 1976).

Several studies have evaluated the influence of stand management practices or growing conditions on tip moth infestation and tree damage levels. Tip moth levels have been observed to be higher in plantations compared to natural stands (Beal et al. 1952, Berisford and Kulman 1967), in plantations with the widest tree spacing (Hansbrough 1956), and are positively correlated with intensity of site preparation (Hertel & Benjamen 1977, White et al. 1984, Hood et al. 1988), weed control (Ross et al. 1990), and fertilization (Ross and Berisford 1990).

Technological developments in pine plantation management and tree improvement programs within the past two decades have dramatically increased rates of tree growth. Intensive management of southern pines typically includes thorough mechanical site preparation and/or one or more herbicide applications plus fertilization on most sites. Although these practices increase tree growth, sometimes dramatically, they can exacerbate tip moth attacks and prevent realization of potential tree growth (Ross et al. 1990). Over the past ten years (2001 – 2010), the FPMC has established and monitored 142 hazard-rating plots across the Western Gulf Region. A preliminary hazard-rating model, developed by Andy Burrow from 2001 – 2005 data, indicates (in order of increasing importance)- site index, percent sand, clay and silt in the soil, drainage class, texture of soil in B horizon, and depth to B horizon are primary factors that influence the occurrence and severity of tip moth damage. The remaining data from second-year sites (established in 2010) needs to be collected. Dr. Dean Coble and Trevor Walker, SFASU, have agreed to provide assistance in completing the tip moth hazard-rating model.

Objectives: 1) Complete data collections on sites established in 2010, 2) complete development of models using stand characteristics and other abiotic factors to predict future levels of tip moth damage, 3) identify factors which may facilitate hazard rating of stands for tip moth damage, and 4) develop GIS maps to show levels of tip moth risk across the Western Gulf Region.

Cooperators

Forest Pest Management Cooperative members

Mr. Trevor Walker	Stephen F. Austin State University, Nacogdoches, TX
Dr. Dean Coble	Stephen F. Austin State University, Nacogdoches, TX

Research Approach:

From 2001 to 2010, 142 hazard-rating plots were established across the Western Gulf Region, many in association with the Impact Study. Each hazard-rating plot has/will be evaluated in the 1st and 2nd year after establishment, so the 4 plots established in 2010 need to be monitored in 2011.

Data will be collected for the following soil, tree, and site characteristics:

Soil - Drainage class
- Soil description/profile: depth of 'A' and to 'B' horizons; color of 'B' horizon; soil auger 5 samples (remove organic layer & keep next 3-5") between tree rows within plot; bulk and send pint subsample to Water's lab for standard soil analysis (minus N) plus pH and micronutrients
- Texture: soil auger 5 samples (remove top 5" & keep next 4") between tree rows within plot; bulk and send pint subsample to Water's lab for analysis
- Depth to hard-pan or plow-pan
- Depth to gleying

Tree - Age (1-2)
- Percent tip moth infestation of terminal and top whorl shoots
- Height and diameter at 6 inches (do not measure at root collar swell)
- Tree form (presence or absence of forks)
- Fusiform rust occurrence

Site - Previous history of stand
- Site Index (base 25 yrs)
- Silvicultural prescription *(*for entire monitoring period*)*
- Slope & aspect
- Competing vegetation- (see below for protocol)
- Presence or absence of well-developed sod
- Rainfall: install a rain gauge (11" capacity – available from Forestry Supply) on each site which will be read at least once per 2-4 weeks (once per week best); add 1/10" of antifreeze after each reading to reduce evaporation; a fallback would be from the nearest weather station (not recommended by climatologist).
- Proximity of susceptible loblolly stands in the 1-4 year age class (< 15 ft. tall) adjacent to or within 0.5 miles of study stand boundary: estimate total acreage in this class; record percent infestation in top whorl of 20 randomly encountered trees in closest proximal stand during winter or early spring

The 2nd year sample trees were/will be assessed for:

- Percent infestation of terminal and top whorl shoots after tip moth generations 1, 2, 3, and 4 (on sites north of LA/AR border) and 5 (on sites south of the border)
- Height and diameter (at 6 inches)
- Fusiform rust

Incidence of fusiform rust was/will be measured by counting the number of fusiform galls on the main stem and on branches within 12 inches of the main stem of each tree.

Competing vegetation was/will be estimated twice (after the 2nd and after the last tip moth generation) at each of the 5 random points within the 50 tree plot. At each point, an estimate was/will be made of the proportion of bare ground, grasses, forbes, and non-arborescent woody material occurring within a 0.5 meter radius of the point. The combined percentage of the four categories should equal 100%.

Data Analysis: Mr. Trevor Walker, with a Bachelors' in Forestry and minor in statistics SFASU, has developed the model. The data (eight years' worth; 2001- 2008) was consolidated and sent to Mr. Walker by the end of February 2009. Additional data collected from 2009 was sent to Mr. Walker in April 2010.

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

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

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

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

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

E) Develop hazard-rating map.
- - Map rating class based on important predictor variables.
- - Bayou Bleu Farms, LLC case study/poster.

Project Support: The remainder of the trial will be supported by FPMC funds.

Research Time Line:

CY 2011

<u>January - February 2011</u>
- Work with participating FPMC members to identify and receive all missing data from previously established hazard rating plots (2001 – 2008) (Grosman).

<u>March - July 2011</u>
- Establish new hazard-rating plots
- Evaluate tip moth damage after 1st and 2nd generations on first- and second-year sites; conduct competing vegetation assessment; photograph damage.

<u>August – October 2011</u>
- Evaluate tip moth damage after 3rd generation for all sites and 4th generation for sites south of the LA/AR border; photograph damage.
- Collect site information for hazard rating study.

November - December 2011

- Evaluate tip moth damage, conduct competing vegetation assessment after last generation (4th for sites north of border or 5th for sites south of the border) and evaluate for occurrence of fusiform rust on second-year sites.

CY 2012

January 2012

- Conduct statistical analyses of all data; prepare and distribute final report to members (Grosman, Walker and Coble).

References:

Beal, R.H., H. Halburton, and F.B. Knight. 1952. Forest insects of the southeast with special reference to species occurring in the piedmont plateau of North Carolina. Duke University School of Forestry, Bull. 14. 168 p.

Berisford, C.W. 1988. The Nantucket pine tip moth. p. 141-161. *In* Berryman, R.R., Ed. Dynamics of forest insect populations. Plenum Publishing Corp.

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.

Hansbrough, T. 1956. Growth of planted loblolly and slash pines in North Louisiana. La. State University For. Note 10. 2 p.

Hertel, G.D., and D.M. Benjamen. 1977. Intensity of site preparation influences on pine webworm and tip moth infestations of pine seedlings in North-Central Florida. Environ. Entomol. 6: 118-122.

Hood, M.W., R.L. Hedden, and C.W. Berisford. 1988. Hazard rating forest sites for pine tip moth, *Rhyacionia* spp. in the upper Piedmont Plateau. For. Sci. 34: 1083-1093.

Powell, J.A., and W.E. Miller. 1976. Nearctic pine tip moths of the genus *Rhyacionia*: Biosystematic review (Lepidoptera: Tortricidae, Olethreutidae). USDA Agric. Handbook No. 514. 51 p.

Ross, D.W., and C.W. Berisford. 1990. Nantucket pine tip moth (Lepidoptera: Tortricidae) response to water and nutrient status of loblolly pine. For. Sci. 36: 719-733.

Ross, D.W., C.W. Berisford, and J.F. Godbee, Jr. 1990. Pine tip moth, *Rhyacionia* spp., response to vegetation control in an intensively-site-prepared loblolly pine plantation. For. Sci. 361105-1118.

White, M.N., D.L. Kulhavy, and R.N. Conner. 1984. Nantucket pine tip moth (Lepidoptera: Tortricidae) infestation rates related to site and stand characteristics in Nacogdoches County Texas. Environ. Entomol. 13: 1598-1601.

Yates III, H.O. 1960. The Nantucket pine tip moth. A literature review. US For. Serv. SE For. Exp. Stat., Stat. Pap. No. 115. Asheville, NC. 19 p.

PINE TIP MOTH

Fipronil/PTM™ Treatment Trials
(Initiated in 2008)

Justification

Several trials (2003 - 2005) have shown that fipronil applied to bare root seedlings before or after planting is highly effective in reducing tip moth damage for 2+ years. EPA recently approved the registration and use of PTM™ SC Insecticide for tip moth control. It is possible that a landowner may not wish to treat for tip moth at the time of planting. However, later in the first growing season tip moth becomes a significant problem. The landowner may then wish to treat to protect trees during the second growing season. Trials were established to determine the efficacy of fipronil applied to pines before the second growing season using different application techniques.

Objectives: 1) Evaluate the efficacy of fipronil applied using different rates and techniques for reducing pine tip moth infestation levels, and 2) determine the duration of chemical activity.

Cooperators

Mr. Bill Stansfield	Campbell Group, Diboll, TX
Ms. Fances Peavy	Private landowner, Hudson, TX
Mr. Ragan Bounds	Hancock Forest Management, Colmesneil, TX
Dr. Harold Quicke	BASF, Auburn, AL

Research Approach:

Trials 1 (2008) and 2 (2009):

Two plantations containing one-year old (trees beginning their second year in January 2008 or January 2009) loblolly pine were selected in the East Texas area. Treatments included**:**

Trial 1 (2008):

1 =	PTM™ (1.4 ml in 12 ml/tree solution) -	single injection into soil 4” deep
2 =	PTM™ (1.4 ml in 12 ml/tree solution) -	double injection (6 ml ea.) into soil 4” deep
3 =	PTM™ (1.4 ml in 12 ml/tree solution) -	single injection into soil 8” deep
4 =	PTM™ (1.4 ml in 12 ml/tree solution) -	double injection (6 ml ea.) into soil 8” deep
5 =.	Foliar spray -	Mimic® applied 5X/ seedling
6 =	Check (untreated) -	Resident seedling

Trial 2 (2009):

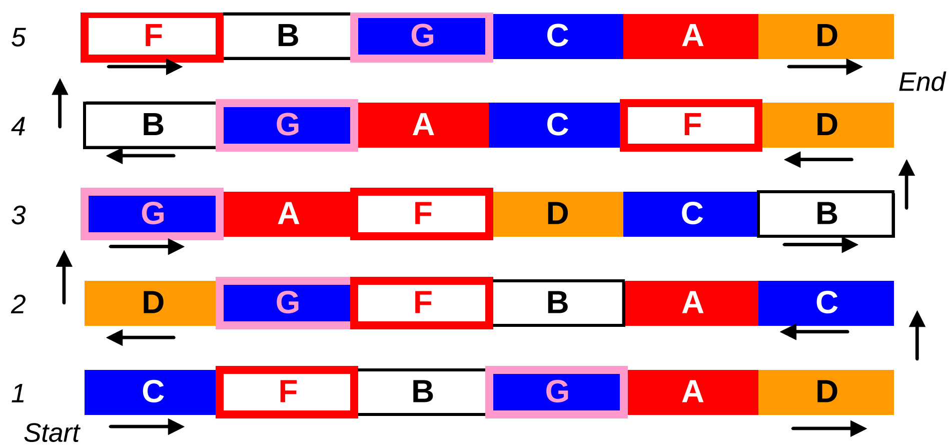
1 =	PTM™ (1.4 ml in 15 ml/tree solution) -	double injection (7.5 ml ea.) into soil 4” deep
2 =	PTM™ (1.4 ml in 30 ml/tree solution) -	double injection (15 ml ea.) into soil 4” deep
3 =	PTM™ (2.8 ml in 15 ml/tree solution) -	double injection (7.5 ml ea.) into soil 4” deep
4 =	PTM™ (2.8 ml in 30 ml/tree solution) -	double injection (15 ml ea.) into soil 4” deep
5 =.	SilvaShield™ Tablet -	1 tablet in each of 2 locations 4” deep
6 =	Check (untreated) -	Resident seedling

A 1 acre (approximate) area within each site was selected. A randomized complete block design was established with beds (or rows of trees) serving as blocks, i.e., each treatment was randomly selected for placement along a bed. Fifty trees for each treatment were selected on each site. Ten trees were assigned a given treatment on each of five beds. (Figure 3). If the length of bed is problematic (too long), it is acceptable to start laying the first group of treatments along the first bed and wrap the remaining treatments along the second bed. The second group of treatments would start on the second bed but then wrap onto the third bed, etc.

The plot corners were marked with PVC pipe and the individual trees with different color pin flags and tags. It may be necessary to apply herbicide over the area in the spring to ensure that the seedlings remain exposed to tip moth attack throughout the year.

Treatment Evaluation:
Tip moth damage was/will be evaluated by determining percent of trees infested, percent of infested shoots in top whorl and percent terminals infested about 4 weeks after peak moth flight of each generation for at least the first 2 years. Observe and record presence and extent of damage caused by other insects, i.e., weevils, coneworm, webworm, aphids, etc. All study trees

Figure 3. Randomized Block Design Layout for a 6 Treatment Trial.



A = Red (single inj 4" deep) *C = Blue (single inj 8" deep)* *F= Rd&Wht (Pounce Foliar)*
B = White (double inj 4" deep) *D = Orange (double inj. 8" deep)* *G = Pk&Bl (Check)*

were measured (height & diameter @ 6 inches) at the beginning of the study (when treatments are first applied). Measurements also will be taken when tree growth has stopped in mid- to late November for at least the first 2 years of the study. Tree form will be evaluated at end of year 3. Form ranking of the seedling or tree will be categorized as follows: 0 = no forks; 1 = one fork; 2 = two to four forks; 3 = five or more forks. A fork is defined as a node with one or more laterals larger than one half the diameter of the main stem (Berisford and Kulman 1967). Data will be analyzed by GLM and the Tukey's Compromise test using Statview or SAS statistical programs.

Project Support: These trials are supported by BASF grant funds.

Research Time Line:

CY 2011

January - February 2011

- Begin trap monitoring of tip moth populations near each site

March - October, 2011

- Evaluate tip moth damage after 1st through 4th generations; photograph damage.

November - December 2011

- Evaluate tip moth damage after 5th generations; measure seedling and height of seedlings.
- Conduct statistical analysis of 2010 data.
- Prepare and submit report to FPMC Executive Committee, BASF.
- Present results at annual Entomological Society of America meeting.

PINE TIP MOTH

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

Justification

Several FPMC trials (2003 - 2005) showed that fipronil applied to bare root seedlings before or after planting was highly effective in reducing tip moth damage for 2+ years. Operationally, it would be desirable to apply chemical solutions to containerized seedlings. Because these trees have higher value, it would be more economical to treat large numbers of seedlings in the nursery, and there may be less restriction on the amount of active ingredient that could be applied to each seedling.

A trial was initiated in 2006 to determine the efficacy of fipronil applied at different rates to containerized seedlings. Seedlings were treated in July 2006 and outplanted in February 2007. Tip moth damage and tree growth were monitored through 2009. The results showed that, as in previous studies, fipronil provided excellent protection against tip moth for 2+ years and improved tree volume growth by 21 to 63% compared to untreated checks.

Based on discussion at the PTM Strategy meeting on July 21, 2010, BASF is willing to support the development of a container plug injection system that would eliminate concerns of t he Environmental Protection Agency (EPA) about 1) movement of the active ingredient (AI, fipronil) out of containers during periodic watering in the nursery and 2) excessive exposure of handlers and planters to the AI when packaging and planting seedlings. It is of interest to evaluate the efficacy and duration of plug injection treatment of containerized pine seedlings.

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

Cooperators

George Lowerts, Keith Byrd	ArborGen LLC
Bill Stansfield, Rick Leeper	The Campbell Group
Jim Bean, Andy Goetz, Victor Canez	BASF
Nick Muir	Cellfor Inc.
Ragan Bounds	Hancock Forest Management
Wayne Bell, Mike Coyle, Chris Rosier	International Forestry Co
James West	North Carolina Forest Service
Alan Wilson, Greg Leach	Rayonier
Tony Fontenot, Wilson Edwards,	Weyerhaeuser Co.

Research Approach:

One family of loblolly pine containerized seedlings will be selected by (Cellfor).

Treatments**:**

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

2 = PTM™ High Concentration/Diluted Soil Injection [5.6 ml PTM in 9.4 ml water (15 ml total volume)/seedling] - Soil injection next to transplanted **container** plug just after planting.
3 = PTM™ High Concentration/Diluted Soil Injection [5.6 ml PTM in 9.4 ml water (15 ml total volume)/seedling] - Soil injection next to transplanted **bareroot** seedling just after planting.
4 = PTM™ Mid Concentration/Undiluted Plug Injection [1.4 ml PTM undilute/seedling (**435 tpa rate**)] - Injection into **container** seedling plug just prior to shipping.
5 = PTM™ Mid Concentration/Diluted Plug Injection [1.4 ml PTM in 1.7 ml water (3ml total volume)/seedling] -Injection into **container** seedling plug just prior to shipping.
6 = PTM™ Mid Concentration/Diluted Soil Injection [1.4 ml PTM in 13.6 ml water (15 ml total volume)/seedling] - Soil injection next to transplanted **container plug** just after planting.
7 = PTM™ Mid Concentration/Diluted Soil Injection [1.4 ml PTM in 13.6 ml water (15 ml total volume)/seedling] - (**Standard 1**) Soil injection next to transplanted **bareroot** seedling just after planting.
8 = PTM™ Low Concentration/Undiluted Plug Injection [1 ml PTM undilute/seedling (**600 tpa rate**)] - Injection into **container** seedling plug just prior to shipping.
9 = PTM™ Low Concentration/Diluted Plug Injection [1 ml PTM in 2 ml water (3ml total volume)/seedling] - Injection into **container** seedling plug just prior to shipping.
10 = PTM™ Low Concentration/Diluted Soil Injection [1 ml PTM in 14 ml water (15ml total volume)/seedling] - Soil injection next to transplanted **container plug** just after planting..
11 = PTM™ Low Concentration/Diluted Soil Injection [1 ml PTM in 14 ml water (15ml total volume)/seedling] - (**Standard 2**) Soil injection next to transplanted **bareroot** seedling just after planting..
12 = Containerized check (untreated)
13 = Bareroot check (untreated)

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

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

TX – Hancock (Bounds), Rayonier (Leach), Weyerhaeuser (Fontenot)
LA - Campbell Group (Stansfield)
AR – ArborGen (Byrd)
MS – Cellfor (Muir)
GA – Rayonier (Wilson)
FL – Rayonier (Wilson)
NC – NC Forest Service (West), Weyerhaeuser (Edwards)

All stands will have been intensively site prepared, i.e., subsoil, bedding, and/or herbicide. A 1-acre (approximate) area within each site will be selected. A multiple Latin Square design will be established with single tree plots (1 tree X 13 treatments) serving as blocks, i.e., each treatment will be randomly selected for placement along a row (beds). Thirty-nine (39) blocks will be established on each site. Seedlings will be planted at 8 foot spacing along each row. Individual tree locations will be marked with different color pin flags prior to tree planting.

The plot corners should be marked with PVC pipe (1 at each end of the plot) and metal tags. It may be necessary to apply herbicide over the area in the spring to ensure that the seedlings remain exposed to tip moth attack throughout the year.

Damage and Tree Measurements
Tip moth damage 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 will be calculated; and 3) separately, the terminal will be identified as infested or not. Observations also will be made as to the occurrence and extent of damage caused by other insects, i.e., coneworm, aphids, sawfly, etc. All study trees will be measured for height & diameter at ground line) at the beginning of the study (when seedlings are planted). Measurements also will be taken when tree growth has stopped in mid- to late November for at least the first 2 years of the study. Tree form will be evaluated at end of year 3. Form ranking of the seedling or tree will be categorized as follows: 0 = no forks; 1 = one fork; 2 = two to four forks; 3 = five or more forks. A fork is defined as a node with one or more laterals larger than one half the diameter of the main stem (Berisford and Kulman 1967).

Efficacy will be evaluated by comparing treatment differences for direct and indirect measures of insect-caused losses. Direct treatment effects include reduction in pine tip moth damage. Indirect treatment effects include increases in tree growth parameters (height, diameter and volume index). Data will be subjected to analyses of variance (Table 3) using Statview software (SAS Institute, Inc. 1999). Percentage and measurement data will be transformed by the arcsine % and log transformations, respectively, prior to analysis. Costs of treatment per acre also will be calculated.

If one or more treatments continue to be successful in reducing tip moth damage by > 75% in the 4th generation in 2011, the "best" treatment(s) will be followed into 2012 to continue evaluating duration of treatments. In addition, the study may be expanded in 2012 to refine application rates and techniques for the promising treatment(s).

Treatments and Plot Design Example

Code	Treatment	Color	
A	High UD PTM container plug injection	red	R
B	High D PTM container soil injection	blue	B
C	High D PTM bareroot soil injection	orange	O
D	Med UD PTM container plug injection	pink/blue	P/B
E	Med D PTM container plug injection	white	W
F	Med D PTM container soil injection	red/white	R/W
G	Med D PTM bareroot soil injection (Standard 1)	yellow/blue	Y/B
H	Low UD PTM container plug injection	yellow	Y
I	Low D PTM container plug injection	green	G
J	Low D PTM container soil injection	pink	P
K	Low D PTM bareroot soil injection (Standard 2)	blue/white	B/W
L	Check (containerized)	green/orange	G/O
M	Check (bareroot))	blue/red	B/R

UD = undilute; D = dilute

	Block 1													Block 2						
Tree	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
1	G	G	E	L	D	I	A	E	A	B	A	J	H	I	I	J	G	M	J	B
2	L	F	B	D	H	H	J	G	G	F	D	B	M	K	J	A	E	I	E	L
3	K	B	C	E	E	M	H	H	D	I	E	G	K	L	E	F	I	J	B	C
4	M	E	K	J	I	E	E	A	F	L	J	D	D	H	G	I	F	A	I	H
5	D	A	F	A	F	B	C	J	H	G	F	E	F	A	A	C	M	H	A	D
6	A	K	I	G	G	C	K	L	B	E	B	M	J	B	C	L	J	L	C	A
7	F	J	M	K	A	A	G	D	K	C	M	L	I	F	K	B	K	F	M	I
8	J	I	J	C	M	K	F	F	M	M	I	C	B	C	B	E	B	K	L	E
9	H	C	L	H	C	L	D	K	I	K	H	K	L	M	M	H	C	D	D	F
10	I	L	A	F	J	J	B	I	E	D	K	H	A	D	H	K	A	B	F	K
11	E	H	H	M	L	F	M	C	C	H	L	A	C	G	L	D	L	C	H	G
12	C	D	G	B	B	G	L	M	J	A	C	F	E	E	F	G	D	E	K	J
13	B	M	D	I	K	D	I	B	L	J	G	I	G	J	D	M	H	G	G	M

	Block 2						Block 3												
Tree	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**
1	M	J	C	H	K	A	H	M	C	D	M	I	I	G	B	B	E	I	G
2	H	F	B	L	B	M	C	G	B	J	H	M	C	K	F	K	B	H	E
3	B	M	F	M	F	B	A	F	K	A	B	E	A	F	H	I	G	M	D
4	G	B	M	K	G	J	J	I	A	B	F	H	E	B	L	F	F	C	A
5	I	A	A	F	H	F	G	D	D	L	A	L	B	J	A	A	L	B	K
6	J	E	I	E	L	L	E	H	J	H	K	B	J	E	K	G	A	G	L
7	C	L	G	B	C	H	I	E	H	I	C	J	F	D	I	L	M	K	C
8	A	G	J	I	E	D	D	A	I	G	E	G	G	C	J	E	K	F	J
9	L	K	H	C	A	K	B	B	F	K	D	D	L	M	E	D	J	D	H
10	K	H	K	G	I	C	M	L	E	C	G	F	M	A	D	J	C	J	F
11	D	I	E	A	J	E	K	C	G	F	L	K	K	H	C	M	I	A	B
12	E	C	D	J	D	G	F	K	M	E	J	A	D	I	G	C	H	L	M
13	F	D	L	D	M	I	L	J	L	M	I	C	H	L	M	H	D	E	I

Tree	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	Y/B	Y/B	W	G/O	P/B	G	R	W	R	B	R	P	Y	G	G	P	Y/B	B/R	P	B
2	G/O	R/W	B	P/B	Y	Y	P	Y/B	Y/B	R/W	P/B	B	B/R	B/W	P	R	W	G	W	G/O
3	B/W	B	O	W	W	B/R	Y	Y	P/B	G	W	Y/B	B/W	G/O	W	R/W	G	P	B	O
4	B/R	W	B/W	P	G	W	W	R	R/W	G/O	P	P/B	P/B	Y	Y/B	G	R/W	R	G	Y
5	P/B	R	R/W	R	R/W	B	O	P	Y	Y/B	R/W	W	R/W	R	R	O	B/R	Y	R	P/B
6	R	B/W	G	Y/B	Y/B	O	B/W	G/O	B	W	B	B/R	P	B	O	G/O	P	G/O	O	R
7	R/W	P	B/R	B/W	R	R	Y/B	P/B	B/W	O	B/R	G/O	G	R/W	B/W	B	B/W	R/W	B/R	G
8	P	G	P	O	B/R	B/W	R/W	R/W	B/R	B/R	G	O	B	O	B	W	B	B/W	G/O	W
9	Y	O	G/O	Y	O	G/O	P/B	B/W	G	B/W	Y	B/W	G/O	B/R	B/R	Y	O	P/B	P/B	R/W
10	G	G/O	R	R/W	P	P	B	G	W	P/B	B/W	Y	R	P/B	Y	B/W	R	B	R/W	B/W
11	W	Y	Y	B/R	G/O	R/W	B/R	O	O	Y	G/O	R	O	Y/B	G/O	P/B	G/O	O	Y	Y/B
12	O	P/B	Y/B	B	B	Y/B	G/O	B/R	P	R	O	R/W	W	W	R/W	Y/B	P/B	W	B/W	P
13	B	B/R	P/B	G	B/W	P/B	G	B	G/O	P	Y/B	G	Y/B	P	P/B	B/R	Y	Y/B	Y/B	B/R

replicate

Tree	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39
1	B/R	P	O	Y	B/W	R	Y	B/R	O	P/B	B/R	G	G	Y/B	B	B	W	G	Y/B
2	Y	R/W	B	G/O	B	B/R	O	Y/B	B	P	Y	B/R	O	B/W	R/W	B/W	B	Y	W
3	B	B/R	R/W	B/R	R/W	B	R	R/W	B/W	R	B	W	R	R/W	Y	G	Y/B	B/R	P/B
4	Y/B	B	B/R	B/W	Y/B	P	P	G	R	B	R/W	Y	W	B	G/O	R/W	R/W	O	R
5	G	R	R	R/W	Y	R/W	Y/B	P/B	P/B	G/O	R	G/O	B	P	R	R	G/O	B	B/W
6	P	W	G	W	G/O	G/O	W	Y	P	Y	B/W	B	P	W	B/W	Y/B	R	Y/B	G/O
7	O	G/O	Y/B	B	O	Y	G	W	Y	G	O	P	R/W	P/B	G	G/O	B/R	B/W	O
8	R	Y/B	P	G	W	P/B	P/B	R	G	Y/B	W	Y/B	Y/B	O	P	W	B/W	R/W	P
9	G/O	B/W	Y	O	R	B/W	B	B	R/W	B/W	P/B	P/B	G/O	B/R	W	P/B	P	P/B	Y
10	B/W	Y	B/W	Y/B	G	O	B/R	G/O	W	O	Y/B	R/W	B/R	R	P/B	P	O	P	R/W
11	P/B	G	W	R	P	W	B/W	O	Y/B	R/W	G/O	B/W	B/W	Y	O	B/R	G	R	B
12	W	O	P/B	P	P/B	Y/B	R/W	B/W	B/R	W	P	R	P/B	G	Y/B	O	Y	G/O	B/R
13	R/W	P/B	G/O	P/B	B/R	G	G/O	P	G/O	B/R	G	O	Y	G/O	B/R	Y	P/B	W	G

Table 1. ANOVA Table and Expected Mean Squares for Fipronil Treatment Study

Source of Variation	df	Expected Mean Squares
Blocks (B)	r-1	
Treatments (T)	t-1	$\sigma^2{}_{\varepsilon} + rm\sigma^2{}_{B}$
BxT	(b-1) (t-1)	$\sigma^2{}_{\varepsilon} + m\sigma^2{}_{BT}$
Sampling error	rt (m-1)	$\sigma^2{}_{\varepsilon}$
Total	rtm-1	

Project Support: This trial is supported by BASF grant funds. BASF is providing chemical and Cellfor is the containerized and bareroot seedlings.

Research Time Line:

CY 2010

June – September 2010

- Meeting with cooperators to discuss treatment options (June)
- Develop treatment techniques

November - December 2010

- Select research sites (November)
- Treat seedlings (December)
- Lift and plant all seedlings in plantation sites (December)
- Treat seedlings during and after planting with PTM via soil injection
- Begin trap monitoring of tip moth populations near each site

CY 2011

January - February 2011

- Continue trap monitoring of tip moth populations near each site

March - October, 2011

- Evaluate tip moth damage after 1st through 4th generations; photograph damage.

November - December 2011

- Evaluate tip moth damage after 5th generations; measure seedling and height of seedlings.
- Conduct statistical analysis of 2011 data.
- Prepare and submit report to FPMC Executive Committee, BASF.

CY 2012

<u>January - February 2012</u>

- Begin trap monitoring of tip moth populations near each site

<u>March - October, 2012</u>

- Evaluate tip moth damage after 1st through 4th generations; photograph damage.

<u>November - December 2012</u>

- Evaluate tip moth damage after 5th generations; measure seedling and height of seedlings.
- Conduct statistical analysis of 2012 data.
- Prepare and submit report to FPMC Executive Committee, BASF.

CY 2013 (if warranted based on CY 2012 results)

<u>January - February 2013</u>

- Begin trap monitoring of tip moth populations near each site

<u>March - October, 2013</u>

- Evaluate tip moth damage after 1st through 4th generations; photograph damage.

<u>November - December 2013</u>

- Evaluate tip moth damage after 5th generations; measure seedling and height of seedlings.
- Conduct statistical analysis of 2013 data.
- Prepare and submit report to FPMC Executive Committee, BASF.
    - Present results at annual Entomological Society of America me

PINE TIP MOTH TRIALS

Imidacloprid/Silvashield™ Trials – Western Gulf
(Initiated in 2007)

Justification

Imidacloprid, a neonicotinoid insecticide, is highly systemic in plants and is known to have activity against several Lepidopteran pests including pine tip moth.

In 2003 and 2004, imidacloprid plus fertilizer spikes (Bayer 2 – N – 1 Plant Spikes®) reduced tip moth damage for three generations (2nd, 3rd and 4th) in both years. The treatments also resulted in significant improvements in height, diameter and volume index compared to check trees. We propose to continue evaluating the residual effects of imidacloprid on tree growth.

Bayer Environmental Science has developed tablets containing imidacloprid. The tablets have been used operationally in Australia to control chrysomelid beetles and lepidopteran larvae on eucalyptus and pine. Mr. Nate Royalty (Bayer Environmental Science) asked the FPMC in 2004 and 2005 to evaluate the efficacy of tablets containing several different concentrations of imidacloprid alone or combined with fertilizer. Trials established on two sites showed that all imidacloprid treatments provided good to excellent protection from tip moth during the 2nd through the 5th generation. The absence of control in the first generation indicates that the tablets were slow to release the insecticide. On the other hand, a slower than expected release of chemical from the tablets may have prolonged the treatment effects into the second year. Bayer has developed a new FXT Ball formulation that may provide early and extended protection against tip moth.

In January 2007, Bayer announced that the label for the SilvaShield™ Forestry tablet had been approved by EPA. State registrations have been approved in all states except CA. We are interested in further evaluating the efficacy of these tablets in the Western Gulf Region.

Objectives: 1) Determine the efficacy of imidacloprid/ SilvaShield™ in reducing pine tip moth infestation levels on loblolly pine seedlings; and 2) determine the duration of chemical activity.

Cooperators:

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

Study Sites: In 2007 - 2010, first- or second-year plantations were selected in East Texas. Second-year plantations were used in the study because tip moth populations are usually well established at this age, increasing the likelihood that significant tip moth pressure would be placed on treated seedlings. The plots contained 4 - 9 treatments with 50 trees per treatment.

Insecticides:

Imidacloprid (SilvaShield™) – highly systemic neonictinoid with activity against Lepidoptera.
Fipronil (PTM)– a phenyl pyrazole with some systemic activity against Lepidoptera.

Design: Randomized complete block design 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.

Year & Treatments:

2007 All 6 study sites had:

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

2008 Trial 1:

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

Trial 2:

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

2009 :

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

2010 :

1)	SilvaShield™ (20% Imid.) tablet -	1 tablet in soil (4”) next to transplant
2)	SilvaShield™ (20% Imid.) tablet -	2 tablets in soil (4”) next to transplant
3)	SilvaShield™ (20% Imid.) tablet -	3 tablets in soil (4”) next to transplant

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

Treatment Evaluation: Tip moth damage will be 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 will be calculated; and 3) separately, the terminal will be identified as infested or not. Observations also will be made as to the occurrence and extent of damage caused by other insects, i.e., aphids, weevils, coneworm, etc. Second-year trees will be measured for diameter and height (at 6”) in the fall (November) following planting. If warranted, third-year trees will be measured for height and diameter (at DBH) and ranked for form. 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). Data will be analyzed by GLM and the Fisher’s Protected LSD test using Statview or SAS statistical programs.

Project Support: These trials are supported by Bayer Environmental Science grant funds.

Research Time Line:

CY 2011

<u>May - October, 2011</u>

- Evaluate tip moth damage after 1st through 4th generations; photograph damage.

<u>November - December 2011</u>

- Evaluate tip moth damage after 5th generation; measure diameter and height of each seedling.
- Measure tree height and DBH.
- Conduct statistical analysis of 2009 data.
- Prepare and submit report to Bayer Environmental Science, FPMC Executive Committee.
- Present results at annual Entomological Society of America meeting.

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.

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

SilvaShield™ Operational Treatment of Loblolly Pine Seedlings
At or After Planting for Control of Pine Tip Moth
(Initiated in 2008)

Justification: The Nantucket pine tip moth, *Rhyacionia frustrana* (Comstock) (Lepidoptera: Tortricidae), is a serious pest in young pine plantations of the southeastern United States. Foliar applications of Pounce®, Warrior T®, dimethoate, and Mimic® have proven effective in reducing volume losses by this insect. However, there are several concerns about the use of insecticides in commercial forests, including cost effectiveness, public perceptions, and impact on nontarget organisms, including biological control agents.

Objectives:

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

Cooperators

Ms. Frances Peavy	Private landowner, Hudson, TX
Mr. Steve Anderson	Texas Forest Service, Hudson, TX
Mr. Ragan Bounds	Hancock Forest Management, Colmesneil, TX
Dr. Tom Macom	Bayer Environmental Science, Research Triangle Park, NC

Research Approach:

Containerized seedlings from a single family of loblolly pine were selected from the cooperator's nursery, Magnolia, AR.

One recently-planted tract east of Lufkin, TX, and one one-year old tract near Hudson, TX, each 80 acres in size, were selected in 2008 and a cleared tract near Rockland, TX was selected in 2009 based on uniformity of soil, drainage, topography and susceptibility to tip moth infestation.

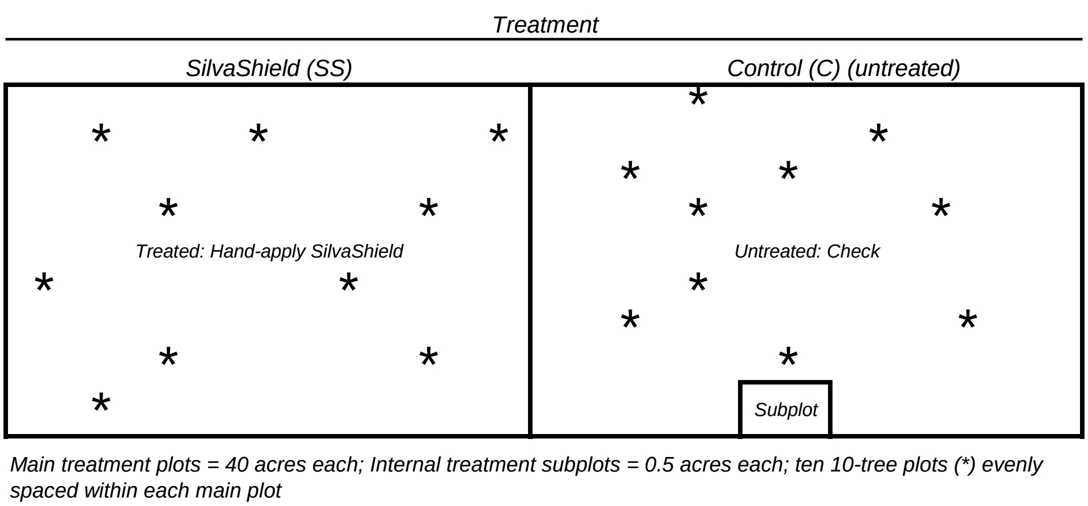


Figure 4. Generalized Plot Design

Treatments 2008:

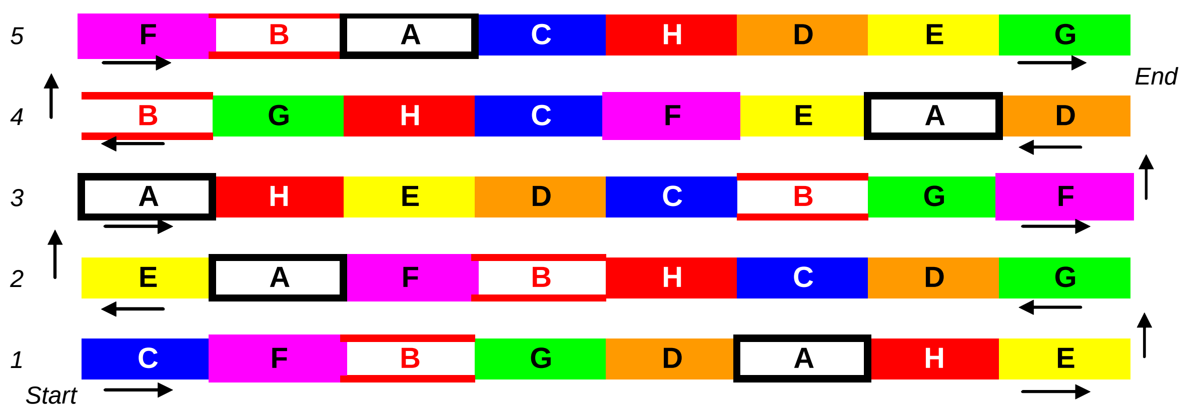
Main Plot (40 acres each) (2008)

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

Sub-plot (0.5 acres)

3) Check
4) SilvaShield™ (one tablet) applied after planting next to each seedling to a depth of 4 inches.
1) SilvaShield™ (two tablets) applied after planting next to each seedling to a depth of 4 inches.
2) SilvaShield™ (three tablets) applied after planting next to each seedling to a depth of 4 inches.
3) SilvaShield™ (one tablet) applied after planting next to each seedling to a depth of 8 inches.
4) SilvaShield™ (two tablets) applied after planting next to each seedling to a depth of 8 inches.
5) SilvaShield™ (three tablets) applied after planting next to each seedling to a depth of 8 inches.
6) SilvaShield™ (one tablet) applied at planting in plant hole with seedling (depth of ~8 inches).

Figure 5. Randomized Block Design Layout for an 8 Treatment Trial.



A = White (Check)
B = Rd&Wht (1 tablet after planting 4"
C = Blue (2 tablet after planting 4")
D = Orange (3 tablets after planting 4")
E = Yellow (1 tablet after planting 8")
F= Pink (2 tablets after planting 8")
G = Green (3 tablets after planting 8")
H = Red (1 tablet in plant hole 8")

Treatments 2009:

Main Plot (40 acres each)

3) SilvaShield™ (one tablet) applied into plant hole at planting.
4) Untreated control (Check) – seedling planted without tablet

To evaluate the effects of treatment on large area tip moth damage levels a randomized complete block design, with sites as blocks, was used. Each plantation was hand or machine-planted. On one half of the plantation, the applicator applied one SilvaShield™ tablet into each plant hole at planting (2009) or to each seedling after planting (2008) (Figure 4.). If after planting, a lance was used to create a 4 inch deep hole in the soil, angled toward the seedling. The tablet was then dropped into the hole and covered up. In the other half of the plantation, seedlings were hand or machine planted at the same spacing.

Additionally in 2008, a 0.75 acre subplot was installed within main check plot. Each treatment was randomly assigned to ten trees on each of five rows (Figure 5).

In both years, ten 10-tree plots were spaced equally within each main plantation half (but outside the internal treatment plots) to evaluate tip moth damage levels in these area. A 50-tree plot was positioned within each internal treatment subplot to evaluate tip moth damage levels in these areas. All stands were treated with herbicide after planting to minimize herbaceous and/or woody competition.

Tip moth damage 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 will be calculated; and 3) separately, the terminal will be identified as infested or not. Observations also will be made as to the occurrence and extent of damage caused by other insects, i.e., coneworm, aphids, sawfly, etc. Each tree will be measured for diameter (at ground line) and height and ranked as to form in the fall (November) of the second year following planting. 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).

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

If one or more treatments continue to be successful in reducing tip moth damage by > 75% in the 4th generation in 2010, the "best" treatment(s) will be followed into 2011 to continue evaluating duration of treatments.

Project Support: These trials are supported by Bayer Environmental Science grant funds.

Research Time Line:

CY2011

January – February 2011

- Begin trap monitoring of tip moth populations near each site

May - October, 2011

- Evaluate tip moth damage after 1st through 4th generations; photograph damage.

November - December 2011

- Evaluate tip moth damage after 5th generations; measure diameter and height of seedlings.
- Conduct statistical analysis of 2011 data.
- Prepare and submit report to FPMC Executive Committee and Bayer Crop Science.
- Present results at annual Entomological Society of America meeting.

PINE TIP MOTH

SilvaShield™ Forestry Tablet – Input Comparison Trials
(Initiated in 2009)

Justification

Several recent trials (2003 - 2008) have shown that imidacloprid + fertilizer tablets applied to bare root and containerized seedlings during or after planting are highly effective in reducing tip moth damage for 18+ months. EPA recently approved the registration and use of the SilvaShield™ Forestry tablet for tip moth control. The product has been shown to produce significant growth benefits in the years subsequent to planting. The impact of the fertilizer load in the SilvaShield™ tablet, relative to at-plant applications of DAP, have not been described. The impact of SilvaShield™ relative to the different input types (alone or combined), has not been described.

Objectives: The objectives of this study are to: 1) determine the efficacy of SilvaShield™ tablets in reducing pine tip moth infestation levels on loblolly pine seedlings when applied at planting to bedded areas with and without fertilizer and/or herbaceous weed control; and 2) determine the duration of protection provided by this insecticide application.

Cooperators

Mr. Bill Stansfield	The Campbell Group, Diboll, TX
Dr. Tom Macom	Bayer Environmental Science, Research Triangle Park, NC

Research Approach:

A recently site prepared tract was selected in east Texas.

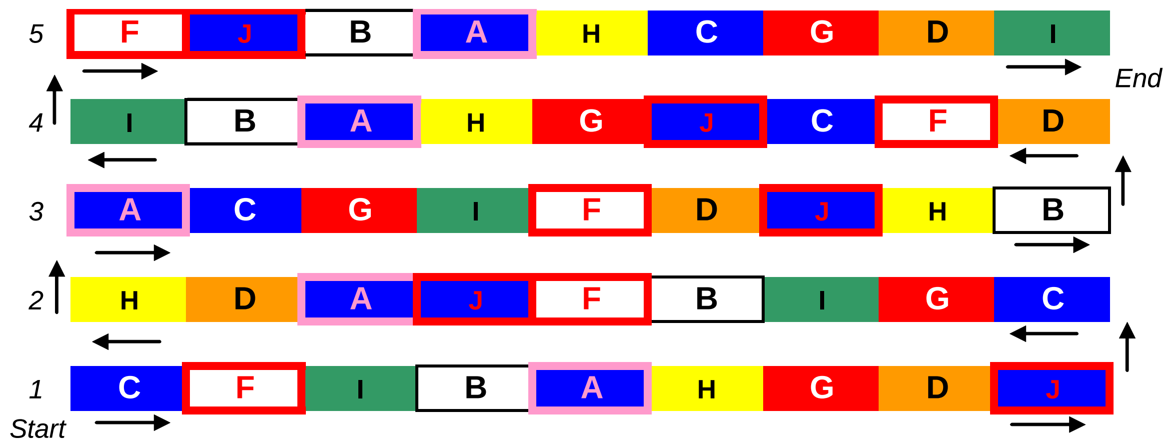
<u>Treatments</u>**:**

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

A 1 acre (approximate) area was selected within each selected site. A randomized complete block design was established with beds (or rows of trees) serving as blocks, i.e., each treatment was randomly selected for placement along a bed. Fifty trees for each treatment were selected on each site. Ten trees were assigned a given treatment on each of five beds (Figures 6).

All plot corners were marked with PVC pipe and the individual trees were marked with different color pin flags and tags. **<u>NO</u>** additional herbicide applications were made over the area in the spring so as not to interfere with trial results. Site index, soil classification, and weather/rainfall information was/will be collected for all sites. An overview of site preparation and post-plant management will be provided.

Figure 6. Randomized Block Design Layout for a 9 Treatment TX Trial.



A (1) = Pk&Bl (Check)
B (2) = White (1 SS tablet in PH)
C (3) = Blue (DAP 1X)
D (4) = Orange (SS + DAP 1/2X)
F (5) = Rd&Wht (HWC only)
G (6) = Red (SS + HWC)
H (7) = Yellow (SS + DAP 1/2X + HWC)
I (8) = Green (SS + DAP 1X = HWC)
J (9) = Rd&Blue (DAP 1X + HWC)

Damage and Tree Measurements

Tip moth damage will be evaluated by determining percent of trees infested, percent of infested shoots in top whorl and percent terminals infested about 4 weeks after peak moth flight of each generation for at least the first 2 years. Other activities will be to: 1) quantify the severity of attack; 2) observe and record presence and extent of phytotoxicity, if any, to the seedling and damage caused by other insects, i.e., weevils, coneworm, webworm, aphids, etc.; and 3) quantify seedling survivorship at the end of 2009 (and 2010). All study trees will be measured (height & diameter @ 6 inches) when tree growth has stopped in mid- to late November for at least the first 2 years of the study. Tree form will be evaluated at end of year 3. Form ranking of each 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). Data will be analyzed by GLM and the Tukey's Compromise test using Statview or SAS statistical programs.

Project Support: This trial is supported by Bayer Environmental Science grant funds.

Research Time Line:

CY 2011

January - February 2011

- Begin trap monitoring of tip moth populations near each site

March - October, 2011

- Evaluate tip moth damage after 1st through 4th generation where possible.

November - December 2011

- Measure height and diameter of trees.
- Conduct statistical analysis of 2011 data.
- Prepare and submit report to FPMC Executive Committee, Bayer.
- Present results at annual Entomological Society of America meeting.

PINE TIP MOTH

PTM™ and SilvaShield™ Comparison Trial
(Initiated in 2009)

Justification

Both fipronil (PTM™, BASF Corp.) and imidacloprid (SilvaShield™ Forestry Tablets, Bayer Environmental Science) have been proven effective in protecting pine seedlings against pine tip moth. A few cursory comparisons between these two products have been made in the past. We are interested in a more formal comparison in the Western Gulf Region.

Objectives: 1) Evaluate the efficacy of PTM™ and SilvaShield™ Forestry tablets in reducing pine tip moth infestation levels on loblolly pine seedlings; 2) evaluate these products applied at different rates and timing to pine seedlings; and 3) determine the duration of treatment efficacy.

Cooperators

Mr. Greg Garcia	The Campbell Group, Jasper, TX
Mr. Jim Bean	BASF Corp., Research Triangle Park, NC
Mr. Tom Macom	Bayer Environmental Science, Research Triangle Park, NC
Mr. Bruce Monke	Bayer Environmental Science, Waco, TX

Insecticides:

PTM™ (fipronil)– a phenyl pyrazole with some systemic activity against Lepidoptera.

SilvaShield™ Forestry tablet (Imidacloprid + fertilizer) – highly systemic neonictinoid with activity against Lepidoptera and fertilizer with NPK ratio of 12:9:4.

Research Approach:

A recently-harvested tract, 121 acres in size and owned by The Campbell Group, was selected NW of Jasper, TX (Jasper Co.).

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 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 & M were applied as the seedling is planted. Just after seedling transplant, Treatments B, G, I, & 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 & K, one tablet or solution was applied to each seedling in fall 2010. The remaining treatments (E,F,G, L, M & N) will be applied in early spring 2011.

Treatments and Layout

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

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

Treatment description:

1) PTM solution (1.4ml product in 13.6 ml water) applied into plant hole at planting (Dec. ’09).
2) PTM solution (1.4ml product in 13.6 ml water) applied post plant at 1 point next to seedling (Dec. ’09).
3) PTM solution (0.7ml product in 14.3 ml water) applied post plant at 2 points next to seedling (Sept. ’10).
4) 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).
5) PTM solution (0.7ml product in 14.3 ml water) applied post plant at 2 points next to seedling (Feb. ’11).
6) 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).
7) 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).
8) SilvaShield (SS) (1 tablet) applied into plant hole at planting (Dec. ’09).
9) SS (1 tablet) applied post plant next to seedling (Dec. ’09).

10) SS (1 tablet) applied post plant next to seedling (Sept. '10).
11) SS (1 tablet) applied into plant hole at planting (Dec. '09) and SS (1 tablet) applied post plant next to seedling (Sept. '10).
12) SS (1 tablet) applied post plant next to seedling (Feb. '11).
13) SS (1 tablet) applied to plant hole at planting (Dec. '09) and SS (1 tablet) applied post plant next to seedling (Feb. '11).
14) SS (1 tablet) applied post plant next to seedling (Dec. '09) and SS (1 tablet) applied post plant next to seedling (Feb. '11).
15) Check –seedlings planted by hand without additional treatment.

Treatment Evaluation: 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 was 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/will be identified as infested or not. Observations also was/will be made as to the occurrence and extent of damage caused by other insects, i.e., aphids, weevils, coneworm, etc. First- and second-year trees will be measured for diameter and height (at 6") in the fall (November) following planting. If warranted, third-year trees will be measured for height and diameter (at DBH) and ranked for form. 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).

Tip Moth Damage Assessment or Tree Measurement 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

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

Project Support: This trial is supported by FPMC funds.

Research Time Line:

CY 2011

January - February 2011

- Begin trap monitoring of tip moth populations near each site
- Treat seedlings in February.

March - October, 2011

- Evaluate tip moth damage after 1st through 4th generations; photograph damage.

November - December 2011

- Evaluate tip moth damage after 5th generations; measure seedling and height of seedlings.
- Conduct statistical analysis of 2011 data.
- Prepare and submit report to BASF and Bayer, FPMC Executive Committee.
- Present results at ETFES.

CY 2012 (if warranted based on CY 2011 results)

January - February 2012

- Begin trap monitoring of tip moth populations near each site

March - October, 2012

- Evaluate tip moth damage after 1st through 4th generations; photograph damage.

November - December 2012

- Evaluate tip moth damage after 5th generations; measure seedling and height of seedlings.
- Conduct statistical analysis of 2012 data.
- Prepare and submit report to BASF and Bayer, FPMC Executive Committee.
- Present results at annual Entomological Society of America meeting.

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.

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

WHITE-TAILED DEER

Deer Repellent Trial
(Initiated in 2011)

Justification

Plant damage caused by wildlife has increased significantly over the past 30 years (Conover and Decker 1991). In the eastern United States, the wildlife species that causes the most damage to landowner property is the white-tailed deer, *Odocoileus virginianus*. Serious economic damage may occur when deer feed on commercial crops, nursery-grown ornamentals and regenerated forest seedlings, resulting in serious economic losses (Curtis and Richmond 1994).

Nurserymen and landscapers attempt to deter deer by spraying ornamental plants with foliar applied repellents. Several comparative studies have looked at the efficacy of different repellents (Hani and Conover 1995, Trent et al. 2001, Ward and Williams 2010). Generally, Deer Away Big Game Repellent (powder and/or spray) provide good protection against deer for 8 – 12 weeks, sometimes longer (Trent et al. 2001). However, such repellents are ultimately diluted and washed off by rain, thereby losing their effectiveness.

Systemic repellents may hold the solution to the problem of repellents being washed away with rain. Repellex USA Inc. has recently registered a systemic tablet containing the natural hot pepper chemical, capsicum. It is of interest to test this product and other systemic products (PTM™ and SilvaShield™) for their ability to deter feeding of deer on hardwood seedlings.

Objectives: 1) Evaluate the efficacy of systemic tablets in reducing deer browsing damage on hardwood seedlings; 2) evaluate these products applied at different rates and timing to seedlings; and 3) determine the duration of treatment efficacy.

Cooperators

Forest Pest Management Cooperative members

Mr. Jeff Wineke	Repellex USA Inc., Niles, MI
Mr. Bruce Monke	Bayer Environmental Science, Waco, TX
Mr. Jim Bean	BASF Corp., Research Triangle Park, NC
? Professor of Wildlife	Stephen F. Austin State UNiversity

Pesticides:

Repellex ™ tablet (capsicum) –
PTM™ (fipronil) – a phenyl pyrazole with some systemic activity in trees.
SilvaShield™ Forestry tablet (Imidacloprid + fertilizer) – highly systemic in trees.
Deer Away Big Game Repellent (BGR) spray (37% putrescent whole egg solids)

Research Approach:

Treatments:

1) Repellex (2 tablet) applied into plant hole at planting (November).
2) Repellex (2 tablets) applied post plant next to seedling (December).
3) PTM solution (2.8 ml product in 27.2 ml water) applied to plant hole (November).
4) SilvaShield (SS) (2 tablet) applied into plant hole at planting (November).
5) Deer Away BGR spray (1 part BGR: 1 part Formula 2104 : 6 parts water) (December)

6) Check –seedlings planted by hand without additional treatment.

The study methods, in part, follow those described by Henderson et al. 2001. Plants (oaks, poplar) for this study (in trade gallon containers) will be provided by an FPMC member nursery. They will be grown in a standard growing medium. Twenty replications of each treatment will be used at each study site.

Plants treated with the systemic tablets/dilution will be maintained at the nursery for six to eight weeks to give the material sufficient time to be absorbed by the foliage (manufacturer recommendations). Then all plants will be transported to one of two study locations (SFA Experimental Forest and ?). Once there, the foliar spray will be applied to selected treatments, according to the manufacturer's recommendations, and allowed to dry. Then all plants will be placed randomly throughout a deer holding pen, 2- to 1 acre in size, containing a constant number of deer throughout the study (study 1 had 5 deer in a 2 acre pen, study 2 had 16 deer in a 1-acre pen, and study 3 had 7 deer in a 2 acre pen).

To prevent the deer from knocking over the containers or pulling the plants out of the containers, the containers will be secured with two metal rods (2 inch wide and 12 inches long) placed just inside the rim and on opposite sides of the container. The rods will be p[ounded through the bottom of the container and into the ground, leaving about 1-inch of each metal rod above the soil line. Then a 10-inch length of 12-gauge wire will be carefully placed across the top of the container and secured to each metal rod to prevent the deer from pulling the plants from the container. Once secured, the wire will be pushed down to the soil surface to mask its visibility.

Plants will be watered by hand once per week by applying approximately 24 ounces of water onto the surface of the container. Deer will be given supplemental feed and water by the forestry staff, and the only vegetation in the pens, in addition to native pines and hardwoods, will be native broadleaf weeds. Rainfall at the site will be monitored during studies.

Treatment Evaluation: The number of bites taken by deer (Trent et al. 2001) and plant growth index, initially and at weekly intervals, will be used to measure the degree of deer browsing. The plant growth index is determined by multiplying three measurements: plant height, plant width at the widest point and plant width perpendicular to the first width measurement. Growth index will be then analyzed statistically using the using Statview software (SAS Institute, Inc. 1999) to contrast and determine the difference between treatments at each observation. Percentage and measurement data will be transformed by the arcsine % and log transformations, respectively, prior to analysis.

Project Support: This trial is supported by ???? grant funds.

Research Time Line:

CY 2011

<u>April 2011</u>

- Transplant seedlings into pots (April).
- Treat assigned seedlings with systemic treatments (May).

<u>June - October, 2011</u>

- Deploy potted seedlings into deer enclosure (June).
- Spray assigned seedlings with BGR treatment (June, August, October).
- Evaluate deer damage monthly; photograph damage.

<u>November - December 2011</u>

- Plant and treat seedlings in forested area (June).
- Evaluate deer damage monthly; photograph damage.
- Conduct statistical analysis of 2011 data.
- Prepare and submit preliminary report to FPMC Executive Committee, BASF, Bayer, and Repellex.
- Present results at ETFES.

CY 2012 (if warranted based on CY 2011 results)

<u>January - October, 2012</u>

- Evaluate deer damage monthly; photograph damage.

<u>November - December 2012</u>

- Conduct statistical analysis of 2011 data.
- Prepare and submit preliminary report to FPMC Executive Committee, BASF, Bayer, and Repellex.
- Present results at annual Society of American Foresters meeting.

References:

Conover, M.R., and D.J. Decker. 1991. Wildlife damage to crops: perceptions of agricultural and wildlife professionals in 1957 and 1987. Wildl. Soc. Bull. 19:46-52.

Curtis, P.D., and M.E. Richmond. 1994. Reducing deer damage to home gardens and landscape plantings. Department of Natural resources, Cornell University, Ithica, New York. 14853. 22 pp.

Hani, E.H., and M.R. Conover. Comparative Analysis of Deer Repellents. In the *Repellents in Wildlife Management Symposium Proceedings*. National Wildlife Research Center, United States Department of Agriculture Animal and Plant Health Inspection Service, Fort, Collins, CO. Held in Denver, CO on August 8-10, 1995, pp. 147 to 155.

Trent, A., D. Nolte, AND K. Wagner. 2001. Comparison of commercial deer repellents. Tech Tips 0124-2331-MTDC.

Ward, J. S., & S. C. Williams. 2010. Effectiveness of Deer Repellents in Connecticut. *Human-Wildlife Interactions* 4:56–66.

Forest Pest Management Cooperative
Activity Time Line - CY2011

January
- Contact FPMC members to arrange meeting to discuss tip moth program.
- Deploy pheromone traps for tip moth impact, hazard rating, and control (fipronil) studies.
- Monitor tip moth populations for tip moth studies.
- Establish leaf-cutting ant bait efficacy trial.

February
- Establish new tip moth research plots.
- Treat selected tip moth impact plots with insecticides.
- Monitor tip moth populations on tip moth study sites.
- Monitor leaf-cutting ant colonies for efficacy of bait formulations.

March
- Monitor tip moth populations on tip moth study sites.
- Make selection of study sites and trees for bark beetle injection studies.
- Bait SPB trees in AL
- Prepare draftFPMC accomplishment report for 2010 and proposals/budget for 2011.
- Monitor leaf-cutting ant colonies for efficacy of bait formulations.

April
- Treat pine study trees for *Ips* Injection Trial.
- Treat live oak study trees with designated treatments and evaluate microinjection systems.
- Treat study trees with standard foliar treatment for Seed Orchard Injection Trial.
- Flag 6-10 branches/tree and record number of conelets and cones on all treatment and check trees for Injection Trial at each seed orchard.
- Monitor pest occurrence on oaks at Hudson.
- Monitor condition of SPB trees in AL.
- Collect site information and soil samples for tip moth hazard rating study.
- Monitor tip moth populations on tip moth study sites.
- Monitor leaf-cutting ant colonies for efficacy of bait formulations.
- Finalize FPMC 2010 accomplishment report and 2011 proposals/budgets.
- Host FPMC Executive Committee Meeting.

May
- Evaluate tip moth damage after 1st generation for all tip moth studies; photograph damage.
- Fell trees, deploy bolts, traps and bark beetle pheromones for *Ips* Bark Beetle Injection Trial.
- Retrieve and evaluate bolts for *Ips* Bark Beetle Injection Trial.
- Inoculate live oaks with oak wilt fungi.
- Monitor tip moth populations on tip moth study sites.
- Monitor oak pests for seed orchard trial.
- Monitor condition of baited trees in AL.
- Monitor condition of injected athel and soapberry trees.

Forest Pest Management Cooperative
Activity Time Line - CY2011

June

- Monitor oak pests for seed orchard trial.
- Evaluate tip moth damage after 2nd generation for all tip moth studies; conduct competing vegetation assessment for hazard rating study; photograph damage.
- Monitor tip moth populations on tip moth study sites.
- Monitor condition of baited trees in AL
- Monitor oak pests for seed orchard trial.
- Monitor condition of injected live oaks

July

- Fell trees, deploy bolts, traps and bark beetle pheromones for *Ips* Bark Beetle Injection Study.
- Retrieve and evaluate bolts for *Ips* Bark Beetle Injection Trial.
- Monitor tip moth populations on tip moth study sites.
- Bait injected trees in UT.
- Monitor oak pests for seed orchard trial.
- Monitor condition of injected live oaks.
- Monitor condition of baited trees in AL.
- Monitor condition of soapberry trees.

August

- Treat study trees with standard foliar treatment for Seed Orchard Injection Studies.
- Evaluate tip moth damage after 3rd generation for all tip moth studies; photograph damage.
- Monitor tip moth populations on tip moth study sites.
- Monitor condition of injected live oaks.
- Monitor condition of baited trees in AL.
- Monitor oak pests for seed orchard trial.

September

- Fell trees, deploy bolts, traps and bark beetle pheromones for *Ips* Bark Beetle Injection Study.
- Retrieve and evaluate bolts for *Ips* Bark Beetle Injection Trial.
- Evaluate loblolly pine conelet and cone survival on flagged branches (early September).
- Evaluate tip moth damage after 4th generation for all tip moth studies; photograph damage.
- Evaluate chalcid infestation on Afghan pine branches.
- Monitor tip moth populations on tip moth study sites.
- Monitor oak pests for seed orchard trial.
- Monitor condition of baited trees in AL and UT
- Monitor condition of live oaks
- Collect all cones from sample trees for Seed Bug Injection trial.

Forest Pest Management Cooperative
Activity Time Line - CY2011

October

- Monitor condition of soapberry and athel trees
- Retrieve and evaluate bolts for *Ips* Bark Beetle Injection Study.
- Evaluate coneworm damage for Pine Seed Orchard studies.
- Monitor tip moth populations on tip moth study sites.
- Monitor condition of baited trees in AL
- Monitor oak pests for seed orchard trial.
- Monitor condition of live oaks
- Present selected results at East Texas Forest Entomology Seminar.

November

- Evaluate tip moth damage and tree form after last generation for all tip moth studies; collect tree height and diameter measurements; photograph damage.
- Monitor tip moth populations on tip moth study sites.
- Monitor condition of live oaks.
- Transplant and treat hardwoods with deer repellent.
- Monitor condition of baited trees in AL
- Conduct vegetation evaluation for hazard rating study.

December

- Extract, radiograph and evaluate seed samples for Seed Orchard studies.
- Conduct statistical analyses of 2010 data.
- Monitor deer damage on hardwood seedlings.
- Monitor tip moth populations on tip moth study sites.
- Prepare and submit reports to FPMC Executive Committee, Syngenta, Bayer, BASF, Mauget, Arborjet, FSPIAP and SPB Initiative.
- Present selected results at Entomological Society of America annual meeting.
- Take a few days off to celebrate Christmas.

2010 Expenditures vs. Budget

Expenditures to operate the FPMC for CY 2010 totaled $263,007 (Table 1). This was $1,871 more than the projected $261,136 budget (Table 2) primarily due to additional costs to support the SFASU graduate student. Sources of funding to cover expenses were derived from membership dues (41%), the SPBI and FSPIAP federal grants, industry grants from BASF, Syngenta, Bayer, Fort Dodge, Mauget (24%), and the Texas Forest Service (35%). Of this total, 85% was devoted to professional salaries, fringe benefits, and seasonal wages, and the remainder (15%) to equipment, operating expenses, and indirect costs. Overall, FPMC account funds exceeded expenditures by $344. Due to the 2010 federal and corporate grants ($43,290), we currently have a surplus of $67,303 in these accounts at the end of CY 2010.

Emergency funds totaling $30,706 (recovered FPMC funds from FY2006 – FY2010) are being held in a separate account and will be available in CY 2011 or subsequent years if needed.

2011 Proposed Budget

The proposed budget for CY 2011 totals $264,544 (Table 3). The proposed budget includes the support of a graduate student at SFASU. Monies budgeted for operating expenses were increased by $3,649, primarily in anticipation of rising fuel costs. Current membership dues ($92,500) plus $12,500 from the FPMC surplus and $1,000 for seed analysis work for WGTIP will provide $111,000 (42%). An additional $98,020 (37%) is available from gifts/grants ($68,116) provided by BASF, Syngenta, Bayer, Fort Dodge, Arborjet and Mauget, as well as funds available from SPBI and ISAT (injection) grants ($29,904). The remaining (21%) will be borne by the Texas Forest Service and any new members that join during the year (Figure 3). The addition of a new member(s) to the FPMC will serve to reduce the TFS contribution to the FPMC. A summary by project or activity for CY 2011 is given in Table 4.

2012 Proposed Budget

A proposed budget for CY 2012 is given in Table 5 by source of funding. A total of $264,589 is proposed for CY 2012. No dues increase is anticipated. Assuming that membership stays at 7 full members and five associate members in 2012, $87,500 (40%) would be provided by membership dues, $16,500 from the FPMC surplus and anticipated funds from WGTIP for seed analysis. The remainder of the budget, 60%, will come from other sources (new member dues, federal grants, chemical industry contributions, and the Texas Forest Service).

The proposed budget summary by project or activity for CY 2012 is given in Table 6. We anticipate that one or more small projects will terminate at the end of CY 2011 (p. 3-4), allowing the funding of one new applied research or technology transfer project in CY 2012.

Table 7 provides a summary of funding sources and expenditures since the FPMC was initiated in 1996. Figure 8 illustrates FPMC sources of funding as a percentage of total expenditures. Finally, Figure 9 is a graph of the number of FPMC members and dues levels for the period 1996 – 2012.

Table 1. FPMC Expenditures by Source of Funding - CY 2010

	Source								
	FPMC		TFS		Fed./Ind. Grants *		Total	% of Total
A. Salaries and Wages								
Principal Investigator (Grosman) (100%)	$ 16,772	(26%)	$ 47,736	(74%)	$ 0		$ 64,508	
Research Specialist (Kavanagh) (100%)	24,660	(75%)	0		8,220	(25%)	32,880	
Staff Forester (Upton) (78%)	15,169	(30%)	24,271	(48%)	0		39,440	
SPB Specialist (Murphrey) (9%)	4,291	(9%)	0		0		4,291	
Staff Assistant (Spivey) (20%)	4,576	(20%)	0		0		4,576	
Graduate Student (Walker) (100%)	14,025	(100%)	0		0		14,025	
4 Seasonal Technician (two 4 mo. periods)	781		0		19,167		19,948	
Total Salaries and Wages	$ 80,274		$ 72,007		$ 27,387		$ 179,668	
B. Fringe Benefits / TFS Matching	$ 17,088		$ 18,722		$ 3,766		$ 39,576	
	97,362		90,729		31,153		219,244	85%
C. Operating Expenses								
Total Operating Expenses	$ 10,741		$ 1,356		$ 26,732		$ 38,830	15%
Indirect Costs (26%)					4,933		4,933	
Grand Total	$ 108,104		$ 92,085		$ 62,818		$ 263,007	
% of Total	41%		35%		24%		100%	100%

* Grant/Gift funds remaining from 2009; grants awarded to TFS from the Southern Pine Beetle Initiative; BASF, Bayer, Mauget, and Syngenta in CY2010.

	FPMC	TFS	Fed./Ind. Grants
Funding Available from January 1 - December 31, 2010	$ 108,200		$ 116,030

Table 2. FPMC Proposed Budget by Source of Funding - CY 2010

	Source: FPMC	Source: TFS and Others*	Total	% of Total
A. Salaries and Wages				
FPMC Coordinator (Grosman) (100%)	$ 17,275 (26%)	$ 49,118 (74%)	$ 66,393 **	
Research Specialist (Kavanagh) (100%)	25,394 (75%)	8,465 (25%)	33,859 **	
Staff Forester (Upton) (75%)	15,527 (30%)	23,290 (45%)	38,816 **	
Staff Assistant (Spivey) (20%)	4,713 (20%)		4,713 **	
Graduate Student (Walker) (100%)	10,200 (20%)		10,200	
3 Seasonal Technician (4.5 mo.)		26,973	26,973	
Total Salaries and Wages	$ 73,109	$ 107,845	$ 180,954	
B. Fringe Benefits (26% of Salaries & 8% of Wages)	$ 16,356	$ 23,185	$ 39,541	
	89,466	131,030	220,495	84%
C. Operating Expenses				
Supplies	$ 6,534	$ 6,773	$ 13,307	
Vehicle Use and Maintainance	5,000	7,000	12,000	
Travel	3,500	3,500	7,000	
Telecommunications (15% of PCS)	1,400	0	1,400	
Utilities (15% of PCS)	0	1,500	1,500	
Other Services (rentals, publications, postage, etc.)	2,300	3,134	5,434	
Total Operating Expenses	$ 18,734	$ 21,907	$ 40,641	16%
Grand Total	$ 108,200 ***	$ 152,937	$ 261,136	
% of Total	41%	59%	100%	100%

* includes $21,920 SPB grant and any new members or federal grants.

** includes 3% salary increase

*** member dues at $10,000/yr for seven members; $9,000/yr for one member; $3,500/yr for two members, $21,200 FPMC surplus and $1,000 for WGTIP seed analysis. = $108,200

Table 3. FPMC Proposed Budget by Source of Funding - CY 2011

		Source: FPMC	Source: TFS and Others*	Total	% of Total
A.	**Salaries and Wages**				
	FPMC Coordinator (Grosman) (100%)	$ 16,772 (26%)	$ 47,736 (74%)	$ 64,508	
	Research Specialist (Kavanagh) (100%)	24,660 (75%)	8,220 (25%)	32,880	
	Staff Forester (Upton) (78%)	15,169 (30%)	24,271 (48%)	39,440	
	Staff Assistant (Spivey) (20%)	4,576 (20%)		4,576	
	SPB Specialist (Murphrey) (9%)	4,291 (9%)		4,291	
	Graduate Student (Walker) (100%)	6,375 (100%)		6,375	
	3 Seasonal Technician (4.5 mo.)		27,972	27,972	
	Total Salaries and Wages	$ 71,843	$ 108,199	$ 180,042	
B.	**Fringe Benefits (26% of Salaries & 8% of Wages)**	$ 17,022	$ 23,237	$ 40,258	
		88,865	131,435	220,300	83%
C.	**Operating Expenses**				
	Supplies	$ 6,683	$ 6,975	$ 13,658	
	Vehicle Use and Maintainance	8,252	7,000	15,252	
	Travel	3,500	3,500	7,000	
	Telecommunications (15% of PCS)	1,400	0	1,400	
	Utilities (15% of PCS)	0	1,500	1,500	
	Other Services (rentals, publications, postage, etc.)	2,300	3,134	5,434	
	Total Operating Expenses	$ 22,135	$ 22,109	$ 44,244	17%
	Grand Total	$ 111,000 **	$ 153,544	$ 264,544	
	% of Total	42%	58%	100%	100%

* includes any new members or federal grants.

** member dues at $10,000/yr for seven members, $3,500/yr for five members, $5,000 for one former member, $12,500 FPMC surplus and $1,000 for WGTIP seed analysis. = $111,000

Table 4. FPMC Proposed Budget by Source of Project - CY 2011

	Activity: Administration Site Visits/Service	Activity: Tip Moth Studies (Impact & HR)	Activity: Tip Moth Studies (Systemic Trt)	Activity: Systemic Injection Studies	Activity: LCA or Other Study	Total
A. Salaries and Wages						
FPMC Coordinator (100%)	$ 25,803 (40%)	$ 9,676 (15%)	$ 9,676 (15%)	$ 9,676 (15%)	$ 9,676 (15%)	$ 64,508
Research Specialist (100%)	0	13,152 (40%)	13,152 (40%)	3,288 (10%)	3,288 (10%)	32,880
Staff Forester (78%)	0	5,056 (10%)	5,057 (10%)	15,169 (30%)	14,158 (28%)	39,440
Staff Assistant (20%)		1,144 (5%)	1,144 (5%)	1,144 (5%)	1,144 (5%)	4,576
SPB Specialist (9%)				2,384 (5%)	1,907 (4%)	4,291
Graduate Student (100%)		6,376 (100%)				6,376
3 Seasonal Technician (4.5 mos.)	0	6,993 (25%)	9,790 (35%)	8,392 (30%)	2,797 (10%)	27,972
B. Fringe Benefits (26% of Salaries & 8.4% of Wages)	$ 6,709	$ 8,142	$ 8,380	$ 8,945	$ 8,083	$ 40,258
C. Operating Expenses						
Travel and Vehicle Use	$ 4,388	$ 4,500	$ 5,000	$ 4,000	$ 3,753	$ 21,641
Supplies & Postage	4,577	2,990	2,990	2,990	2,990	16,537
Other Operating Expenses	1,065	1,000	2,000	1,000	1,000	6,065
Grand Total	$ 42,542	$ 51,509	$ 56,045	$ 53,460	$ 46,889	$ 264,544

Table 5. FPMC Proposed Budget by Source of Funding - CY 2012

		Source			% of
		FPMC	TFS and Others*	Total	Total
A.	**Salaries and Wages**				
	FPMC Coordinator (Grosman) (100%)	$ 17,324 (26%)	$ 49,308 (74%)	$ 66,632 **	
	Research Specialist (Kavanagh) (100%)	25,574 (75%)	8,525 (25%)	34,099 **	
	Staff Forester (Upton) (78%)	15,671 (30%)	25,073 (48%)	40,744 **	
	Staff Assistant (Spivey) (30%)	7,248 (30%)		7,248 **	
	3 Seasonal Technician (4.5 mo.)		29,970	29,970	
	Total Salaries and Wages	$ 65,817	$ 112,876	$ 178,693	
B.	**Fringe Benefits (26% of Salaries &**	$ 17,112	$ 24,103	$ 41,215	
	8% of Wages)	82,929	136,979	219,909	83%
C.	**Operating Expenses**				
	Supplies	$ 6,700	$ 6,975	$ 13,675	
	Vehicle Use and Maintainance	8,500	7,000	15,500	
	Travel	3,600	3,500	7,100	
	Telecommunications (15% of PCS)	1,500	0	1,500	
	Utilities (15% of PCS)	0	1,500	1,500	
	Other Services	2,271	3,134	5,405	
	(rentals, publications, postage, etc.)				
	Total Operating Expenses	$ 22,571	$ 22,109	$ 44,680	17%
	Grand Total	$ 105,500 **	$ 159,088	$ 264,589	
	% of Total	40%	60%	100%	100%

* includes any new members or federal grants.

** member dues at $10,000/yr for seven members; $3,500/yr for five members, $16,500 FPMC surplus, and $1,500 for WGTIP seed analysis. = $105,500

Table 6. FPMC Proposed Budget by Source of Project - CY 2012

	Activity					
	Administration	Tip Moth Studies		Systemic		
	Site Visits/Service	(Impact & HR)	(Systemic Trt)	Injection Studies	Other Studies	Total
A. Salaries and Wages						
FPMC Coordinator (100%)	$ 26,652 (40%)	$ 9,995 (15%)	$ 9,995 (15%)	$ 9,995 (15%)	$ 9,995 (15%)	$ 66,632
Research Specialist (100%)	0	13,640 (40%)	13,640 (40%)	3,410 (10%)	3,410 (10%)	34,099
Staff Forester (78%)	0	5,224 (10%)	5,224 (10%)	15,671 (30%)	14,626 (28%)	40,744
Staff Assistant (10%)	0	1,812 (5%)	1,812 (5%)	1,812 (5%)	1,812 (5%)	7,248
3 Seasonal Technician (4.5 mos.)	0	7,493 (25%)	10,490 (35%)	8,991 (30%)	2,997 (10%)	29,970
B. Fringe Benefits (26% of Salaries & 8.4% of Wages)	$ 6,930	$ 8,611	$ 8,866	$ 8,795	$ 8,014	$ 41,215
C. Operating Expenses						
Travel and Vehicle Use	$ 4,289	$ 4,890	$ 4,900	$ 4,000	$ 4,000	$ 22,079
Supplies & Postage	4,577	2,990	2,990	2,990	2,990	16,537
Other Operating Expenses	1,065	1,000	2,000	1,000	1,000	6,065
Grand Total	$ 43,513	$ 53,842	$ 58,104	$ 54,851	$ 48,844	$ 264,589

Table 7: List of Funding Sources and Expenditures by Calendar Year

Year	No. Full / Assoc. Members **	Membership Dues: Full / Assoc. / Year	Membership Dues: Total Revenue	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	$87,500	$90,000	$86,520	$264,020	33%	33%	***
Mean			$58,676	$54,773	$68,580	$178,808	32%	44%	

* estimated
** Not including TFS
*** Years TFS not paying more than all other members combined.

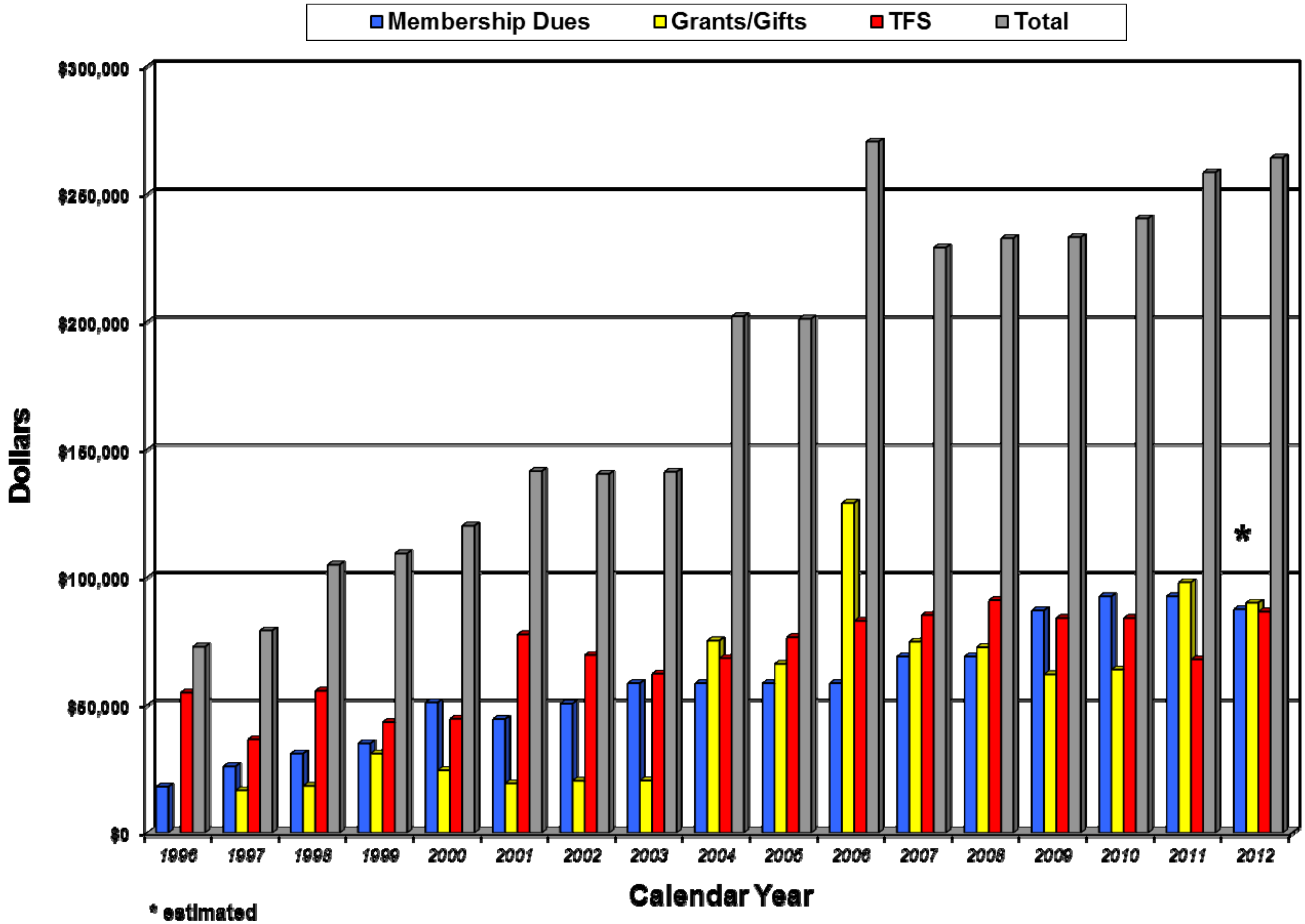


Figure 7: Forest Pest Management Cooperative budget by source.

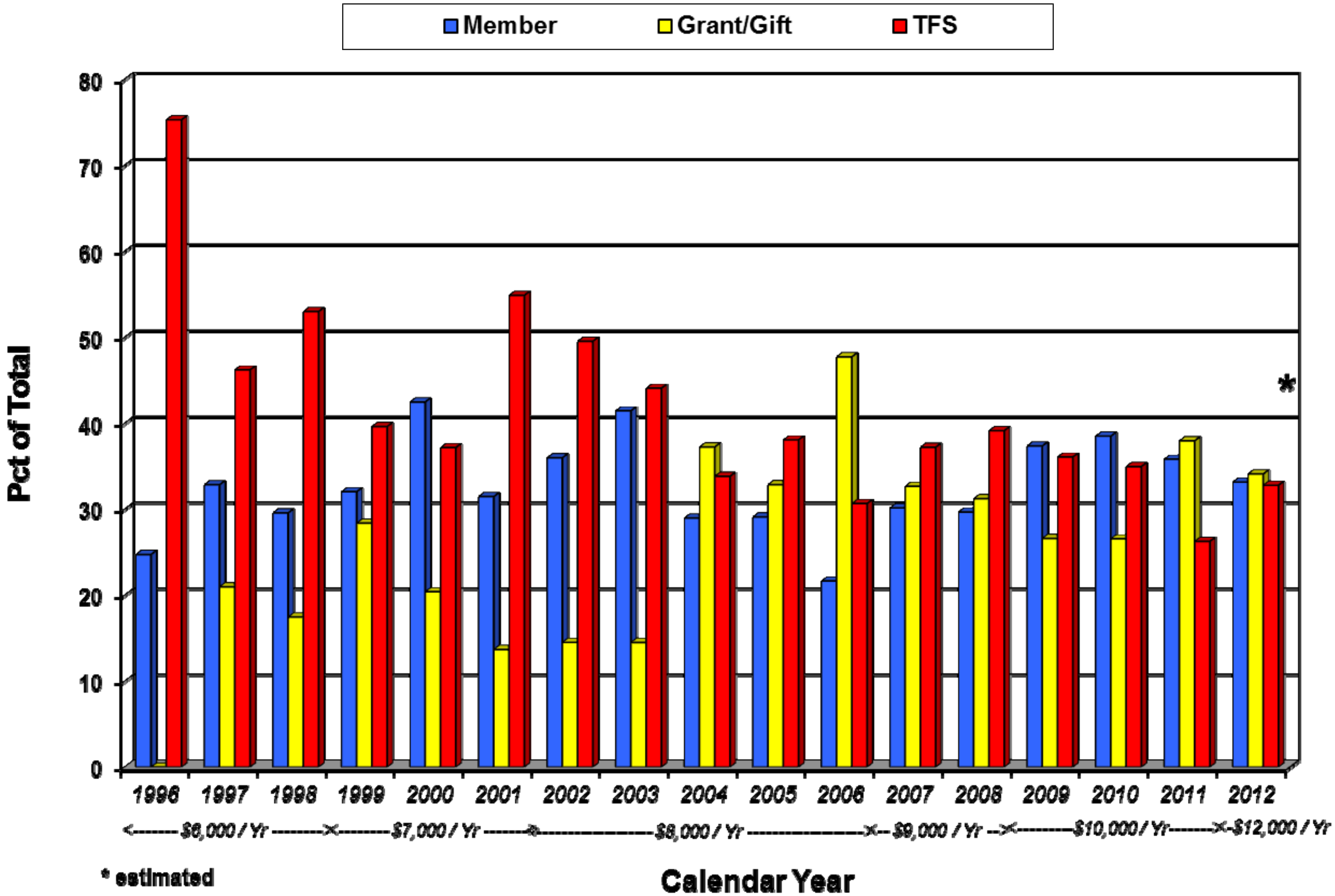


Figure 8. Forest Pest Management Cooperative membership dues, grants/gifts, and TFS support as percentage of total expenditures.

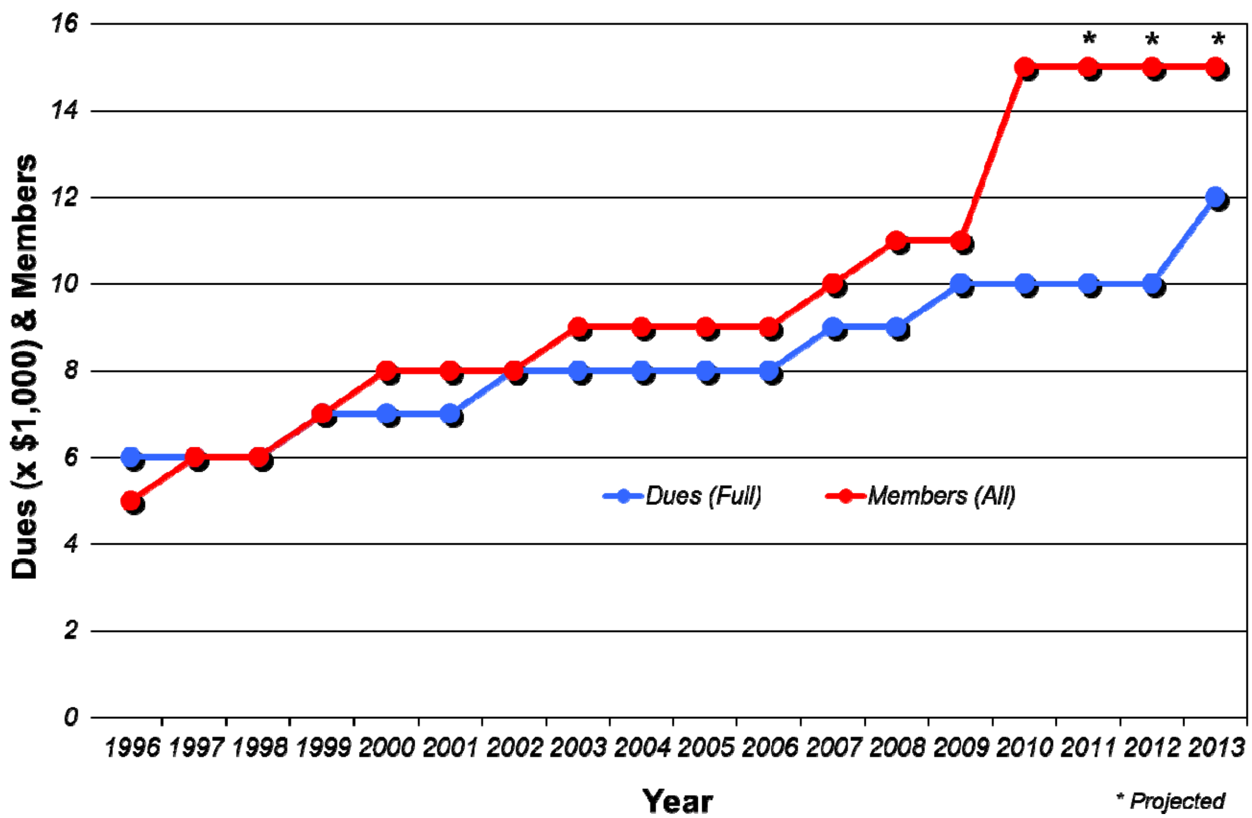


Figure 9. Forest Pest Management Cooperative membership levels and dues from 1996 to 2013 (projected).

FPMC Executive and Contact Member Representatives In 2011

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