Forest Pest Management Cooperative

2012 Research Project Proposals

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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 hazard rating/control, and leaf-cutting ant control) in 2012. Results obtained this past year warrant further evaluations in these areas.

The following trials were completed/discontinued in 2011:

- Development and Evaluation of Larger Amdro Bait for Control of Leaf-cutting Ants
- Evaluation of Emamectin Benzoate for Protection of Oaks Against Insect Pests
- Evaluation of Emamectin Benzoate for Protection of Afghan Pines Against Chalcid Wasps
- Evaluation of Fipronil for Containerized Seedlings – Preliminary Trial
- Evaluation of Fipronil for Second-Year Pines – East Texas

Proposed objectives and methods for the systemic injection, tip moth, and leaf-cutting ant studies in 2012 are presented below. Studies to test the efficacy of various pesticides for protection of trees against 1) pine bark beetles, 2) hardwood pests, and 3) 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 2012. In addition, a new trial will be established in 2012 to evaluate efficacy of a containerized seedling plug injection system to treat seedlings with different rates of PTM™ and fungicide, Insignia, at five 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 2012.

PTM™ soil injection treatment was registered in 2009 to treat leaf-cutting ant colonies. A new formulation of bait (modified Amdro®) was found to be effective against leaf-cutting ants in 2009 and 2010 trials. However, a request to register the bait with EPA has yet to be submitted. Syngenta is interested in developing a new leaf-cutting ant bait. Preference and efficacy trials will be established in 2012 to test this new control options.

The following trials are expected to be completed in 2012:

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

Evaluation of Systemics for Protection Against Southern Pine Beetle (SPB) – Alabama
Evaluation of Systemics for Protection Against Mountain Pine Beetle (MPB) – Utah
Evaluation of Systemics for Protection Against Soapberry Borer
Imidacloprid Tablets for Control of Pine 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 2013 will depend on the degree of success achieved in 2012 and remaining gaps in knowledge.

LEAF-CUTTING ANT

Leaf-cutting Ant Control Evaluation - East Texas
(Initiated in 2012)

Justification: Currently, there is only one safe and effective control option available for control of Texas leaf-cutting ants. PTM™ (fipronil) was registered in 2009. FPMC trials have shown it to be 90+% effective with a single application. Unfortunately it is fairly labor intensive, requiring about an hour to treat an average-size (600 ft^2) colony.

The other registered product, Amdro® Ant Block, is largely ineffective with a single application, only halting ant activity in 25% of the treated 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 and 2010. 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. Central Garden & Pet had indicated in late 2010 that they would submit a request to EPA for registration. However, CGP has delayed submittal of the registration package "due to company reorganization." It seems uncertain whether or not this bait will ever be registered.

Recently, it has been announced that several leaf-cutting ant baits, containing fipronil, sulfluramid, and hydramethylnon, will be phased out in Central and South America in the next five years based on Forest Stewardship Council (FSC) policy guidelines (2005). Syngenta has expressed an interest in developing a new bait. A trial will be initiated this spring to evaluate the attractiveness and efficacy of a new bait formulation at different AI rates.

Objectives: 1) To determine the attractiveness of the Texas leaf-cutting ant to baits.
2) To determine the efficacy of baits for control of Texas leaf-cutting ants.
3) To determine effect of active ingredient rate on ant preference and treatment efficacy.

Cooperators:
Forest Pest Management Cooperative members
Private landowners
David Cox, Syngenta Crop Protection, Madera, CA

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:
?

Research Approach:
Corn or orange citrus pulp bait formulations will be developed based on discussions with Phil Brown, DuPont. Citrus or deer corn will be ground into flour or corn meal will be used. Upon mixing the corn/citrus and active ingredient, bait pellets will be formed using a laboratory pellet mill equipment provided by DuPont.

Preference Trial

As needed, trials will be conducted by placing 5 g portions of different baits (indoxacarb 0.3% ai + antioxidants, (indoxacarb 0.3% ai alone, indoxacarb 0.15% ai + antioxidant, indoxacarb 0.15% ai alone, corn blank, and/or Amdro® Ant Block) into petri dishes. Each treatment will be replicated ten times per trial period. For each trial replicate, one dish of each treatment will be distributed at random within the central nest area (but near areas of high activity) or along foraging trails. All dishes within each replicate will be retrieved when the dish, containing the most attractive bait, is nearly empty or at the end of the test period (approximately 3 hours). The amount (weight) of bait removed by ants from each petri dish will be noted and means calculated for each treatment.

Efficacy Trial

Experiments will be conducted in east Texas; within 100 miles of Lufkin. In this area, 50 - 80 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 10 replicates per treatment. At least 10 untreated colonies will be monitored as checks.

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 will not be included in the central nest area. Application rates will be based on the area (length X width) of the central nest. Depending on the results of the above preference trial, the treatments may include:

1) Trt 1 - during the **spring, summer, fall and winter 2012,** Formulation A bait will be spread uniformly over CNA at 10.0 g/m^2.
2) Trt 2 - during the **spring, summer, fall and winter 2012,** Formulation A bait will be spread uniformly over CNA at 4.0 g/m^2.
3) Trt 3 - during the **spring, summer, fall and winter 2012,** Formulation B bait will be spread uniformly over CNA at 10.0 g/m^2.
4) Trt 4 - during the **spring, summer, fall and winter 2012,** Formulation B bait will be spread uniformly over CNA at 4.0 g/m^2.
5) Trt 5 - during the **spring, summer, fall and winter 2012**, Amdro® Ant Block® (AI = hydramethylnon; bait standard) bait will be spread uniformly over CNA at label rate.
6) Trt 6 - during the **spring, summer, fall and winter 2012**, PTM™ (AI = fipronil) will be soil injected into entrance holes of the CNA at label rate.
7) Trt 7 - Check - untreated colonies (**winter, spring and fall 2008 and winter and summer 2009)**

It is of interest to determine the rate at which leaf-cutting ants retrieve the applied bait formulation. To do this, five petri dishes containing four bait particles (= $10g/m^2$) will be distributed evenly within the CNA just after each colony is treated. The dishes will be checked at 3 hour intervals during the first 24 - 36 hours after treatment. At each interval, the number of particles removed will be recorded. In addition, observations will be made to determine if animals (birds), other than leaf-cutting ants, are feeding on the applied bait.

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, 8, and 16 weeks. Ten untreated colonies will be included as checks and monitored in both spring 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 divided by the initial number of active mounds. Differences in mean percent of initial activity among treatments will be tested for significance. Also, the percent of colonies totally inactive will be calculated for each treatment at each post-treatment evaluation. Data will be analyzed by GLM and the Tukey's Compromise test using SuperANOVA or SAS statistical programs.

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

Research Time Table:

July - August, 2012

- Acquire insecticide formulation(s) from Syngenta.
- Develop bait with corn matrix
- Select 3 leaf-cutting ant colonies for preference trial
- Conduct preference trials (August)

September - October, 2012

- Select 70+ town ant colonies for efficacy trial from mapped leaf-cutting ant colonies and randomly assign treatments (September)
- Evaluate ant activity on day of treatment.
- Treat colonies with assigned treatment (September - October)
- Revisit treated and check nests at 2, 4, 8 & 16weeks after treatment date to evaluate ant activity (October - November).
- Conduct statistical analysis of spring data and submit seasonal report to Syngenta.

November - December, 2012

- Select 70+ town ant colonies for efficacy trial from mapped leaf-cutting ant colonies and randomly assign treatments (November)
- Evaluate ant activity on day of treatment.
- Treat colonies with assigned treatment (November - December)
- Revisit treated and check nests at 2, 4, 8 and 16 weeks after treatment date to evaluate ant activity (May – August).
- Conduct statistical analysis of summer data and submit seasonal report to Syngenta.

January - May, 2013

- Select 70+ town ant colonies for efficacy trial from mapped leaf-cutting ant colonies and randomly assign treatments (January)
- Evaluate ant activity on day of treatment.
- Treat colonies with assigned treatment (January - February)
- Revisit treated and check nests at 2, 4, 8 and 16 weeks after treatment date to evaluate ant activity (January – May).
- Conduct statistical analysis of winter data and submit final report to Syngenta.

Reference:

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

Forest Stewardship Council. 2005 FSC Pesticides Policy: Guidance On Implementation, FSC-GUI-30-001 Version 2-0 En. Forest Stewardship Council. 23 p.

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 Studies have demonstrated that trunk injection of emamectin benzoate (TREE-age™) alone were effective in reducing coneworm damage by 80% for 6 years following a single appliication, but seed bug damage was reduced by only 34% for 2 years (Grosman et al. 2002, FPMC Annual Report 2001, 2002, and 2003).

The FPMC tested imidacloprid (IMA-jet®), another neonictinoid insecticide, in 2007 and 2008, at Weyerhaeuser's Magnolia Seed Orchard. Only imidacloprid applied at a high rate (0.4g/ inch DBH alone or combined with emamectin benzoate (at 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, and dinotefuran. 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 into loblolly pine can significantly reduce coneworm 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 (ArborGen's Woodville Seed Orchard, Texas). A second phase of the study was initiated in fall 2009 in a loblolly pine block (Weyerhaeuser's Magnolia Seed Orchard, Arkansas). A block in each orchard was selected that had not been sprayed with insecticide for 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:

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

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

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 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 was $\geq$20 m to minimize the effects of drift. No additional spray applications will be made in 2012.

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) 2012. From the samples, counts will be made of healthy- and coneworm-attacked cones. 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:

September - December 2012

- Collect all cones and 50 conelet sample from sample trees for evaluation of coneworm and seed bug damage levels, respectively (late September).
- Clean and conduct 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 2010)

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.

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. Bill Stansfield	The Campbell Group, Diboll, TX
Ms. Marianne Waindle	JJ Mauget, Arcadia, CA

Treatments:

Trial 1: Established October 2010

Trt #	Chemical	Formulation	Application Timing	Rate (g ai/inch dbh)	Volume (mls / inch dbh)	No. of Trees Treated	Felling Dates
1	Abamectin	Abacide	Oct-10	0.1	10	30	July '11, '12 & '13
2	Abamectin	Abacide	Oct-10	0.2	20	30	July '11, '12 & '13
3	Abamectin	Abacide	Oct-10	0.4	40	30	July '11, '12 & '13
4	Abamectin	Abacide	Apr-11	0.1	10	30	July '11, '12 & '13
5	Abamectin	Abacide	Apr-11	0.2	20	30	July '11, '12 & '13
6	Abamectin	Abacide	Apr-11	0.4	40	30	July '11, '12 & '13
7	Untreated					30	July '11, '12 & '13
						210	

Trial 2: Established November 2011

Trt #	Chemical	Formulation	Application Timing	Rate (g ai/inch dbh)	Volume (mls / inch dbh)	Date Treated	No of Trees Treated	Felling Dates
1	Abamectin	Aba Ultra	Nov-11	0.2	10	Nov '11	30	April, Jul. & Oct. '12
2	Abamectin	Aba Ultra	Nov-11	0.1	5	Nov '11	30	April, Jul. & Oct. '12
3	Abamectin	Aba Ultra	Nov-11	0.05	2.5	Nov '11	30	April, Jul. & Oct. '12
4	Untreated						30	April, Jul. & Oct. '12
						Total	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 30 trees in October 2010 and 30 more trees were treated April 2011. Additional trees (Trial 2) were/will be treated in November 2011.

In April, July and/or October 2012, 5 - 10 trees of each treatment will be felled. One or more1.5 m-long bolt will be removed from the bole at heights of 3, 5 or 8m. 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 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:

November, 2011

- Select and treat study trees (Trial 2).

CY 2012

April - May, 2012

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

July - August, 2012

- Fell second (trial 1 and 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

- Fell third (trial 2) series of trees, transport bolts to thinned stand, lay out bolts and install lures (October).
- Remove bolts and record attacks and gallery lengths (November).
- 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 2011). 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, Mississippi 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., Alabama, respectively. Both trials demonstrated that emamectin benzoate could significantly reduce tree mortality from SPB attacks 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 fungicides, 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 Fettig,	USDA Forest Service – PSW Research Station, Davis, CA
Mr. 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 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) of each year. The surviving treated trees in each treatment (if there are no more than 6 killed by the bark beetle challenge), and the second and third sets of check trees were baited again for the same length of time in 2010 and 2011, respectively. Similarly, the treated trees and fourth set of check trees will be baited in 2012.

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 ≥ 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 2012

March, 2012

- Bait AL trees (March)

April - September, 2012

- 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, 2012

- 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.

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SYSTEMIC INJECTION TRIALS

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

Justification: The southern pine beetle (SPB) is considered the most destructive insect pest of southern pine forests. No SPB infestations have been detected in Western Gulf states (TX, AR, LA & OK) since 1997; no SPB have been caught in pheromone traps in East Texas since 2001 (11 SPB). Pheromone traps deployed during the spring have proven effective for predicting SPB population increases since 1988 across the South (Billings and Upton 2010). SPB populations are currently at unprecedented low population levels throughout the South and Northeast, with the exception of southern New Jersey and local areas in Virginia (see 2011 SPB trend predictions at http://texasforestservice.tamu.edu/uploadedFiles/FRD/PestManagement/Insects/2011%20STATE%20SPB%20SUMMARY%20TABLE.pdf). The SPB Prevention Program, sponsored by US Forest Service/Forest Health Protection, has cost shared the thinning of high hazard pine stands as a SPB prevention measure since 2003; some 90,000 acres have been treated to date on small private landholdings in Texas (Billings 2009); over a million acres have been treated throughout the South under this program. Although prevention efforts are important, they are not being applied to all land ownerships, suggesting that it is just a matter of time before SPB outbreaks reoccur in Texas and other southern states. A method for effectively dealing with SPB outbreaks in early stages of development is needed. Much is known about SPB biology and seasonal habits (see Coulson and Klepzig 2011). Most new SPB infestations are initiated following long-distance dispersal in the spring (March-May) and to a lesser extent in the fall (October-December). A new systemic insecticide (emamectin benzoate) has been developed by the Texas Forest Service Forest Pest Management Cooperative and is sold by Syngenta under the trade name Tree-äge™. This insecticide is effective against SPB (Grosman et al 2009, 2010) and has been registered and is now available for pine bark beetle control in forest situations. This is the only insecticide registered for control of SPB in forests. Allee effects (positive density dependence) have been shown to play an important role in the establishment and spread of invasive species. A certain population density is essential before an invasive species can become established and spread in a new environment (and because of Allee effects, many new introductions of invasive plants and animals fail to succeed). Increased interest in recent years is being focused on the potential to exploit Allee effects as a means to manage invasions of exotic species (Tobin et al. 2011). We propose to exploit this same phenomenon for control of SPB when populations begin to return, treating this native bark beetle as if it were an invasive species.

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

Cooperators

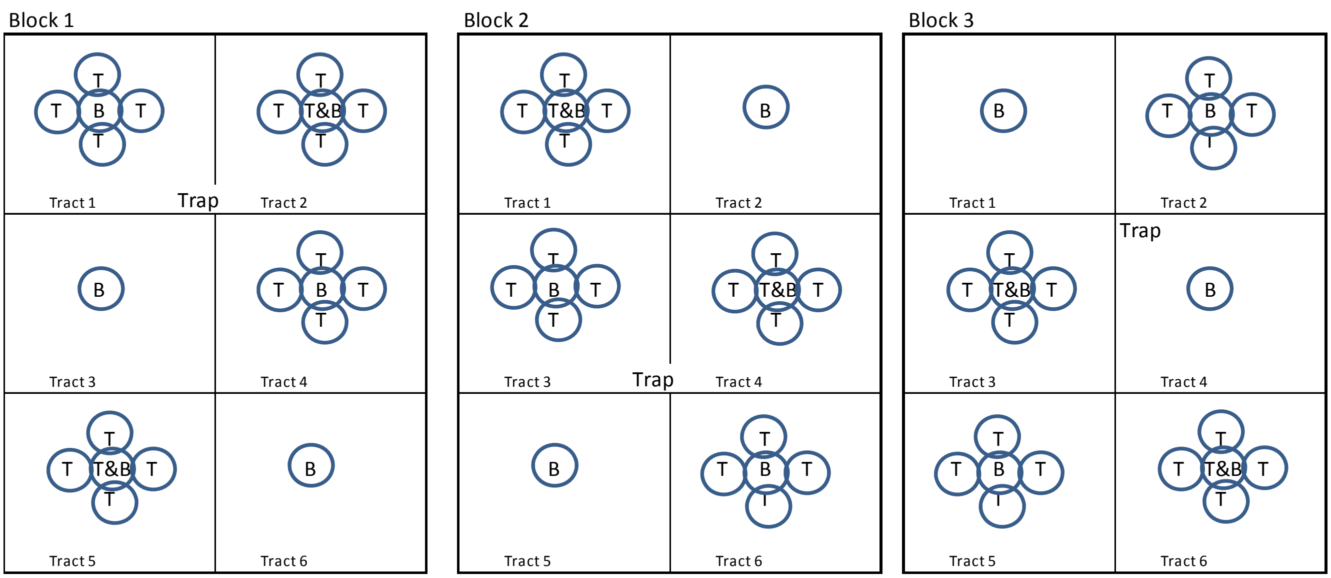
Dr. Steve Clarke	USDA Forest Service – FHP R8, Lufkin, TX
Dr. Roger Menard	USDA Forest Service – FHP R8, Pineville, LA
Dr. Chris Asaro	Virginia Dept of Forestry, Charottesville, VA

Ms. Cindy Ragland — USDA Forest Service – Talladega National Forest, AL
Dr. Dave Cox — Syngenta Crop Protection LLC

Anticipated Products: This project will provide a new technique for managing southern pine beetle at low populations using trunk injections of systemic pesticides. The technique is likely most applicable for protecting mature, unthinned stands in national and state forests and private landholdings.

Research Approach: This study will be conducted in the Appomattox-Birmingham and Prince Edward State Forests, Virginia, and Talladega National Forest, Alabama. Six to 18, >30 acre forest tracts, with loblolly pine predominate, similar in age (>30 years old) and density (>100 basal area), will be selected at each State or National Forest. One of three treatments will be randomly assigned to each tract. One trap tree will be selected within each tract and 50m of an access road to facilitate treatment. (Figure 1).

Figure 1: Schematic of potential block/sub-plot layout. One to three blocks may be installed at each state or national forest area.



Each tract = predominantly loblolly, >30 acres, >30 YO, basal area >100

B = Bait only, T = Treat only, T&B - Treat & Bait

The treatments are:

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

One Lindgren funnel trap baited with frontalin + Sirex lure + endo-brevicomin (displaced by 4 m) bait will be deployed in the center of each block. Poor quality (form, health, etc.) trees should be selected as trap trees.

Treatment evaluation:

1) Monitor attack success and survival and emergence of SPB broods in all baited and injected trees at five (5) week intervals after the installation of baits.
   - For each study tree (trap tree and treated and untreated within 12 ft of trap tree; *N* = 18-30 per block), we will nondestructively sample, using head lamps and hand lens, the number of SPB successful attacks (i.e., oxidized phloem material present in pitch tubes or points of attack containing phloem boring dust and/or dry frass) and unsuccessful attacks (i.e., pitch tubes without oxidized phloem material) in 20 X 25 cm (500 cm^2) sample windows at approximately 1.5, 4.0 and 6.5 m in height at northern and southern aspects.
   - At the end of the field season (September), all study trees will be felled. Bark plates (10 X 10 cm = 100 cm^2) will be collected at approximately 1.5, 4.0 and 6.5 m height at northern and southern aspects. SPB gallery length and density of emergence holes will be measured.
   - Deadfall catchment devices will be set up at the base of study trees to catch dead and dying insects as they fall from the tree (Smith 1986). These catchment devices will be made of cloth and set up when the pheromone is installed. Catchment width will be equal to tree diameter, and length outward from the tree was 1 foot (0.3 m). The catchment cloth will be attached to the tree and suspended on stakes about 8 inches (0.2 m) above the ground. All study trees will have at least one catchment cloth.

2) Compare the number of new SPB infestations that become established in treated and untreated areas with similar host/climatic conditions.

Each systemic insecticide treatment will be injected with Arborjet Tree IV™ microinfusion system (Arborjet, Inc. Woburn, MA) into 8 cardinal points 0.3 m above the ground. The injected trees will be allowed 6 weeks to translocate chemicals prior to being challenged by the application of synthetic pheromone baits.

All trap trees will be baited with frontalin, Sirex lure (alpha-pinene) and endo-brevicomin lures (Synergy Semiochemicals, Delta, BC) for three 5-week intervals in 2012.

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

Project Support: The SPB trial is to be funded by a grant from Syngenta to FPMC. Syngenta and Arborjet, Inc. are providing chemicals or injection equipment, respectively, for the project.

Project Timetable:

CY 2012:

1) Identify and select study areas (April).
2) Implementation (injection) of treatments (April).
3) Bait trees (May).
4) Post-treatment evaluations (June, July, September).
5) Data summary and analyses (November).
6) Progress report (December).

CY 2013:

1) Post-treatment evaluation (March).
2) Data summary and analyses (April).
3) Progress report (May).

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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 of 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. Arborists want 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, Austin, TX
Dr. David Appel	Texas A&M University, College Station, TX
Mr. Joe Doccola	Arborjet, Inc., Woburn, MA
Mr. Chip Doolittle	ArborSystems, Omaha, NE
Ms. Marianne Waindle	JJ Mauget, Arcadia, CA
Mr. Shawn Bernick	Rainbow Treecare Scientific Advancements, Minnetonka, MN
Mr. Jim Rediker	Scenic Hills Nursery, Kerrville, TX
Mr. Gene Gehring	Urban Renewal, Inc., Arlington, TX
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 ?)

<u>Portle</u> System (ArborSystems; contact: Chip Doolittle) – moderate volume (10 – 20+ ml/inj pt); high pressure (500+ psi)
<u>Tree IV</u> System (Arborjet, Inc.; contact: Joe Doccola) – high volume (20 – 125+ ml/inj pt); moderate pressure (60 psi)
<u>Chemjet</u> System (Scenic Hills Nursery; contact: Jim Rediker) – moderate volume (20 ml/inj pt); low pressure (10 psi ?)
<u>Macro Injection</u> 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) Does chemical come prepackaged; can you inject product undiluted or is it necessary to dilute with water? (5 pts)
3) Time and ease to fill system with chemical product (5 pts)
4) Time and ease to install system on tree (5 pts)
5) Number of injection points required per tree (5 pts)
6) Can the system be left alone on tree or does the applicator need to manually operate the system continuously? (5 pts)
7) Time and ease to inject X amount of product. (10 pts)
8) Cumulative time applicator spends at each tree. (10 pts)
9) Potential for chemical exposure. (10 pts)
10) Disposable and Time and ease to clean system. (10 pts)
11) Weather restrictions (moisture, temperature) (5 pts)
12) Effectiveness of treatment at 6, 12 and 18 months (10 pts each period)

<u>Treatment Methods and Evaluation</u>**:**

This study, initiated in 2011, is being conducted within the range of live oak and oak wilt in central Texas. Non-symptomatic plateau live oak (*Quercus fusiformis*) test trees (75), ranging from 15 to 46cm (6 – 18 in) dbh (diameter at breast height), were selected on the periphery of active oak wilt centers. In late April 2011, ten (10) trees per delivery system were injected with Alamo® (Syngenta) at the label rate (20 ml/inch tree dbh) using each of the six systems described above. Fifteen trees were selected as untreated controls. The application procedure used to inject the propiconazole formulation was based on the recommendations of each system manufacturer. The injected trees were allowed at least 1 month to translocate chemicals prior to being challenged with fungal inoculations. Note: As part of the Texas Cooperative Oak Wilt Suppression Project (Billings 2009), a 4-foot deep trench had been installed completely around the study trees prior to inoculation to reduce the likelihood of underground spread.

Inoculations were performed using standard procedures (Camilli et al. 2009, Peacock and Fulbright 2009). One wild-type strain of *Ceratocystis fagacearum* was/will be recovered from infected trees in fall 2010 and spring 2012 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 May 2011, ½" wide chisel was used to cut through the outer bark and into the outer sapwood at two points (north and south sides) on roots of each tree about six inches below injection points. Using a dropper, 1-2ml of spore suspension, was dispensed into wound site. Each tree will be reinoculated with fungal spore suspension in May 2012.

Trees were/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 2012

April - December, 2012

- Monitor for tree decline (January –February and April - October).
- Reinoculate each treewith fungal spore suspension (May).
- 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.

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SYSTEMIC INJECTION TRIALS

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

Justification: Thousand cankers disease (TCD), caused by a fungus, *Geosmithia morbida*, that is vectored into the tree by the walnut twig beetle (WTB, *Pityophthorous juglandis*) was recently discovered in TN, VA and PA, within the native range of black walnut. Protection of individual, high-value walnut trees from insect attack has historically involved applications of liquid formulations of contact insecticides to the tree bole and/or foliage. Recently, an experimental formulation of an injected systemic insecticide, emamectin benzoate (TREE-age™; Arborjet Inc., Woburn, MA) was registered by Syngenta Crop Protection, LLC, Greensboro, NC, with EPA, and may prove promising for protecting back walnut. In this study, the effectiveness of recommended rates of TREE-age™ alone and combined with the fungicide propiconazole (ALAMO®; Syngenta Crop Protection, LLC Greensboro, NC) will be evaluated for reducing the attack success of WTB on individual black walnut trees and the progression of the thousand cankers disease fungus introduced during initial phases of tree colonization. Additionally, effects on other walnut pests will be evaluated. The extent of disease infection and its influence on the distribution and concentration of emamectin benzoate and propiconazole in xylem, phloem, and nuts will be determined.

Objectives:

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

Cooperators:

Paul Merten,	USDA Forest Service, Forest Health Protection, Ashville, NC
Dr. Steve J. Seybold	US Forest Service, PSW Research Station, Davis, CA
Dr. David Cox	Syngenta Crop Protection, LLC, Madera, CA
Bill France	Private landowner, Sevier Co., TN
Phillip Power	Private landowner, Rusk, TX
Harold Read	Private landowner, Martinsville, TX

Research approach:

This study will be conducted at two primary locations: TCD-confirmed location(s) within or around Knox County, TN (about 35°52 N, 83°45 W, elev. 955 ft) and uninfested locations in Rusk County, TX (about 31°45 N, 95°11 W, elev. 397 ft) and Nacogdoches County, TX (about 31°41 N, 94°26 W, elev. 431 ft . There will be as many as seven treatments: emamectin benzoate (TREE-äge™) alone injected into TCD symptomatic (treatment **1**) and non-symptomatic (treatment **2**) trees; propiconazole (Alamo®) alone injected into TCD symptomatic (treatment **3**) and non-symptomatic (treatment **4**) trees; TREE-äge™+ Alamo® injected into TCD symptomatic (treatment **5**) and non-symptomatic (treatment **6**) tree; and an untreated control (treatments **7**).

Each treatment will be applied to 10 randomly-assigned trees (*N* = 40-70 per site). Test trees will be located in areas with abundant insect activity, spaced >10 m apart, 13 to 38 cm dbh, and within 100 m of access roads to facilitate the treatment. Each insecticide, fungicide or insecticide + fungicide treatment (treatments 1-6) will be injected with the Arborjet Tree IV™ or QUIK-jet™ microinfusion system (Arborjet, Inc. Woburn, MA) into 4-8 evenly spaced points 0.3 m above the ground. Injections will occur in March or April, 2012 (i.e., about 1 month prior to initiation of WTB adult flight and tunneling). All experimental trees (treated and untreated) in TN will be baited with WTB pheromones (provided by Steve Seybold) beginning in June, 2012 and throughout the growing season. All surviving treated trees in treatments 1-6, and the untreated control trees (treatment 7) will be baited for the same length of time in June, 2013. WTB populations will be monitored throughout the season at the TN location with 3-5 baited 4-unit Lindgren funnel traps placed at 10 feet on steel conduit poles. Trap catches will be recovered and WTB counted every two weeks throughout the season.

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

Two HOBO data loggers (Onset Computer Corp., Bourne, MA) will be placed in the study area for accumulation of temperature data. These data will later be used to describe the general temperature regime (i.e., maximum, minimum, mean) during the course of this study from 1 April through 30 October 2012 and 2013. Precipitation will be obtained from the nearest weather station for the same periods of time.

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

At the termination of the experiment in November 2013 (about 18 months after treatment), final crown ratings will be made. An analysis of variance will be used to test for differences among injection treatments. A χ^2 (Chi-square) test for homogeneity will be used to test the null hypothesis that the percentage of trees with a crown rating of 2 did not differ between the insecticide-, fungicide- or combination-treated trees and the untreated control group (Mayfield et al. 2008). The null hypothesis will be rejected if more than 20% of the treated trees reached a crown rating of 2. The test will be invalidated if fewer than 60% of the control trees reach a crown rating of 2.

Xylem and phloem samples will be collected at the TX site in June 2012 and June 2013 (treatments 2, 4, 6 & 7). Nut samples will be collected in June and September 2012 and 2013 (treatments 2, 4, 6 & 7). If sufficient concentrations exist in phloem collected in September 2013, we may continue sampling in 2014 if additional funding can be obtained.

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

Project Support: This trial is be funded by a grant from the Forest Service Pesticide Impact Assessment Program. Syngenta Crop Protection is providing chemical and Arborjet, is providing injection equipment for the project.

Research Time Line:

CY 2012

April – December, 2012

- Field site selection (April)
- Trees selected, tagged and treatments assigned; treatments 1 - 6 applied (April).
- Trees baited (May).
- Xylem, phloem & nut samples collected (treatments 2, 4, 6 & 7) (June).
- Nut sampled (treatments 2, 4, 6 & 7) (September).
- Post-treatment assessment of efficacy (June, August & October).
- Data summary and analyses (November).
- Preliminary report, (December).
- Presentation at Bark Beetle Technical Working Group.

CY 2013

May – December, 2013

- Trees baited (all) and xylem, phloem and nut samples collected (Treatments 2, 4, 6 and 7) (May).
- Post-treatment assessment of efficacy (June, August & October).
- Presentation at Southern Forest Insect Work Conference (July).
- Nut samples collected (treatments 2, 4, 6 & 7) (September).
- Data summary and analyses (November).
- Final report, peer-reviewed publication submitted (December).

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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 2). 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 infestations 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 - 2011, we have observed substantial higher tip moth populations and damage compared to those during 2003 – 2006 (Figure 1). High levels are expected for 2012 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.

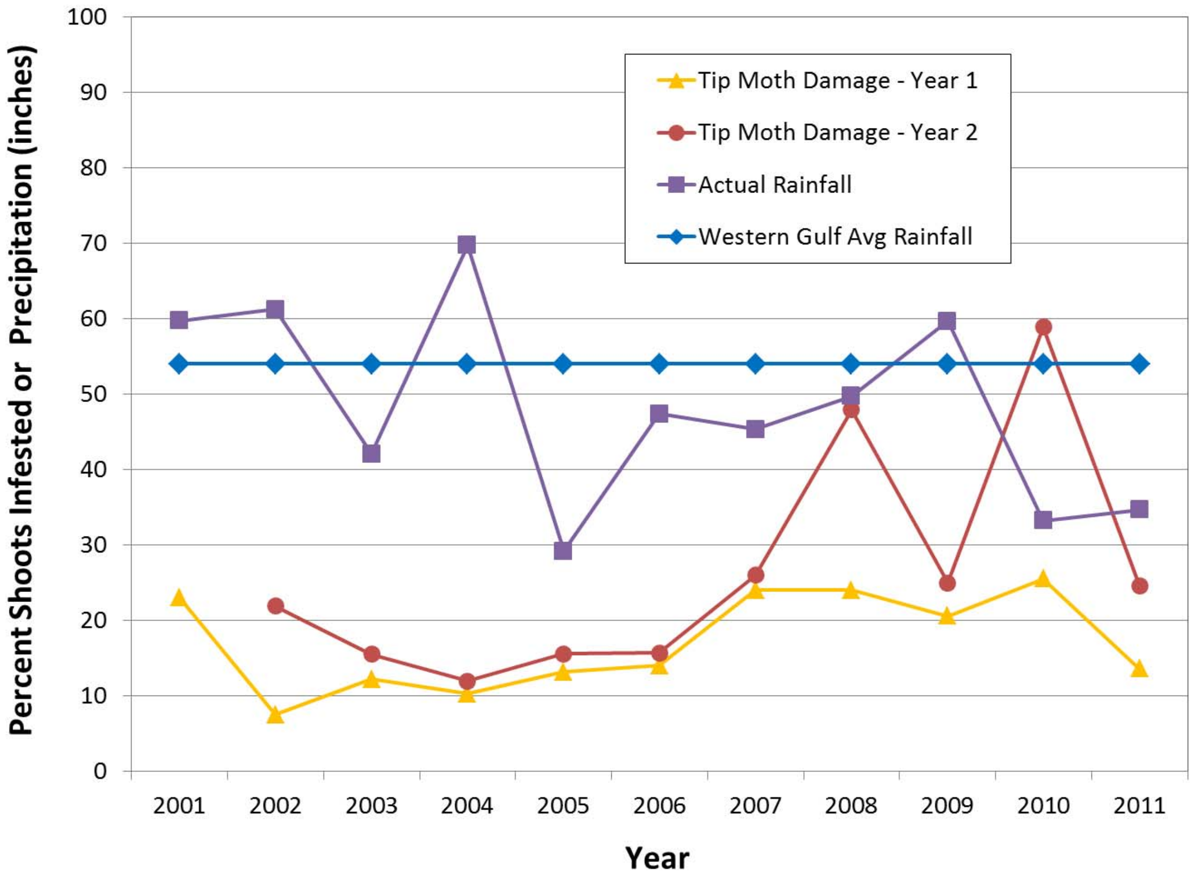


Figure 2: Average tip moth damage levels on first- and second-year loblolly pine in relation to rainfall totals in the Western Gulf: 2001 – 2011.

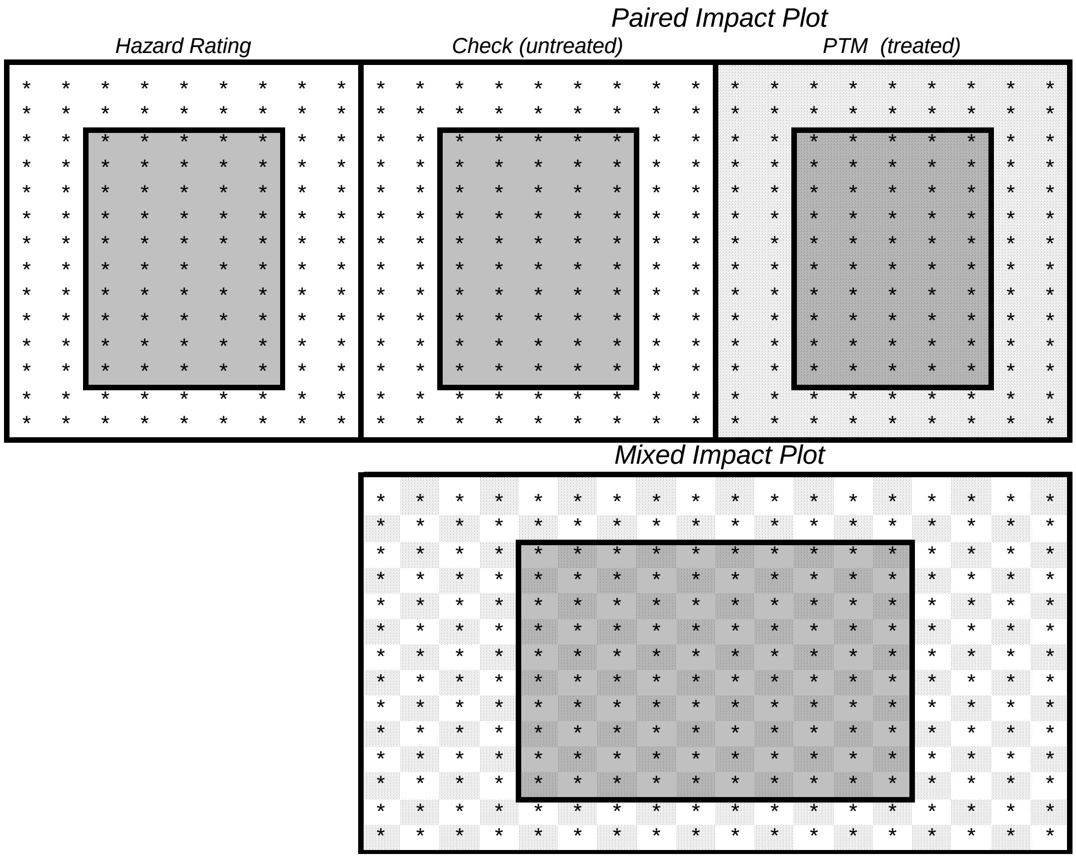
Cooperators

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 established one or more impact sites from 2001 to 2008. TFS (FPMC) established five new sites in 2011 and plan to establish five additional sites in 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) were/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, were/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, former graduate student in the College of Agriculture and Forestry at Stephen F. Austin State University, 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 2012

January - February 2012

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

March - September 2012

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

October - November 2012

- 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).

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PINE TIP MOTH

Hazard Rating Study
(Initiated in 2011)

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* (Comstock), 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 10 years (2001 – 2010), the FPMC has established and monitored 135 hazard-rating plots across the Western Gulf Region. Computer models, developed by Trevor Walker, indicate that "site and stand properties that produce significant tests of fixed effects on the probability of terminal infestation differed between generations, and associations appeared to differ between states and between establishment years within the same state. The sites spanned a wide geographic and are spread out between establishment years, inducing a large amount of variability in infestation that made detection of strong relationships between individual site and stand properties difficult" (Walker 2011). However, the analyses did indicate that soil texture composition and drainage class maybe two of the more important factors that influence the occurrence and severity of tip moth damage. Further discussions have led to the hypothesis that collection of data during a tip moth outbreak year from specific site types (texture/drainage class combinations) in a limited geographic range could significantly reduce variability.

Objectives: 1) Establish new plots to collect tip moth damage levels in association with soil texture and drainage class, and 2) develop models using site factors to predict future levels of tip moth damage.

Research Approach: Sixty (60), 1/8 acre (42' radius) plots will be established on 2nd year sites within 60 miles of Lufkin, TX. Sites will be selected based on the following site types:

1) Sandy and excessively well-drained
2) Sandy and moderately well-drained
3) Silt and well-drained
4) Silt and poorly-drained
5) Clay and poorly-drained

Tip moth damage was/will be evaluated on all trees within the circular plot after the 5th tip moth generation (between November 1, 2011 and January 31, 2012) by 1) identifying if the tree is infested or not, 2) if infested, the proportion of tips infested on the top whorl and terminal was/will be calculated, and 3) separately, the terminal was/will be identified as infested or not.

Data also will be obtained from cooperators for the following site characteristics:

- Previous history of stand
- Site Index (base 25 yrs)
- Tree spacing
- Silvicultural prescription (for first two years)

Cooperators:

Bill Stansfield	The Campbell Group
Al Lyons	Hancock Forest management
Mark Hebert	Rayonier
Trevor Walker	Stephen F. Austin State University
Dean Coble	Stephen F. Austin State University

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

Research Time Line:

November 2011 – March 2012

- Evaluate tip moth damage after 5th generation on second-year sites

April - June 2012

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

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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 containerized 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 was selected by Cellfor.

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

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

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

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

The plot corners were marked with PVC pipe (1 at each end of the plot) and metal tags. Herbicide was applied over the area in the spring 2010 to ensure that the seedlings remain exposed to tip moth attack throughout the year.

Damage and Tree Measurements

Tip moth damage was/will be evaluated after each tip moth generation (3-4 weeks after peak moth flight) by 1) identifying if the tree is infested or not, 2) if infested, the proportion of tips infested on the top whorl and terminal was/will be calculated; and 3) separately, the terminal was/will be identified as infested or not. Observations also were/will be made as to the occurrence and extent of damage caused by other insects, i.e., coneworm, aphids, sawfly, etc. All study trees were measured for height & diameter at ground line) at the beginning of the study (when seedlings are planted). Measurements also were/will be taken when tree growth has stopped in mid- to late November for at least the first 2 years of the study. Tree form will be evaluated at end of year 3. Form ranking of the seedling or tree will be categorized as follows: 0 = no forks; 1 = one fork; 2 = two to four forks; 3 = five or more forks. A fork is defined as a node with one or more laterals larger than one half the diameter of the main stem (Berisford and Kulman 1967).

Efficacy was/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 was/will be subjected to analyses of variance (Table 1) using Statview software (SAS Institute, Inc. 1999). Percentage and measurement data was/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).

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

Square 1

row/column	1	2	3	4	5	6	7	8	9	10	11	12	13
1	L	H	M	D	E	K	G	B	C	F	I	J	A
2	I	E	J	A	B	H	D	L	M	C	F	G	K
3	G	C	H	L	M	F	B	J	K	A	D	E	I
4	M	I	A	E	F	L	H	C	D	G	J	K	B
5	J	F	K	B	C	I	E	M	A	D	G	H	L
6	C	L	D	H	I	B	K	F	G	J	M	A	E
7	B	K	C	G	H	A	J	E	F	I	L	M	D
8	D	M	E	I	J	C	L	G	H	K	A	B	F
9	A	J	B	F	G	M	I	D	E	H	K	L	C
10	E	A	F	J	K	D	M	H	I	L	B	C	G
11	K	G	L	C	D	J	F	A	B	E	H	I	M
12	F	B	G	K	L	E	A	I	J	M	C	D	H
13	H	D	I	M	A	G	C	K	L	B	E	F	J

Square 2

row/column	1	2	3	4	5	6	7	8	9	10	11	12	13
1	C	A	M	H	J	E	K	F	B	L	G	I	D
2	H	F	E	M	B	J	C	K	G	D	L	A	I
3	I	G	F	A	C	K	D	L	H	E	M	B	J
4	A	L	K	F	H	C	I	D	M	J	E	G	B
5	G	E	D	L	A	I	B	J	F	C	K	M	H
6	J	H	G	B	D	L	E	M	I	F	A	C	K
7	B	M	L	G	I	D	J	E	A	K	F	H	C
8	M	K	J	E	G	B	H	C	L	I	D	F	A
9	K	I	H	C	E	M	F	A	J	G	B	D	L
10	E	C	B	J	L	G	M	H	D	A	I	K	F
11	F	D	C	K	M	H	A	I	E	B	J	L	G
12	L	J	I	D	F	A	G	B	K	H	C	E	M
13	D	B	A	I	K	F	L	G	C	M	H	J	E

Square 3

row/column	1	2	3	4	5	6	7	8	9	10	11	12	13
1	I	M	G	H	F	D	J	L	B	E	C	K	A
2	G	K	E	F	D	B	H	J	M	C	A	I	L
3	C	G	A	B	M	K	D	F	I	L	J	E	H
4	H	L	F	G	E	C	I	K	A	D	B	J	M
5	M	D	K	L	J	H	A	C	F	I	G	B	E
6	B	F	M	A	L	J	C	E	H	K	I	D	G
7	E	I	C	D	B	M	F	H	K	A	L	G	J
8	K	B	I	J	H	F	L	A	D	G	E	M	C
9	F	J	D	E	C	A	G	I	L	B	M	H	K
10	D	H	B	C	A	L	E	G	J	M	K	F	I
11	A	E	L	M	K	I	B	D	G	J	H	C	F
12	J	A	H	I	G	E	K	M	C	F	D	L	B
13	L	C	J	K	I	G	M	B	E	H	F	A	D

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

Research Time Line:

CY 2012

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 FPMC Executive Committee, BASF.

CY 2013 (if warranted based on CY 2012 results)

January - February 2013

- Begin trap monitoring of tip moth populations near each site.

March - October, 2013

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

November - December 2013

- 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 meeting.

PINE TIP MOTH TRIALS

Evaluation of Plug Injection System for Application of PTM™ and Insignia®SC for Containerized Pine Seedlings (To be Initiated in 2012)

Justification

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 the Environmental Protection Agency (EPA) concerns about 1) movement of the active ingredient (AI, fipronil) out of containers during periodic watering in the nursery and 2) reduce exposure of handlers and planters to the AI when packaging and planting seedlings, respectively. A containerized plug injection system is being developed by S&K Designs (Stewart Boots) to allow treatment of seedlings in the nursery. A prototype wase available for testing in December 2011.

Last year, it was of interest to evaluate the efficacy and duration of plug injection treatment (applied by hand) to containerized seedlings. A trial initiated in 2011 thus far (through the 5th generation) shows that hand treatment of seedling plugs prior to planting provides somewhat better protection compared to container seedlings treated after planting and significantly better protection compared to bare-root seedlings treated after planting (Figure 3).

Pyraclostrobin (Insignia®SC) belongs to the strobilurin class of fungicides. In addition to excellent, broad-spectrum disease control, research has shown pyraclostrobin-based fungicides also provide additional plant health benefits. Pyraclostrobin-based fungicides control foliar fungal diseases by inhibiting respiration in the mitochondria of fungi. This inhibition prevents the breakdown of energy-rich carbon compounds the fungus needs to produce energy for growth. Pyraclostrobin-based fungicides also have activity on plant mitochondria and reduce respiration in the plant. Since the plant's primary source of energy comes from sunlight through photosynthesis, this decrease in respiration can have a positive effect on growth. Decrease in respiration allows the plant to keep more stored carbon compounds for growth and triggers a chain reaction of positive physiological changes in the plant. These positive physiological changes may include an increase in nitrate reductase activity, elevated levels of antioxidants and defense signaling compounds, and a decrease in the stress hormone ethylene. The combination of disease control, stress reduction, and increased growth efficiency lead to the plant health benefits observed with the use of pyraclostrobin-based fungicides as described in this report (BASF Intrinsic™ report). It is of interest to evaluate the efficacy and duration of plug injection treatment of containerized seedlings with fipronil and pyraclostrobin alone or combined.

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

Cooperators

George Lowerts, Keith Byrd	ArborGen LLC
Jim Bean, Andy Goetz, Victor Canez	BASF
Bill Stansfield, Rick Leeper	The Campbell Group
Al Lyons, Ragan Bounds	Hancock Forest Management

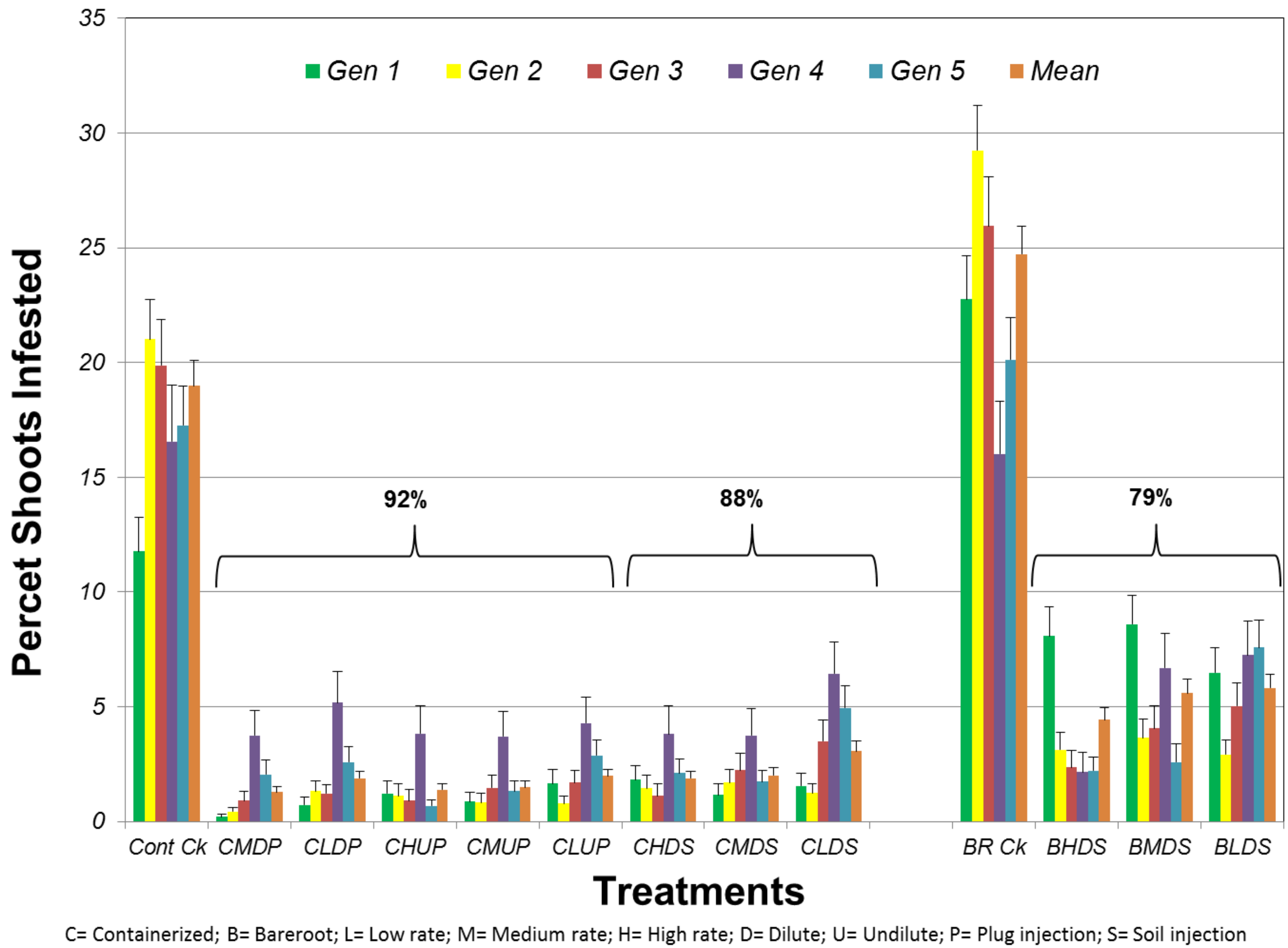


Figure 3. Effect of PTM™ plug and soil injection dose on tip moth infestation of containerized or bareroot loblolly pine on ten sites across the southeastern United States, 2011.

Wayne Bell, Chris Rosier	International Forestry Co
Steve Meeks	Meeks' Farm and Nursery
James West, Bobby Smith	North Carolina Forest Service
Doug Sharp	Plum Creek Timber Co.
Alan Wilson, Becki Stratton	Rayonier
Billy Moore, Wilson Edwards Tony Fontenot	Weyerhaeuser Co.

Research Approach:

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

Treatments**:**

1 = Insignia®SC Mid Concentration/Undiluted Plug Injection [4.9 ml Insignia undilute/seedling (**435 tpa rate**)] - Injection into **container** seedling plug just prior to shipping.

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

3 = PTM™ + Insignia®SC Mid Concentration/Undiluted Plug Injection [1.4 ml PTM + 4.9 ml Insignia (6.3ml total volume)/seedling] -Injection into **container** seedling plug just prior to shipping.

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

5 = PTM™ (Low) + Insignia®SC (Mid) Concentration/Diluted Plug Injection [1 ml PTM + 4.9 ml Insignia (5.9 ml total volume)/seedling] - Injection into **container** seedling plug just prior to shipping.

6 = Insignia®SC High Concentration/Diluted Soil Injection [13 ml Insignia in 17 ml water (30 ml total volume)/seedling] - Soil injection at two points next to transplanted **bareroot** just after planting.

7 = Insignia®SC Mid Concentration/Diluted Soil Injection [4.9 ml Insignia in 25.1 ml water (30 ml total volume)/seedling] - Soil injection at two points next to transplanted **bareroot** just after planting.

8 = PTM™ Mid Concentration/Diluted Soil Injection [1.4 ml PTM in 28.6 ml water (30 ml total volume)/seedling] - Soil injection at two points next to transplanted **bareroot** just after planting.

9 = PTM™ + Insignia®SC Mid Concentration/Diluted Soil Injection [1.4 ml PTM + 4.9 ml Insignia in 23.7 ml water (30 ml total volume)/seedling] - Soil injection at two points next to transplanted **bareroot** just after planting.

10 = PTM™ Low Concentration/Diluted Soil Injection [1 ml PTM in 29 ml water (30 ml total volume)/seedling] - Soil injection next to transplanted **bareroot** just after planting.

11 = PTM™ (Low) + Insignia®SC (Mid) Concentration/Diluted Soil Injection [1 ml PTM + 4.9 ml Insignia in 25.5 ml water (30 ml total volume)/seedling] - Soil injection next to transplanted **bareroot** just after planting.

12 = Containerized Check (untreated)

13 = Bareroot Check (untreated)

Containerized seedlings will be individually treated at the nursery prior to planting using a plug injection system developed by Stewart Boots, S&K Designs. The seedlings will be treated with PTM™ and/or Insignia®SC at different rates based on the restricted rate of 59 g AI/acre/year (PTM™) or 530 g AI/acre/year (Headline®) and the number of trees planted per acre (tpa). For example, fipronil will be applied 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.

Five (5) recently-harvested tracts were selected in fall 2011 across the southeastern United States (in TX, AR, AL, GA, and NC) based on uniformity of soil, drainage and topography.

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

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

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

Damage and Tree Measurements
Tip moth damage 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. Measurements of tree health will be collected periodically and/or at the end of each growing season. Tree health measurements include tree height and diameter; crown diameter, density and color (vigor); number and length of shoots in the top whorl, and tree survival. 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 (height, diameter and volume index; shoot length) and health (crown density and color; nuber of shoots and tree survival) parameters. 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 2012, the "best" treatment(s) will be followed into 2012 to continue evaluating duration of treatments. In addition, the study may be expanded in 2013 to refine application rates and techniques for the promising treatment(s).

Project Support: This trial is supported by BASF grant funds. BASF is providing chemical and International Forestry Co. the containerized seedlings and Plum Creek the bare-root seedlings.

Research Time Line:

CY 2012

January - February 2012

- Select research sites (January)
- Treat seedlings (January)
- Lift and plant all seedlings in plantation sites (January)
- Treat seedlings during and after planting with PTM via soil injection

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 FPMC Executive Committee, BASF.

CY 2013

March - October, 2013

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

November - December 2013

- 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.

CY 2014 (if warranted based on CY 2013 results)

March - October, 2014

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

November - December 2014

- Evaluate tip moth damage after 5th generations; measure seedling and height of seedlings.
- Conduct statistical analysis of 2014 data.
- Prepare and submit report to FPMC Executive Committee, BASF.
- Present results at annual Entomological Society of America meeting.

Square 1

row/column	1	2	3	4	5	6	7	8	9	10	11	12	13
1	L	H	M	D	E	K	G	B	C	F	I	J	A
2	I	E	J	A	B	H	D	L	M	C	F	G	K
3	G	C	H	L	M	F	B	J	K	A	D	E	I
4	M	I	A	E	F	L	H	C	D	G	J	K	B
5	J	F	K	B	C	I	E	M	A	D	G	H	L
6	C	L	D	H	I	B	K	F	G	J	M	A	E
7	B	K	C	G	H	A	J	E	F	I	L	M	D
8	D	M	E	I	J	C	L	G	H	K	A	B	F
9	A	J	B	F	G	M	I	D	E	H	K	L	C
10	E	A	F	J	K	D	M	H	I	L	B	C	G
11	K	G	L	C	D	J	F	A	B	E	H	I	M
12	F	B	G	K	L	E	A	I	J	M	C	D	H
13	H	D	I	M	A	G	C	K	L	B	E	F	J

Square 2

row/column	1	2	3	4	5	6	7	8	9	10	11	12	13
1	C	A	M	H	J	E	K	F	B	L	G	I	D
2	H	F	E	M	B	J	C	K	G	D	L	A	I
3	I	G	F	A	C	K	D	L	H	E	M	B	J
4	A	L	K	F	H	C	I	D	M	J	E	G	B
5	G	E	D	L	A	I	B	J	F	C	K	M	H
6	J	H	G	B	D	L	E	M	I	F	A	C	K
7	B	M	L	G	I	D	J	E	A	K	F	H	C
8	M	K	J	E	G	B	H	C	L	I	D	F	A
9	K	I	H	C	E	M	F	A	J	G	B	D	L
10	E	C	B	J	L	G	M	H	D	A	I	K	F
11	F	D	C	K	M	H	A	I	E	B	J	L	G
12	L	J	I	D	F	A	G	B	K	H	C	E	M
13	D	B	A	I	K	F	L	G	C	M	H	J	E

Square 3

row/column	1	2	3	4	5	6	7	8	9	10	11	12	13
1	I	M	G	H	F	D	J	L	B	E	C	K	A
2	G	K	E	F	D	B	H	J	M	C	A	I	L
3	C	G	A	B	M	K	D	F	I	L	J	E	H
4	H	L	F	G	E	C	I	K	A	D	B	J	M
5	M	D	K	L	J	H	A	C	F	I	G	B	E
6	B	F	M	A	L	J	C	E	H	K	I	D	G
7	E	I	C	D	B	M	F	H	K	A	L	G	J
8	K	B	I	J	H	F	L	A	D	G	E	M	C
9	F	J	D	E	C	A	G	I	L	B	M	H	K
10	D	H	B	C	A	L	E	G	J	M	K	F	I
11	A	E	L	M	K	I	B	D	G	J	H	C	F
12	J	A	H	I	G	E	K	M	C	F	D	L	B
13	L	C	J	K	I	G	M	B	E	H	F	A	D

Treatments and Plot Design Example

Code	*Treatment*	*Color*
A	*Mid UD Insignia container plug injection*	*red*
B	*Mid UD PTM container plug injection*	*blue*
C	*Mid UD PTM + Mid Insignia container plug injection*	*orange*
D	*Low UD PTM container plug injection*	*pink/blue*
E	*Low UD PTM + Mid Insignia container plug injection*	*white*
F	*High D Insignia bareroot soil injection*	*red/white*
G	*Mid D Insignia bareroot soil injection*	*yellow/blue*
H	*Mid D PTM bareroot soil injection*	*yellow*
I	*Mid D PTM + Insignia bareroot soil injection*	*green*
J	*Low D PTM bareroot soil injection*	*pink*
K	*Low D PTM + Mid Insignia bareroot soil injection*	*blue/white*
L	*Check (containerized)*	*green/orange*
M	*Check (bareroot))*	*blue/red*

UD = undilute; D = dilute

PINE TIP MOTH TRIALS

Evaluation of PTM™ and Insignia®SC Rates for Bareroot Pine Seedlings (To be Initiated in 2012)

Justification

Several FPMC trials (2003 - 2005) showed that fipronil (PTM™) applied to bare-root pine seedlings before or after planting was highly effective in reducing tip moth damage for 2+ years.

Pyraclostrobin (Insignia®SC) belongs to the strobilurin class of fungicides. In addition to excellent, broad-spectrum disease control, research has shown pyraclostrobin-based fungicides also provide additional plant health benefits. Pyraclostrobin-based fungicides control foliar fungal diseases by inhibiting respiration in the mitochondria of fungi. This inhibition prevents the breakdown of energy-rich carbon compounds the fungus needs to produce energy for growth. Pyraclostrobin-based fungicides also have activity on plant mitochondria and reduce respiration in the plant. Since the plant's primary source of energy comes from sunlight through photosynthesis, this decrease in respiration can have a positive effect on growth. Decrease in respiration allows the plant to keep more stored carbon compounds for growth and triggers a chain reaction of positive physiological changes in the plant. These positive physiological changes may include a defense signaling compounds, and a decrease in the stress hormone ethylene. The combination of disease control, stress reduction, and increased growth efficiency lead to the plant health benefits observed with the use of pyraclostrobin-based fungicides as described in this report (BASF Intrinsic™ report). It is of interest to evaluate the efficacy and duration of soil injection treatment of bareroot seedlings with fipronil and pyraclostrobin alone or combined.

Objectives: 1) Evaluate efficacy of PTM™ (fipronil) and Insignia®SC (pyraclostrobin) alone or combined applied to bareroot seedlings at different rates for reducing pine tip moth infestation levels and improving seedling health; and 3) determine the duration of chemical activity.

Cooperators

Ken Smith	Hancock Forest Management
Jim Bean, Andy Goetz, Victor Canez	BASF

Research Approach:

A recently planted loblolly pine bareroot seedlings will be selected (from ArborGen, Cellfor or IFCo).

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

1 = PTM™ High Concentration/Diluted Soil Injection [5.6 ml PTM (**110 tpa rate**) in 24.4 ml water (30 ml total volume)/seedling] - Soil injection at two points next to transplanted **bareroot** just after planting.

2 = PTM™ Mid Concentration/Diluted Soil Injection [1.4 ml PTM (**435 tpa rate**) in 28.6 ml water (30 ml total volume)/seedling] - Soil injection at two points next to transplanted **bareroot** just after planting.

3 = PTM™ Low Concentration/Diluted Soil Injection [1.0 ml PTM (**600 tpa rate**) in 29.0 ml water (30 ml total volume)/seedling] - Soil injection at two points next to transplanted **bareroot** just after planting.

4 = Insignia®SC High Concentration/Undiluted Soil Injection [51.6 ml Insignia (**110 tpa rate**) undiluted/seedling] - Soil injection at four points next to transplanted **bareroot** just after planting.
5 = Insignia®SC Mid Concentration/Diluted Soil Injection [13.1 ml Insignia (**435 tpa rate**) in 11.9 ml water (30 ml total volume)/seedling] - Soil injection at two points next to transplanted **bareroot** just after planting.
6 = Insignia®SC Low Concentration/Diluted Soil Injection [9.5 ml Insignia (**600 tpa rate**) in 20.5 ml water (30 ml total volume)/seedling] - Soil injection at two points next to transplanted **bareroot** just after planting.
7 = PTM™ + Insignia®SC High Concentration/Undiluted Soil Injection [5.6 ml PTM + 51.6 ml Insignia (57.2 ml total volume)/seedling] - Soil injection at four points next to transplanted **bareroot** just after planting.
8 = PTM™ + Insignia®SC Mid Concentration/Diluted Soil Injection [1.4 ml PTM + 13.1 ml Insignia in 15.5 ml water (30 ml total volume)/seedling] - Soil injection at two points next to transplanted **bareroot** just after planting.
9 = PTM™ + Insignia®SC Low Concentration/Diluted Soil Injection [1.0 ml PTM + 9.5 ml Insignia in 19.5 ml water (30 ml total volume)/seedling] - Soil injection at two points next to transplanted **bareroot** just after planting.
10 = Bareroot Check (untreated)

Bareroot seedlings will be individually treated after planting using a PTM Injection Probe system developed by Sammy Keziah (formerly with Enviroquip). The seedlings will be treated with PTM™ and/or Insignia®SC at different rates based on the restricted rate of 59 g AI/acre/year (PTM™) or 1,416 g AI/acre/year (Insignia®) and the number of trees planted per acre (tpa). For example, fipronil will be applied 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).

One (1) recently hand planted tracts will be selected in January 2012 in Texas based on uniformity of soil, drainage and topography. Rayonier has agreed to provide a research site.

The harvested tract will have been intensively site prepared, i.e., subsoil, bedding, and/or herbicide. A half-acre (approximate) area will be selected. A triple Latin square design will be established with single tree plots (10 rows X 10 treatments) serving as blocks, i.e., each treatment will be randomly selected for placement along each row (bed). Thirty (30) rows will be established on each site. Seedlings will be planted at 6 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 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. Measurements of tree health will be collected periodically and/or at the end of each growing season. Tree health measurements include tree

height and diameter; crown diameter, density and color (vigor); number and length of shoots in the top whorl, and tree survival. 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 (height, diameter and volume index; shoot length) and health (crown density and color; nuber of shoots and tree survival) parameters. Data will be subjected to analyses of variance (Table 1) 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 2012, the "best" treatment(s) will be followed into 2012 to continue evaluating duration of treatments. In addition, the study may be expanded in 2013 to refine application rates and techniques for the promising treatment(s).

Project Support: This trial is supported by FPMC funds. BASF is providing chemical and Hancock Forest Management the bare-root seedlings

Research Time Line:

CY 2012

January - February 2012

- Select research site (January)
- Treat seedlings after planting with PTM and Insignia via soil injection

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 FPMC Executive Committee, BASF.

CY 2013

March - October, 2013

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

November - December 2013

- 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.

Square	1										2										3									
row/column	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10
1	C	J	H	A	D	F	B	G	I	E	E	H	I	F	C	B	J	D	A	G	I	B	J	G	E	H	C	D	F	A
2	I	F	J	G	H	B	E	D	A	C	D	E	J	I	A	G	B	C	H	F	C	F	D	J	B	G	E	A	I	H
3	F	G	A	E	I	D	H	C	B	J	J	I	H	A	G	D	E	B	F	C	A	J	C	I	G	F	H	E	D	B
4	B	D	G	C	A	H	J	I	E	F	B	J	E	H	F	C	D	G	I	A	E	I	A	D	F	J	B	H	C	G
5	H	I	C	F	E	A	G	B	J	D	G	B	D	E	I	A	C	F	J	H	B	C	H	A	I	D	F	G	E	J
6	D	C	E	J	B	I	A	F	H	G	I	F	A	C	B	E	H	J	G	D	F	E	G	H	C	A	I	J	B	D
7	J	A	I	B	C	G	D	E	F	H	H	A	F	G	D	J	I	E	C	B	J	H	F	B	A	E	D	I	G	C
8	E	H	D	I	G	J	F	A	C	B	F	G	C	D	J	H	A	I	B	E	G	A	B	E	D	C	J	F	H	I
9	G	E	B	H	F	C	I	J	D	A	C	D	B	J	H	F	G	A	E	I	D	G	I	F	H	B	A	C	J	E
10	A	B	F	D	J	E	C	H	G	I	A	C	G	B	E	I	F	H	D	J	H	D	E	C	J	I	G	B	A	F

Treatments and Plot Design Example

Code	Treatment	Color
A	*High D PTM bareroot soil injection*	*red*
B	*Mid D PTM bareroot soil injection*	*blue*
C	*Low D PTM bareroot soil injection*	*orange*
D	*High UD Insignia bareroot soil injection*	*pink/blue*
E	*Mid D Insignia bareroot soil injection*	*white*
F	*Low D Insignia bareroot soil injection*	*red/white*
G	*High UD PTM + Insignia bareroot soil injection*	*yellow/blue*
H	*Mid D PTM + Insignia bareroot soil injection*	*yellow*
I	*Low D PTM + Insignia bareroot soil injection*	*green*
J	*Check (bareroot))*	*pink*

UD = undilute; D = dilute

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

Justification

Export of US-produced softwood lumber exceeded $1 billion in 2011 (Timber Trends, Dec, '11/Jan. '12). However, export of unfinished southern pine logs has been severely restricted due to the potential export with the logs of pine wood nematode (PWN), *Bursaphelenchus xylophilus,* the causal agent of pine wilt disease. The PWN is transmitted (vectored) to conifers by pine sawyer beetles (*Monochamus* spp., Coleoptera: Cerambycidae) either when adult beetles feed on bark and phloem of twigs of susceptible live trees (primary transmission) or when female beetles lay eggs (oviposition) in dying trees or freshly-cut logs (secondary transmission). Bark must be present on tree or log for the adult beetles to oviposit and for the insect larvae to develop (Craighead 1950, Webb 1909). Pines *(Pinus* spp.) appear to be the most susceptible to PWN, and at least 27 species in the continental United States and 38 species worldwide (15) have been reported as hosts. Yellow pines (loblolly, shortleaf, slash and longleaf) of the southeastern United States tend to be resistant to the development of pine wilt disease symptoms, even though they may contain PWN.

Because there is no cure for pine wilt, management practices have concentrated on preventing the spread of *Bursaphelenchus* and *Monochamus***.** Logs should not be exposed during the July-to-September egg-laying period of *Monochamus***.** If bark is immediately peeled from felled green trees, damage by sawyers is prevented (Webb 1909). A mill certification program (no bark, no grub holes) is strongly supported by the United States and Canada. Based on the biology of *Monochamus***,** this program assumes that if no grub (entrance) holes are visible, no insects in the sawn wood will emerge and transmit the PWN. Furthermore, the European *Monochamus***,** which requires bark for oviposition, will be unable to breed in bark-free wood, eliminating contamination by the PWN (Dwindell 1997).

Phytosanitary certificate requires log shipments to be PWN free. China requires logs to be debarked or fumigated (methyl bromide or phosphine) prior to export. Debarking generally costs a few dollars per ton while fumigation is prohibitively expensive, costing tens of dollars per ton (Hugh McManus, personal communication). Note: The general sampling protocol to obtain phytosanitary certificate: xylem tissue taken using a 2.5" wide drill bit at two points (one third distance) of the ends of each of 29 - 59 logs (number depends on state of harvest).

Data is needed to confirm that PWN does not occur/survive in "healthy", standing southern yellow pine (e.g., loblolly pine); that risk of PWN infection is eliminated by harvesting during winter months and/or by promptly debarking logs prior to export.

Objectives: Determine 1) if PWN occurs in standing loblolly pine; 2) seasonal timing of PWN infection on standing trees and/or felled logs; 3) extent to which debarking logs eliminates PWN risk; and 4) time limit after felling in which PNW infection risk is sufficiently low to be acceptable to exporters/importers of southern pines.

Potential Cooperators

Hugh McManus	Hancock Forest Management, Shreveport, LA
Doug Long	Rayonier US Forest Resources, Lufkin, TX

Conner Fristoe — Plum Creek Timber Company, Crossett, AR
Wilson Edwards — Weyerhaeuser Company, New Bern, NC
Simon Stronge — TPT Forests, New Zealand

Research Approach:

Parameters:

Tree Species: loblolly pine
Sites: Two (2) or more per period provided by participating members
Seasonal periods:
- Spring (April – June)
- Summer (July – September)
- Fall (October – December)
- Winter (January – March)

Tree (upper crown, lower crown, lower bole) @ 0 hrs after felling
Felled Log:
- On-site Time: 24hrs, 2d, 4d and 6d before transport to debarking facility;
- Debark Time: logs debarked within 24h, 2d, or 4d of arrival at facility.

During the initial season (spring 2012), two sites will be selected in east Texas, within 40 miles of Lufkin/Nacogdoches. Additional sites may be added across the South in later seasons if there is interest.

During each season, six (6) "healthy appearing" trees of export size (28-30.5cm (=11 -12") DBH, 25-30 YO?) will be felled. Immediately (within an hour of felling), wood samples will be taken from the main stem of the upper crown, lower crown, and lower bole. Each full log (18-20cm top, >10 m long) will be cut into nine (9) - 1.0 m sections. Each of the 9 log sections will be randomly assigned a treatment (Figure 1). The treatments include:

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

Groups of 18 log sections will be held at the harvest site for three different intervals (24h, 3d, or 6d) (Figure 4). Individual log sections will be placed about 1 m apart on discarded, dry pine bolts to maximize surface area available for colonization as well as to discourage predation by ground and litter-inhabiting organisms. A bait blend (ethanol, (-) a-pinene, ipsenol, ipsdienol, and monochamol) will be deployed in the harvest area to attract cerambycid beetles. At the end of each on-site interval, 18 logs will be transported (rotated to simulate movement) to debarking site. Groups of 6 logs will be debarked (with chainsaw and planer) at different intervals (24h, 2d, 6d) after arrival (rotation). All logs will be sampled for PWN 21d after debarking.

Figure 4. Sampling scheme for pinewood nematode at each of two east Texas sites in spring 2012

Days onsite prior to move to debarking site

		1	3	6
Days Until Debarking	1	2	4	7
	3	4	6	9
	6	7	9	12
Post-debarking period	21	23	24	28

Treatments

		1	3	6
Days Until Debarking	1	A	D	G
	3	B	E	H
	6	C	F	I

6 trees per site per season
9 - 1.0 meter logs from 30 foot log w 7" top

Workload

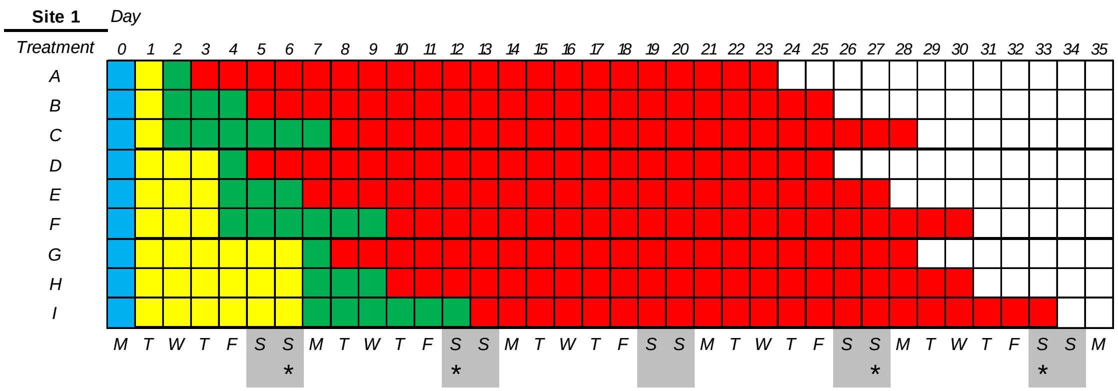
Day # => After Fell	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Logs samples/evaluations	18	18	6	18	12	0	24	6	0	12	6	0	6	0	18	18	6	18	12	0	24	6	0	12	0

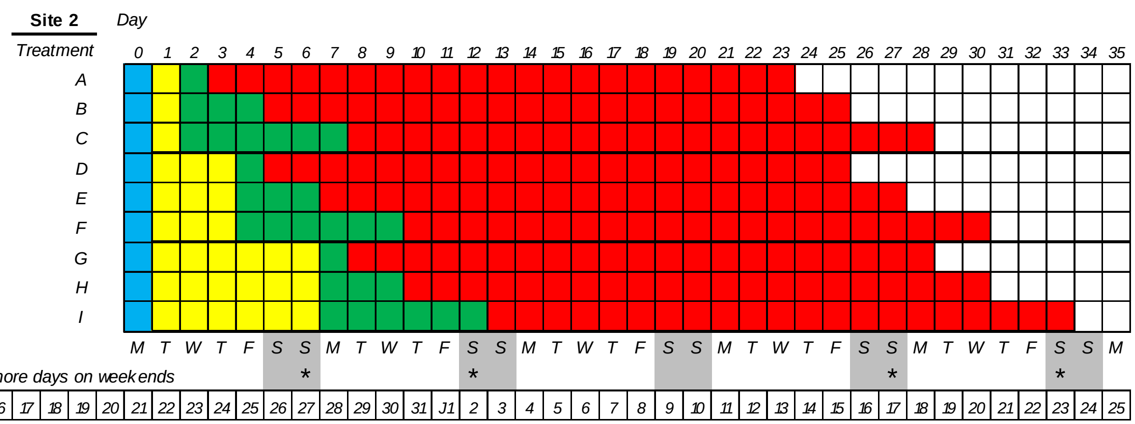
Day # => After Fell	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49
Logs samples/evaluations	12	0	6	12	0	12	0	0	6	0	0	0	12	0	12	0	6	12	0	12	0	0	6	0	0

Total **348**

Day 0 --> Collect wood samples from 6 trees @ 3 levels
Day 1 - 12 --> Evaluate bark surface or remove & evaluate bark plates
Day 23 - 33 --> Collect wood samples from 6 -12 logs each day

(blue) = *Study trees felled & wood samples taken @ 3 levels*
(yellow) = *interval on site (between fell and move)*
(green) = *interval at debarking site (between move and debarking)*
(red) = *interval between debarking and shipment*





Monitoring *Monachamus* species and PWN occurrence in beetles.
Modified funnel traps will be deployed (beginning in April 2012) at 2-3 nearby harvest sites. Traps will be baited with kairomone blend (ethanol, (-)alpha-pinene, ipsenol, ipsdienol, & monochamol) placed inside the funnels and using a wet cup (Miller et al. 2011, Dave Wakarchuk, personal communication). Traps will be monitored year around at two week intervals. Collected cerambycids will be identified to species. *Monochamus* specimens will be dissected to determine presence/absence of PWN (Linit 1988, Linit et al. 1983).

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

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

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

Sampling logs for pinewood nematodes 21 days after debarking
Each log is sampled at five locations: at two points approximately one-third distance from the ends and 3 times at the end of the log, 1.5 cm below the cambium, in a triangular pattern (holes may overlap on small logs). A wire brush is used to remove dirt and debris from the sample locations. At log ends, the first 5 cm from the sample locations should be discarded due to contaminates. Place a clean container beneath the work site to catch shavings throughout the process. Using a 5.4 cm (2 1/8 in) drill bit, slowly drill to the center of the log, reversing and removing the bit from the hole every 3.81 – 5.08 cm (1.5 – 2.0 inches) to collect the shavings. For large diameter trees a utensil will be required to remove the final shavings.

Pool into a bucket all of the material drilled (except the external discard, as recommended on the protocol) from a given log, mix it well, placed in a sealable plastic bag and keep at room temperature. In the lab, half of the material is used for nematode extraction (the remaining half will serve as a backup, in case there is a need to repeat the test).

Extraction of nematodes from wood shavings:
The following extraction method using a pie-pan is commonly used by nematologists to extract PWN. This method is only good for extracting live, motile nematodes. An alternative device is a Baermman funnel if the sample size is small.

- Each sample is assigned a Lab ID number.
- Make a single layer of wood shavings inside plastic or wire baskets lined with double-folded large Kimwipes™. Make sure the wood shavings are completely wrapped in the Kimwipes. Place the baskets into plastic containers. Add water to the containers until the

wood shavings are completely submerged. Incubate for 24 hours at room temperature to allow nematodes to move out.

- After incubation, the supernatant water is decanted from the containers, after gently removing the wood-containing baskets.
- The nematode suspension in the container is left to settle for about 10 minutes at a slant, approximately 45 degrees. Decant supernatant water again.
- Approximately 100 ml of the nematode solution is decanted into beakers and allowed to settle for 60 minutes.
- Supernatant water is then collected to approximately 20ml.
- Pour the sample into a counting dish. Identify and count nematodes under inverted microscope. Use publications by Mamiya & Kiyohara, 1972 and Mamiya, 1984 as references for identification.
- Save the samples in water and 4% Formalin accordingly for further test and future reference.
- Left over wood with paper is heat-treated in a dry heat oven for 2 hours at 250°F and disposed in a receptacle for biodegradable items.
- Observe for female, male, and dauer larvae of *Bursaphelenchus xylophilus* and any suspects with a stylet. Prepare permanent slides following the procedure described below for fixing and mounting specimens and take digital photos of any positively identified specimens.

Identification of nematodes:
Nematodes extracted from the wood samples will be identified based on morphological characteristics. In cases where morphological diagnosis is not conclusive (e.g., for juveniles only, insufficient specimens) an identification as *B. xylophilus* cannot be ruled out.

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

Data Analysis: The number of cerambycid egg niches, bark beetle attacks, nematodes present per log treatment, position on tree, and interval after felling and debarking, will be used to measure the degree of risk of PWN export. Risk of export will be analyzed statistically 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 in part by FPMC funds. Additional funds will be requested from participating members.

Research Time Line:

CY 2012

April - June 2012

- Select stands (April).
- Install and monitor traps (April - June).
- Collect tissue samples from trees and logs (May).
- Laboratory extraction and identification of nematode from plant tissue and adult *Monochamus* (May - June).

July - September, 2012

- Select stands (July).
- Install and monitor traps (July - September).
- Collect tissue samples from trees and logs (August).
- Laboratory extraction and identification of nematode (August - September).

October - December 2012

- Select stands (October).
- Install and monitor traps (October - December).
- Collect tissue samples from trees and logs (November).
- Extract and identify nematode (November - December).
- Conduct statistical analysis of 2012 data (December).
- Prepare and submit preliminary report to FPMC Executive Committee.
- Present results at East Texas Forest Entomology Seminar.

CY 2013

January - March 2013

- Select stands (January).
- Install and monitor traps (January - March).
- Collect tissue samples from trees and logs (February).
- Extract and identify nematode (February - March).
- Conduct statistical analysis of 2012 data (December).
- Prepare and submit preliminary report to FPMC Executive Committee.
- Present results at East Texas Forest Entomology Seminar.
- Publish results

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Forest Pest Management Cooperative
Activity Time Line - CY2012

January
- Contact FPMC members to arrange meeting to discuss tip moth program.
- Evaluate tip moth damage after 5th generation on second-year Hazard-rating sites
- Deploy pheromone traps for tip moth impact, hazard rating, and control (fipronil) studies.
- Monitor tip moth populations for tip moth studies.

February
- Establish new tip moth research plots.
- Treat selected tip moth impact plots with insecticides.
- Evaluate tip moth damage after 5th generation on second-year Hazard-rating sites
- Monitor tip moth populations on tip moth study sites.

March
- Monitor tip moth populations on tip moth study sites.
- Complete evaluation of tip moth damage after 5th generation on second-year hazard-rating sites
- Make selection of study sites and trees for bark beetle injection studies.
- Bait SPB trees in AL

April
- Treat loblolly pine study trees in AL and VA with designated treatments.
- Treat black walnut study trees in TX and TN with designated treatments.
- Monitor condition of SPB trees in AL.
- 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.
- Collect site information and soil samples for tip moth hazard rating study.
- Monitor tip moth populations on tip moth study sites.

May
- Evaluate tip moth damage after 1st generation for all tip moth studies; photograph damage.
- Reinoculate live oaks with oak wilt fungi.
- Initiate PW Nematode study on two east Texas sites
- Monitor tip moth populations on tip moth study sites.
- Walker to conduct statistical analyses of 2012 hazard-rating data.
- Monitor walnut pests for TCD trial.
- Bait injected trees in AL.
- Monitor condition of baited trees in AL.
- Finalize FPMC 2011 accomplishment report and 2012 proposals/budgets.
- Hold FPMC Executive Committee Meeting.

Forest Pest Management Cooperative
Activity Time Line - CY2012

June

- 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 pine trees in AL & VA.
- Monitor walnut pests and tree condition for TCD trial; collect xylem, phloem and nut samples.
- Monitor condition of injected live oaks.
- Monitor condition of injected athel and soapberry trees.

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.
- Develop LCA bait with corn matrix
- Initiate PW Nematode study on two east Texas sites
- Monitor tip moth populations on tip moth study sites.
- Bait injected trees in UT.
- Monitor condition of injected live oaks.
- Monitor condition of baited pine trees in AL & VA.
- Present selected results at Southern Forest Insect Work Conference meeting.

August

- Conduct preference trials for LCA bait (August)
- 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 pine trees in AL & VA.
- Monitor walnut pests and tree condition for TCD trial.
- Monitor condition of soapberry trees.

September

- Select and treat LCA colonies with assigned treatment
- Monitor leaf-cutting ant colonies for efficacy of bait formulations.
- Evaluate tip moth damage after 4th generation for all tip moth studies; photograph damage.
- Monitor tip moth populations on tip moth study sites.
- Monitor condition of SPB trees in AL.
- Collect nut samples from walnut trees.
- Monitor condition of baited pine trees in AL, VA 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 - CY2012

October
- 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 leaf-cutting ant colonies for efficacy of bait formulations.
- Monitor condition of soapberry and athel trees
- 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 walnut pests and tree condition for TCD trial.
- Monitor condition of live oaks
- Present selected results at East Texas Forest Entomology Seminar and International Society of Aboriculture - Texas.

November
- Select and treat LCA colonies with assigned treatment
- Monitor leaf-cutting ant colonies for efficacy of bait formulations
- 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.
- Monitor condition of baited trees in AL

December
- Monitor leaf-cutting ant colonies for efficacy of bait formulations
- Extract, radiograph and evaluate seed samples for Seed Orchard studies.
- Conduct statistical analyses of 2012 data.
- 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.

2011 Expenditures vs. Budget

Expenditures to operate the FPMC for CY 2011 totaled $260,122 (Table 2). This was $4,422 less than the projected $264,544 budget (Table 3) primarily due to reduced costs to support seasonal workers. Sources of funding to cover expenses were derived from membership dues (41%), the SPBI and FSPIAP federal grants, industry grants from BASF, Syngenta, Bayer, Mauget, and Arborjet (24%), and the Texas Forest Service (35%). Of this total, 76% was devoted to professional salaries, fringe benefits, and seasonal wages, and the remainder (24%) to equipment, operating expenses, and indirect costs. Overall, FPMC account funds exceeded expenditures by $534. Due to the 2011 federal and corporate grants ($35,572), we currently have a surplus of $46,038 in these accounts at the end of CY 2011.

Emergency funds totaling $23,835 (recovered FPMC funds from FY2008 – FY2011) are being held in a separate account and will be available in CY 2012 or subsequent years if needed.

2012 Proposed Budget

The proposed budget for CY 2012 totals $260,053 (Table 4). Current membership dues ($84,000) plus $12,000 from the FPMC surplus and $1,500 for seed analysis work for WGTIP will provide $97,500 (37%). An additional $91,018 (35%) is available from gifts/grants ($49,274) provided by BASF, Syngenta, Bayer, Arborjet and Mauget, as well as funds available from FSPIAP and ISAT (injection) grants ($41,744). The remaining (28%) will be borne by the Texas Forest Service and any new members that join during the year (Figure 5). 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 2012 is given in Table 5.

2013 Proposed Budget

A proposed budget for CY 2013 is given in Table 6 by source of funding. A total of $261,553 is proposed for CY 2013. No dues increase is anticipated. Assuming that membership stays at 7 full members and four associate members in 2012, $84,000 (37%) would be provided by membership dues, $12,000 from the FPMC surplus and anticipated funds from WGTIP for seed analysis. The remainder of the budget, 63%, 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 2013 is given in Table 7. We anticipate that one or more small projects will terminate at the end of CY 2012 (p. 3-4), allowing the funding of one new applied research or technology transfer project in CY 2013.

Table 8 provides a summary of funding sources and expenditures since the FPMC was initiated in 1996. Figure 6 illustrates FPMC sources of funding as a percentage of total expenditures. Finally, Figure 7 is a graph of the number of FPMC members and dues levels for the period 1996 – 2014.

Table 2. FPMC Expenditures by Source of Funding - CY 2011

	Source				% of
	FPMC	TFS	Fed./Ind. Grants *	Total	Total
A. Salaries and Wages					
Principal Investigator (Grosman) (100%)	$ 16,793 (26%)	$ 47,795 (74%)	$ 0	$ 64,588	
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	
Staff Assistant (Spivey) (20%)	4,651 (20%)	0	0	4,651	
Graduate Student (Walker) (100%)	6,375 (100%)	0	0	6,375	
3 Student Workers (one 4 mo. period ea.)	909	0	5,764	6,673	
Total Salaries and Wages	$ 68,557	$ 72,066	$ 13,984	$ 154,607	
B. Fringe Benefits / TFS Matching	$ 16,008	$ 18,737	$ 2,627	$ 37,373	
	84,565	90,803	16,611	191,980	76%
C. Operating Expenses					
Total Operating Expenses	$ 22,510	$ 1,356	$ 35,795	$ 59,661	24%
Indirect Costs (26%)			8,482	8,482	
Grand Total	$ 107,075	$ 92,159	$ 60,888	$ 260,122	
% of Total	41%	35%	23%	100%	100%

* Grant/Gift funds remaining from 2010; grants awarded to TFS from Arborjet, Mauget, and International Society of Aboriculture in CY2011.

Funding Available from January 1 - December 31, 2011	$ 134,543		$ 99,612		

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

		Source			
		FPMC	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 Funding - CY 2012

		Source			% of
		FPMC	TFS and Others*	Total	Total
A.	**Salaries and Wages**				
	FPMC Coordinator (Grosman) (100%)	$ 16,834 (26%)	$ 47,913 (74%)	$ 64,747	
	Research Specialist (Kavanagh) (100%)	24,795 (75%)	8,265 (25%)	33,060	
	Staff Forester (Upton) (95%)	23,812 (47%)	24,319 (48%)	48,131	
	Resource Specialist (Spivey) (20%)	5,040 (20%)		5,040	
	3 Seasonal Technician (4.5 mo.)		29,970	29,970	
	Total Salaries and Wages	$ 70,481	$ 110,467	$ 180,948	
B.	**Fringe Benefits (26% of Salaries & 8% of Wages)**	$ 18,325	$ 23,477	$ 41,802	
		88,806	133,944	222,750	86%
C.	**Operating Expenses**				
	Supplies	$ 8,000	$ 6,975	$ 14,975	
	Vehicle Use and Maintainance	0	9,000	9,000	
	Travel	0	6,500	6,500	
	Telecommunications (15% of PCS)	0	1,500	1,500	
	Utilities (15% of PCS)	0	1,500	1,500	
	Other Services (rentals, publications, postage, etc.)	694	3,134	3,828	
	Total Operating Expenses	$ 8,694	$ 28,609	$ 37,303	14%
	Grand Total	$ 97,500 **	$ 162,553	$ 260,053	
	% of Total	37%	63%	100%	100%

* includes any new members or federal grants.

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

Table 5. 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%)	$ 25,899 (40%)	$ 9,712 (15%)	$ 9,712 (15%)	$ 9,712 (15%)	$ 9,712 (15%)	$ 64,747
Research Specialist (100%)	0	13,224 (40%)	13,224 (40%)	3,306 (10%)	3,306 (10%)	33,060
Staff Forester (95%)	0	5,066 (10%)	5,067 (10%)	20,266 (40%)	17,732 (35%)	48,131
Resource Specialist (20%)	0	1,260 (5%)	1,260 (5%)	1,260 (5%)	1,260 (5%)	5,040
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)	$ 6,734	$ 8,245	$ 8,500	$ 9,746	$ 8,577	$ 41,801
C. Operating Expenses						
Travel and Vehicle Use	$ 2,000	$ 1,600	$ 4,900	$ 5,000	$ 2,000	$ 15,500
Supplies & Postage	1,700	1,146	9,070	1,690	1,569	15,175
Other Operating Expenses	1,704	1,100	1,625	1,100	1,100	6,629
Grand Total	$ 38,037	$ 47,585	$ 62,587	$ 59,811	$ 48,253	$ 260,053

Table 6. FPMC Proposed Budget by Source of Funding - CY 2013

		Source				% of
		FPMC		TFS and Others*	Total	Total
A.	**Salaries and Wages**					
	FPMC Coordinator (Grosman) (100%)	$ 16,834 (26%)		$ 47,913 (74%)	$ 64,747	
	Research Specialist (Kavanagh) (100%)	24,795 (75%)		8,265 (25%)	33,060	
	Staff Forester (Upton) (95%)	23,812 (47%)		24,319 (48%)	48,131	
	Staff Assistant (Spivey) (20%)	5,040 (20%)			5,040	
	3 Seasonal Technician (4.5 mo.)			29,970	29,970	
	Total Salaries and Wages	$ 70,481		$ 110,467	$ 180,948	
B.	**Fringe Benefits (26% of Salaries & 8% of Wages)**	$ 18,325		$ 23,477	$ 41,802	
		88,806		133,944	222,750	85%
C.	**Operating Expenses**					
	Supplies	$ 2,500		$ 11,975	$ 14,475	
	Vehicle Use and Maintainance	3,000		7,500	10,500	
	Travel	1,600		4,500	6,100	
	Telecommunications (15% of PCS)	0		1,500	1,500	
	Utilities (15% of PCS)	0		1,500	1,500	
	Other Services (rentals, publications, postage, etc.)	1,594		3,134	4,728	
	Total Operating Expenses	$ 8,694		$ 30,109	$ 38,803	15%
	Grand Total	$ 97,500 **		$ 164,053	$ 261,553	
	% of Total	37%		63%	100%	100%

* includes any new members or federal grants.

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

Table 7. FPMC Proposed Budget by Source of Project - CY 2012

	Activity: Administration Site Visits/Service	Activity: Tip Moth Studies (Impact & HR)	Activity: Tip Moth Studies (Systemic Trt)	Activity: Systemic Injection Studies	Activity: Other Studies	Total
A. Salaries and Wages						
FPMC Coordinator (100%)	$ 25,899 (40%)	$ 9,712 (15%)	$ 9,712 (15%)	$ 9,712 (15%)	$ 9,712 (15%)	$ 64,747
Research Specialist (100%)	0	13,224 (40%)	13,224 (40%)	3,306 (10%)	3,306 (10%)	33,060
Staff Forester (95%)	0	5,066 (10%)	5,067 (10%)	20,266 (40%)	17,732 (35%)	48,131
Resource Specialist (20%)	0	1,260 (5%)	1,260 (5%)	1,260 (5%)	1,260 (5%)	5,040
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)	$ 6,734	$ 8,245	$ 8,500	$ 9,746	$ 8,577	$ 41,801
C. Operating Expenses						
Travel and Vehicle Use	$ 3,189	$ 3,790	$ 3,800	$ 2,940	$ 2,941	$ 16,660
Supplies & Postage	4,228	2,650	2,650	2,650	2,650	14,828
Other Operating Expenses	1,116	1,300	2,300	1,300	1,300	7,316
Grand Total	$ 41,166	$ 51,479	$ 55,742	$ 58,911	$ 50,475	$ 261,553

Table 8: 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	$104,500	$63,463	$92,159	$260,122	40%	35%	***
2012 *	7 /4 *	$10K / $3.5K	$92,000	$75,894	$92,159	$260,053	35%	35%	
2013 *	7 /4 *	$10K / $3.5K	$84,000	$85,394	$92,159	$261,553	32%	35%	
Mean			$61,000	$53,712	$71,556	$183,284	32%	44%	

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

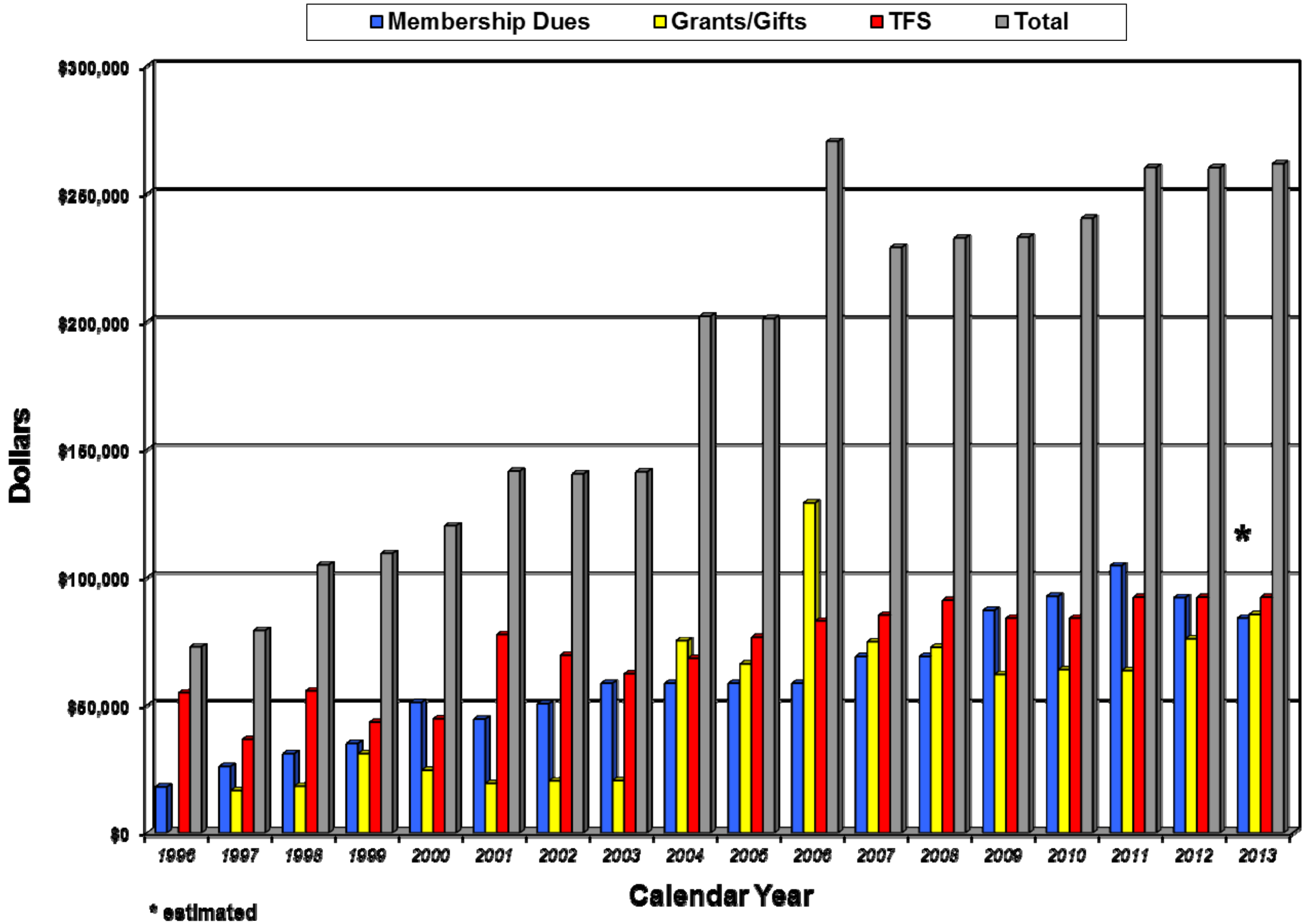

Figure 5: Forest Pest Management Cooperative budget by source.

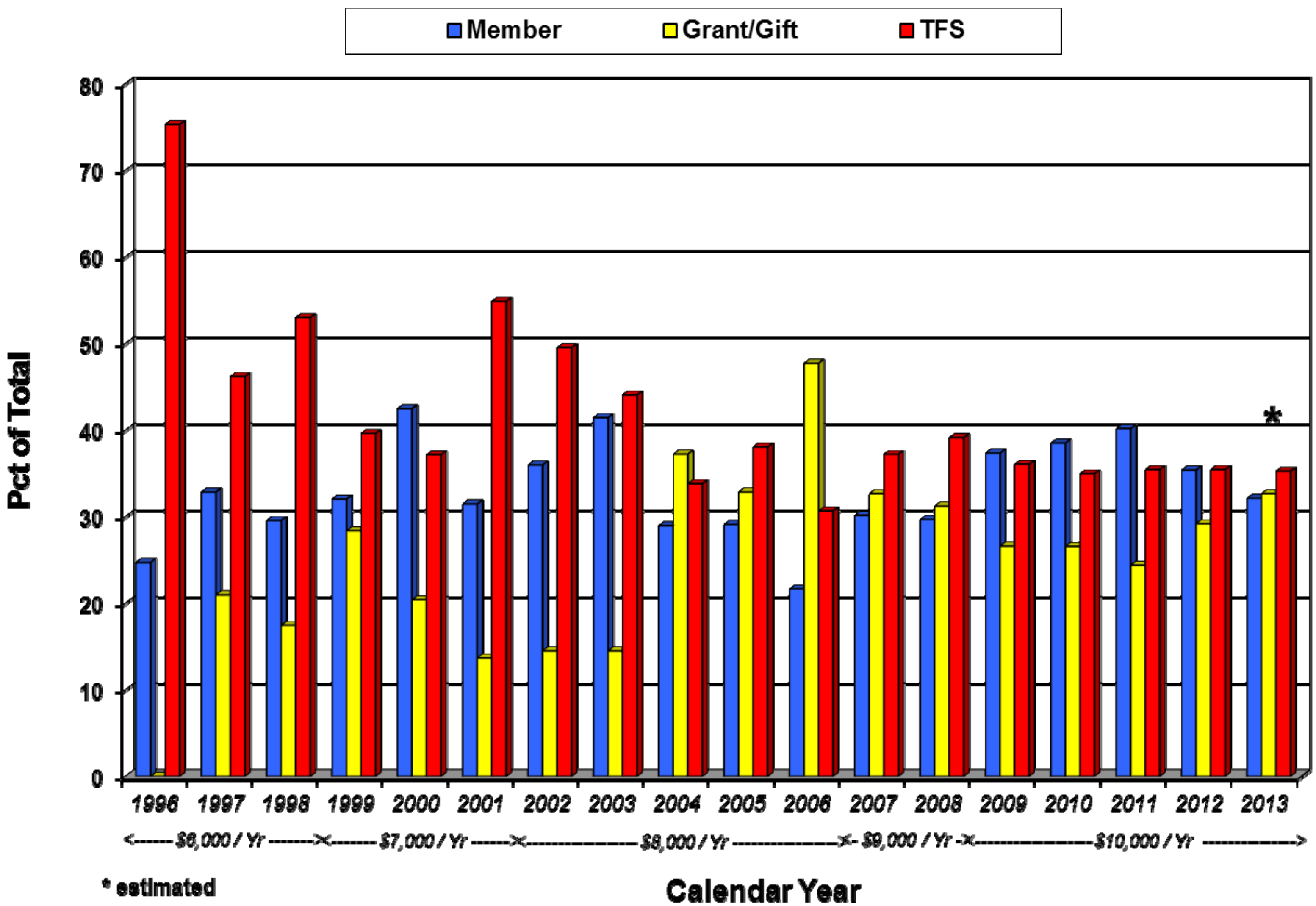

Figure 6. Forest Pest Management Cooperative membership dues, grants/gifts, and TFS support as percentage of total expenditures.

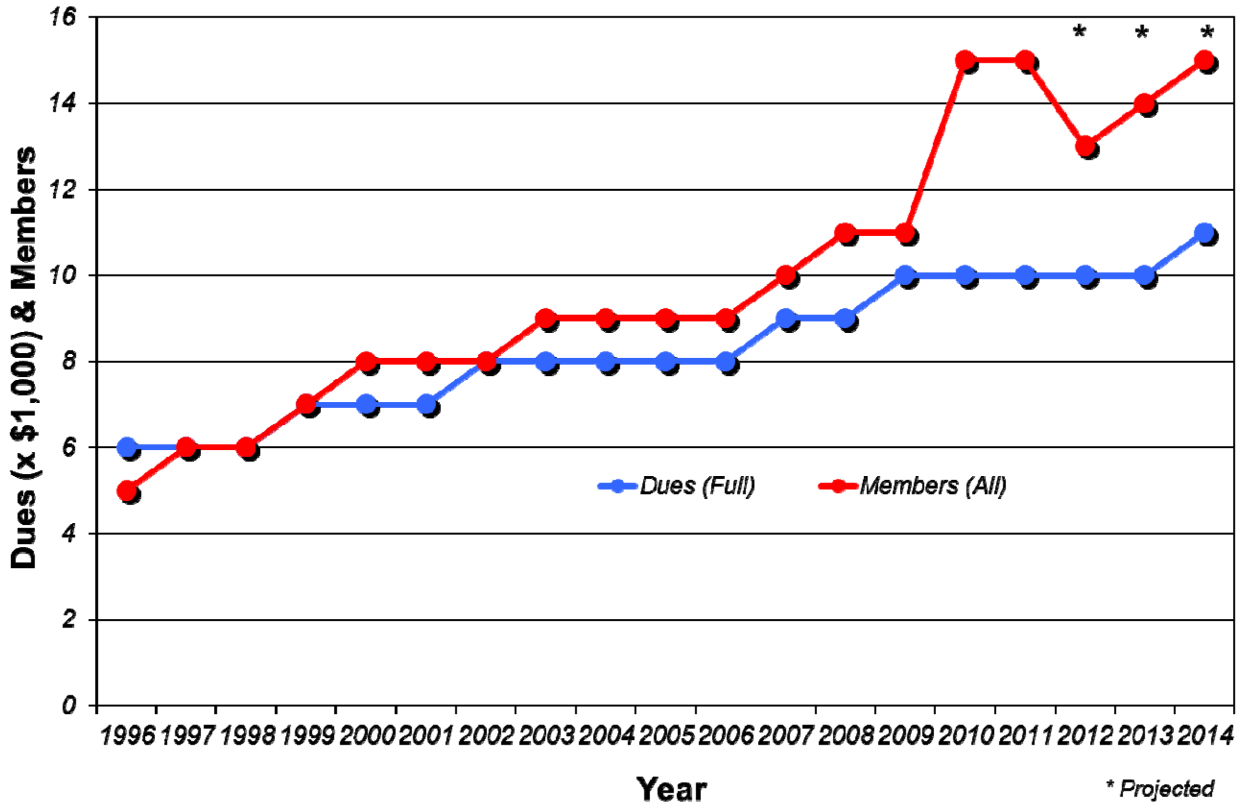

Figure 7. Forest Pest Management Cooperative membership levels and dues from 1996 to 2014 (projected).

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FPMC Executive and Contact Member Representatives In 2012

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