Western Gulf
Forest Pest Management Cooperative

2007 Research Project Proposals

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With the approval of the Executive Committee representatives, the Western Gulf Forest Pest Management Cooperative (WGFPMC) will continue to address two primary research areas (trunk injection of systemic insecticides and tip moth impact/hazard rating/control) in 2007. Results obtained this past year warrant further evaluations in these areas. One new project, to test potential baits for control of Texas leaf-cutting ants is presented for consideration in 2007.

Proposed objectives and methods for the systemic injection and tip moth studies in 2007 are presented below. Arborjet/Syngenta and BASF have/are in the process of developing new formulations of emamectin benzoate and fipronil, respectively, for injection use. The two studies to test the efficacy of the new formulations of emamectin benzoate and fipronil for protection of cone crops from seed and cone insects and for protection of trees against pine bark beetles will be continued. In addition, two new studies are proposed, one to evaluate different insecticide injection systems for application of these new formulations for protection of trees against bark beetles and the second to evaluate potential insecticides for control of seed bug in pine seed orchards.

As a result of the outbreak of Nantucket pine tip moth in the Western Gulf Region (1998 – 2001) and the perceived damage being caused by this insect, the WGFPMC initiated two new projects in 2001 and will extend/expand them into 2007. The first, a cooperative study with Andy Burrow, Temple - Inland, is to evaluate the impact of pine tip moth and develop hazard-rating models to assess the susceptibility of sites to this pest across the South. The second project area evaluates 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 – 2005), technique and rate (2003 - 2005), operational planting (2003 - 2005), technique and rate refinement studies (2004 - 2006), and soil injection (2005 - 2006), evaluation of operational treatments will be expanded in 2006. The Bayer trials (2003 – 2006) showed that imidacloprid / fertilizer spikes and tablets have some potential for protection of pine seedlings against tip moth. A new trial will be established to test the newly registered SilvaShield formulation.

Continuation of these or initiation of other projects will be dependent upon approval by the WGFPMC Executive Committee. Extension of each project into 2008 will depend on the degree of success achieved in 2007 and remaining gaps in knowledge.

LEAF-CUTTING ANT

Leaf-cutting Ant Bait Trial - East Texas
(To Be Initiated in 2007)

Cooperators:

Western Gulf Forest Pest Management Cooperative members
Mr. David Stevens — Dupont Crop Protection, Natchitoches, LA
Mr. Ray Prewett — Texas Citrus Mutual

Objective: Evaluate the preference for and efficacies of different indoxacarb/citrus pulp bait formulations to Texas leaf-cutting ants.

Justification: Currently, there is no safe and effective control option available for control of Texas leaf-cutting ants. Volcano (sulfluramid/citrus pulp bait) and methyl bromide was phased out in 2003 and 2005, respectively. In 2003, Grant Laboratories, CA, began marketing their Grant's Total Ant Killer bait. Trials conducted by the WGFPMC early in 2004, found that a single application only halted the activity of 25% of the treated colonies – about equal to the efficacy of the old Amdro® bait in the mid-1990s. In late 2004, Ambrands (formerly American Cyanamid) began marketing a new Amdro® Ant Block bait. Additional trials conducted in early spring 2005 and later in 2006 found that a single application of this bait did not halt the activity of most treated colonies, but did reduce all colonies by 60% compared to untreated colonies.

The use of baits have several advantages over fumigants and contact poisons, including being far safer to use, being more effective particularly during the summer months, and less costly and labor intensive to apply. Research trials conducted by R.S. Cameron (unpublished data) and Grosman (et al. 2002) have shown that leaf-cutting ants prefer citrus pulp to other carriers, such as, defatted corn grit. A citrus pulp bait containing sulfluramid (Volcano® leafcutter ant bait, Griffin L.L.C., Mexico, 0.5% ai) was registered as an alternative to methyl bromide in Texas and Louisiana in 1999 and 2000, respectively. The registered application rates were 4.0 g/m^2 for winter treatments and 10.0 g/m^2 for summer treatments. This sulfluramid bait was nearly 100% effective in halting ant activity year around with a single application (D. M. Grosman, unpublished data; Darwin Foster, Temple-Inland Forest Products, and Ken Addy, Louisiana Pacific, personal communications). In addition, Grosman (et al. 2002) determined preference to orange peel compared to a mixture of different citrus pulps (lemon, lime, and grapefruit).

Bait formulations have been very effective for control of imported fire ants, *Solenopsis invicta* Buren. Active ingredients currently used in fire ant baits include several toxicants (indoxacarb, fipronil, hydramethylnon, and spinosad) and insect growth regulators (IGR) (fenoxycarb, s-methoprene and pyriproxyfen). Indoxacarb is a relatively new active ingredient being released by DuPont as Advion fire ant bait. This AI blocks the insect's sodium channels in the nervous system. The Advion fire ant bait is reported to halt fire ant activity within 3 – 7 days after application. A similar response when applied to TLCA colonies would be desirable as ant colonies are often found and treated as pine seedlings are planted in the winter. We propose to develop one or more formulations that combine indoxacarb with citrus pulp and then test them for attractiveness and efficacy for the Texas leaf-cutting ant.

Study Sites: Active Texas leaf-cutting ant colonies (60) will be selected in East Texas on lands owned by forest industries, investment organizations and private individuals.

Insecticide:

Indoxacarb – undectable, slow-acting poison

Citrus pulp bait - concentration (0.1 – 1.0% a.i.); orange citrus pulp carrier with soybean oil; packing (tight); color (tan to brown); size (3 - 5 mm dia.).

Research Approach:

Citrus pulp bait formulations will be developed based on instructions provided by DuPont. Orange citrus pulp/peel will be obtained from a source in the Rio Grande Valley through Ray Prewett, Texas Citrus Mutual. Upon mixing the citrus pulp and active ingredient, bait pellets will be formed using pelletizer equipment provided by DuPont.

<u>Preference Trial</u>

Trials will be conducted in March 2007 by placing 5 g portions of different baits (indoxacarb 1.0% ai, indoxacarb 0.1% ai, and/or untreated placebo) 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.

<u>Efficacy Trial</u>

Experiments will be conducted in east Texas; within 75 miles of Lufkin. In this area, 60 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.

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) <u>indoxacarb, 1.0% ai</u> - during the winter only, bait will be spread uniformly over CNA at 4.0 g/m^2.
2) <u>indoxacarb, 1.0% ai</u> - during the summer and winter, bait will be spread uniformly over CNA at 10.0 g/m^2.
3) <u>indoxacarb, 0.1% ai</u> - during the winter only, bait will be spread uniformly over CNA at 4.0 g/m^2.
4) <u>indoxacarb, 0.1% ai</u> - during the summer and winter, bait will be spread uniformly over CNA at 10.0 g/m^2.
5) <u>untreated placebo 0% ai</u> - during the winter and summer, bait will be spread uniformly over CNA at 10.0 g/m^2.
6) <u>Check</u> - untreated colonies

Bait application rates will be based on the Volcano/Blitz® label recommendation of 4 or 10 g / m^2. A cyclone spreader will be used to evenly spread measured amounts of indoxacarb bait over the CNA.

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.

Data Collection: Procedures used to evaluate the effect of treatments on Texas leaf-cutting ant colonies will follow those described by Cameron (1990). 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 winter and summer treatments to account for possible seasonal changes in ant activity. For each colony, the percent of initial activity will be calculated as the current number of active mounds at each post-treatment check (X 100) divided by the initial number of active mounds.

Application Dates:

Spring 2007: Treatments applied to 10 colonies in March.
Late Summer 2007: Treatments applied to 10 colonies in July.

Project Support: The trial will be supported by WGFPMC funds.

Research Time Line:

March - April 2007

- Develop formulations of citrus pulp bait (March).
- Locate 60 leaf-cutting ant colonies (March).
- Evaluate preference of ants to different formulations (February).
- Randomly assign and treat colonies (March and April)
- Reevaluate ant activity 2 weeks post treatment

May - June, 2007

- Reevaluate ant activity 8 weeks post treatment.

July - August, 2007

- Reevaluate ant activity 16 weeks post treatment.
- Conduct statistical analyses of data.

September - October, 2007

- Locate 30 - 40 leaf-cutting ant colonies depending on results from the spring trials (September)
- Randomly assign and treat colonies (September and October)
- Reevaluate ant activity 2 weeks post treatment

November - December, 2007

- Reevaluate ant activity 8 weeks post treatment.

January - February, 2008

- Reevaluate ant activity 16 weeks post treatment.
- Conduct statistical analyses of data.
- Prepare and submit report to WGFPMC and Dupont.

SYSTEMIC INSECTICIDE INJECTION TRIALS

Emamectin Benzoate and Fipronil Tree Injections for Cone and Seed Insect Control in Southern Seed Orchards (DISCONTINUE)

Cooperators:

Mr. Doug Sharp	Plum Creek Timber Company, LA
Mr. Tim Slicter	International Paper Company, FL
Mr. Jim Tule	Temple-Inland Forest Products, TX
Mr. Terry Willaford	Smurfit-Stone Container Corporation, FL
Dr. David Cox	Syngenta, Modesta, CA
Dr. Harold Quicke	BASF, Auburn AL
Mr. Joseph Doccola	Arborjet, Inc., Worchester, MA

Justification: The purpose of this study was to 1) determine the efficacy of newer formulations of emamectin benzoate and fipronil against cone and seed insects in loblolly pine and slash pine and 2) determine the duration of treatment efficacy.

In 2005, the trials in LA, TX and FL again demonstrated that injections of emamectin benzoate and fipronil were effective in reducing coneworm damage by an average of 86% and 65%, respectively, and seed bug damage by 26% and 15%, respectively (WGFPMC Annual Report 2006).

In 2006, emamectin benzoate and fipronil remained highly effective against coneworm, reducing damage by 86% and 77%, respectively, compared to checks. In contrast, the effects emamectin benzoate and fipronil against seed bug declined, reducing damage by only 10% and 9%, respectively (WGFPMC Annual Report 2006).

The above results mirror those results obtained from previous trials (1999 and 2003). Thus, the expectation is that treatments will continue to be effective against coneworms but ineffective against seed bugs. The recommendation is to discontinue this project and focus efforts on evaluation of new products for protection of seed crops against seed bug.

SYSTEMIC INSECTICIDE INJECTION TRIALS

Potential Insecticides for Seed Bug Control in Pine Seed Orchards (For Initiation in 2007)

Cooperators:

Dr. Tom Byram	Western Gulf Tree Improvement Program
Mr. Steve Altsuler	Weyerhaeuser Company, Magnolia, AR
Mr. Joseph Doccola	Arborjet, Inc., Worchester, MA

Objectives: The objectives of this research proposal are to: 1) evaluate the potential efficacy of systemic injections of new formulations of imidacloprid and dinotefuran in reducing seed crop losses due seed bugs in pine seed orchards; and 2) determine the duration of treatment efficacy.

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

Fipronil (BASF), a new pheny pyrazole insecticide, has been shown to have systemic activity in pine and is highly effective in reducing pine tip moth damage on young seedlings (Grosman, unpublished data). An experimental EC formulation of fipronil was found to reduce coneworm damage by 80% in the second year after injection, but it had no significant effect against seed bugs (Grosman, unpublished data).

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

Dinotefuran (Valent) is a “3rd generation” neonicotinoid insecticide with primary activity against sucking insects as well as Coleoptera (beetles). Arborjet has found that injections of dinotefuran at 0.4g/DBH” was as effective as imidacloprid against emerald ash borer (Joe Doccola, personal communication). One advantage dinotefuran has over imidacloprid is that it is 100X more water soluble (40g/L vs 0.4g/L). Thus, higher concentrations can be developed that translocate more quickly compared to imidacloprid. Arborjet is currently developing a formulation of dinotefuran that may be injected alone or combined with other chemicals, e.g., emamectin benzoate or fipronil, for seed orchard use.

With the potential loss of currently-registered foliar insecticides, there is an obvious need for an effective alternative to control cone and seed insects in southern pine seed orchards. A chemical alternative that provides long term protection (> 1 year) and could by applied via a closed system to individual trees would be preferred by orchard managers because it could be easily applied, economical, and generally pose little hazard to the applicator. Trials conducted thus far indicate that injections of emamectin benzoate and fipronil into loblolly pine can significantly reduce coneworm-caused damage, but generally have little or no effect to against seed bugs. The purpose of this study is to 1) evaluate the potential efficacy of a new formulation of imidacloprid and dinotefuran against seed bugs in pine seed orchards and 2) determine the duration of treatment efficacy.

Research Approach: The study will be conducted in 2007 in a loblolly pine and slash pine seed orchard (to be determined). A block in each orchard will be selected that has not been sprayed with insecticide for 1 or more years prior to initiation of this experiment. In January 2007, 1-4 ramets from each of 3-10 loblolly/slash clones will be selected. The treatments will be evaluated using the experimental design protocol described by Gary DeBarr (1978) (i.e., randomized complete block with clones as blocks). The treatments will include:

1) Imidacloprid (Ima-jet®) (0.2 – 0.4 g AI per inch DBH of tree)
2) Dinotefuran (0.2 – 0.4 g AI per inch DBH of tree)
3) Imidacloprid + Emamectin benzoate (each at 0.2 – 0.4 g AI per inch DBH of tree)
4) Imidacloprid + Fipronil (each at 0.2 – 0.4 g AI per inch DBH of tree)
5) Dinotefuran + Emamectin benzoate (each at 0.2 – 0.4 g AI per inch DBH of tree)
6) Dinotefuran + Fipronil (each at 0.2 – 0.4 g AI per inch DBH of tree)
7) Emamectin benzoate (0.2 – 0.4 g AI per inch DBH of tree)
8) Fipronil (0.2 – 0.4 g AI per inch DBH of tree)
9) Capture®, Asana®XL, Guthion®, or Imidan® (standard) applied by hydraulic sprayer to foliage 5 times per year at labeled rate at 5-week intervals beginning in March or April.
10) Check

Injection treatments will be applied in March (slash) or April (loblolly) 2007 using the Arborjet Tree IV™ microinfusion system (Arborjet, Inc. Woburn, MA). Each treatment will be injected into four or more cardinal points (depending on tree diameter) about 0.3 m above the ground.

The rate also will depend on tree diameter: 0.2g AI/inch DBH in trees <12"DBH and 0.4g AI/DBH" in trees 12-23"DBH.

Treatment 9 (Capture®, Asana® XL, Guthion®, or Imidan® standard) will be applied to foliage beginning in April 2007 using a hydraulic sprayer from a bucket truck (if necessary) at 10 gal/tree. The distance between test trees will be $\geq$20 m to minimize the effects of drift.

Conelet and cone survival will be evaluated in 2007 and 2008 by tagging 6 to 10 branches on each tree (50 conelets and 50 cones, if possible) in early April. Counts of surviving conelets and cones from these branches will be made in August (slash) or September (loblolly) of each year. Conelet and cone survival generally reflects protection from seed bugs and coneworms, respectively. In July and September, 50 conelets will be randomly sampled from each tree and evaluated for seed bug damage. Reduction of coneworm attacks will be evaluated by collecting all cones present from each tree in August (slash) or September (loblolly) of 2006 and 2007. From the samples, counts will be made of healthy- and coneworm-attacked cones. Each year, a subsample of 10 healthy cones/tree will be selected; seed lots from these cones will be radiographed to determine seed yield/cone and filled-seed yield/cone to measure the extent of seed bug and seedworm damage.

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

Research Time Line:

<u>January - April 2007</u>

- Select orchards, clones and ramets (January & February).
- Inject study trees with assigned product(s) (March and April)
- Treat study trees with standard (Capture®, Asana®XL, Guthion®, or Imidan®) foliar treatment (April)
- Flag 6-10 branches/tree and record number of conelets and cones on all treatment and check trees (April).

<u>May - August, 2007</u>

- Treat study trees with standard (Capture®, Asana®XL, Guthion®, or Imidan®) foliar treatment (May, June, July, August)
- Collect conelet sample (July) and evaluate for early season seed bug damage.

<u>September - December 2007</u>

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

January - April 2008

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

May - August, 2008

- Treat study trees with standard (Capture®, Asana®XL, Guthion®, or Imidan®) foliar treatment (May, June, July, August)
- Collect conelet sample (July) and evaluate for early season seed bug damage.

September - December 2008

- Evaluate conelet and cone survival on flagged branches (early September).
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- Conduct statistical analyses of data.
- Prepare and submit report to WGFPMC, Syngenta, BASF, Arborjet, and Valent

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SYSTEMIC INSECTICIDE INJECTION TRIALS

Emamectin Benzoate Dose Rate for Single Tree Protection from Southern Engraver Beetles (*Ips* spp.) (Continued from 2005)

Cooperators

Dr. David Cox	Syngenta, Modesta, CA
Mr. Joseph Doccola	Arborjet, Inc., Worchester, MA
Ms. Emily Goodwin	Temple-Inland Forest Products, Diboll, TX

Objectives: 1) Evaluate the duration of systemic injections of emamectin benzoate at different rates in reducing success of pine engraver beetles attacks on loblolly pine bolts

Justification: Bark beetles (Coleoptera: Curculionidae, Scolytinae) such as the southern pine beetle (SPB), *Dendroctonus frontalis* Zimmerman, mountain pine beetle (MPB), *D. ponderosae* Hopkins, western pine beetle (WPB), *D. brevicomis* LeConte, and spruce beetle (SB), *D. rufipennis* (Kirby), are responsible for extensive conifer mortality throughout North America including Alaska (Miller and Keen 1960, Amman et al. 1989, Holsten et al. 1999, Report on losses caused by forest insects, Southern Forest Insect Work Conference, 2000 - 2003). These species do not just affect the timber industry; they also have a significant impact on recreation, water, and wildlife resources as well as residential property values.

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 (McGregor and Cole 1985). This situation emphasizes the need for assuring that effective preventative insecticides and treatment techniques are available for individual tree protection in the future. 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, can be a high risk for worker exposure and drift, and can be detrimental to natural enemies (Billings 1980). The use of newly-developed injection technology to inject systemic insecticides with long residuals (3+ years) could markedly reduce or eliminate all of the limitations associated with hydraulic spray applications.

Systemic insecticides have been suggested as a potentially useful tool for protection of individual trees or forested areas. Trials have been conducted using acephate (Orthene®) (Crisp, Richmond, and Shea 1979 unpublished data, in Billings 1980), fenitrothion (Pestroy®) and dicrotophos (Bidrin®) (Dalusky et al. 1990), oxdydementon methyl (Inject-a-cide®) (Haverty et al. 1997), and azadirachtin (neem) (Duthie-Holt et al. 1999). Although attack success and tree mortality were not prevented in any of the trials, all trials showed some level of reduced brood development or production. Until very recently, no systemic insecticide has been field tested and determined capable of protecting individual trees from bark beetle attacks.

In 2004, the WGFPMC conducted an injection trial in East Texas to evaluate the potential efficacy of several reported systemic insecticides, including: emamectin benzoate, fipronil, imidacloprid and dinotefuran, for protection of loblolly pine against *Ips* engraver beetles.

Emamectin benzoate injections had been found to be highly effective (4+ years) against both pine wood nematode, *Bursaphelenchus xylophilis* (Takai et al. 2000, 2001, 2003a and b), and coneworm, *Dioryctria* spp. (Grosman et al. 2002, unpublished data). Fipronil also is efficacious against coneworm as well as Nantucket pine tip moth, *Rhyacionia frustrana* (Grosman, unpublished data)). The results from the 2004 trials with *Ips* bark beetles have shown that both emamectin benzoate and fipronil were highly effective in preventing both the successful colonization of treated bolts 3 and 5 months after tree injection and the mortality of standing trees (see 2004 Accomplishment Report, Grosman & Upton 2006). Trials are needed to confirm efficacy against SPB, MPB, WPB, SB and other bark beetle species as well as to determine duration of treatment efficacy.

In 2005, the WGFPMC conducted an injection trial in East Texas to evaluate the efficacy of a new formulation of emamectin benzoate for protection of loblolly pine against *Ips* engraver beetles. The results showed that emamectin benzoate (Ava-jet) was highly effective in preventing the successful colonization of treated bolts 1 and 3 months (see 2005 Accomplishment Report) and 13 months (see 2006 Accomplishment Report) after tree injection. It is unknown if the activity of the new emamectin benzoate formulation will extend into the third year after injection. This study will evaluate the duration of efficacy of emamectin benzoate applied at two rates against *Ips* engraver beetles.

Treatments:

1) Emamectin benzoate (0.2 g AI per inch DBH of tree) by Tree IV.
2) Emamectin benzoate (0.4 g AI per inch DBH of tree) by Tree IV.
3) Check

Treatment Methods and Evaluation:

A 20-year-old, recently-thinned loblolly pine plantations was selected near Diboll (Angelina County), Texas. Twenty trees were injected with one of two emamectin benzoate treatments. A staging area was set up in the second plantation where bolts from the first plantation are exposed to bark beetles and wood borers.

Loblolly pine trees (60), 15 – 20 cm diameter at breast height (DBH), were selected in March 2005. Each treatment (1 & 2) consisted of a single insecticide treatment injected into four cardinal points about 0.3 m above the ground on each tree in early to mid-April using the new Arborjet Tree IV™ microinfusion system (Arborjet, Inc. Woburn, MA).

After 25 (May 2007) months post-injection, 5 trees of each treatment will be felled and one 1.5 m-long bolt will be removed from the 5 m height of the bole. Each series of bolts will be transported to a nearby plantation that was recently thinned and contains fresh slash material. Each bolt will be placed about 1 m from other bolts on discarded, dry pine bolts to maximize surface area available for colonization as well as to discourage predation by ground and litter-inhabiting organisms. To facilitate timely bark beetle colonization, packets of *Ips* pheromones (racemic ipsdienol and cis-verbenol; Phero Tech, Inc., Delta, BC, Canada) will be attached separately to nine 1 m stakes evenly spaced in the study area. The packets will be removed after 2 weeks when signs of bark beetle attacks (boring dust) are observed on most test bolts.

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 *Ips* beetle attacks, *Ips* egg gallery length and cerambycid feeding for each treatment. The 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.

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

Research Time Line:

CY 2007

<u>May - June, 2007</u>

- Fell trees injected in 2007, transport to thinned stand, lay out bolts and install traps and lures (May)
- Remove bolts and record trap catch, attacks and gallery lengths (June)

<u>June - December, 2007</u>

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

References:

Zar, J. H. 1984. Biostatistical Analysis. Prentice Hall, Englewood Cliffs, N.J. 718 p.

SYSTEMIC INSECTICIDE INJECTION TRIALS

Systemic Insecticide Treatment Timing, Rate and Duration for Protection of Loblolly Pine from Bark Beetles. (Continued from 2006)

Cooperators

Ms. Emily Goodwin	Temple-Inland Forest Products, Diboll, TX
Mr. Greg Atwood	Texas Forest Service, Jacksonville, TX
Dr. Harold Quicke	BASF, Auburn, AL
Dr. David Cox	Syngenta, Modesta, CA
Mr. Joseph Doccola	Arborjet, Inc., Worchester, MA

Objectives: 1) Determine the efficacy of systemic injections of emamectin benzoate and fipronil 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, 4) determine the duration of treatment efficacy, and 5) determine chemical concentrations in plant tissues that affect attacking adult beetles and brood development.

Justification: In 2005, a trial was conducted to evaluate the efficacy of a new formulations of emamectin benzoate and fipronil for protection of loblolly pine against *Ips* engraver beetles. The results showed that both emamectin benzoate (Ava-jet) and 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 and timing of emamectin benzoate, fipronil and nemadectin on efficacy against Ips engraver beetles. Generally, efficacy of emamectin benzoate treatments was not influenced by timing (season) of treatment application. However, efficacy of treatments did improve with increasing chemical rate. The study should be continued to evaluate the duration of treatment efficacy at different rates.

Treatments:

1) Emamectin benzoate injection at 0.4 g AI per inch DBH,
2) Emamectin benzoate injection at 0.08 g AI per inch DBH,
3) Emamectin benzoate injection at 0.016 g AI per inch DBH,
4) Fipronil injection at 0.4 g AI per inch DBH,
5) Fipronil injection at 0.08 g AI per inch DBH
6) Fipronil injection at 0.016 g AI per inch DBH,
7) Nemadectin injection at 0.4 g AI per inch DBH,
8) Nemadectin injection at 0.08 g AI per inch DBH
9) Nemadectin injection at 0.016 g AI per inch DBH,
10) Untreated (control) - used to assess beetle pressure during each summer (2007 - 2008)

Treatment Methods and Evaluation:

This study was established in loblolly pine plantation (about 20 years old) that was recently thinned in the Fairchild State Forest, Rusk Co., Texas. Test trees (390), ranging from 15 to

23cm dbh, were selected. Each of the above emamectin benzoate and fipronil treatments was applied to 30 trees in October 2005 and 30 more trees were treated with emamectin benzoate and nemadectin treatments in April 2006. The insecticides were injected using the Arborjet Tree IV™ microinfusion system (Arborjet, Inc. Woburn, MA) into four cardinal points 0.3 m above the ground. The injected trees were allowed at least 3 months to translocate chemicals prior to being challenged by bark beetles.

In June 2007 and 2008, 10 trees of each treatment will be felled and one 1.5 m-long bolt will be removed from the 5 m height of the bole. The bolts will be transported to a nearby plantation that had been recently thinned and contains fresh slash material. Bolts will be randomly placed 1 m from other bolts on discarded, dry pine bolts to maximize surface area available for colonization as well as to discourage predation by ground and litter-inhabiting organisms. To facilitate timely bark beetle colonization, packets of *Ips* pheromones (racemic ipsdienol and cis-verbenol; Phero Tech, Inc., Delta, BC, Canada) will be attached to 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.).

At the time of annual tree felling (July), plant tissue samples will be collected from several points (bole phloem and xylem, crown foliage and cones) of five randomly-selected emamectin benzoate-treated trees. Phloem, xylem and foliage samples also will be collected from fipronil-treated trees.

1) Phloem tissue – strips of bark plates (1-2 " wide) will be excised using a hammer and chisel around the circumference of the bole at 5 m (= 16 ft; both EB and FIP trees) and 11 m (= 36 ft; EB trees only) heights. The phloem tissue layer (50 g) will be peeled from each bark plate, placed in properly labeled plastic cups and stored temporarily in a freezer prior to analysis. Chisels will be cleaned with acetone after collecting each sample.

2) Xylem tissue – a drill (1/2" dia.) will be used to collect xylem wood chips from numerous points around the circumference of the bole at 5 m (= 16 ft; both EB and FIP trees) height. Samples will be collected from the cambial layer to a depth of 1". The samples from around the bole will be combined (50 g), placed in a labeled plastic cups and stored temporarily in a freezer prior to analysis. Drill bits will be cleaned with acetone after collecting each sample.
3) Foliage tissue – Approximately 100 new 1st year needles will be collected from each of the lower, middle, and upper portions of the crown of each EB and FIP tree. The needles will be combined, placed in a labeled zip-loc bag and stored temporarily in a freezer prior to analysis.
4) Cone tissue – Ten 2nd-year cones from EB trees will be placed in a labeled zip-loc bag. Both cone samples will be stored temporarily in a freezer prior to analysis.

All emamectin benzoate samples will be analyzed in-house by Syngenta via HPLC analysis (Takai et al. 2003b) to determine chemical concentrations present in individual tissue samples. Samples from fipronil trees will be analyzed in-house by BASF.

Project Support: BASF and Syngenta have provided funding toward the project and agreed to donate chemical product and analyze the tissue samples from injected trees in house. Arborjet, Inc. has agreed to loan the WGFPMC injection equipment for the project.

Research Time Line:

CY 2007 and CY 2008 (if warranted, based on 2007 results)

<u>June - August, 2007 & 2008</u>

- Fell second and third series of trees, collect tissue samples, transport bolts to thinned stand, lay out bolts and install lures; send off tissue sample for analysis (July)
- Remove bolts and record attacks and gallery lengths (August)

<u>September - December, 2007 and 2008</u>

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

References:

Amman, G.D., M.D. McGregor and R.E. Dolph, Jr. 1989. Mountain pine beetle. U.S. Dept. Agric. For. Insect & Dis. Leaflet. 2. 9 p.

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

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Holsten, E.H., R.W. Their, A.S. Munson and K.E. Gibson. 1999. The spruce beetle. U.S. Dept. Agric. For. Insect & Dis. Leaflet. 127, 8 p.

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SYSTEMIC INSECTICIDE INJECTION TRIALS

Evaluation of Emamectin Benzoate and Fipronil for Protection of High-Value Southern and Western Conifers from Bark Beetles – AL, CA, ID, UT, CO, BC (Continued from 2005)

Cooperators

Dr. Steve Clarke,	USDA Forest Service – FHP R8, Lufkin, Texas
Dr. Christopher J. Fettig,	USDA Forest Service – PSW Research Station, Davis, CA
Dr. Steve Munson	USDA Forest Service – FHP R4, Ogden, Utah
Dr. Carl L. Jorgensen	USDA Forest Service – FHP R4, Boise, Idaho
Mr. Leo Rankin	British Columbia Ministry of Forests, Williams Lake, BC
Mr. Gary Severson	Private landowner, Breckenridge, CO
Dr. David Cox	Syngenta, Modesta, CA
Dr. Harold Quicke	BASF, Auburn, AL
Mr. Joseph Doccola	Arborjet, Inc., Worchester, MA

Objectives: 1) Evaluate the efficacy of systemic injections of emamectin benzoate and fipronil for preventing mortality of high value conifers by several species of *Dendroctonus* spp. bark beetles found in the southeastern and western regions of the United States and 2) to determine the duration of treatment efficacy.

Justification: The 2004 WGFPMC injection trial in East Texas showed both emamectin benzoate and fipronil were highly effective in preventing both the successful colonization of treated bolts by *Ips* engraver beetles 3 and 5 months after tree injection and the mortality of standing trees (see 2004 Accomplishment Report). Trials are needed to confirm efficacy against SPB, MPB, WPB, SB and other bark beetle species as well as to determine duration of treatment efficacy. Final data from the SPB (MS and AL) and WPB (CA) indicate that again emamectin benzoate and fipronil are effective in preventing mortality by bark beetles (see 2006 Accomplishment Report). In contrast, preliminary data from the MPB (ID) and SB (UT) indicate that the treatments were largely ineffective. The trials need to be continued to determine the duration of treatment efficacy (AL and CA) and confirm the level of efficacy (ID, BC and UT). Other trials (CO and AL) are need to further validate treatment efficacy.

Research Approach: This study has been established at 8 sites: 1) DeSoto National Forest, Chickasawhay Ranger District in Wayne and Green Co. Mississippi with southern pine beetle (SPB) and Ips engraver beetle attacking loblolly pine, 2) private timberland owned by Sierra Pacific Industries (SPI) in Calaveras Co. California, with western pine beetle (WPB) attacking ponderosa pine; 3) Challis National Forest, Yankee Ranger District in Custer Co. Idaho, with mountain pine beetle (MPB) attacking lodgepole pine; 4) Manti-LaSal National Forest , Sanpete Ranger District in Carbon and Emery Counties, Utah with spruce beetle (SB) attacking Engelmann spruce, 5) provincial timberland near 100 Mile House, British Columbia with mountain pine beetle (MPB) attacking lodgepole pine, 6) Talladega National Forest, Oakmulgee Ranger District in Bibbs and Perry Co., Alabama with southern pine beetle attacking loblolly pine; 7 & 8) private land owned by Gary Severson in Summit Co., CO and State Forest State

Park in Jackson Co., CO with MPB attacking lodgepole pine. There were 2-4 treatments at each site:

1) emamectin benzoate injection at 0.2 –0.4 g AI per inch DBH,
2) fipronil injection at 0.2 –0.4 g AI per inch DBH,
3) bifenthrin or carbaryl spray (standard) at 0.06% AI or 2% AI, respectively (optional)
4) Untreated (control) - used to assess beetle pressure during each summer (2007 - 2008)

Test trees were located in areas with recent beetle activity and isolated from other sample trees. Trees selected will be 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 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 May (CA & ID), August (UT) and September (BC) 2005, and April (AL), May (BC) and September (CO) 2006, preferably after a heavy rain event or snow melt. The injected trees are generally allowed one to two months (depending on water availability) to translocate chemicals prior to being challenged by the application of synthetic pheromone baits. Due to the short season because elevation, the trees in Utah will not be baited until April 2006 (Table 11). Additional sets of trees also will be injected in Alabama and Colorado in April or May 2006, respectively.

The standard (bifenthrin or carbaryl) spray was applied at the same time as the injections in CA and ID, respectively. Insecticides were applied with a trailer-mounted hydraulic sprayer (300 psi, #8 oriface), which allowed treatment of the entire bole of each tree, until saturation, to a height of >10m. Approximately 8 to 15 liters of formulated material was required per tree. All treatments were applied between 0600 and 1100 when wind speeds average <10 mph.

All test trees and the first set of untreated check trees were/will be baited with appropriate species-specific lures (Phero Tech Inc., Delta, BC) for 2 to 4 weeks in May (MS and AL), June (CA and ID) 2005 and April (UT – several months) 2006. The surviving treated trees in each treatment (if there are no more than 6 killed by the bark beetle challenge), and the second set of check trees were/will be baited again for the same length of time in 2006 (MS, AL, CA and ID) and 2007 (UT). Similarly, the treated trees and third set of check trees will be baited in 2007 and 2008.

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 in the month of August for multiple, consectutive 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 mortality. Presence of species-specific galleries will be verified in each tree classified as dead or dying.

Treatments will be considered to have sufficient beetle pressure if 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 trials are being funded by a grant from the Southern Pine Beetle Initiative. The WPB, MPB (ID) and SB trials are being funded by grant from the Western Bark Beetle Initiative. BASF, Syngenta and Arborjet, Inc. are providing chemicals or injection equipment for the project.

Research Time Line:

CY 2007 and CY 2008 (if warranted, based on 2007 results)

March - April, 2006

- Select study trees in Alabama and Colorado (March).
- Inject trees in AL (April) and CO (May) with assigned treatment (early April)
- Bait second series trees in Utah (April)

May - September, 2007 and 2008

- Bait AL, CA, BC & CO trees (May and June)
- Monitor tree (loblolly, ponderosa and lodgepole pines and Engelmann spruce) mortality (August and September)

November - December, 2007 and 2007

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

References:

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

SYSTEMIC INSECTICIDE INJECTION TRIALS

Evaluation of Injection Systems for Application of Emamectin Benzoate in Loblolly Pine (Initiated in 2007)

Cooperators

Dr. David Cox	Syngenta, Modesta, CA
Mr. Joseph Doccola	Arborjet, Inc., Worchester, MA
Ms. Emily Goodwin	Temple-Inland Forest Products, Diboll, TX

Objectives: 1) Evaluate systems ability inject EB formulation based on time to prepare/load, install and treat each tree and safety; 2) Evaluate speed of uptake based on control 30-60 days after injection, and then yearly for 2 more years.

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

Research Approach: Seven injection/infusion systems will be evaluated:

Tree IV System (Arborjet, Inc.; contact: Joe Doccola) – hi vol (125+ ml/inj pt); hi pres

Wedgle Tip Portal System (ArborSystems; contact: Chip Doolittle) – hi vol (?∞ml/inj pt); hi pres

Ecoject System (Bioforest Technology, Inc.; contact: Joe Meating) – med vol (30 ml/inj pt); hi pres (?)

Sidewinder System (Sidewinder; contact: Geoff Eldridge) hi vol (∞ ml/inj pt); hi pres

Information about the systems will be requested from each manufacturer. 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 disposable or reusable?
6) Does chemical product need to prepackaged or mixed?

Rating Criteria

1) Time needed to fill system with chemical product
2) Ease to fill system with chemical product
3) Time needed to install system on tree
4) Ease of system installation on tree
5) Number of injection points required per tree

6) Can the system be left alone on tree or does the applicator need to manually operate system continuously?
7) Time required to inject/infuse X amount of product.
8) Potential for chemical exposure
9) Time needed to clean system
10) Ease to clean system
11) Weather restrictions (moisture, temperature)
12) Effectiveness of treatment

Treatment Methods and Evaluation:

This study will be conducted in a loblolly pine plantation (about 20 years old) that has been recently thinned in Texas. Test trees (135), ranging from 15 to 23cm dbh, will be selected. Fifteen (15) trees will be each injected with the same AI concentration (0.2g/ inch diameter of tree) but at one of two volume rates (low = 5ml/in dia. or high = 10ml/in dia) of EB (Arborjet, Inc.) using each system in late March 2007 (Table 1). Fifteen trees will serve as untreated controls. The application procedure used to inject the EB formulation will be based on the recommendations of each system manufacturer. The injected trees will be allowed at least 1 month to translocate chemicals prior to being challenged by bark beetles.

Table 1. Volume (ml) of Emamectin benzoate formulation injected per tree diameter class

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

Groups of five (5) trees for each treatment will be felled at 1 month, 1 year and 2 years after injections. One 1.5 m-long bolt will be removed from the 5 m height of the bole. The bolts will be transported to a nearby plantation that had been recently thinned and contains fresh slash material. Bolts will be randomly placed 1 m from other bolts on discarded, dry pine bolts to maximize surface area available for colonization as well as to discourage predation by ground and litter-inhabiting organisms. To facilitate timely bark beetle colonization, packets of *Ips* pheromones (racemic ipsdienol and cis-verbenol; Phero Tech, Inc., Delta, BC, Canada) will be attached to 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.).

Research Time Line:

CY 2007

March, 2007

- Select study trees
- Inject trees with assigned treatments

April – July, 2007

- Fell first series of trees and transport bolts to thinned stand, lay out bolts and install lures (April)
- Remove bolts and record attacks and gallery lengths (May)
- Conduct statistical analyses of data (June)
- Prepare and submit report to WGFPMC Executive Committee, Syngenta and System manufacturers (July).

CY 2008 and CY 2009 (if warranted, based on 2007 results)

April - July, 2007

- Fell second and third series of trees and transport bolts to thinned stand, lay out bolts and install lures (April)
- Remove bolts and record attacks and gallery lengths (May)
- Conduct statistical analyses of data (June)
- Prepare and submit report to WGFPMC Executive Committee, Syngenta and System manufacturers (July).
- Present results at annual Entomological Society of America meeting.

SYSTEMIC INSECTICIDE INJECTION TRIALS

Evaluation of Emamectin Benzoate and Fipronil for Protection of Pine Wood Against Termites
(DISCONTINUE)

Cooperators

Dr. Harold Quicke	BASF, Auburn, AL
Dr. David Cox	Syngenta, Modesta, CA
Mr. Joseph Doccola	Arborjet, Inc., Worchester, MA
Ms. Emily Goodwin	Temple-Inland Forest Products, Diboll, TX

Objectives: 1) Evaluate the potential of emamectin benzoate and fipronil to prevent colonization of pine wood by subterranean termites (*Coptotermes*, *Heterotermes* and *Reticulitermes* spp.) and 2) determine the depth of wood penetration of each chemical.

Justification: The objectives were to evaluate the potential of emamectin benzoate and fipronil to prevent colonization of pine wood by subterranean termites (*Coptotermes*, *Heterotermes* and *Reticulitermes* spp.) and determine the depth of wood penetration of each chemical.

It was observed that residual logs from trees that had been injected with emamectin benzoate or fipronil as part of the bark beetle injection trial (2004), felled in May and June, and lying on the ground still had not been colonized by termites or other wood boring insects by October 2004. In contrast, logs from most untreated study trees were being colonized by termites and wood boring insects within the 3 to 5 months they had been on the ground.

Cookies from the above mentioned logs were deployed at an East Texas forested site in fall 2004. Due to severe drought conditions, the cookies have not been attacked by termites. It is questionable whether or not WGFPMC members have interest in pursuing this project further. Time and effort perhaps should be spent on other new projects, i.e., leaf-cutting ant bait development and evaluation.

PINE TIP MOTH

Impact Study
(Continued from 2001 -2006)

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.

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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).

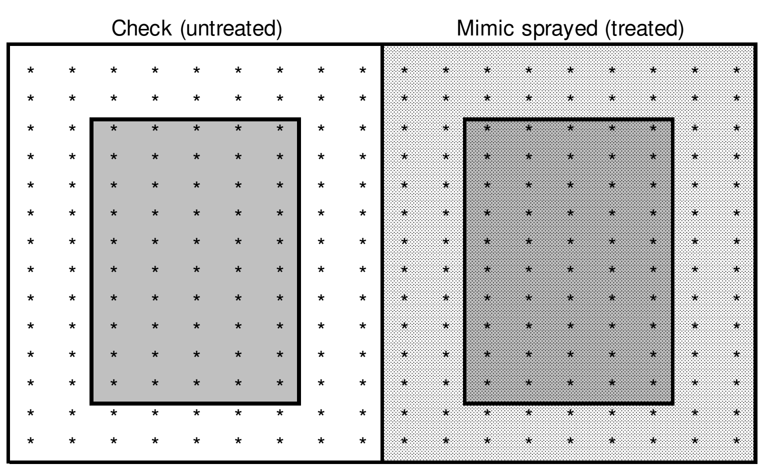
The impact of tip moth attack on tree growth has not been clearly established. Beal (1967) showed that pine trees protected from tip moth attack grew significantly faster than unprotected trees during the first 6 years after planting on some sites, but not on others. At age 16, differences in height 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 WGFPMC Tip Moth Impact Study, the unprotected seedlings in 16 study sites averaged 22% of shoots infested over five generations. 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) of the study, 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. However, the higher damage levels in second-year sites did significantly impact 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 third year (2003) of the study, tip moth populations were again low with the percent of shoots infested on seedlings in 10 first-year (planted in 2003) and 7 second-year (planted in 2002) sites averaging 12% and 15%, respectively. The near complete exclusion of tip moth from Mimic®-treated seedlings improved tree height, diameter and volume by 13%, 14% and 25%, respectively, compared to untreated trees. Tip moth pressure and protection by Mimic® treatments was insufficient to produce an impact on second-year tree growth in 2003. However, the higher damage levels in second-year sites did significantly impact the growth of unprotected trees. After three years, the height, diameter, and volume of Mimic®-treated trees were improved by 10%, 17%, and 38%, respectively, compared to check trees. During the fourth year (2004) of the study, six additional sites were established for a total of 40 impact sites. Tip moth populations were again low with the percent of shoots infested on seedlings in 6 first-year and 10 second-year (planted in 2003) sites averaging 10% and 12%, respectively. Tip moth pressure was insufficient to result in an impact on first- or second-year tree growth in 2004. In 2005, four additional sites were established. Tip moth damage levels were the highest since 2001 with the percent of shoots infested on 4 first-year and 6 second-year sites averaging 13% and 16%, respectively. The relatively high tip moth pressure and the nearly complete exclusion of tip moth from first year Mimic®-treated seedlings improved tree height, diameter and volume by 16%, 20% and 58%, respectively, compared to untreated trees. Similarly, second-year sites saw a marked improvement in height (14%), diameter (2%) and volume (17%) compared to its previous years growth. In 2006, outstanding efforts by several Cooperative members resulted in twenty-nine additional sites being established. Tip moth damage levels were the similar to 2005 with the percent of shoots infested on 29 first-year and 4 second-year sites averaging 14% and 16%, respectively. The relatively high tip moth pressure and the exclusion of tip moth from most first year Mimic®-treated seedlings improved tree height, diameter and volume by 7%, 8% and 19%, respectively, compared to untreated trees. Similarly, second-year sites saw a marked improvement in height (10%), diameter (10%) and volume (28%) compared to its previous years growth.

In 2007, the prediction is for a warm and dry weather at least through June. Based on experience over the past 8 years, if this prediction holds true, we should see generally similar tip moth populations and damage levels compared to 2006. Therefore, it is proposed that we continue the establishment of five new sites (per member) in 2007 and 2008 and continue the analysis of data already obtained to determine the effects of tip moth attacks on tree growth.

Research Approach: Most participating company/organization has established one or more impact sites from 2001 to 2006. We are asking that each member establish five new sites during each of the next two years 2007 & 2008). All sites 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 established in each block. Each plot contains 126 trees (9 rows X 14 columns at approximately 6 ft X 9 ft spacing; see below). The treatments include:

1) a check (standard company practices, i.e., site prep., herbicide, and fertilizer)
2) standard practices plus tip moth control applied at recommended times before each tip moth generation for the first **2 years** after planting.



Insecticides (Mimic® and/or Pounce®) will be applied on first- and second-year sites by backpack sprayer at label rates (0.6 ml / liter of water = 2.4 ml / gal) during the optimal spray period for each tip moth generation based on Fettig's (et al. 2003) recommendation for the location closest to each study site.

Tip moth damage 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 6 inches) will be measured at the end of the growing season on first- and second-year sites (established in 2007 and 2006, respectively); tree height, diameter (at breast height (DBH)), and form will be measured after year 3 (2005), and 5 (2003). In the future, tree height and DBH, and form will be measured after year 8 and year 12.

Tree form will be determined using the method of Berisford and Kulman (1967). Four form classes, based on the number of forks present per tree, 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).

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

Research Time Line:

January - February 2007

- Locate and establish new plots.

March - September 2007

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

October - November 2007

- 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 2007 - January 2008

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

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PINE TIP MOTH

Hazard Rating Study
(Continued from 2001 - 2006)

Objectives: 1) Establish new plots to validate the tip moth hazard-rating model, 2) complete data collections on sites established in 2006, 3) continue development of regression models using stand characteristics and other abiotic factors to predict future levels of tip moth damage, and 4) identify factors which may facilitate hazard rating of stands for tip moth damage.

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 six years (2001 – 2006), we have established and monitored 105 hazard-rating plots across the Western Gulf Region. A hazard-rating model, developed by Andy Burrow, indicates that site index and soil texture composition are the two primary factors that influence the occurrence and severity of tip moth damage. We propose that five additional plots be established by each member during each of the next two years (2007 & 2008) to validate the new hazard-rating model.

Research Approach:

From 2001 to 2006, 105 hazard-rating plots were established across the Western Gulf Region, many in association with the Impact Study. Each hazard-rating plot has/will be evaluated in the 1st and 2nd year after establishment, so the 29 plots established in 2006 need to be monitored in 2007. Based on the two factors identified to date to influence tip moth (site index and % sand), members are asked to select at least one site that represents one of the four factor combinations (< 65 site index and > 30% sand, < 65 site index and < 30% sand, > 65 site index and > 30% sand & > 65 site index and < 30% sand. The 50-tree plot should be situated in an area that is generally representative of the stand. A single plot can be established in a plantation block if the soil, topography and site index are similar across the block. Do not locate plots too near swamps, cypress domes, rocky outcrops, drainage ditches, etc. However, if these characteristics are variable across the block, then two or more plots can be established in a block. For example: 1) one plot can be on a flat area and another on a "steep" slope or 2) one plot can be on a well-drained area and another on a poorly-drained area, etc.

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

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

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

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

One or more plots of 50 trees (5 X 10) each will be established at each site. **Note:** As mentioned above, the Impact study check plots can serve as Hazard Rating plots. The sample trees will be assessed for:

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

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

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

Research Time Line:

January - February 2007

- Work with participating WGFPMC members to identify and receive all missing data from previously established hazard rating plots (2001 – 2006) (Grosman).
- Select and establish new sites based on target characteristics.

March - July 2007

- Evaluate tip moth damage after 1st and 2nd generations on first- and second-year sites; conduct competing vegetation assessment; photograph damage.

August – October 2007

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

November - December 2007

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

January 2008

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

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PINE TIP MOTH

Fipronil Control Evaluation Studies
(DISCONTINUE)

Objectives: The objectives had been to evaluate the efficacy of fipronil for reducing tip moth damage on loblolly pine seedlings; and determine the duration of treatment efficacy.

Justification: Several field trials were initiated in 2002, 2003, 2004, 2005 and 2006 to evaluate the efficacy of fipronil, applied by various techniques and rates, for reducing tip moth damage on loblolly pine seedlings. The results from all trials indicate that fipronil is highly effective in reducing tip moth damage through the first year, in many cases, well into the second year, and a few cases, through most or all of the third year. Several trials also show that plant hole and soil injection treatments at or post planting are effective techniques of application. Further efforts to monitor small recently established trials are not warranted. Given the anticipated registration of fipronil by EPA, perhaps by fall 2007, future efforts should focus on 1) operational techniques of fipronil application by hand or machine planter, 2) evaluating the efficacy of fipronil when applied to containerized seedlings, and 3) confirm efficacy of the recently-registered SilvaShield (imidacloprid + fertilizer) tablet.

PINE TIP MOTH

Fipronil Operational Soil Injection Study
(Continued from 2006)

Cooperators

Ms. Valerie Sawyer,	Weyerhaeuser Co., Columbus, MS
Mr. Randy Winston	Private landowner, Lufkin, TX
Ms. Lou Ann Miller	Private landowner, Nacogdoches, TX
Mr. Jim Rogers & Lane Day	Precision Machine Services, Lufkin, TX
Mr. Justin Penick	Acorn Operational Services, Lufkin, TX
Dr. Harold Quicke	BASF, Auburn, AL

Objective: 1) Determine the efficacy of fipronil in reducing pine tip moth infestation levels on loblolly pine seedlings; 2) evaluate this product applied via soil injection by hand or machine planter; and 3) determine the duration of protection provided by this insecticide application.

Justification: The Technique and Rate Trials (2003 –2005) showed that fipronil (Regent®) applied in plant holes at planting or soil injection post planting was effective in reducing potential tip moth damage on several study sites during the first two years after planting. Also, the first Operational Planting Trial (2003 – 2005) showed that planting large areas with fipronil-treated seedlings deters tip moth from colonizing new plantations, subsequently populations are kept low within the treated area. Machine planter and hand systems can be used to apply fipronil solution at or after planting, respectively. The efficacy of fipronil applied via soil injection by machine planter or hand in reducing pine tip moth infestation levels on loblolly pine seedlings needs to be determined.

Research Approach:

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

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

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

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

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

To further evaluate the effects of treatment on tip moth damage levels, an internal randomized block design, with quarter plots as blocks, was used. At each site, 4 – 0.5 acre plots were established. Each treatment was randomly assigned to one of the four internal plots in each main treatment plot quarter (Figure 1).

For sites 2 & 3, the study design was modified to focus on fipronil treatments applied by machine planting. A C&G planter (owned by Acorn Outdoor Services, Lufkin, TX) was fitted with a 50-gallon tank, electrical pump, tubing and valves (designed by Lane Day and Jim Rogers, Precision Machine Services, Lufkin, TX). At each site, 4 replicates of 4 – 0.5 acre plots (16 plots total) were established (Figure 2). On 4 preselected plots, the fitted machine planter injected fipronil solution (0.3% ai in 37 ml volume) into the soil as each seedling was placed in the planting furrow. In all other plots, seedlings were machine planted at the same spacing. Afterward, in 4 plots each, seedlings were treated with fipronil by hand using a Kioritz soil injector or with a foliar spray (5x). Additional sites will be established in January 2007 and later in the fall (October – December 2007).

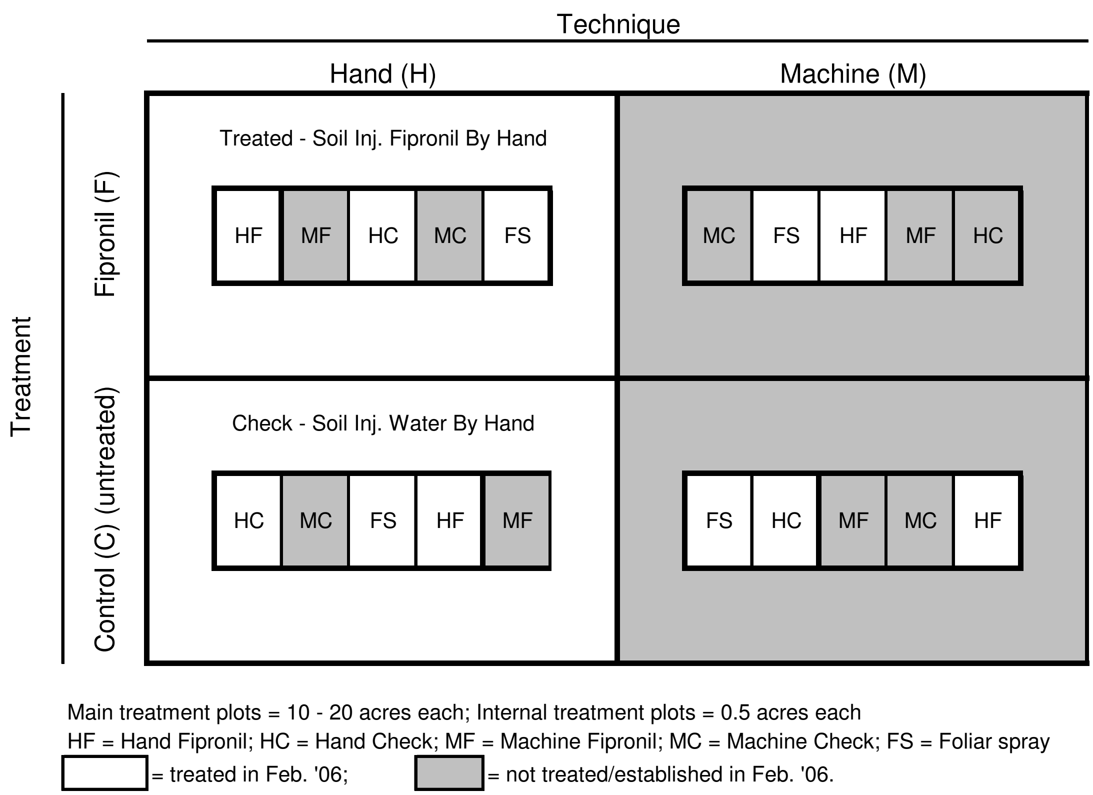
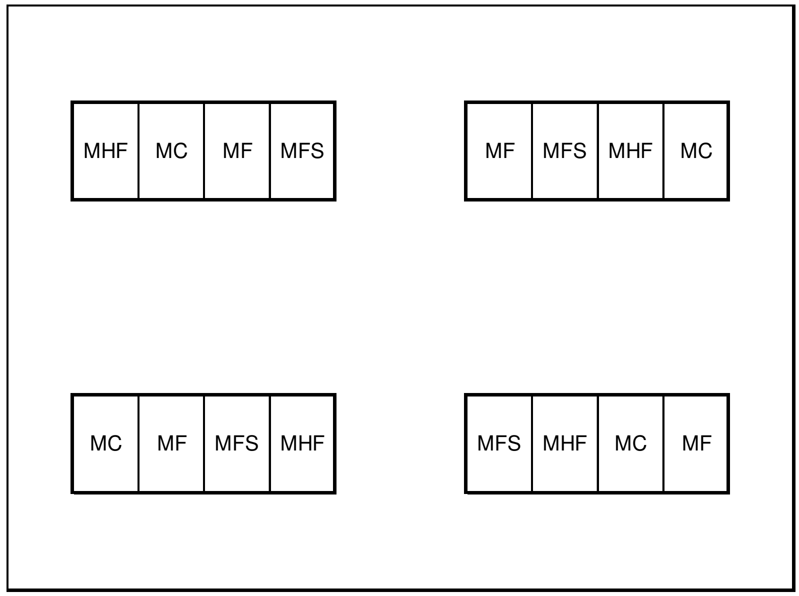


Figure 1. Generalized Plot Design for Arkansas site established in February 2006.



Site = 40 - 50 acres each; Internal treatment plots = 0.5 acres each

MF = Machine Fipronil; MC = Macine Check; MHF = Machine Hand Fipronil; MFS = Machine Foliar spray

Figure 2. Generalized Plot Design for two Texas sites established in December 2006.

Treatments:
Site 1:

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

Site 2 & 3

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

Site 1: Ten 10-tree plots will be spaced equally within each plantation quarter (but outside the internal treatment plots) to evaluate tip moth damage levels in this area. Sites 1 –3: A 50-tree plot will be positioned within each internal treatment plot to evaluate tip moth damage levels in this area. All stands will be treated with herbicide after planting to minimize herbaceous and/or woody competition.

Tip moth populations will be monitored weekly at each site using at least three Phericon® 1C traps with Trece® septa lures. Tip moth damage will be evaluated for all three trials after each tip moth generation (3-4 weeks after peak moth flight) by 1) identifying if the tree is infested or not, 2) if infested, the proportion of tips infested on the top whorl and terminal will be calculated; and 3) separately, the terminal will be identified as infested or not. Observations also will be made as to the occurrence and extent of damage caused by other insects, i.e., coneworm, aphids, sawfly, etc. Each tree will be measured for diameter and height and ranked as to form in the fall (November) following planting. Form ranking of the seedling or tree will be categorized as follows: 0 = no forks; 1 = one fork; 2 = two to four forks; 3 = five or more forks. A fork is defined as a node with one or more laterals larger than one half the diameter of the main stem (Berisford and Kulman 1967). Data will be analyzed by GLM and the Fisher's Protected LSD test using Statview or SAS statistical programs.

Project Support: Weyerhaeuser and BASF will provide extra funds toward the rental and fitting of a machine planter with application equipment. BASF is donating chemical product. The remainder of the project will be funded by a Forest Service Pesticide Impact Assessment Program grant and WGFPMC funds.

Research Time Line:

CY2007

<u>January - February 2007</u>

- Select research sites.
- Fit machine planter with injection equipment
- Lift, plant and treat seedlings in plantation sites
- Begin trap monitoring of tip moth populations near each site
- Apply foliar spray to appropriate plots prior to 1st generation

<u>March - October, 2007</u>

- Apply foliar spray to appropriate plots prior to each of generations 2 - 5.
- Evaluate tip moth damage after 1st through 4th generations; photograph damage.

<u>November - December 2007</u>

- Evaluate tip moth damage after 5th generations; measure diameter and height of seedlings.
- Select research sites.
- Fit machine planter with injection equipment
- Lift, plant and treat seedlings in plantation sites
- Conduct statistical analysis of 2007 data.
- Prepare and submit report to FSPIAP sponsor, WGFPMC Executive Committee, BASF.
- Present results at annual Entomological Society of America meeting.

CY2008 (if warranted based on results from 2007)

<u>January - February 2008</u>

- Select research sites.
- Fit machine planter with injection equipment
- Lift, plant and treat seedlings in plantation sites
- Begin trap monitoring of tip moth populations near each site

- Apply foliar spray to appropriate plots prior to 1st generation

March - October, 2008

- Apply foliar spray to appropriate plots prior to each of generations 2 - 5.
- Evaluate tip moth damage after 1st through 4th generations; photograph damage.

November - December 2008

- Evaluate tip moth damage after 5th generations; measure diameter and height of seedlings.
- Select research sites.
- Fit machine planter with injection equipment
- Lift, plant and treat seedlings in plantation sites
- Conduct statistical analysis of 2008 data.
- Prepare and submit report to FSPIAP sponsor, WGFPMC Executive Committee, BASF.
- Present results at annual Entomological Society of America meeting.

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PINE TIP MOTH

Evaluation of Fipronil Treatments for Containerized Pine Seedlings (To be Initiated in 2007)

Cooperators

Mr. James Tule	Temple Inland Forest Products, Jasper, TX
Dr. Harold Quicke	BASF, Auburn, AL

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

Justification

Several recent trials (2003 - 2005) have shown that fipronil applied to bare root seedlings before or after planting is highly effective in reducing tip moth damage for 2+ years. Operationally, it also is desirable to apply chemical solutions to containerized seedlings because of their higher value and there is less restriction on the amount of active ingredient that could be applied to each seedling. A trial will be established to determine the efficacy of fipronil applied at different rates to containerized seedling.

Research Approach:

A two families of loblolly pine containerized and bare-root seedlings will be selected at the Temple Inland Nursery, Jasper, TX.

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

1 =	Containerized Fipronil (1X - 3 ml/seedling) -	Injection into cell in July
2 =	Containerized Fipronil (5X - 15 ml/seedling) -	Injection into cell in July
3 =.	Containerized Single Pounce® Foliar -	Pounce® applied (2qts/100K) 1X/ seedling
4 =	Containerized Check (untreated)	
5 =	Bare Root Fipronil (3 ml/seedling) -	Soil injection next to transplant in Nov.
6 =.	Bare Root Single Pounce® Foliar -	Pounce® applied (2qts/100K) 1X/ seedling
7 =	Bare Root Check (untreated)	Resident seedling

Containerized seedlings will be individually treated using a small syringe in July 2006. The seedlings will be treated at 1X and 5X the rate designated for transplanted bare root seedlings (1X = 0.13 lbs AI/acre/year = 0.118 g AI/seedling at 500 seedlings/acre). All bare root seedlings will be operationally lifted by machine in March 2007, culled of small and large caliper seedlings, treated with Terrasorb™ root coating, bagged and stored briefly in cold storage. Each family will be planted on each of two plantation sites. At each site, treatments will be randomly assigned to 1 of 7 plot areas. One hundred seedlings will be planted per plot at 9’ X 10’ (?) spacing (500 TPA) (see layout below).

Treatment Evaluation: Tip moth damage will be evaluated on 50 internal trees within each plot after each tip moth generation (3-4 weeks after peak moth flight) by 1) identifying if the tree was infested or not, 2) if infested, the proportion of tips infested on the top whorl and terminal will be calculated; and 3) separately, the terminal will be identified as infested or not. Observations also will be made as to the occurrence and extent of damage caused by other insects, i.e., aphids, weevils, coneworm, etc. The trees will be measured for diameter and height (at 6") in the fall (November) following planting. Data will be analyzed by GLM and the Tukey's Compromise test using Statview or SAS statistical programs.

Research Time Line:

CY 2006

July 2006

- Treat containerized seedling cells with fipronil

CY 2007

March 2007

- Select research sites
- Lift and plant all seedlings in plantation sites
- Treat bare root seedlings after planting with fipronil via soil injection
- Begin trap monitoring of tip moth populations near each site

May - October, 2007

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

November - December 2007

- Evaluate tip moth damage after 5th generations; measure seedling and height of seedlings.
- Conduct statistical analysis of 2007 data.
- Prepare and submit report to WGFPMC Executive Committee, BASF.

CY 2008 & 2009 (if warranted based on results from 2007 & 2008)

January - February 2008 & 2009

- Begin trap monitoring of tip moth populations near each site

March - October, 2008 & 2009

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

November - December 2008 & 2009

- Evaluate tip moth damage after 5th generations; measure seedling and height of seedlings.
- Conduct statistical analysis of 2008 (and 2009) data.
- Prepare and submit report to WGFPMC Executive Committee, BASF.

PINE TIP MOTH

Imidacloprid Tablet Trial
(To Be Initiated in 2007)

Cooperators

Ms. Valerie Sawyer,	Weyerhaeuser Co., Columbus, MS
Mr. Bob Cassell	Hancock Forest Management, Silsbee, TX
Nick Chappell	Potlatch Forest Holdings, Warren, AR
Conner Fristoe	Plum Creek Timber Co., Crossett, AR
Mr. Nate Royalty	Bayer Environmental Science, Research Triangle Park, NC
Mrs. Anne Thurston	Bayer Environmental Science, Waco, TX

Objectives: 1) Evaluate the efficacy of imidacloprid in reducing pine tip moth infestation levels on loblolly pine seedlings; 2) evaluate this chemical applied by tablet at different rates to transplanted seedlings; and 3) determine the duration of chemical activity.

Justification

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

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

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

In January 2007, Bayer announced that the label for the FXT Ball formulation had been approved by EPA and that registrations in TN, AR, MS, FL, SC & WV have been approved and expected soon NC, GA, TX, AL, and VA. We are interested in further evaluating the efficacy of these tablets in the Western Gulf region.

Research Approach:

In 2007, a single family (Advanced Generation) of loblolly pine bare-root seedlings will be selected at the TFS Indian Mounds Nursery, Alto, TX (or member nursery if available). All seedlings will be operationally lifted by machine in February 2007, culled of small and large caliper seedlings, treated with Terrasorb™ root coating, bagged and stored briefly in cold storage.

Fifty seedlings for each treatment (A – D, see below) will be planted (standard spacing depending on member) on each of six second-year plantation sites – to ensure a high level of tip moth pressure on the treatment trees. Treatments E & F will be added at two of the six sites. At each site, resident trees will be removed and replaced with treatment trees. A randomized complete block design will be used at each site with beds or site areas serving as blocks, i.e., each treatment will be randomly selected for placement along a bed. Ten seedlings from each treatment will be planted on each of five beds. Treatments A, E & F will be applied as the seedling is planted. Just after seedling transplant, one tablet (Treatment B) will be pushed into the soil 6 cm deep and 4 cm from each assigned seedling or poured onto the surface of the ground around each seedling. For treatment C, a Mimic foliar spray will be applied by backpack sprayer to each seedling 4 – 5 times per season based on location and recommendations of Fettig et al. (2003).

Treatments and Layout on 4 sites

Code	Treatment	Color
A	20% FXT Ball tablet in plant hole at planting	pink
B	20% FXT Ball tablet in soil next to seedling after planting	green
C	Foliar application (5X) of pine seedlings with Mimic 2LV (0.6ml / 1 water)	orange
D	Check (lift and plant bare root seedlings)	red

Bed 1	Bed 2	Bed 3	Bed 4	Bed 5
C	D	A	B	B
B	B	D	A	C
A	A	C	C	D
D	C	B	D	A

Treatments and Layout on 2 site

Code	Treatment	Color
A	20% FXT Ball tablet in plant hole at planting	pink
B	20% FXT Ball tablet in soil next to seedling after planting	green
C	Foliar application (5X) of pine seedlings with Mimic 2LV (0.6ml / 1 water)	orange
D	Check (lift and plant bare root seedlings)	red
E	15% FXT Ball tablet in plant hole at planting	yellow
F	10% FXT Ball tablet in plant hole at planting	blue

Bed 1	Bed 2	Bed 3	Bed 4	Bed 5
F	D	E	A	B
C	B	A	D	E
E	A	D	B	F
B	C	C	F	C
A	F	B	C	D
D	E	F	E	A

Treatment Evaluation: Tip moth damage will be evaluated after each tip moth generation (3-4 weeks after peak moth flight) by 1) identifying if the tree was infested or not, 2) if infested, the proportion of tips infested on the top whorl and terminal will be calculated; and 3) separately, the terminal will be identified as infested or not. Observations also will be made as to the occurrence and extent of damage caused by other insects, i.e., aphids, weevils, coneworm, etc. Second-year trees will be measured for diameter and height (at 6”) in the fall (November) following planting. If warranted, third-year trees will be measured for height and diameter (at DBH) and ranked for form. Form ranking of the seedling or tree will be categorized as follows: 0 = no forks; 1 = one fork; 2 = two to four forks; 3 = five or more forks. A fork is defined as a node with one or more laterals larger than one half the diameter of the main stem (Berisford and Kulman 1967). Data will be analyzed by GLM and the Fisher's Protected LSD test using Statview or SAS statistical programs.

Research Time Line:

CY 2007

January - February 2007

- Select research sites
- Lift, plant and treat seedlings in plantation sites
- Begin trap monitoring of tip moth populations near each site

March - October, 2007

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

November - December 2007

- Evaluate tip moth damage after 5th generations; measure seedling and height of seedlings.
- Conduct statistical analysis of 2007 data.
- Prepare and submit report to Bayer Environmental Science, WGFPMC Executive Committee.
- Present results at annual Entomological Society of America meeting.

CY 2008 (if warranted based on CY 2007 results)

January - February 2008

- Begin trap monitoring of tip moth populations near each site

March - October, 2008

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

November - December 2008

- Evaluate tip moth damage after 5th generations; measure seedling and height of seedlings.
- Conduct statistical analysis of 2008 data.
- Prepare and submit report to Environmental Science, WGFPMC Executive Committee.
- Present results at annual Entomological Society of America meeting.

Reference:

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

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

Western Gulf Forest Pest Management Cooperative
Activity Time Line - CY2007

January

- Contact and meet with WGFPMC members to identify suitable tip moth sites; gather information on management plans for each site.
- Deploy pheromone traps for tip moth impact, hazard rating, and control (fipronil) studies.
- Monitor tip moth populations and rainfall for tip moth studies.

February

- Machine plant for Operational Soil Injection Trial.
- Establish new tip moth research plots.
- Monitor tip moth populations and rainfall for tip moth studies.
- Begin development of leaf-cutting ant bait

March

- Treat selected tip moth impact plots with insecticides.
- Monitor tip moth populations and rainfall for tip moth studies.
- Make selection of study sites and trees for Bark Beetle and Seed Bug Injection studies.
- Test preference of leaf-cutting ants to bait formulations.
- Treat study trees with injection treatments for Seed Bug Injection Study.
- Evaluate tree injection systems.

April

- Flag 6-10 branches/tree and record number of conelets and cones on all treatment and check trees for Injection Trial at each seed orchard.
- Collect site information and soil samples and conduct vegetation evaluation for hazard rating study.
- Monitor tip moth populations and rainfall for tip moth studies.
- Treat study trees with standard foliar treatment for Seed Orchard Injection Studies.
- Begin treatment of leaf-cutting ant colonies for efficacy of bait formulations.

May

- Evaluate tip moth damage after 1st generation for all tip moth studies; photograph damage.
- Treat study trees with standard foliar treatment for Seed Orchard Injection Studies.
- Treat selected tip moth impact plots with insecticides.
- Fell trees, deploy bolts, traps and bark beetle pheromones for Injection System Injection Trial.
- Monitor tip moth populations and rainfall for tip moth studies.
- Continue treatment of leaf-cutting ant colonies for efficacy of bait formulations.

June

- Treat study trees with standard foliar treatment for Seed Orchard Injection Studies.
- Fell trees, collect tissue samples, deploy bolts, traps and bark beetle pheromones for *Ips* Bark Beetle Injection Study.
- Retrieve and evaluate bolts for Injection System Injection Trial.
- Evaluate tip moth damage after 2nd generation for all tip moth studies; conduct competing vegetation assessment for hazard rating study; photograph damage.
- Monitor tip moth populations and rainfall for tip moth studies.
- Evaluate leaf-cutting ant activity.

Western Gulf Forest Pest Management Cooperative
Activity Time Line - CY2007

July
- Treat study trees with standard foliar treatment for Seed Orchard Injection Studies.
- Retrieve and evaluate bolts for *Ips* Bark Beetle Injection Study.
- Treat selected tip moth impact plots with insecticides.
- Monitor tip moth populations and rainfall for tip moth studies.

August
- Evaluate tip moth damage after 3rd generation for all tip moth studies; photograph damage.
- Treat study trees with standard foliar treatment for Seed Orchard Injection Studies.
- Treat selected tip moth impact plots with insecticides.
- Monitor tip moth populations and rainfall for tip moth studies.
- Evaluate slash pine conelet and cone survival on flagged branches (late August).

September
- Evaluate loblolly pine conelet and cone survival on flagged branches (early September).
- Evaluate tip moth damage after 4th generation for all tip moth studies; photograph damage.
- Monitor tip moth populations and rainfall for tip moth studies.
- Collect all cones from sample trees for Pine Seed Orchard studies.

October
- Treat selected tip moth impact plots with insecticides.
- Evaluate coneworm damage for Pine Seed Orchard studies.
- Monitor tip moth populations and rainfall for tip moth studies.

November
- Evaluate tip moth damage and tree form after last generation for all tip moth studies; collect tree height and diameter measurements; photograph damage.
- Conduct vegetation evaluation for hazard rating study.
- Monitor tip moth populations and rainfall for tip moth studies.

December
- Extract, radiograph and evaluate seed samples for Seed Orchard studies.
- Conduct statistical analyses of 2007 data.
- Prepare and submit reports to WGFPMC Executive Committee, Syngenta Crop Protection, Inc, and Bayer Cropscience, and BASF Co.
- Present results at annual Entomological Society of America meeting.
- Monitor tip moth populations and rainfall for tip moth studies.
- Take a few days off to celebrate Christmas.

2007 Proposed Budget

The proposed budget for CY 2006 totals $211,803 (Table 1). The proposed budget includes an increase of $4,782 for system-mandated raises for salary and wage employees. Monies budgeted for operating expenses increased $6,429 primarily in response to rising fuel costs. One member was lost at the end of CY2006 but two were gained and dues were increased for the first time in five years. Therefore, current membership dues ($69,000) plus $1,000 for seed analysis work for WGTIP will provide $70,000 (33%). An additional $86,100 (41%) is available from BASF, Syngenta, Bayer and Fort Dodge gifts ($24,268), and funds available from SPBI (injection) and FSPIAP (fipronil) grants. The remaining (26%) will be borne by the Texas Forest Service and any new members that join during the year (Figure 3). The addition of a new member(s) to the WGFPMC will serve to reduce the TFS contribution to the WGFPMC. A summary by project or activity for CY 2006 is given in Table 2.

2008 Proposed Budget

A proposed budget for CY 2008 is given in Table 3 by source of funding. A total of $214,479 is proposed for CY 2008. No dues increase is anticipated. Assuming that membership stays at 7 full members and one associate member in 2007, $70,000 (33%) would be provided by the increased membership dues and anticipated funds from WGTIP for seed analysis. Even with this proposed dues increase, 67% of the budget 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 2008 is given in Table 4. We anticipate that one or more small projects will terminate at the end of CY 2007, allowing the funding of one new applied research or technology transfer project in CY 2008.

Table 1. WGFPMC Proposed Budget by Source of Funding - CY 2007

	Source			% of
	WGFPMC	TFS and Others*	Total	Total
A. Salaries and Wages				
Principal Investigator (Grosman) (100%)	$ 17,974 (30%)	$ 41,939 (70%)	$ 59,913 **	
Research Specialist (Helvey) (100%)	9,962 (30%)	23,245 (70%)	33,207 **	
Staff Forester (Upton) (75%)	12,853 (30%)	19,280 (45%)	32,133 **	
SPB Specialist (Murphrey) (9%)	3,616 (9%)		3,616 **	
2 Seasonal Technician (4.5 mo.)		19,980	19,980	
Total Salaries and Wages	$ 44,405	$ 104,444	$ 148,849	
B. Fringe Benefits (26% of Salaries &	$ 11,545	$ 23,559	$ 35,104	
8% of Wages)	55,950	128,003	183,953	87%
C. Operating Expenses				
Supplies	$ 3,861	$ 3,000	$ 6,861	
Vehicle Use and Maintainance	4,000	4,000	8,000	
Travel	3,200	3,300	6,500	
Telecommunications (15% of PCS)	500	100	600	
Utilities (15% of PCS)	0	1,200	1,200	
Other Services (rentals, publications, postage, etc.)	2,489	2,200	4,689	
Total Operating Expenses	$ 14,050	$ 13,800	$ 27,850	13%
Grand Total	$ 70,000 ***	$ 141,803	$ 211,803	
% of Total	33%	67%	100%	100%

* includes $86,100 remaining from 2005 and 2006 grants and gifts and any new members or federal grants.

** includes 3% salary increase

*** member dues at $9,000/yr for seven members; $3,000/yr for two members, and $1,000 for WGTIP seed analysis. = $70,000

Table 2. WGFPMC Proposed Budget by Source of Project - CY 2007

	Activity					
	Administration	Tip Moth Studies		Systemic	LCA or Other	
	Site Visits/Service	(Impact & HR)	(Systemic Trt)	Injection Studies	Study	Total
A. Salaries and Wages						
Entomologist III (100%)	$ 23,965 (40%)	$ 8,987 (15%)	$ 8,987 (15%)	$ 8,987 (15%)	$ 8,987 (15%)	$ 59,913
Research Specialist (100%)	0	13,283 (40%)	13,283 (40%)	3,320 (10%)	3,321 (10%)	33,207
Staff Forester (75%)	0	4,284 (10%)	4,284 (10%)	12,854 (30%)	10,711 (25%)	32,133
SPB Specialist (9%)	0			3,616 (9%)		3,616
2 Seasonal Technician (4.5 mos.)	0	4,995 (25%)	6,993 (35%)	5,994 (30%)	1,998 (10%)	19,980
B. Fringe Benefits (26% of Salaries & 8% of Wages)	$ 6,231	$ 7,304	$ 7,463	$ 7,962	$ 6,145	$ 35,104
C. Operating Expenses						
Travel and Vehicle Use	$ 3,200	$ 2,200	$ 3,200	$ 3,200	$ 2,700	$ 14,500
Supplies & Postage	3,461	1,100	1,100	1,100	1,100	7,861
Other Operating Expenses	1,112	1,000	1,427	1,000	950	5,489
Grand Total	$ 37,969	$ 43,153	$ 46,737	$ 48,033	$ 35,912	$ 211,803

Table 3. WGFPMC Proposed Budget by Source of Funding - CY 2008

		Source			% of
		WGFPMC	TFS and Others*	Total	Total
A.	**Salaries and Wages**				
	Principal Investigator (Grosman) (100%)	$ 17,974 (30%)	$ 41,939 (70%)	$ 59,913	
	Research Specialist (Helvey) (100%)	9,962 (30%)	23,245 (70%)	33,207	
	Staff Forester (Upton) (75%)	12,853 (30%)	19,280 (45%)	32,133	
	SPB Specialist (Murphrey) (9%)	3,616 (9%)		3,616	
	2 Seasonal Technician (4.5 mo.)		19,980	19,980	
	Total Salaries and Wages	$ 44,405	$ 104,444	$ 148,849	
B.	**Fringe Benefits (26% of Salaries &**	$ 11,545	$ 23,559	$ 35,104	
	8% of Wages)	55,950	128,003	183,953	86%
C.	**Operating Expenses**				
	Supplies	$ 3,861	$ 3,139	$ 7,000	
	Vehicle Use and Maintainance	4,000	5,000	9,000	
	Travel	3,200	3,800	7,000	
	Telecommunications (15% of PCS)	500	114	614	
	Utilities (15% of PCS)	0	1,300	1,300	
	Other Services (rentals, publications, postage, etc.)	2,489	3,123	5,612	
	Total Operating Expenses	$ 14,050	$ 16,476	$ 30,526	14%
	Grand Total	$ 70,000 **	$ 144,479	$ 214,479	
	% of Total	33%	67%	100%	100%

* includes $25,000 FSPIAP grant and any new members or federal grants.

** member dues at $9,000/yr for seven members; $3,000/yr for two members, and $1,000 for WGTIP seed analysis. = $70,000

Table 4. WGFPMC Proposed Budget by Source of Project - CY 2008

	Activity					
	Administration Site Visits/Service	Tip Moth Studies (Impact & HR)	Tip Moth Studies (Systemic Trt)	Systemic Injection Studies	LCA or Other Study	Total
A. Salaries and Wages						
Entomologist III (100%)	$ 23,965 (40%)	$ 8,987 (15%)	$ 8,987 (15%)	$ 8,987 (15%)	$ 8,987 (15%)	$ 59,913
Research Specialist (100%)	0	13,283 (40%)	13,283 (40%)	3,320 (10%)	3,321 (10%)	33,207
Staff Forester (75%)	0	4,284 (10%)	4,284 (10%)	12,854 (30%)	10,711 (25%)	32,133
SPB Specialist (9%)	0			3,616 (9%)		3,616
2 Seasonal Technician (4.5 mos.)	0	4,995 (25%)	6,993 (35%)	5,994 (30%)	1,998 (10%)	19,980
B. Fringe Benefits (26% of Salaries & 8% of Wages)	$ 6,231	$ 7,304	$ 7,463	$ 7,962	$ 6,145	$ 35,104
C. Operating Expenses						
Travel and Vehicle Use	$ 3,800	$ 2,700	$ 3,000	$ 3,500	$ 3,000	$ 16,000
Supplies & Postage	3,200	1,250	1,250	1,250	1,250	8,200
Other Operating Expenses	1,111	1,000	2,214	1,000	1,000	6,325
Grand Total	$ 38,307	$ 43,803	$ 47,474	$ 44,867	$ 36,412	$ 214,479

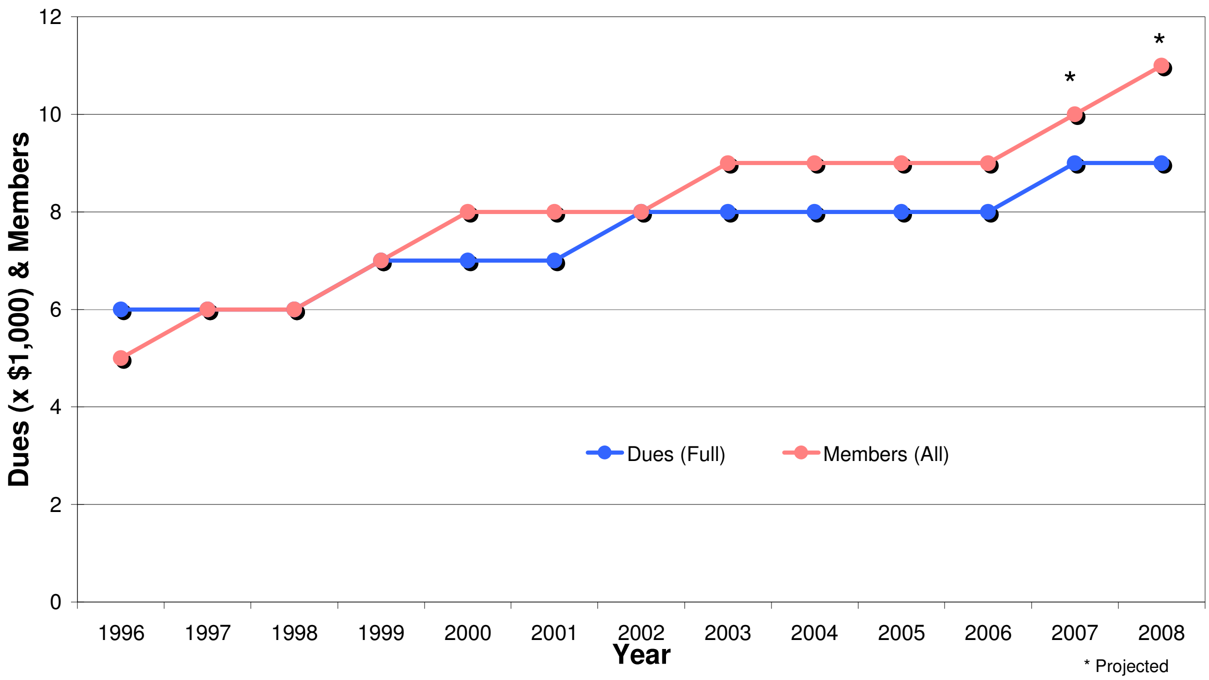

Figure 3. Dues and membership levels in the Western Gulf Forest Pest Management Cooperative from 1996 to 2008 (projected).

WGFPMC Executive and Contact Member Representatives in 2007

FULL MEMBERS

Forest Investment Associates (since 1996)

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Cel:	Cel:
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Hancock Forest Management, Inc. (since 2006)

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Temple-Inland Forest Products Corporation (since 1996)

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WGFPMC Executive and Contact Member Representatives in 2007

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U.S.D.A. Forest Service - Forest Health Protection (since 1998)

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