Western Gulf
Forest Pest Management
Cooperative

2006 Research Project Proposals

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2006 WGFPMC Members:

Anthony Forest Products Company
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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 2006. Results obtained this past year warrant further evaluations in these areas. Two small trials also will be established or continued in 2006 to test the several potential baits for control of Texas leaf-cutting ants and potential of emamectin benzoate and fipronil for wood protection against termites. A third evaluate new systemic insecticides for protection of seed crops against pine seed bugs, and fourth trial to test bifenthrin treatment of pine seedlings for protection against regeneration weevils are presented for consideration in 2007.

Proposed objectives and methods for the systemic injection and tip moth studies in 2006 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, a new study is proposed to further evaluate these new formulations for protection of trees against *Ips* engraver beetles.

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 2006. The first, a cooperative study with Drs. Wayne Berisford, University of Georgia, and 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 prior to 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 - 2005), and soil injection (2005), the refinement study will be expanded in 2006. The Bayer trials (2003 – 2005) 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 several new formulations.

Continuation of these or initiation of other projects will be dependent upon approval by the WGFPMC Executive Committee. Extension of each project into 2007 will depend on the degree of success achieved in 2006 and remaining gaps in knowledge.

LEAF-CUTTING ANT

Leaf-cutting Ant Bait Trial - East Texas
(To Be Initiated in 2006)

Cooperators:

Mr. Ken Brown	Environmental Sensitive Pest Control, Wimberly, TX
Dr. Harold Quicke	BASF, Auburn AL
Ms. Donna Racer	Ambrands, Atlanta, GA
Mr. David Stevens	Dupont Crop Protection, Natchitoches, LA

Objective: Evaluate the efficacy of hydramethylnon/corn grit (Amdro® Ant Block), indoxacarb/corn grit (Advion™ fire ant bait), hydramethylnon/citrus pulp, and/or archaea/citrus pulp bait formulations in halting activity in Texas leaf-cutting ant colonies.

Justification: Currently, there is no safe and effective control option available for control of Texas leaf-cutting ants. Methyl bromide was phased out in 2005 by EPA. The Amdro® leaf-cutting ant bait was marketed by American Cyanamid in the late 1980s to mid-1990s. The bait contained the active ingredient hydramethylnon and an oil on a corn grit carrier. The bait was taken off the market around 1997, due to low sales as a result of dissatisfaction with the bait's performance. 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. A second trial conducted in early spring 2005, found that a single application of this bait did not halt the activity of any of the treated colonies, but did reduce of all colonies by 60% compared to untreated colonies. One reason for the relatively poor efficacy may be that the bait is only moderately attractive to leaf-cutting ants and in the spring it does not compete well with other green vegetation that had flushed. The Amdro bait may prove to be more effective if it is applied in mid-winter when little green vegetation is available. We propose to evaluate the efficacy of the Amdro® Ant Block bait for halting the activity of Texas leaf-cutting ant colonies with a single application applied during mid-winter.

The Grant's and Amdro baits were originally designed for fire ants with regards to an protein-based carrier (corn grit with peanut oil) and bait particle size (2 mm dia). However, these characteristics are not optimal for a leaf-cutting ant bait. Leaf-cutting ants prefer a plant-based carrier, such as citrus pulp. Also, leaf-cutting ant workers tend to be much larger in size and prefer a larger bait particle ($\geq$ 4mm dia.).

Mr. Ken Brown, a local PCO, has recently discovered that Archaea, a bacteria-like organism, are capable of reducing activity in fire ant and leaf-cutting ant colonies. He has offered to mix this microbe with citrus pulp if we agree to test its efficacy in field trials.

BASF owns the rights to hydramethynon, the active ingredient in the Grant's and Amdro fire ant and leaf-cutting ant baits. Harry Quicke has agreed to look into the possibility of developing a leaf-cutting ant bait that combines hydramethylnon with citrus pulp. If such a bait could be made, we plan to test it in preference and field efficacy trials.

Study Sites: Active Texas leaf-cutting ant colonies (40) will be selected in East Texas on lands owned by forest industries and private individuals.

Insecticide:

Hydramethylnon – undectable, slow-acting poison.

Amdro® Ant Block Ant Bait - concentration (0.88% a.i.); corn grit carrier with soybean oil and sugars; packing (tight); color (yellow); size (< 1mm to 4 mm).

BASF Bait – unknown concentration; citrus pulp carrier; packing (tight); color (unknown); size ≥ 4 mm).

Indoxacarb – undectable, slow-acting poison

Advion™ fire ant bait - concentration (0.046% a.i.); corn grit carrier with soybean oil and sugars; packing (tight); color (light yellow); size (< 1mm to 4 mm).

Archaea – bacteria-like organism.

Brown Bait – unknown concentration; citrus pulp carrier; packing (loose); color (unknown); size ≥ 4 mm).

Research Approach:

Amdro® and Advion™ application rates will be based on the Amdro® label recommendation of ¾ lb per colony. A cyclone spreader will be used to evenly spread measured amounts of hydramethylnon bait over the central nest area (CNA). Application rates of other baits remain to be determined.

Bait - Loose bait spread evenly over entire CNA at ¾ lb per colony in February and July 2006.

Check - untreated colonies

Application Dates:

Late Winter 2006: Treatments applied to 10 colonies in January and February.

Summer 2006: Treatments applied to 10 colonies in July and August.

Data Collection: The number of active entrance/exit mounds will be counted prior to treatment and periodically following treatment at 2, 8, and 16 weeks. Ten untreated colonies will be included as checks and monitored 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.

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

Research Time Line:

January - February 2006

- Locate 30 - 40 leaf-cutting ant colonies (January).
- Randomly select and treat colonies (January and February)
- Reevaluate ant activity 2 weeks post treatment

March - April, 2006

- Reevaluate ant activity 8 weeks post treatment.

May – June, 2005

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

July – August, 2006

- Locate 20 - 40 leaf-cutting ant colonies depending on results from the spring trials (July)
- Randomly select and treat colonies (July and August)
- Reevaluate ant activity 2 weeks post treatment

September - October, 2006

- Reevaluate ant activity 8 weeks post treatment.

November - December, 2006

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

SYSTEMIC INSECTICIDE INJECTION TRIALS

Emamectin Benzoate and Fipronil Tree Injections for Cone and Seed Insect Control in Southern and Western Seed Orchards (Continued from 2005)

Cooperators:

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

Objectives: The objectives of this research proposal are to: 1) further evaluate of efficacy of systemic injections of new formulations of emamectin benzoate and fipronil in reducing seed crop losses due to cone and seed insects in loblolly pine, slash pine, Douglas-fir and cherrybark oak seed orchards; and 2) determine the duration of treatment efficacy.

Justification: The WGFPMC Systemic Insecticide Duration and Rate Studies have demonstrated that trunk injections of emamectin benzoate (Arise® or Denim®) alone are effective in reducing coneworm damage by 80% for 6 years and seed bug damage by 34% for 2 years (Grosman et al. 2002, WGFPMC Annual Report 2001, 2002, and 2003). Regression curves indicate that about 0.2 g active ingredient per inch of tree diameter of the emamectin benzoate is necessary to obtain maximum reduction of coneworm- and seed bug damage and provide the greatest gain in cone survival and filled seed per cone. Unfortunately, the Arise® formulation from Japan will not be registered for use in the United States due to the flammability of the carrier (Dave Cox, Syngenta Crop Protection, personal communication) and the current Denim® formulation contains an inert ingredient (organic solvent) that is phytotoxic to phloem tissue upon injection (Grosman, unpublished data).

In 2004, emamectin benzoate (Denim®) was also highly effective in protecting loblolly pine from bark beetle attack (Grosman, unpublished data). Syngenta has expressed a renewed interest in pursuing the registration of emamectin benzoate for tree injection use (Dave Cox, Syngenta Crop Protection, personal communication). An agreement between Syngenta and Arborjet, Inc. resulted in the development of a new "Ava-jet" formulation. Preliminary data from three (2 loblolly and 1 slash) of six orchards indicate that the new emamectin benzoate formulation reduced coneworm damage by 77 - 92% compared to untreated checks.

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). Injections of an experimental EC formulation of fipronil were found to reduce coneworm damage by 80% in the second year after injection (Grosman, unpublished data). The same formulation also was found in 2004 to be highly effective against *Ips* bark beetles. BASF also developed a new formulation for injection use that was tested in 2005. Fipronil was slightly less effective than emamectin benzoate in two orchards (74% and 90%), but markedly less effective (32% reduction) in a third orchard.

With the potential loss of currently-registered foliar insecticides, particularly azinphos methyl, 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 older formulations of emamectin benzoate and fipronil into loblolly pine can significantly reduce coneworm-caused damage. The purpose of this study is to 1) determine the efficacy of newer formulations of emamectin benzoate and fipronil against cone and seed insects in loblolly pine, slash pine, Douglas-fir and cherrybark oak and 2) determine the duration of treatment efficacy.

Research Approach: The study was initiated in 2005 in six seed orchards. Trial replicates were established in orchard blocks containing loblolly pine at Plum Creek's Hebron Orchard (LA) and International Paper's Bellamy Orchard (FL); slash pine at Temple-Inland's Forest Lake Orchard (TX) and Smurfit Stone's Brewton orchard (AL); Douglas-fir at Plum Creek's Cottage Grove orchard (OR); and cherrybark oak at Texas Forest Service's orchard at Hudson (TX). A block was selected in each orchard that had not been sprayed with insecticide for 1 or more years prior to initiation of this experiment. In February 2005, 1-4 ramets from each of 3-10 loblolly/slash/Douglas-fir/live oak clones were selected. The treatments are being evaluated using the experimental design protocol described by Gary DeBarr (1978) (i.e., randomized complete block with clones as blocks). The treatments include:

1) Emamectin benzoate (0.2 – 0.8 g AI per inch DBH of tree)
2) Fipronil (0.2 – 0.8 g AI per inch DBH of tree)
3) 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.
4) Check

Injection treatments were applied in March (slash) or April (loblolly, Douglas-fir and live oak) 2005 using the Arborjet Tree IV™ microinfusion system (Arborjet, Inc. Woburn, MA, http://www.arborjet.com/). Each treatment was injected into four or more cardinal points (depending on tree diameter) about 0.3 m above the ground. The rate was dependent on tree diameter: 0.2g AI/inch DBH in trees <12"DBH, 0.4g AI/DBH" in trees 12-23"DBH, 0.6g AI /DBH" in trees 24-35"DBH and 0.8g/DBH" in trees >36"DBH.

Treatment 3 (Capture®, Asana® XL, Guthion®, or Imidan® standard) will be applied to foliage beginning in March or April 2006 using a hydraulic sprayer from a bucket truck (if necessary) at 10 gal/tree. The distance between test trees will be ≥20 m to minimize the effects of drift. **Note:** Where hydraulic spray equipment is not available at an orchard, a rough comparison of treatment efficacy on injected trees is made to operationally sprayed trees in another block.

Conelet and/or cone survival will be evaluated in 2006 by tagging 6 to 10 branches on each tree (50 conelets and 50 cones, if possible) in early April. Counts of surviving conelets and/or cones from these branches will be made in August (slash) or September (loblolly and Douglas-fir) of each year. Conelet survival generally reflects protection from seed bugs, while cone survival is a measure of protection from coneworms. Coneworm damage will be evaluated by collecting all cones present from each tree in August (slash) or September (loblolly and Douglas-fir) of 2006. From the samples, counts will be made of healthy and coneworm-, midge-, and/or thrip-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.

Acorn collections will begin in early September when acorns begin dropping from sample trees. Twenty-five acorns will be randomly collected weekly from the ground within 2 m from the tree trunk. Collections will continue until acorn drop ceases (usually early December). After each collection, all acorns will be dried for 24 hrs, counted and evaluated for weevil damage. Acorns will be initially divided into three categories: 1) Acorns with weevil oviposition sites <u>and</u> larvae emergence holes, 2) acorns with weevil oviposition site(s) only, and 3) clean healthy acorns. Acorns with oviposition sites only will be further evaluated by splitting each acorn in half at the oviposition site. The interior of each half will be evaluated for the presence of weevil larvae and/or feeding damage in excess of 5% of the acorn meat.

Data will be 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 in part by a gift provided by Syngenta and by WGFPMC funds.

Research Time Line:

<u>January - April 2006</u>

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

<u>May - August, 2006</u>

- Treat study trees with standard (Capture®, Asana®XL, Guthion®, or Imidan®) foliar treatment (May, June, July, August) in conifer orchards
- Evaluate slash conelet and cone survival on flagged branches (late August).
- Collect all slash cones from sample trees for evaluation of coneworm, seed bug and flower thrip damage levels (late August).

<u>September - December 2006</u>

- Conduct weekly acorn collections from under sample trees for evaluation of acorn weevil damage levels (early September - December).
- Evaluate loblolly and Douglas-fir conelet and/or cone survival on flagged branches (late September).

- Collect all loblolly and Douglas-fir cones from sample trees for evaluation of coneworm, midge, thrips and/or seed bug damage levels (late September).
- Cleaning and radiographic analysis of loblolly, slash and Douglas-fir seed lots (October – December).
- Conduct statistical analyses of data.
- Prepare and submit report to WGFPMC, WGTIP, NCSTIP, CFGRP, Syngenta Crop Protection, Inc. and BASF

Literature Cited:

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

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

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

Grosman, D.M., W.W. Upton, F.A. McCook, and R.F. Billings. 2002. Systemic Insecticide Injections for Control of Cone and Seed Insects in Loblolly Pine Seed Orchards – 2 Year Results. So. J. Appl. For. 26: 146-152.

SYSTEMIC INSECTICIDE INJECTION TRIALS

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 new formulations of emamectin benzoate at different rates in reducing success of pine engraver beetles attacks on loblolly pine bolts

Justification: 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 after tree injection (see 2005 Accomplishment Report). It is unknown if the activity of the new emamectin benzoate formulation will extend into the second or third year after injection. This study will evaluate the duration of efficacy of the new formulations of emamectin benzoate applied at different rates against *Ips* engraver beetles.

Treatments:

	Formulation	Rate (g ai/DBH")	Volume	Application Method
1)	EB 05	0.2 g		Inject
2)	EB 05	0.4 g		Inject
3)	Check (untreated)	0	0	

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 13 (May 2006) and 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 unsuccessful attacks - penetration to phloem, but no egg galleries.
2) Number of successful attacks - construction of nuptial chamber and at least one egg gallery extending from it.
3) Number and lengths of egg galleries with larval galleries radiating from them.
4) Number and lengths of egg galleries without larval galleries.
5) Percent of bark sample with cerambycid activity, estimated by overlaying a 100 cm^2 grid on the underside of each bark strip and counting the number of squares where cerambycid larvae had fed.

Treatment efficacy 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 2006 and CY 2007 (if warranted, based on 2006 results)

May - June, 2006 and 2007

- Fell trees injected in 2006, transport to thinned stand, lay out bolts and install traps and lures (May)
- Remove bolts and record trap catch, attacks and gallery lengths (June)

June - December, 2006 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:

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

SYSTEMIC INSECTICIDE INJECTION TRIALS

Emamectin Benzoate and Fipronil Treatment Timing, Rate and Duration for Protection of Loblolly Pine from Bark Beetles. (To Be Initiated in 2006)

Cooperators

Dr. Fred Hain	North Carolina State University, Raleigh, NC
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) 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: 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, a second 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 0.08 g/cm diameter were highly effective in preventing the successful colonization of treated bolts 1, 3 and 5 months after tree injection (see 2005 Accomplishment Report). It is unknown what the best time of year to inject trees, what is the lowest rate that provided efficacy and if the activity of the new emamectin benzoate formulation will extend into the second or third year after injection. Trials are needed to confirm the efficacy of these new formulations against bark beetles, determine the optimal treatment rates and application timing as well as to determine duration of treatment efficacy. Methodologies are available for determining concentrations of emamectin benzoate in conifer plant tissue (Takai et al. 2003b).

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) Untreated (control) - used to assess beetle pressure during each summer (2006 - 2008)

Treatment Methods and Evaluation:

This study will be conducted in loblolly pine plantation stands (about 20 years old) that have been recently thinned in Texas and North Carolina. Test trees (390 at each site), ranging from 15 to 23cm dbh, will be selected. Each of the above treatments will be applied to 30 trees in October 2005 and 30 more trees in April 2006 at the Texas site; in April 2006 and October 2006 at the North Carolina site. The insecticides will be injected using the Arborjet Tree IV™ microinfusion system (Arborjet, Inc. Woburn, MA) into 4 cardinal points 0.3 m above the ground. The injected trees will be allowed at least 3 months to translocate chemicals prior to being challenged by bark beetles.

In July 2006, 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 unsuccessful attacks - penetration to phloem, but no egg galleries.
2) Number of successful attacks - construction of nuptial chamber and at least one egg gallery extending from it.
3) Number and lengths of egg galleries with larval galleries radiating from them.
4) Number and lengths of egg galleries without larval galleries.
5) Percent of bark sample with cerambycid activity, estimated by overlaying a 100 cm^2 grid on the underside of each bark strip and counting the number of squares where cerambycid larvae had fed.

Treatment efficacy 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 also will be collected from five randomly-selected trees per treatment and analyzed via HPLC analysis (Takai et al. 2003b) to determine chemical concentrations that affect attacking adult beetles and brood development.

Project Support: BASF has offered to provide $24,000 toward the project and agreed to donate chemical product and analyze the tissue samples from fipronil-injected trees in house. Syngenta has tentatively agreed to provide funding to have tissue samples analyzed by a private laboratory. Arborjet, Inc. has agreed to loan the WGFPMC injection equipment for the project.

Research Time Line:

CY 2005

<u>September - October, 2006</u>

- Select study trees in Texas (September)
- Inject Texas trees with assigned treatments (October)

CY 2006

<u>March - April, 2006</u>

- Select study trees in Texas and North Carolina (March)

- Inject trees with assigned treatments (April)

July - August, 2006

- Fell first 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)
- Send off tissue sample for analysis

September - October, 2006

- Select study trees in North Carolina (September)
- Inject North Carolina trees with assigned treatments (October)

September - December, 2006

- 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.

CY 2007 and CY 2008 (if warranted, based on 2006 and 2007 results)

July - August, 2007 & 2008

- 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)

September - December, 2007 and 2008

- 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.

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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 – MS, CA, ID, UT, 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
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 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. Preliminary data from the SPB (MS) and WPB (CA) indicate that again emamectin benzoate and fipronil are effective in preventing mortality by bark beetles. The trials need to be continued to determine the duration of treatment efficacy and confirm efficacy against MPB and SB.

Research Approach: This study was established at 5 sites: 1) DeSoto National Forest, Chickasawhay Ranger District in Wayne and Green Co. Mississippi with southern pine beetle (SPB) 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 and 5) provincial timberland near 100 Mile House, British Columbia with mountain pine beetle (MPB) attacking lodgepole pine. There were 3-4 treatments at each site:

1) emamectin benzoate injection at 0.08 –0.32 g AI per cm DBH,
2) fipronil injection at 0.08 – 0.32g AI per cm 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 (2005 - 2007)

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 early-April (MS), May (CA & ID), August (UT) and September (BC) 2005, 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). A second set of trees also will be injected in Mississippi and British Columbia in April 2006.

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 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 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 $\geq$ 90%). These parameters provide a conservative binomial test ($\alpha = 0.05$) to reject Ho when more than six trees die. The power of this test, that is the probability of having made the correct decision in rejecting Ho, is .84 when the true protection rate is 70% (Shea et al. 1984).

Project Support: The SPB trial is being funded by a grant from the Southern Pine Beetle Initiative. The WPB, 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 2006

March - April, 2006

- Select study trees in British Columbia and Mississippi (March).
- Inject trees in BC and MS with assigned treatment (early April)
- Bait trees in Utah (April)

May - September, 2006

- Bait first series trees in MS (May) and second series trees in CA (June) and ID (July)
- Monitor tree (loblolly, ponderosa and lodgepole) mortality (August and September)

November - December, 2006

- 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.

CY 2007 and CY 2008 (if warranted, based on 2006 and 2007 results, respectively)

May - September, 2007 and 2008

- Bait 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.

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SYSTEMIC INSECTICIDE INJECTION TRIALS

Evaluation of Emamectin Benzoate and Fipronil for Protection of Pine Wood Against Termites (Continued from 2004)

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: It is well know that subterranean termites (*Coptotermes*, *Heterotermes* and *Reticulitermes* spp.) will quickly locate and begin colonization of downed timber. However, we noticed 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 laying 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.

Fipronil is already registered as a termiticide under the brand name, Termidor® (BASF), so it seems likely that injections of this chemical, allowing adequate time to translocate into the wood of the tree, will provide some protection against termite. It is unknown to what extent emamectin benzoate has activity against termites. One question, of particular interest, is how far does either chemical penetrate into the wood layers?

Study Site: 20 acre loblolly pine stand thinned in late 2003, 15 km northwest of Lufkin, TX.

Insecticides:

Emamectin benzoate (Denim®) -- avermectin derivative
Fipronil (experimental EC formulations) -- a pheny pyrazole insecticide that has shown systemic activity against Lepidoptera and Coleoptera and Isoptera.

Research Approach:

Loblolly pine trees, *Pinus taeda* L.**,** 15 – 20 cm (= 6 – 8 inch) diameter at breast height (DBH), were selected in March 2004 in a pine stand (Comp 04679. Std 013) 15 km northwest of Lufkin, Texas. Each treatment was injected into four cardinal points on each of 15 trees in April using the new Arborjet Tree IV™ microinfusion system (Arborjet, Inc. Woburn, MA).

The treatments include:

1) Emamectin benzoate (Denim®, 2.15% ai) – Denim® was mixed 1:1 with methanol and applied at 18.6 ml solution per inch tree DBH (= 0.2 g active per inch DBH).
2) Fipronil (Regent 2.5EC, 28.2% ai) – Regent was mixed 1:2.8:7.5 with methanol and water and applied at 8 ml solution per inch tree DBH (= 0.2 g active per inch DBH).
3) Check (untreated)

After 3 (July) and 5 (September) months post-injection, 5 trees of each treatment were felled and two 1.5 m long bolts were removed from the 3m and 6m heights of the bole as part of the Bar Beetle Trial. The remainder of the tree had been left on-site.

In November 2004, a 30 cm (= 12 in) long bolt was cut from the 1m height of the bole of each tree and tagged. From each bolt, two 2.5 cm thick cookies were cut and tagged (60 cookies total). The wood surfaces of each cookie were sanded smooth.

The cookies were transported to a thinned stand (Comp 04704) and randomly placed on three 7' rows of 30 cm X 30 cm X 5 cm brick pavers. Pinewood 2 X 4 boards were placed in between the brick paver rows to encourage movement of termites from the soil to the cookies. The brick paver and cookies were covered with a plywood box.

In May and November 2006 (6 and 12 months after deployment), the cookies will be evaluated for termite damage. Ratings will be made at the location of the most extensive damage as follows:

Rating	Description
10	Sound, 1 to 2 small nibbles permitted
9	Slight evidence of feeding to 3% of cross section
8	Attack from 3 to 10% of cross section
7	Attack from 10 to 30% of cross section
6	Attack from 30 to 50% of cross section
4	Attack from 50 to 75% of cross section
0	Attack of more than 75% of cross section (Failure)

Treatment efficacy will be determined by comparing termite feeding damage for each treatment. The data will be transformed by $\log_{10}(x + 1)$ to satisfy criteria for normality and homoscedasticity (Zar 1984) and analyzed by GLM and the Fisher's Protected LSD test using the Statview statistical program.

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

Research Time Line:

CY 2004

- Select study trees (March).
- Inject trees with assigned treatment (early April)
- Fell trees (July and September)
- Remove bolts and record trap catch, attacks and gallery lengths (June, August, October)
- Collected log cookies from felled trees; established termite trial (November)

CY 2005 and CY 2006 (if warranted, based on 2005 results)

- Evaluate cookies; rank on level of termite damage (May & November)
- 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.

PINE TIP MOTH

Impact Study
(Continued from 2001, 2002, 2003, 2004 and 2005)

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).

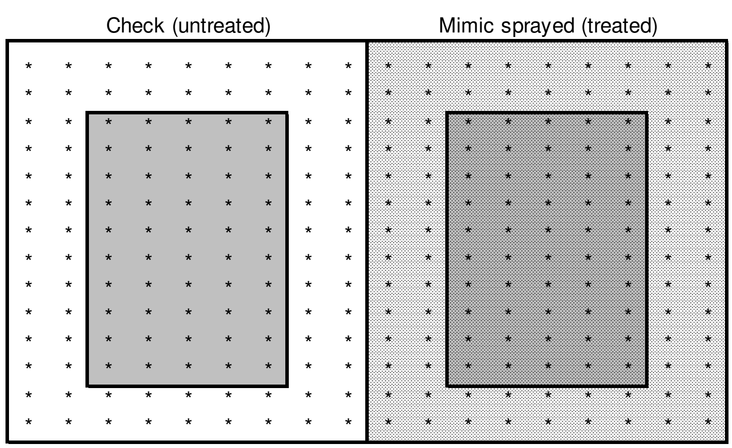
The impact of tip moth attack on tree growth has not been clearly established. Beal (1967) showed that pine trees protected from tip moth attack grew significantly faster than unprotected trees during the first 6 years after planting on some sites, but not on others. At age 16, differences in height 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 18%, 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 20%, 31% and 106%, respectively, compared to untreated trees. Similarly, second-year sites saw a marked improvement in height (20%), diameter (9%) and volume (25%) compared to its previous years growth.

In 2006, 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 or higher tip moth populations and damage levels compared to 2005. Therefore, it is proposed that we continue the establishment of five new sites (per member) in 2006, 2007 and 2008 and continue the analysis of data already obtained to determine the effects of tip moth attacks on tree growth.

Research Approach: Each participating company/organization has established one or more impact sites from 2001 to 2005. We now ask that each member establish five new sites during each of the next three years (2006, 2007 & 2008). All sites will be planted with improved 1-0 bare-root loblolly pine seedlings. The study uses a randomized block design with 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 2006 and 2005, respectively); tree height, diameter (at breast height (DBH)), and form will be measured after year 3 (2004), and 5 (2002). 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:

<u>January - February 2006</u>

- Locate and establish new plots.

<u>March - September 2006</u>

- 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.

<u>October - November 2006</u>

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

<u>December 2006 - January 2007</u>

- 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, 2002, 2003, 2004 & 2005)

Objectives: 1) Establish new plots to validate the tip moth hazard-rating model, 2) complete data collections on sites established in 2005, 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 five years (2001 – 2005), we have established and monitored 76 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 three years (2006, 2007 & 2008) to validate the new hazard-rating model.

Research Approach:

From 2001 to 2005, 76 hazard-rating plots were established across the Western Gulf Region, many in association with the Impact Study. Each hazard-rating plot has/will be evaluated in the 1st and 2nd year after establishment, so the 4 plots established in 2005 need to be monitored in 2006. 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 2006

- Work with participating WGFPMC members to identify and receive all missing data from previously established hazard rating plots (2001 – 2005) (Grosman).
- Select and establish new sites based on target characteristics.

March - July 2006

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

August – October 2006

- 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 2006

- 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 2007

- 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
(Continued from 2004 & 2005)

Objectives: 1) Continue to evaluate the efficacy of fipronil for reducing tip moth damage on loblolly pine seedlings; and 2) determine the duration of treatment efficacy.

Justification: Forest industry has steadily increased the intensity of management in southern pine plantations to increase growth. Tip moth populations typically increase with intensive management (Grosman, unpublished data), resulting in increased damage and economic losses. Numerous insecticides (applied as foliar sprays) are registered to control tip moths, i.e., Azatin®, Orthene®, Talstar®, Carbaryl®, Cyren®, Warrior T®, Dimilin®, Dimethoate®, Asana XL®, Merit®, Pounce®, SpinTor®, and Mimic®. However, control is difficult due to the need for life stage monitoring and precise timing, especially when a manager is dealing with several, large plantations. Also, multiple aerial sprays during the first 2 to 3 years to control tip moths in pine plantations may be marginally economical over 20-30 year rotations.

Most pine plantations in the South are regenerated by planting "bare-root" seedlings at a density of about 550-600 trees per acre. In the past, some forest industries used Furadan® 15G in new pine plantations to effectively control tip moths for about one year by applying granules in the seedling planting hole, or in covered depressions adjacent to recently planted seedlings. A systemic insecticide that is applied to seedlings as a drench in the nursery, as a dip after lifting, or to recently planted seedlings in plantations, and effectively controls pine tip moths for one or more years, is likely to be used widely in the South.

Several field trials were initiated in 2002, 2003 and 2004 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 and, in most cases, well into the second year. As a result of concerns about chemical exposure, research emphasis is now being placed on treating seedlings at or after planting. We propose to continue monitoring the effects of fipronil plant hole or soil injection treatments on tip moth damage levels in second-year sites (Fipronil Soil Injection Trial, 2005) and tree growth on third-year (Fipronil Technique and Rate Refinement Trial 1, 2004). In addition, a new trial is proposed to evaluate the efficacy of different soil injection volumes on tip moth damage levels.

Research Approach:

For all 2004 trials established in the Western Gulf Region, a single family of loblolly pine bare-root seedlings was selected at the TFS Indian Mounds Nursery, Alto, TX. All seedlings were dipped in TerraSorb™ solution, bagged and placed in cold storage for 2 - 14 days.

The Trials and Treatments include:

<u>Seedling Treatment Trial</u> (established in 2002)
<u>Discontinued after 2005</u>

Fipronil Technique and Rate Trial (established in 2003)

Discontinued after 2005

Technique and Rate Refinement Trial 1: In-furrow (December) alone or combined with plant hole treatment (established 2004 on 4 sites)

Continued, in part, in 2006)

1) ~~In-furrow (2X - 0.026%, 0.62 ml Regent®/liter of water)~~ **discontinued**
2) ~~In-furrow (4X - 0.051%, 1.24 ml Regent®/liter)~~ **discontinued**
3) ~~In-furrow (4X - 0.051%, 1.24 ml Regent®/liter + methanol)~~ **discontinued**
4) ~~In-furrow (8X - 0.102%, 2.48 ml Regent®/liter)~~ **discontinued**
5) In-furrow (2X - 0.0256%, 0.62 ml Regent®/liter) + Plant hole, 30 ml (0.267%, 6.8 ml/liter)
6) In-furrow (4X - 0.0512%, 1.24 ml Regent®/liter) + Plant hole, 30 ml (0.267%, 6.8 ml/liter)
7) In-furrow (4X - 0.0512%, 1.24 ml Regent®/liter + methanol) + Plant hole, 30 ml (0.267%, 6.8 ml/liter + methanol)
8) In-furrow (8X - 0.1%, 2.48 ml Regent®/liter) + Plant hole, 30 ml (0.267%, 6.8 ml/liter)
9) Plant hole only - 30 ml (0.267%, 6.8 ml Regent®/liter) applied to plant hole
10) Foliar application (5X in '04 & '05) of pine seedlings with Mimic® 2LV (0.6 ml / liter of water)
11) Check (lift and plant)
12) In-furrow (4X - 0.0512%, 1.24 ml Regent®/liter) + Root-dip (1.0% Regent® (243 ml Regent® + 9.26 liters of water + 60.8g Terrasorb™) + Plant hole, 30 ml (0.267%, 6.8 ml Regent®/liter) (TFS site only)

Technique and Rate Refinement Trial 2: Root soak of containerized and bare-root seedlings (established 2004 on 6 sites)

Discontinued after 2005

Technique and Rate Refinement Trial 3: Root-dip of bare-root seedlings (established 2004 on 5 sites)

Discontinued after 2005

Soil Injection Trial (established 2005 on 2 sites)

Continued in 2006)

1) Regent® 4SC applied by soil injector at 3ml solution/seedling
2) Regent® 4SC applied by soil injector at 30ml solution/seedling
3) Regent® 2.5EC applied by soil injector at 3ml solution/seedling
4) BAS350 UB 120EC applied by soil injector at 3ml solution/seedling
5) Check (lift and plant)

Soil Injection Volume Trial (established 2006 on 2 sites)

1) **Regent® 4SC** applied by soil injector at **3**ml solution/seedling
2) **Regent® 4SC** applied by soil injector at **6**ml solution/seedling
3) **Regent® 4SC** applied by soil injector at **12**ml solution/seedling
4) **Regent® 4SC** applied by soil injector at **24**ml solution/seedling
5) Foliar application (5X in '06) of pine seedlings with Mimic® 2LV (0.6 ml / liter of water)
6) Check (lift and plant)

For plant hole treatments, fifty seedlings from each treatment were planted (spacing variable) on second-year plantation sites for each trial. Planting on second-year sites increased the likelihood for a high level of tip moth pressure on the treatment trees. At each site, resident trees were removed and replaced with treatment trees.

A randomized complete block design was used at each site with beds or site areas serving as blocks, i.e., each treatment was randomly selected for placement along a bed. Ten seedlings from each treatment were planted on each of five beds.

The trials, sites and cooperators are:

Fipronil Technique and Rate Refinement Trial (established in 2004)
Trial 1: Marshall, TX (Anthony Forest Products), Jefferson, TX (International Paper), Evadale, TX (Texas Forest Service), Many, LA (Weyerhaeuser)

Fipronil Soil Injection Trial (established in 2005)
Trial 1: Zavalla, TX and Evadale, TX (Temple-Inland Forest Products)

Tip moth damage will be evaluated on all Soil Injection Trial sites (first and second-year) 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. Trees on first and second-year sites will be measured for height, diameter (at 6") in the fall (November). Three-year old trees (Technique and Rate Refinement Trial sites) will be measured for height, diameter (at DBH) and ranked for form in the fall (November). Form ranking of seedling or tree will be ranked 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).

Project Support: BASF has recently provided the WGFPMC with generous gift of $24,000 to support a portion of this research and donate chemical product.

Research Time Line:

CY 2006

January - February 2006

- Select and establish new sites for Soil Injection Volume trial.

March – October 2006

- Evaluate tip moth damage on treated and untreated on first- and second-year trees 3-4 weeks after generations 1 – 4 (where required).

November - December 2006

- Evaluate tip moth damage on treated and untreated on first- and second-year trees 3-4 weeks after the 5th or last generation.
- Measure height, diameter (at 6” on 1st- and 2nd-year and at breast height on 3rd and 4th-year) and form of trees (on 3rd and 4th year) (November).
- Conduct statistical analyses of 2006 data.
- Prepare and submit report to WGFPMC Executive Committee and BASF.

CY 2007 (if warranted, based on 2006 results)

March - December 2007

- Evaluate tip moth damage on treated and untreated on second-year trees 3-4 weeks after generations 1 – 5 or last generation (where required).
- Measure height, diameter (at 6” on 2nd-year and at breast height on 3rd and 4th-year) and form of trees (on 3rd and 4th year) (November).
- Conduct statistical analyses of 2007 data.
- Prepare and submit report to WGFPMC Executive Committee and BASF.

Literature Cited:

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.

PINE TIP MOTH

Fipronil Operational Soil Injection Study
(To Be Initiated in 2006)

Cooperators

Ms. Emily Goodwin	Temple-Inland Forest Products, Diboll, TX
Ms. Valerie Sawyer,	Weyerhaeuser Co., Columbus, MS
Mr. Jim Huggins	Angelina Steel, Lufkin, TX
Mr. Justin Penick	Acorn Services., Lufkin, TX
Dr. Harold Quicke	BASF, Auburn, AL

Objective: 1) Determine the efficacy of fipronil in reducing area-wide 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. The duration of the area-wide effects has yet to be determined.

Research Approach:

A single family of loblolly pine bare-root seedlings was selected at the Temple Inland Nursery, Jasper, TX or Weyerhaeuser Nursery in Magnolia, AR in 2006. Seedlings will be 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.

When ready, seedlings will be hand- or machine-planted (spacing is dependent on practices of participating members) in each of 2 plantations - preferably near a young (< 4 years old) plantation.

Two tracts (~40 acres in size) were selected in the TX and AR 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. Each tract will be divided in half with one half to be machine planted and the other half to be hand-planted.

To evaluate the effects of treatment on large area tip moth damage levels a randomized complete block design, with sites as blocks, will be used. Each plantation will be initially divided in half. One half will be 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 will be divided in half again and each seedling in one quarter of the plantation will be treated with fipronil (0.3% ai in 3 ml volume) using the Kioritz soil injector. Using the injector, the chemical solution will be 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 will be recorded at each site.

The other section of the plantation will be divided in half. A C&G planter (or equivalent) will be fitted with a 50 gallon tank, electrical pump, tubing and foot peddle (Kevin Darrow, personal communication). On one quarter of the plantation, the planter will inject fipronil solution (0.3% ai in 60 ml volume) into the soil as each seedling is placed in the planting furrow. In the other quarter of the plantation, seedlings will be machine planted at the same spacing with 60 ml of water only injected with the placement of each seedling.

To further evaluate the effects of treatment on tip moth damage levels, an internal randomized block design, with quarter plots as blocks, will be used. Within each main treatment plot, 5 – 0.5 acre plots will be established. Each treatment will be randomly assigned to one of the four internal plots in each main treatment plot quarter (Fig 1).

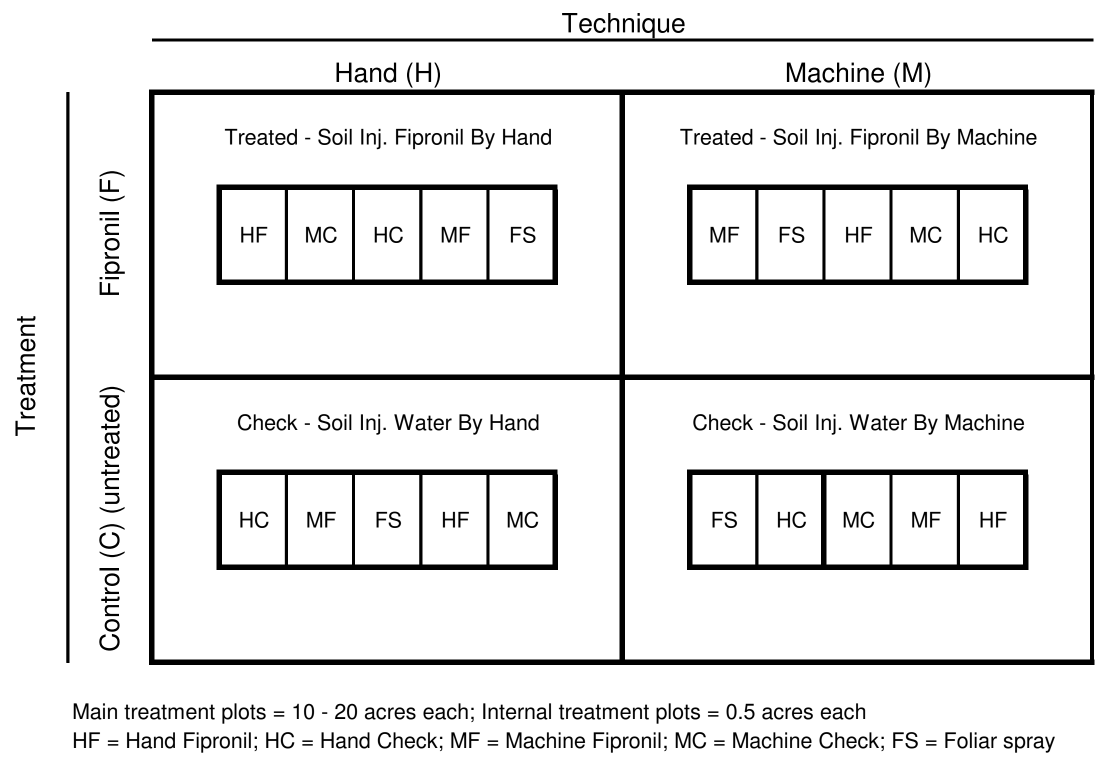

Figure 1. Generalized Plot Design

Treatments:

1) MF = Fipronil applied at 0.1g active ingredient (in 60 ml water) per seedling by machine planter.
2) MC = Check - water (60 ml) applied to each seedling by machine planter.
3) HF = Fipronil applied at 0.1g ai (in 3 ml water) per seedling by hand via Kioritz soil injector.
4) HC = Check - water (3 ml) applied to each seedling by hand via Kioritz soil injector.
5) FS = Foliar spray application (5X) with Pounce® or Mimic®2LV (0.6 ml / liter of water)

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. 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.

If one or more treatments continue to be successful in reducing tip moth damage by > 75% in the 4th generation in 2006, the "best" treatment(s) will be followed into 2007 to continue evaluating duration of treatments. In addition, the study may be expanded in 2004 to refine application rates, timing, and techniques for the promising treatment(s).

Project Support: Temple Inland, Weyerhaeuser and BASF all 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:

CY2005

November – December 2005

- Select research sites.

CY2006

January - February 2006

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

March - October, 2006

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

November - December 2006

- Evaluate tip moth damage after 5th generations; measure seedling and height of seedlings.
- Conduct statistical analysis of 2006 data.
- Prepare and submit report to FSPIAP sponsor, WGFPMC Executive Committee, BASF.
- Present results at annual Entomological Society of America meeting.

CY2007

January - February 2007

- 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, 2007

- 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 2007

- Evaluate tip moth damage after 5th generations; measure diameter and height of seedlings.
- 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.

Literature Cited:

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.

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PINE TIP MOTH

Imidacloprid Tablet/Granular/Gel Study
(To Be Initiated in 2006)

Cooperators

Mr. John Hamilton	Texas Forest Service, Jasper, TX
Mr. Conner Fristoe	Plum Creek Timber Company, Crossett, AR
Mr. Al Cook	Independent contractor, Shreveport, LA
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, granules or gel 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 2002, root soaks of bare-root seedlings with imidacloprid significantly reduced tip moth damage for 2 generations and overall damage for the year was 40% lower compared to check trees. Although, imidacloprid treatment effects did not last nearly as long as that for fipronil (2 versus 10 generations), both treatments had essentially the same significant improvement in height, diameter and volume index compared to check trees for two years in a row.

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

Bayer 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 2nd through the 5th generation. The absence of control in the first generation indicates that the tablets were slow to release the insecticide. On the other hand, a slower than expected release of chemical from the tablets may have prolonged the treatment effects into the second year. Bayer has developed several new formulations that may provide early and extended protection against tip moth.

Research Approach:

In 2006, a single family (Advanced Generation) of loblolly pine bare-root seedlings will be selected at the TFS Indian Mounds Nursery, Alto, TX. All seedlings will be operationally lifted by machine in January 2006, culled of small and large caliper seedlings, treated with Terrasorb™ root coating, bagged and stored briefly in cold storage.

Treatments**:**

1) 20% Merit (Imid.) FXT Std. tablet -	1 tablet in soil next to transplant
2) 20% Merit FXT Std. tablet -	2 tablets in plant hole
3) 20% Merit FXT Std. tablet -	1 tablet in plant hole
4) 20% Merit FXT 'Burst' tablet -	1 tablet in plant hole
5) Fertilizer -	On soil surface next to transplant
6) Gel (5% Imid.) -	In plant hole
7) Combo gel (5% Imid.+ 1% Fipronil) -	In plant hole
8) Merit (Imid.)70 WG -	In plant hole
9) Mimic® or Pounce® Foliar -	Apply Mimic® (0.6 ml/L water) 5X / season
10) Bare-root Check -	Treat w/ Terrasorb™ and plant bare-root

Fifty seedlings for each treatment will be planted (2.1 X 3 m (= 7 X 10 ft) spacing) on each of two plantation sites – to ensure a high level of tip moth pressure on the treatment trees. 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 3 – 5 and 7 – 9 will be applied as the seedling is planted. Just after seedling transplant, one tablet (Treatment 2) 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.

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. 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 2006

January - February 2006

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

March - October, 2006

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

November - December 2006

- Evaluate tip moth damage after 5th generations; measure seedling and height of seedlings.
- Conduct statistical analysis of 2006 data.
- Prepare and submit report to FSPIAP sponsor, WGFPMC Executive Committee, BASF.
- Present results at annual Entomological Society of America meeting.

CY 2007 (if warranted based on CY 2006 results)

January - February 2007

- 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 FSPIAP sponsor, WGFPMC Executive Committee, BASF.
- Present results at annual Entomological Society of America meeting.

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. 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/or slash pine seed orchard (to be determined). A block 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 – 0.8 g AI per inch DBH of tree)
2) Dinotefuran (0.2 – 0.8 g AI per inch DBH of tree)
3) Imidacloprid + Emamectin benzoate (each at 0.2 – 0.8 g AI per inch DBH of tree)
4) Imidacloprid + Fipronil (each at 0.2 – 0.8 g AI per inch DBH of tree)
5) Dinotefuran + Emamectin benzoate (each at 0.2 – 0.8 g AI per inch DBH of tree)
6) Dinotefuran + Fipronil (each at 0.2 – 0.8 g AI per inch DBH of tree)
7) Emamectin benzoate (0.2 – 0.8 g AI per inch DBH of tree)
8) Fipronil (0.2 – 0.8 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 in 2007 will be applied in March (slash) or April (loblolly) using the Arborjet Tree IV™ microinfusion system (Arborjet, Inc. Woburn, MA, http://www.arborjet.com/). 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, 0.4g AI/DBH" in trees 12-23"DBH, 0.6g AI /DBH" in trees 24-35"DBH and 0.8g/DBH" in trees >36"DBH.

Treatment 9 (Capture®, Asana® XL, Guthion®, or Imidan® standard) will be applied to foliage beginning in March or April 2006 using a hydraulic sprayer from a bucket truck (if necessary) at 10 gal/tree. The distance between test trees will be ≥20 m to minimize the effects of drift.

Conelet and cone survival will be evaluated in 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. 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)

<u>September - December 2007</u>

- Evaluate conelet and cone survival on flagged branches (early September).
- Collect all cones from sample trees for evaluation of coneworm, and seed bug damage levels (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, Valent

<u>January - April 2008</u>

- 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)

September - December 2008

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

Literature Cited:

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

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

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

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

PINE REGENERATION WEEVIL

Bifenthrin Efficacy Trial
(For Initiation in 2007)

Cooperators:

Mr. Gary Cramer FMC Corporation

Objectives:

1) Determine the efficacy of bifenthrin (Onyx®) in reducing weevil-caused seedling mortality.
2) Determine the longevity of bifenthrin residuals on treated pine seedlings.

Justification

Pounce® and Waylay™ (permethrin, a pyrethroid insecticide) have 24C registration in several southern states for application to conifer seedlings in the nursery for protection against regeneration weevils after the seedlings are transplanted. Additionally, Pounce® has 2ee (supplemental) registration that allows application to seedlings after being transplanted.

In the very near future, EPA plans to assess all pyrethroids (including permethrin) for reregistration. There is concern that EPA may target permethrin use in conifer nurseries given the high level of product used per acre (2 quarts per 100,000 seedlings = 3 gallons per acre). On the chance that the use of permethrin in nurseries may be lost, we propose to evaluate alternative chemicals for seedling protection.

One active ingredient, bifenthrin, is a second-generation pyrethroid that could be applied at lower rates (1 – 4 pts / 100 gals) compared to permethrin (3.2 quarts /100 gals). Two formulations, Onyx (bifenthrin EC) and a bifenthrin ME (microemulsion), are available for testing.

Research Approach:

A laboratory colony of pine regeneration weevils (pales weevil, *Hylobius pales*, and pitch-eating weevil, *Pachylobius picivorus*) will be established during the winter of 2006/2007. Weevils will be collected once a week using pit traps baited with a 5:1 mix of ethanol and turpentine and set up in recently-harvested tracts. In the laboratory, collected weevil species will be maintained separately in clear plastic boxes containing a layer of vermiculite, split bolts and foliage.

Four hundred loblolly pine seedlings (100 bifenthrin EC-treated, 100 bifenthrin ME-treated, 100 Pounce®-treated and 100 untreated) will be obtained from the Texas Forest Service Indian Mound Nursery in mid-February 2007. Seedlings will be treated prior to lifting in early February with Pounce® 3.2 EC (permethrin @ 2 qt / 100,000 seedlings), Onyx® (bifenthrin EC @ 1.25 pts / 100,000 seedlings), or bifenthrin ME @ 2.5 pts / 100,000 seedlings. All seedlings will be replanted in 1/2 gal pots (four seedlings per pot; treatments separate) and placed outside for exposure to the elements. The soil will be a 3:1 mix of plantation soil and potting soil. The seedlings will be watered once a week or as needed.

At two-week intervals for the first three months and once a month thereafter for four additional months, 64 weevils (eight males and eight females of both species) will be collected from the colony containers. The weevils will be placed in large petri dishes containing moist vermiculite, and starved for 24 hours. After 24 hours, 16 seedlings (four Pounce®-treated, four Onyx®-treated, four bifenthrin ME and four untreated) will be randomly selected and pulled from their pots. The root ball will be clipped off at ground level and all lateral branches will be removed. The remaining above-ground portion of the seedling stem will be clipped into four equal lengths. Each section will be placed in a moistened paper sleeve in a petri dish containing a single weevil. Each dish/weevil will be examined every 24 hours for 3 days and the number of sick or dead weevils recorded. The amount of weevil feeding on each seedling section also will be measured in mm^2 at 24 hour intervals.

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

Research Time Line:

January - February 2007

- Deploy split bolt traps (January & February).
- Establish laboratory colony of regeneration weevils (January & February).
- Treat seedlings in nursery with designated treatment (February)
- Lift and pot pine seedlings (February)

March - May, 2007

- Expose weevils to study trees on two week intervals for first three months after treatment (March, April, May)

June - September, 2007

- Expose weevils to study trees on one month intervals for next four months (June, July, August, September)

October - December, 2007

- Conduct statistical analyses of data.
- Prepare and submit report to WGFPMC & FMC

Western Gulf Forest Pest Management Cooperative
Activity Time Line - CY2006

<u>January</u>

- 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.

<u>February</u>

- Establish new tip moth research plots.
- Monitor tip moth populations and rainfall for tip moth studies.

<u>March</u>

- Machine plant for Operational Soil Injection Trial.
- 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 Injection studies.

<u>April</u>

- 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.
- Treat study trees with injection treatments for Bark Beetle Injection Study (*Ips* and SPB).
- Treat study trees with standard foliar treatment for Seed Orchard Injection Study.
- Collect site information and soil samples and conduct vegetation evaluation for hazard rating study.
- Monitor tip moth populations and rainfall for tip moth studies.

<u>May</u>

- Evaluate tip moth damage after 1st generation for all tip moth studies; photograph damage.
- Evaluate termite damage to log cookies; photograph damage.
- Treat study trees with injection treatments for Western Bark Beetle Injection Study (BC).
- Treat study trees with standard foliar treatment for Seed Orchard Injection Study.
- Treat selected tip moth impact plots with insecticides.
- Monitor tip moth populations and rainfall for tip moth studies.

<u>June</u>

- Treat study trees with standard foliar treatment for Seed Orchard Injection Study.
- 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 weevil damage.

<u>July</u>

- Treat study trees with standard foliar treatment for Seed Orchard Injection Study.
- Fell trees, collect tissue samples, deploy bolts, traps and bark beetle pheromones for *Ips* Bark Beetle Injection Study.
- Treat selected tip moth impact plots with insecticides.
- Monitor tip moth populations and rainfall for tip moth studies.

Western Gulf Forest Pest Management Cooperative
Activity Time Line - CY2006

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 Study.
- Collect and evaluate bolts and traps Ips Bark Beetle Injection Study.
- 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.
- Collect acorns from sample trees for Hardwood Seed Orchard studies.

October
- Treat selected tip moth impact plots with insecticides.
- Treat study trees with injection treatments for *Ips* Injection Study.
- Evaluate coneworm damage for Pine Seed Orchard studies.
- Collect acorns from sample trees for Hardwood Seed Orchard studies.
- Monitor tip moth populations and rainfall for tip moth studies.

November
- Evaluate termite damage to log cookies; photograph damage.
- 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.
- Collect acorns from sample trees for Hardwood Seed Orchard studies.
- 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 2005 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.

2006 Proposed Budget

The proposed budget for CY 2006 totals $198,774 (Table 1). The proposed budget includes an increase of $13,114 for salaries and fringe benefits due to the full year salary of the full-time Research Specialist (hired April 2005), and system-mandated raises for salary workers. Monies budgeted for operating expenses generally remain stable ($21,619). One member was lost at the end of CY2005. Therefore, current membership dues ($50,500) plus use of $8,000 GL account surplus plus $924 for seed analysis work for WGTIP will provide $59,424 (30%). An additional $71,573 (37%) is available from two BASF gifts ($24,268), and funds available from a SPBI (injection) and FSPIAP (fipronil) grants. The remaining (32%) will be borne by the Texas Forest Service and any new members that join during the year (Fig. 1). 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.

2007 Proposed Budget

A proposed budget for CY 2007 is given in Table 3 by source of funding. A total of $200,300 is proposed for CY 2007. The hiring of a research specialist in 2005 was necessary to support a larger WGFPMC research program. By 2007, it will have been 5 years since the last dues increase (Fig. 1). To retain this research specialist position, it will be necessary to increase annual membership dues by $2,000 per year (to $10,000) per full member and $500 (to $3,000) per associate member. Assuming that membership stays at 6 full members and one associate member in 2007, $64,000 (32%) would be provided by the increased membership dues and anticipated funds from WGTIP for seed analysis. Even with this proposed dues increase, 68% 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 2007 is given in Table 4. We anticipate that one or more small projects will terminate at the end of CY 2006, allowing the funding of one new applied research or technology transfer project in CY 2007.

Table 1. WGFPMC Proposed Budget by Source of Funding - CY 2006

		Source							
		WGFPMC		TFS and Others*		Total		% of Total
A.	**Salaries and Wages**							
	Principal Investigator (Grosman) (100%)	$ 15,275	(26%)	$ 43,475	(70%)	$ 58,750	**	
	Research Specialist (Helvey) (100%)	6,512	(20%)	26,050	(80%)	32,562	**	
	Staff Forester (Upton) (75%)	12,603	(30%)	18,905	(45%)	31,508	**	
	SPB Specialist (Murphrey) (8%)	2,453	(8%)	0		2,453	**	
	2 Seasonal Technician (4.5 mo.)	638		17,344		17,982		
	Total Salaries and Wages	$ 37,481		$ 105,774		$ 143,255		
B.	**Fringe Benefits (26% of Salaries & 8% of Wages)**	$ 9,630		$ 24,379		$ 34,010		
		47,111		130,153		177,265		89%
C.	**Operating Expenses**							
	Supplies	$ 3,009		$ 3,000		$ 6,009		
	Vehicle Use and Maintainance	3,800		3,500		7,300		
	Travel	3,200		1,200		4,400		
	Telecommunications (15% of PCS)	504		96		600		
	Utilities (15% of PCS)	0		1,200		1,200		
	Other Services (rentals, publications, postage, etc.)	1,800		200		2,000		
	Total Operating Expenses	$ 12,313		$ 9,196		$ 21,509		11%
	Grand Total	$ 59,424	***	$ 139,349		$ 198,774		
	% of Total	30%		70%		100%		100%

* includes grant funds remaining from 2005; and $24,000 BASF gift, $3,000 Bayer gift, $28,000 FSPIAP grant and any new members or federal grants.

** includes 4% salary increase

*** member dues at $8,000/yr for six members; $2,500/yr for one member, $8,000 GL Acct surplus,and $924 for WGTIP seed analysis. = $59,424

Table 2. WGFPMC Proposed Budget by Source of Project - CY 2006

	Activity					
	Administration	Tip Moth Studies		Systemic		
	Site Visits/Service	(Impact & HR)	(Systemic Trt)	Injection Studies	LCA Studies	Total
A. Salaries and Wages						
Entomologist III (100%)	$ 23,500 (40%)	$ 8,813 (15%)	$ 8,813 (15%)	$ 8,812 (15%)	$ 8,812 (15%)	$ 58,750
Research Specialist (100%)	0	13,025 (40%)	13,025 (40%)	3,256 (10%)	3,256 (10%)	32,562
Staff Forester (75%)	0	5,461 (13%)	5,041 (12%)	10,503 (25%)	10,503 (25%)	31,508
SPB Specialist (8%)	0	0	0	2,453 (8%)	0	2,453
2 Seasonal Technician (4.5 mos.)	0	4,496 (25%)	6,293 (35%)	5,395 (30%)	1,798 (10%)	17,982
B. Fringe Benefits (26% of Salaries & 8% of Wages)	$ 6,110	$ 7,457	$ 7,492	$ 6,938	$ 6,012	$ 34,010
C. Operating Expenses						
Travel and Vehicle Use	$ 3,000	$ 2,200	$ 2,500	$ 2,500	$ 1,500	$ 11,700
Supplies & Postage	2,400	900	1,100	1,100	1,100	6,600
Other Operating Expenses	1,209	500	500	500	500	3,209
Grand Total	$ 36,219	$ 42,852	$ 44,764	$ 39,004	$ 33,481	$ 198,774

Table 3. 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%)	$ 17,375 (29%)	$ 42,538 (71%)	$ 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 **	
	2 Seasonal Technician (4.5 mo.)	0	17,982	17,982	
	Total Salaries and Wages	$ 40,190	$ 103,045	$ 143,235	
B.	**Fringe Benefits (26% of Salaries &**	$ 10,449	$ 23,555	$ 34,004	
	8% of Wages)	50,639	126,600	177,239	88%
C.	**Operating Expenses**				
	Supplies	$ 3,861	$ 3,000	$ 6,861	
	Vehicle Use and Maintainance	4,000	4,000	8,000	
	Travel	3,200	1,200	4,400	
	Telecommunications (15% of PCS)	500	100	600	
	Utilities (15% of PCS)	0	1,200	1,200	
	Other Services	1,800	200	2,000	
	(rentals, publications, postage, etc.)				
	Total Operating Expenses	$ 13,361	$ 9,700	$ 23,061	12%
	Grand Total	$ 64,000 ***	$ 136,300	$ 200,300	
	% of Total	32%	68%	100%	100%

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

** includes 3% salary increase

*** member dues at $10,000/yr for six members; $3,000/yr for one member, and $1,000 for WGTIP seed analysis. = $64,000

Table 4. 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	5,570 (13%)	5,141 (12%)	10,711 (25%)	10,711 (25%)	32,133
2 Seasonal Technician (4.5 mos.)	0	4,496 (25%)	6,293 (35%)	5,395 (30%)	1,798 (10%)	17,982
B. Fringe Benefits (26% of Salaries & 8% of Wages)	$ 6,231	$ 7,598	$ 7,630	$ 6,416	$ 6,129	$ 34,004
C. Operating Expenses						
Travel and Vehicle Use	$ 3,200	$ 2,200	$ 2,500	$ 2,500	$ 2,000	$ 12,400
Supplies & Postage	2,911	1,100	1,100	1,100	1,100	7,311
Other Operating Expenses	1,350	500	500	500	500	3,350
Grand Total	$ 37,657	$ 43,734	$ 45,434	$ 38,929	$ 34,546	$ 200,300

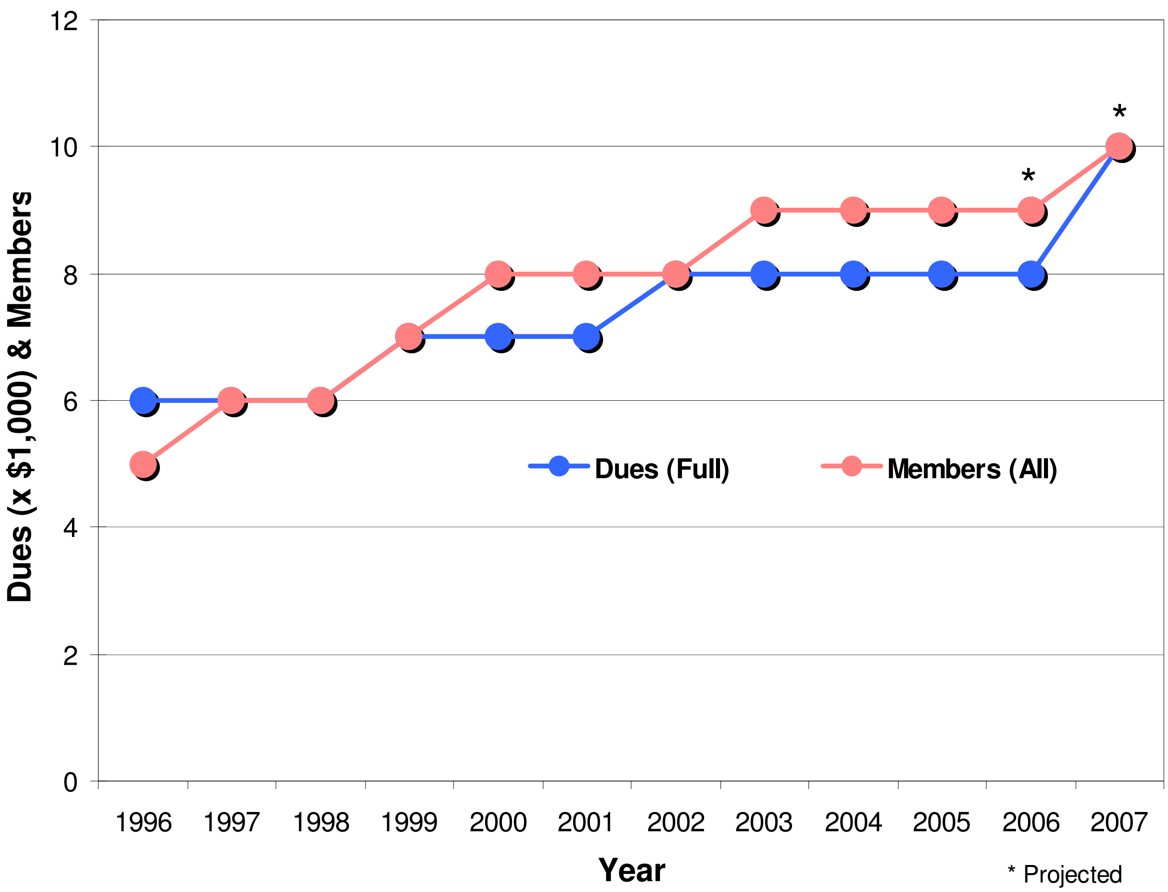

Figure 1. Dues and membership levels in the Western Gulf Forest Pest Management Cooperative from 1996 to 2007 (projected).

WGFPMC Executive and Contact Member Representatives In 2006

FULL MEMBERS

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Plum Creek Timber Company

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