Western Gulf Forest Pest Management Cooperative

2005 Research Project Proposals

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2005 WGFPMC Members:

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Forest Investment Associates
International Paper Company
Plum Creek Timber Company, Inc.
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Texas Forest Service
U.S.D.A. Forest Service - Forest Health Protection R8
Weyerhaeuser 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 2005. Results obtained this past year warrant further evaluations in these areas. Three small trials also will be undertaken in the spring of 2005 to test the efficacy of the new Amdro® Ant Block bait for control of Texas leaf-cutting ants, potential of emamectin benzoate and fipronil for wood protection against termites, and fipronil treatment of pine seedlings for protection against regeneration weevils.

Proposed objectives and methods for the systemic injection and tip moth studies in 2005 are presented below. Neither emamectin benzoate formulations, Arise® and Denim®, tested in the Duration Study (1999 – 2004), and Denim®/Fipronil Study, and neither fipronil formulation (experimental EC and Termidor®), tested in the Denim/Fipronil Study, will be registered in the United States for injection use. Both Syngenta and BASF are in the process of developing new formulations of emamectin benzoate and fipronil, respectively, for injection use. Therefore, all past injection trials (Duration, Rate and Denim/Fipronil) at Magnolia Springs Seed Orchard will be discontinued. A new study is proposed to test the efficacy and duration of the new formulations of emamectin benzoate and fipronil for protection of cone crops from seed and cone insects. In addition, two new studies are proposed to evaluate these new formulations for protection of trees against pine bark beetles, e.g., southern and western pine beetles (*Dendroctonus* spp.) and *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 2005. 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, in reducing pine tip moth damage. As a result of the promising results shown by fipronil in the seedling treatment (2002 – 2004), technique and rate (2003 - 2004), operational planting (2003 - 2004) studies, and technique and rate refinement study (2004), the refinement study will be expanded in 2005. The 2004 Bayer trial showed that imidacloprid / fertilizer tablets have some potential for protection of pine seedlings against tip moth.

Continuation of these or initiation of other projects will be dependent on approval by the WGFPMC Executive Committee. Extension of each project into 2006 will depend on the degree of success achieved in 2005 and remaining gaps in knowledge.

LEAF-CUTTING ANT

Amdro® Ant Block Bait Trial - East Texas
(Initiated in 2005)

Objective: Evaluate the efficacy of the hydramethylnon/corn grit bait formulation (Amdro® Ant Block) 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. The Amdro® leaf-cutting ant bait was marketed by American Cyanimid 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. Recently, Ambrands (formerly American Cyanimid) has begun marketing a new Amdro® Ant Block bait. The company claims that the new formulation is different from the old Amdro® and Grant's bait in that it contains more sugars and should be more attractive to leaf-cutting ants. 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.

Study Sites: Active Texas leaf-cutting ant colonies (20) will be selected in East Texas on lands owned by forest industries and private landowners.

Insecticide:

Hydramethylnon – slow-acting poison on a corn grit carrier.

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

Research Approach:

Application rates will be based on the 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).

<u>Bait</u> - Loose bait spread evenly over entire CNA at ¾ lb per colony in February and March 2005.

<u>Check</u> - untreated colonies

Application Dates:

Late Winter 2005: Treatments applied to 10 colonies in February and March.

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.

Research Time Line:

February - March 2005

- Locate 20 leaf-cutting ant colonies (February).
- Randomly select and treat colonies (February and March)
- Reevaluate ant activity 2 weeks post treatment

April - May, 2005

- Reevaluate ant activity 8 weeks post treatment.

June - July 2005

- 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 (Initiated in 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) evaluate the 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 live oak seed orchards; and 2) determine the duration of treatment efficacy.

Justification: Repeatedly, cone and seed insects severely reduce potential seed yields in southern pine, Douglas-fir and hardwood seed orchards that produce genetically improved seed for regeneration programs. In conifer seed orchards, three of the most important insect pest groups include the coneworms (*Dioryctria* spp.) that attack flowers, cones and stems of pines and Douglas-fir; 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; and the cone gall midge, *Contarinia oregonensis* Heidemann, that attacks flowers and cones of Douglas-fir (Ebel et al. 1980). In addition, slash pine flower thips, *Gnophothrips fuscus* (Morgan), are a significant problem on slash pine in Florida. In hardwood seed orchards, acorn weevils, *Curculio* spp., attack developing acorns on most oak species. Without a comprehensive insect-control program, these insect groups commonly destroy 50% of the potential seed crop; 90% losses are not uncommon (Fatzinger et al. 1980).

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 recently has been made between Syngenta and Arborjet, Inc. for the purpose of developing a new formulation and should be available for testing in the spring 2005.

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 is developing a new formulation for injection use that should also be available for testing in spring 2005 (Harry Quicke, BASF, personal communication).

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 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 live oak and 2) determine the duration of treatment efficacy.

Research Approach: The study will be conducted in 2005 in six seed orchards. Tentative plans call for the establishment of trial replicates in orchard blocks containing loblolly pine at Plum Creek's Hebron Orchard (LA) and International Paper's Marianna Orchard (FL); slash pine at Temple-Inland's Forest Lake Orchard (TX) and one of Smurfit Stone's orchards (AL or FL); Douglas-fir at one of Plum Creek's orchards (OR); and live oak at Texas Forest Service's Hudson Orchard (TX). A block will be selected in each orchard that has 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 will be 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 will be 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 will be injected into four or more cardinal points (depending on tree diameter) about 0.3 m above the ground. **Note:** Don Grosman will provide training to orchard managers on the use of the Tree IV system. 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 3 (Capture®, Asana® XL, Guthion®, or Imidan® standard) will be applied to foliage beginning in March or April 2004 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:** If hydraulic spray equipment is not available at an orchard, it may be possible to make a rough comparison of treatment efficacy on injected trees to operational sprayed trees in another block.

Conelet and/or cone survival will be evaluated in 2005 and 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 2005 and 2006. From the samples, counts will be made of healthy and coneworm-, midge-, and/or thrip-attacked cones. **Note:** Slash pine flower thrips damage flowers in January and February. Thus, the injection treatments likely will not have much, if any, effect on thrips damage levels in 2005. Slash cones collected in 2006 will be evaluated for thrips damage. 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 and 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 Tukey's Compromise test using Statview statistical program.

Project Support: BASF has recently provided the WGFPMC with generous gift of $50,000 to support a portion of this research and will donate the chemical product. Syngenta may also provide additional funding and chemicals. Arborjet, Inc. has agreed to loan the WGFPMC injection equipment for the project.

Research Time Line:

January - April 2005

- Select orchards, clones and ramets (January & February).
- Inject study trees with emamectin benzoate and fipronil (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).

May - August, 2005

- 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 and seed bug damage levels (late August).

September - December 2005

- 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 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

January - April 2006

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- Treat study trees with standard (Capture®, Asana®XL, Guthion®, or Imidan®) foliar treatment (April)

May - August, 2006

- 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).

September - December 2006

- 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

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SYSTEMIC INSECTICIDE INJECTION TRIALS

Fipronil and Emamectin Benzoate Dose Rate and Volume for Single Tree Protection from Southern *Ips* Engraver Beetles (Initiated in 2005)

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 efficacy of systemic injections of new formulations of fipronil and emamectin benzoate at different rates and volumes in reducing success of pine bark beetles attacks on loblolly pine and 2) determine the duration of treatment efficacy.

Justification: In 2004, the WGFPMC conducted an injection trial in East Texas to evaluate the potential efficacy of several reported systemic insecticides, including: emamectin benzoate and fipronil for protection of loblolly pine against *Ips* engraver beetles. The results showed that both emamectin benzoate (Denim®) and fipronil (experimental EC) 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). New formulations of fipronil and emamectin benzoate are currently being developed by BASF and Arborjet, respectively, and both should be available for testing in March 2005. It is unknown if the performance of the new insecticide formulations applied at the same rate and volumes used in 2004 will differ from that observed for Denim® and fipronil EC in 2004. This study will evaluate the efficacy of new formulations of fipronil and emamectin benzoate applied at different rates and volumes against southern *Ips* engraver beetles and determine the duration of treatment efficacy.

Treatments:

	Formulation	Rate (g ai/DBH")	Volume	Application Method
1)	Fipronil (BAS 3501)	0.2 g	100 ml	Inject
2)	Fipronil (BAS 3501)	0.4 g	100 ml	Inject
3)	Fipronil (Regent 2.5EC)	0.2 g	100 ml	Inject
4)	Fipronil (BAS 3501)	0.4 g		Basal Bark Spray
5)	EB 05	0.2 g		Inject
6)	EB 05	0.4 g		Inject
7)	Check (untreated)	0	0	

Treatment Methods and Evaluation:

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

Loblolly pine trees (125), 15 – 20 cm diameter at breast height (DBH), will be selected in March 2005. Each treatment (1-3, 5 and 6) will 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). Fipronil treatment solutions (4) will be applied by backpack sprayer to the bark surface from ground level to a height of 2 m.

After 1 (May) and 3 (July) 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. An additional set of 5 trees for Treatments 1-4 and 7 will be felled 5 months (September) post injection. One set (5 trees) each of Treatments 5 and 6 will be felled 13 (May 2006) and 25 (May 2007) months post injection. 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.

A clear panel of acetate (10 cm X 25 cm) will be attached to the center of each bolt to monitor arrival of bark beetles for a two-week period. The top surface of each panel will be coated with Stikem Special® (Michel and Pelton, Emeryville, CA).

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 Fishers Protected LSD test using the Statview statistical program.

At the time of tree felling, a section of lower bole (~60-80 cm) containing the injection points will be removed from each injected tree. The bark will be removed around the injection points to determine if any damage had resulted from the installation of plugs and/or injection of chemicals. If damage is found, the length and width of any discolored areas (lesions) on the surface of the xylem were measured.

Project Support: BASF has recently provided the WGFPMC with generous gift of $50,000 to support a portion of this research and donate chemical product. Syngenta may also provide additional funding and chemical. Arborjet, Inc. has agreed to loan the WGFPMC injection equipment for the project.

Research Time Line:

CY 2004

March - April, 2005

- Select study trees (March,).
- Inject or spray trees with assigned treatment (early April)

May - October, 2005

- Fell trees, transport to thinned stand, lay out bolts and install traps and lures (May, July, September)
- Remove bolts and record trap catch, attacks and gallery lengths (June, August, October)

November - December, 2005

- Conduct statistical analyses of data.
- Prepare and submit report to WGFPMC Executive Committee, Arborjet and Chemical Companies.

CY 2006 and CY 2007 (if warranted, based on 2005 and 2006 results, respectively)

May - June, 2006 and 2007

- Fell trees injected in 2005, 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.

SYSTEMIC INSECTICIDE INJECTION TRIALS

Emamectin Benzoate and Fipronil for Protection of High-Value Southern and Western Conifers from Bark Beetles (Initiated in 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
Dr. C. Wayne Berisford,	Univ. of Georgia, Dept. of Entomology, Athens, Georgia
Dr. David Cox	Syngenta, Modesta, CA
Dr. Harold Quicke	BASF, Auburn, AL
Mr. Joseph Doccola	Arborjet, Inc., Worchester, MA

Objectives: 1) To determine 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: Bark beetles (Scolytidae) 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), oxydydementon 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 (unpublished) 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). 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.

Research Approach: This study will be conducted at 4 - 5 sites. The exact locations will be dependent on bark beetle activity in 2005, most likely in the: 1) National Forests of Mississippi and/or Alabama, with SPB attacking loblolly pine, 2) National Forests of Idaho, with MPB attacking lodgepole pine, 3) National Forests of California, with WPB attacking ponderosa pine, and 4) National Forest of Utah, with SB attacking Engelmann spruce. There will be 4 treatments for most sites:

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 will be 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 will be >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 will be 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 will be applied in early-April (MS & AL), May (CA & ID) and September (UT) 2005, preferably after a heavy rain event or snow melt. The injected trees will be allowed one to two months (depending on water availability) to translocate chemicals prior to being challenged by bark beetles.

The standard (carbaryl and bifenthrin) will be formulated in water buffered to ph 5. Sprays will be applied at the same time as the injections in each area. Insecticides will be applied with a trailer-mounted hydraulic sprayer (300 psi, #8 oriface), which will allow treatment of the entire bole of each tree, until saturation, to a height of >10m. This application technique has been shown to result in at least 80% of the insecticide being applied to the bole (Haverty et al. 1983).

Approximately 8 to 15 liters of formulated material will be required per tree. All treatments will be 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.

Each insecticide (injection or spray) treatment will be applied to 30 - 35 randomly assigned trees (n = 90 – 105 per site). A similar number of trees will be used for each set of the untreated checks. During the course of the experiment, a few trees may be lost to wood cutting, logging, fire, or top-killing by *Ips* species (Shea et al. 1984). These trees will be deleted from the analysis. The only criterion used to determine the effectiveness of the insecticide treatment will be whether or not individual trees succumb to attack by bark beetles. Tree mortality will be assessed in the month of August for multiple, consectutive years until efficacy is diminished. The period between pheromone removal and mortality assessment will be sufficient for trees to "fade," an irreversible symptom of pending mortality. Presence of species-specific galleries will be verified in each tree classified as dead or dying.

Treatments will be considered to have sufficient beetle pressure if at least 60% of the untreated control trees die from beetle attack. Insecticide treatments will be considered efficacious if less than seven treated trees die as a result of bark beetle attack. These criteria were established based on a sample size of 30 to 35 trees/treatment and the test of the null hypothesis, Ho:S (survival ≥ 90%). These parameters provide a conservative binomial test ($\alpha = 0.05$) to reject Ho when more than six trees die. The power of this test, that is the probability of having made the correct decision in rejecting Ho, is .84 when the true protection rate is 70% (Shea et al. 1984).

Project Support: BASF has recently provided the WGFPMC with generous gift of $50,000 to support a portion of this research and donate chemical product. Syngenta may also provide additional funding and chemical. Arborjet, Inc. has agreed to loan the WGFPMC injection equipment for the project.

Research Time Line:

CY 2005

<u>March - April, 2005</u>

- Select study trees (March, April or August).
- Inject and spray trees with assigned treatment (early April, May and September)

<u>May - September, 2005</u>

- Bait trees (May and June)
- Monitor tree (loblolly, ponderosa and lodgepole) mortality (August and September)

<u>November - December, 2005</u>

- Conduct statistical analyses of data.
- Prepare and submit report to WGFPMC Executive Committee, Arborjet and Chemical Companies.

CY 2006 and CY 2007 (if warranted, based on 2005 and 2006 results, respectively)

<u>May - September, 2006 and 2007</u>

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

<u>November - December, 2006 and 2007</u>

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

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SYSTEMIC INSECTICIDE INJECTION TRIALS

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 2005 (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	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 Fishers Protected LSD test using the Statview statistical program.

Project Support: BASF has recently provided the WGFPMC with generous gift of $50,000 to support a portion of this research.

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)

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 see 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 was improved by 10%, 17%, and 38%, respectively, compared to check trees. Six additional sites were established in 2004 for a total of 40 impact sites. Analyses of 2004 data alone and combined with past years' data are ongoing.

In 2005, it is proposed that we discontinue establishment of new sites and focus our efforts on the analysis of data already obtained to determine the effects of tip moth attacks on tree growth. We propose that tip moth damage assessments and growth measurements be continued on established sites in the Western Gulf Region to evaluate the residual effects of tip moth damage on tree growth after protective sprays have been discontinued

Research Approach: Each participating company/organization has establish one or more impact sites from 2001 to 2004. All sites had been 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). 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 time before each generation for the first **2 years** after planting.

Insecticides (Mimic® and/or Pounce®) will be applied on 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 generation based on Fettig's (et al. 2003) recommendation for the location closest to each study site.

Tip moth damage will be evaluated on 2^{nd}-year sites after the 1^{st}, 2^{nd}, 3^{rd} and 4^{th} (for sites north of the LA/AR border) and 5^{th} (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 second-year sites (established in 2004); tree height, diameter (at breast height (DBH)), and form will be measured after year 3 (2003), and 5 (2001). In the future, tree height and DBH, and form will be measured after year 8 and at 4-year intervals thereafter.

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).

Research Time Line:

March - September 2005

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

October - November 2005

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

December 2005 - January 2006

- 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)

Objectives: 1) Complete data collections on sites established in 2004, 2) continue development of regression models using stand characteristics and other abiotic factors to predict future levels of tip moth damage, and 3) 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 four years (2001 – 2004), we have established and monitored 72 hazard-rating plots across the Western Gulf Region. We propose that the establishment of new hazard-rating sites be discontinued at this time for the purpose of focusing efforts on the full analysis of collected data and development of a functional hazard-rating model.

Research Approach:

From 2001 to 2004, 72 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 10 plots established in 2004 need to be monitored in 2005. Members have select sites that represent the majority of their land base, i.e., soil texture and drainage, topography, and site index. 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 2005

- Work with participating WGFPMC members to identify and receive all missing data from previously established hazard rating plots (2001 – 2004) (Grosman).

March - July 2005

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

August – October 2005

- 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 2005

- 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 2006

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

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PINE TIP MOTH

Fipronil Technique and Rate Studies
(Continued from 2002, 2003 & 2004)

Objectives: 1) Continue to evaluate the efficacy of fipronil in 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 was initiated in 2002, 2003 and 2004 to the efficacy of fipronil, applied by various techniques and rates, in 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. The results from the Seedling Treatment Trial (2002) indicate that fipronil treatment continues to improve tree growth through the third year. We propose to continue monitoring the effects of fipronil treatments on tip moth damage levels in second-year sites (Fipronil Technique and Rate Refinement Trial, 2004) and tree growth on third-year (Fipronil Technique and Rate Trial, 2003) and fourth-year (Seedling Treatment Trial, 2002) sites.

Research Approach:

For all 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. International Paper and Weyerhaeuser used their own seedlings on sites established on the East Coast. For in-furrow treatments, lateral root pruning equipment was used to create 8” deep furrows between drills in a nursery bed section. Immediately afterwards, treatment solutions (as described below) were applied to furrows within one of four 10 foot sections of bed. The seedlings in these sections and from the remaining portion of bed (for other treatments and trials) were lifted in mid-January 2004 in a manner to cause the least breakage of roots, culled of small and large caliper seedlings, grouped in bundles of 60, and temporarily held in seedling bags until treatment. Those seedlings receiving no treatment or treatment at or post-planting were stored temporarily

in coolers. Containerized seedlings for the same family of loblolly pine were used in trials established in 2004.
When ready, the bundles of bare-root seedlings to be used for bare-root soak treatments were soaked in 9.5 liters (2.5 gal) of insecticide solution for 2 hours. For root-dip treatments, bundles of seedlings were dipped in the fipronil plus one of three root coatings (Terrasorb™, Driwater™ or clay) solutions. After treatment, all seedlings not already dipped in a root coating were dipped in TerraSorb™ solution, rebagged and placed in cold storage for 2 - 14 days. Trays of 45 containerized seedlings used for containerized seedling treatments were soaked in 7.6 liters (2 gal) of insecticide solution for 30 minutes. These seedlings were similarly placed in cold storage for 2 – 14 days.

The Trials and Treatments include:

<u>Seedling Treatment Trial</u> (established 2002 on 2 sites):

** 1) ~~Emamectin benzoate (Proclaim®) solution (0.12%) root soak~~
2) Fipronil (Termidor® SC) solution (0.157%) root soak
3) Imidacloprid (technical) solution (0.53%) root soak
** 4) ~~Thiamethoxam (25 WP) solution (0.17%) root soak~~
** 5) ~~Azadirachtin (Neemix® 4.5) solution (0.0000045%) root soak~~
6) Tebufenozide (Mimic®)
7) Check bare-root seedling (lift and plant)

** Evaluation of emamectin benzoate and thiamethoxam treatments will be discontinued from 2004 due to generally poor performance.

<u>Technique and Rate Trial</u> (established 2003 on 8 sites):

1) In furrow treatment of nursery bed with fipronil (0.0246% Termidor® SC) solution applied in October only.
2) In furrow treatment of nursery bed with fipronil (0.0123% Termidor® SC) solution applied once in October and again in December.
3) Root soak of bare-root seedling in fipronil (0.003% Termidor® SC) solution
4) Root soak of bare-root seedling in fipronil (0.03% Termidor® SC) solution
5) Root soak of bare-root seedling in fipronil (0.3% Termidor® SC) solution.
6) Root soak of bare-root seedling in fipronil (0.3% Regent® SC) solution.
7) Root-dip of bare-root seedling in fipronil (0.3% Termidor® SC) and TerraSorb®* solution.
8) Plant hole treatment (liquid) – 30 ml of fipronil (6.5% Termidor® SC) solution per plant hole.
9) Check - Bare-root seedling (lift and plant)

* Weyerhaeuser used clay slurry and International Paper used a proprietary root coating.

<u>Technique and Rate Refinement Trials</u>:

<u>Trial 1: In-furrow (December) alone or combined with plant hole treatment (established 2004 on 4 sites)</u>

1) In-furrow (2X - 0.026%, 0.62 ml Regent®/liter of water)

2) In-furrow (4X - 0.051%, 1.24 ml Regent®/liter)
3) In-furrow (4X - 0.051%, 1.24 ml Regent®/liter + methanol)
4) In-furrow (8X - 0.102%, 2.48 ml Regent®/liter)
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) 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)

<u>Trial 2: Root soak of containerized and bare-root seedlings</u>
<u>(established 2004 on 6 sites)</u>

1) Root soak (0.3% = 73 ml Regent® in 9.43 liters of water) of containerized seedling.
2) Root soak (0.3% = 73 ml Regent® + 950 ml methanol + 8.48 liters of water) of containerized seedling.
3) Root soak (1.0% = 243 ml Regent® in 9.26 liters of water) of containerized seedling.
4) Root soak (3.0% = 730 ml Regent® in 8.77 liters of water) of containerized seedling
5) Root soak (0.3% = 73 ml Regent® in 9.43 liters of water) of bare-root seedling
6) Root soak (0.3% = 73 ml Regent® + 950 ml methanol + 8.48 liters of water) of bare-root seedling.
7) Root soak (1.0% = 243 ml Regent® in 9.26 liters of water) of bare-root seedling
8) Root soak (3.0% = 730 ml Regent® in 8.77 liters of water) of bare-root seedling
9) Foliar application (5X) of pine seedlings with Mimic® 2LV (0.6 ml per l water)
10) Check (lift and plant bare-root seedling)
11) Check (plant containerized seedling)
12) Root soak (1.0% = 157 ml Icon® in 9.26 liters of water) of bare-root seedling (TFS site only)
13) Root soak (2.0% = 340 ml Icon® in 9.16 liters of water) of bare-root seedling (TFS site only)

<u>Trial 3: Root-dip of bare-root seedlings</u>
<u>(established 2004 on 5 sites)</u>

1) Root-dip (1.0% = 243 ml Regent® in 9.26 liters of water) + Terrasorb™ (60.8 g)
2) Root-dip (1.0% = 243 ml Regent® + 950 ml methanol + 8.31 liters of water) + Terrasorb™ (60.8 g)
3) Root-dip (3.0% = 730 ml Regent® in 8.77 l water) + Terrasorb™ (60.8 g)
4) Root-dip (1.0% = 243 ml Regent® in 9.26 l water) + Driwater™ (85.5 g)
5) Root-dip (3.0% = 730 ml Regent® in 8.77 l water) + Driwater™ (85.5 g)
6) Root-dip (1.0% = 243 ml Regent® in 9.26 l water) + clay slurry (2470 g)

7) Root-dip (3.0% = 730 ml Regent® in 8.77 l water) + clay slurry (2470 g)
8) Foliar application (5X) of pine seedlings with Mimic® 2LV (0.6 ml per l water)
9) Terrasorb® Check (60.8 g Terrasorb™ in 9.5 l water)
10) Driwater® Check (85.5 g Driwater™ in 9.5 l water)
11) Clay Check (2470 g clay in 9.5 l water)

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:
Seedling Treatment Trial (established in 2002)
Evans Plot 1 & 2, Rusk Co., TX (Texas Forest Service)

Fipronil Technique and Rate Trial (established in 2003)
Huntington, Wells and Woden, TX (Texas Forest Service), Burke Co., GA 1 & 2 and Sussex Co., VA (International Paper), and Beaufort Co. and Bertie Co., NC (Weyerhaeuser)

Fipronil Technique and Rate Refinement Trials (established in 2004)
Trial 1: Marshall, TX (Anthony Forest Products), Jefferson, TX (International Paper), Evadale, TX (Texas Forest Service), Many, LA (Weyerhaeuser)
Trial 2: Ashdown, AR (Forest Investment Associates), Crossett, AR (Plum Creek Timber), Evadale, TX (Temple-Inland Forest Products) & Groveton, TX (Texas Forest Service), Martin, NC (Weyerhaeuser), & Unknown location in GA (International Paper)
Trial 3: Warren, AR (Potlatch), Evadale, TX (Temple-Inland Forest Products) & Mayflower, TX (Texas Forest Service), Martin, NC (Weyerhaeuser), & Unknown location in GA (International Paper)

Tip moth damage will be evaluated on all Technique and Rate Refinement Trial sites (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 second-year sites will be measured for height, diameter (at 6”) in the fall (November). Three- and four-year old trees (Technique and Rate and Seedling Treatment 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 $50,000 to support a portion of this research and donate chemical product.

Research Time Line:

CY 2005

<u>January – October 2005.</u>

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

<u>November - December 2005</u>

- Evaluate tip moth damage on treated and untreated on second-year trees 3-4 weeks after the 5th or last generation.
- 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 2005 data.
- Prepare and submit report to WGFPMC Executive Committee and BASF.

CY 2006 (if warranted, based on 2005 results)

<u>November - December 2005</u>

- Measure height, diameter (at breast height) and form of trees (November).
- Conduct statistical analyses of 2006 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 In-Furrow Treatment Study
(Initiated from 2005)

Objectives:

The objectives of this research are to 1) determine the efficacy of fipronil applied mid-season to nursery beds in reducing pine tip moth infestation levels on loblolly pine seedlings, and 3) determine the duration of chemical activity.

Justification:

Chemical control of tip moth infestations has not traditionally been performed except in high value plantings such as Christmas tree plantations, seed orchards and progeny tests. However, recently there has been increased interest in developing methods for reducing volume losses associated with tip moth damage in production forests. To make control of tip moth economical in large forest plantations, one option is to use a systemic chemical that can be applied when seedlings are in the nursery bed or after lifting and can protect seedlings for one or more years. Several new systemic insecticides have been developed in recent years.

Over the past three years (2002 – 2004), fipronil has proven to be highly effective in reducing tip moth damage to first-year seedlings. Further evaluations indicate that residual effects can occur into the second year and possibly third year after planting. However, fipronil formulation, application techniques and rates can influence treatment efficacy and need to be considered in the development of one or more operational treatments.

The treatment of pine seedlings in the nursery, prior to lifting, is likely to be the most cost effective and least hazardous (exposure-wise) application technique. The Regent® formulation is already registered for in-furrow applications for corn. Unfortunately, EPA has restricted the amount of active ingredient that can be applied per acre per year, to 0.13 lb. – this is a very small amount of active ingredient spread over approximately 600,000 seedlings per acre of nursery. One hope is that because many pine seedling nurseries grow seedlings on a four-year rotation (two years in seedlings and two years in cover crops), EPA will allow a single application of fipronil at 0.52 lbs ai/acre (4 X 0.13 lbs) at the beginning of the first year of the rotation. With this in mind, we pushed the envelop in the 2003 and 2004 trials by applying fipronil at 2X, 4X, and 8X the annual rate. Unfortunately, the treatments were only marginally effective in reducing tip moth damage. The data suggests that fipronil may require 5 or more months to reach high enough concentrations in the shoots to provide protection. Thus, it may be necessary to treat seedlings in the summer or early fall to provide sufficient time for fipronil to reach protective concentrations in the shoots in the early spring.

We propose to initiate a new study in 2005 on three sites across the South to further evaluate in-furrow fipronil treatment techniques and rates for protection of bare-root pine seedlings against pine tip moth.

Research Approach:

A single family (Advanced Generation) of loblolly pine bare-root seedlings was selected at the TFS Indian Mounds Nursery, Alto, TX. Lateral root pruning equipment was used to create 8” deep furrows between drills in a nursery bed section in early July and September 2004. Immediately afterwards, treatment solutions (as described below for Treatments 1 - 8) were applied to furrows within one of eight 10 foot sections of bed. The seedlings in these sections and from the remaining portion of bed (for other treatments and trials) were lifted in late-January 2005 in a manner to cause the least breakage of roots, culled of small and large caliper seedlings, grouped in bundles of 60, root-dipped in Terrasorb™ and stored temporarily in a cooler until planting.

The treatments included:

A) In-furrow (2X - 0.026%, 0.62 ml Regent®/liter of water) applied at 7ml solution/ft of furrow in July
B) In-furrow (4X - 0.051%, 1.24 ml/liter) applied at 7ml solution/ft of furrow in July
C) In-furrow (8X - 0.102%, 2.48 ml/liter) applied at 7ml solution/ft of furrow in July
D) In-furrow (16X – 0.204%, 4.96 ml/liter) applied at 7ml solution/ft of furrow in July
E) In-furrow (2X - 0.0256%, 0.62 ml/liter) applied at 7ml solution/ft of furrow in September
F) In-furrow (4X - 0.0512%, 1.24 ml/liter) applied at 7ml solution/ft of furrow in September
G) In-furrow (8X - 0.1%, 2.48 ml/liter) applied at 7ml solution/ft of furrow in September
H) In-furrow (2X - 0.026%, 0.62 ml Regent® + 2.25g DriWater™ /liter of water) applied at **14ml** solution/ft of furrow in September
I) Plant Hole - 30 ml (0.267%, 6.8 ml Regent®/liter) applied to plant hole
J) Soil Injection - 30 ml (0.267%, 6.8 ml Regent®/liter) applied to soil after planting
K) Foliar application (5X) of pine seedlings with Mimic® 2LV (0.6 ml / liter of water)
L) Check (lift and plant)

When ready, fifty seedlings from each treatment were planted (spacing variable) on each of 3 second-year plantation sites for each trial. Planting on second-year sites ensure 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 sites and cooperators include:
1) Evadale, TX (Temple-Inland provided and Texas Forest Service monitored)
2) Zavala, TX (Temple-Inland provided and Texas Forest Service monitored)
3) Unknown site, GA (International Paper provided and monitored)

In 2005, tip moth populations will be monitored weekly at each of the TFS sites using at least three Phericon™ 1C traps with Trece™ septa lures. Tip moth damage will be evaluated after each tip moth generation (3-4 weeks after peak moth flight) by 1) identifying if the tree is infested or not, 2) if infested, the proportion of tips infested on the top whorl and terminal will be calculated; and 3) separately, the terminal will be identified as infested or not. Observations also will be made as to the occurrence and extent of damage caused by other insects, i.e., aphids, weevils, coneworm, etc. Each tree will be measured for diameter (at 6") and height in the fall (November 2005 and 2006) following planting. Second-year trees (2006) also will be ranked for form. Form is categorized as follows: 0 = no forks; 1 = one fork; 2 = two to four forks; 3 = five or more forks. A fork is defined as a node with one or more laterals larger than one half the diameter of the main stem (Berisford and Kulman 1967). Data will be analyzed by GLM and the Tukey's Compromise test using Statview or SAS statistical programs.

Project Support: BASF has recently provided the WGFPMC with generous gift of $50,000 to support a portion of this research and donate chemical product.

Research Time Line:

CY2004

<u>July - September 2004</u>

- Apply in-furrow treatments to nursery beds

CY2005

<u>January - February 2005</u>

- Establish research plots
- Lift and plant treated seedlings
- Begin trap monitoring of tip moth populations near each site

<u>March - October, 2005</u>

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

<u>November - December 2005</u>

- Evaluate tip moth damage after 5^{th} generation; measure seedling diameter and height.
- Conduct statistical analysis of 2005 data.
- Prepare and submit report to WGFPMC Executive Committee and BASF.

CY 2006 (if warranted, based on 2005 results)

<u>January - February 2006</u>

- Begin trap monitoring of tip moth populations near each site

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

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

<u>November - December 2006</u>

- Evaluate tip moth damage and tree form after 5^{th} generation; measure seedling diameter and height.
- Conduct statistical analysis of 2006 data.
- Prepare and submit report to WGFPMC Executive Committee and 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.

PINE TIP MOTH

Fipronil Operational Planting Study
(Continued from 2003 & 2004)

Objective: 1) Continue to evaluate fipronil for operational protection of loblolly pine from pine tip moth and 2) determine the duration of fipronil treatment effects on loblolly pine growth.

Justification: The Operational Planting Trial (2003 - 2004) showed that fipronil (Termidor®) was effective in reducing potential tip moth damage on each of four study sites during the first two years after planting. This indicates 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 have yet to be determined.

Research Approach:

A single family of loblolly pine bare-root seedlings was selected at the TFS Indian Mounds Nursery, Alto, TX in 2002. Seedlings were lifted in January in a manner to cause the least breakage of roots, culled of small and large caliper seedlings, bagged and stored briefly in cold storage.

When ready, the cold-stored seedlings were warmed at room temperature (~70^{o}F) for 3 hours. Seedlings were soaked in 190 liter (50 gal) tanks of fipronil (0.3% ai) solution for 2 hours. All seedlings (treated and untreated) were then dipped in TerraSorb® (or Drywater) solution, rebagged and placed in cold storage until the following day. Seedlings from each treatment were hand- or machine-planted (spacing was dependent practices of participating member) in each of 4 plantations - preferably near a young (< 4 years old) plantation.

Four tracts (19 – 38 acres in size) were selected in the Western Gulf Region 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. One half of each of each tract was planted with fipronil-treated seedlings. The other half was planted with untreated seedlings at the same spacing. A small 100 tree plot was established in each half tract as a contrast to the treatment of the other half tract. The plot in treated half contained untreated seedlings, while the plot in untreated half contained treated seedlings. Ten 10 tree plots were spaced equally within each of the half tract (20 – 10 tree plots / whole tract) to evaluate tip moth damage levels in this area. Some tracts were treated with herbicide after planting to minimize herbaceous and/or woody competition.

In 2005, study trees at each site will be measured for diameter (at DBH) 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 Tukey's Compromise test using Statview or SAS statistical programs.

Project Support: BASF has recently provided the WGFPMC with generous gift of $50,000 to support a portion of this research and donate chemical product.

Research Time Line:

CY2005

November - December 2005

- Measure height, diameter (at breast height) and form of trees (November).
- Conduct statistical analyses of 2005 data.
- Prepare and submit report to WGFPMC Executive Committee and BASF.

CY 2006 (if warranted, based on 2005 results)

November - December 2006

- Measure height, diameter (at breast height) and form of trees (November).
- Conduct statistical analyses of 2006 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.

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PINE TIP MOTH

Imidacloprid Spike and Tablet Studies
(Continued from 2004)

Objectives: 1) Continue to evaluate the efficacy of imidacloprid in reducing pine tip moth infestation levels on loblolly pine seedlings; 2) evaluate this product applied at different rates to transplanted seedlings; 3) determine the effect of imidacloprid alone or combined with fertilizer on seedling growth; and 4) determine the duration of chemical activity.

Justification

Imidacloprid, a neonicotinoid insecticide, is highly systemic in plants and know 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. They have been used operationally in Australia to control chrysomelid beetles and lepidopteran larvae on eucalyptus and pine. The WGFPMC was asked by Mr. Nate Royalty (Bayer CropScience) in 2004 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. Further evaluations of the duration of treatment effects are warranted for 2005.

Research Approach:

In both 2003 and 2004, a single family (Advanced Generation) of loblolly pine bare-root seedlings was selected at the TFS Indian Mounds Nursery, Alto, TX. All seedlings were operationally lifted by machine in January 2004, culled of small and large caliper seedlings, treated with Terrasorb™ root coating, bagged and stored briefly in cold storage.

<u>2003 Treatments</u>**:**

A =	2.5% imidacloprid spike + Fertilizer -	3 spikes in soil next to transplant
B =	1% disulfoton spike + Fertilizer-	3 spikes in soil next to transplant
C =	Bare-root Check -	Treat w/ Terrasorb™ and plant bare-root

2004 Treatments**:**

A =	5% imidacloprid tablet -	1 tablet in soil next to transplant
B =	5% imidacloprid tablet + Fertilizer-	1 tablet in soil next to transplant
C =	10% imidacloprid tablet -	1 tablet in soil next to transplant
D =	10% imidacloprid tablet + Fertilizer-	1 tablet in soil next to transplant
E =	15% imidacloprid tablet -	1 tablet in soil next to transplant
F =	15% imidacloprid tablet + Fertilizer-	1 tablet in soil next to transplant
G =	20% imidacloprid tablet -	1 tablet in soil next to transplant
H =	20% imidacloprid tablet + Fertilizer-	1 tablet in soil next to transplant
I =	Fertilizer only-	1 tablet in soil next to transplant
J =	Mimic® Foliar -	Apply Mimic® (0.6 ml/L water) 5X / season
K =	Bare-root Check -	Treat w/ Terrasorb™ and plant bare-root

Fifty seedlings for each treatment were planted (1.8 X 3 m (= 6 X 10 ft) spacing) on each of plantation sites – to ensure 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. Just after seedling transplant, three plant spikes (2003) or one treatment tablet (2004) was pushed into the soil 6 cm deep and 4 cm from each assigned seedling.

Treatment Evaluation: Tip moth damage will be evaluated on second-year sites 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 Tukey's Compromise test using Statview or SAS statistical programs.

Research Time Line:

CY 2005

January – October 2005

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

November - December 2005

- Evaluate tip moth damage on treated and untreated on second-year trees 3-4 weeks after the 5th generation.
- Measure height, diameter (at 6" on 2nd-year trees and at breast height on 3rd-year trees) and form of trees (on 3rd year) (November).
- Conduct statistical analyses of 2005 data.
- Prepare and submit report to WGFPMC Executive Committee and Bayer Crop Protection.

CY 2006 (if warranted based on CY 2005 results)

November - December 2005

- Measure height, diameter (at breast height) and form of trees (November).
- Conduct statistical analyses of 2006 data.
- Prepare and submit report to WGFPMC Executive Committee and Bayer Crop Protection.

REGENERATION WEEVILS

Fipronil for Protection of Pine Seedlings from Regeneration Weevils (Initiated in 2005)

Objectives: The objectives of this research proposal are to: 1) evaluate the potential efficacy of fipronil in protecting pine seedlings from regeneration weevils; and 2) determine the duration of treatment efficacy.

Justification: The pales weevil, *Hylobius pales*, and pitch-eating weevil, *Pachylobius picivorus*, are two of the most serious insect pests of pine seedlings in the eastern United States. Adult weevils of both species are attracted to freshly harvested pine sites where they breed in logging slash, stumps and old root systems. Seedlings planted in freshly-cut areas are injured or killed by adult weevils that feed on the stem bark. It is not uncommon to have 30 to 60 percent weevil-caused mortality among first-year seedlings in the South, and mortality of 90 percent or more has been recorded. In the North, pales weevil is also destructive to pine and other conifers grown for Christmas trees.

Several insecticide products are currently registered with the Environmental Protection Agency (EPA) for treatment of pine seedling after lifting or planting. However, the easiest, most cost-effect and commonly used protective treatment has been, in recent years, to apply permethrin (Pounce® 3.2 EC) at 2 quarts per 100,000 seedlings just prior to lifting the seedlings in the nursery. Trials conducted by the WGFPMC indicate that this treatment can effectively protect seedlings for up to 6 months after planting (Grosman, unpublished data).

Since 1996, EPA has been reevaluated the registrations of several insecticide groups including organophosphates and carbamates. Some uses of several commonly used products (Dursban®, Diazinon®) subsequently were phased out due to their toxicity and potential risk for human exposure. In the next year or two, pyrethroids, including permethrin, will be reevaluated as well.

Fipronil (BASF), a new pheny pyrazole insecticide, has been shown to have systemic activity in pine. 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 bark beetles. Treatment of pine seedlings with fipronil (Regent® and Termidor®) has been highly effective in reducing pine tip moth damage in several trials conducted 2002 – 2004 (Grosman, unpublished data). An operational planting trial established in 2003 also showed that weevil feeding damage on fipronil-treated seedlings was significantly less than that occurring on untreated seedlings.

With the potential loss of currently registered foliar insecticides, there is a need to evaluate effective alternatives to protect pine seedlings from weevils. Additionally, a single treatment to control both weevils and tip moth would be beneficial. A chemical alternative that provides effective protection (> 1 year) and could by applied in the nursery or at planting would be preferred by forest managers because it could be easily applied, economical, and generally pose little hazard to the applicator. Preliminary data indicates that treatment of seedlings with fipronil may reduce weevil damage. BASF is interested in determining the extent to which fipronil can reduce weevil-caused seedling mortality (Harry Quicke, BASF, personal communication). The purpose of this study is to 1) determine the efficacy of fipronil against weevils on loblolly pine seedlings and 2) determine the duration of treatment efficacy.

Research Approach: The study was established in January 2005 on two recently harvested tracts owned by private or industrial landowners. The tracts are 6 and 13 acres in size and classified as having moderate to high risk for weevil infestation (pine plantation cut less than 5 months prior to planting and having an abundant amount of pine slash left on-site). Each tract was planted with untreated loblolly pine seedlings by late January. Tree spacing was at the discretion of the landowner. After planting, 10 plots were established and evenly spaced throughout each plantation. Each plot consists of 4 sub plots (each containing 10 seedlings) spaced 10 feet apart. One of three fipronil treatments was randomly assigned to three of the four subplots. The fourth sub plot will serve as a check. The treatments include:

1) In-furrow (4X - 0.051%, 1.24 ml Regent®/liter) applied at 7ml solution/ft of furrow in nursery bed in July. Treated seedlings lifted and planted.
2) Plant hole - 30 ml (0.267%, 6.8 ml Regent®/liter) applied to plant hole at planting.
3) Soil injection - 30 ml (0.267%, 6.8 ml Regent®/liter) applied via soil injection equipment to the soil near the terminal roots of the seedling (5-6 inches deep).
4) Untreated (Check).

All seedlings will be evaluated monthly for weevil feeding damage from February through November. The amount of damage on each seedling will be ranked as follows:

0 = no damage,
1 = light damage (a few feeding sites),
2 = moderate damage (several feeding sites, but not extensive enough to girdle seedling)
3 = extensive damage or mortality (weevil feeding has girdled seedling and mortality is imminent or has already occurred)

Additional data may be collected on the occurrence of other insect damage (tip moth, aphid, coneworm, pine webworm) as it occurs.

Weevil populations will be monitored by deploying two multiple funnel traps (one within the high-risk plantation and one nearby in a low-risk area). Each trap will be baited with 5:1 mixture of ethanol and turpentine in an amber bottle and wick. A mixture of ethylene glycol and water will be placed in the collecting cup to preserve captured insects. Collections will be made monthly.

Data will be analyzed by GLM and the Tukey's Compromise test using Statview statistical program.

Project Support: The $50,000 grant from BASF will be used to support a portion of this research.

Research Time Line:

January 2005

- Select moderate to high-risk tracts (early January)
- Plant tracts with untreated pine seedlings (mid-January)
- Establish study plots and plant treated seedlings or treat resident seedlings (mid-January)

February - November, 2005

- Monitor for weevil and other insect damage (February - November).

December, 2005

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

Western Gulf Forest Pest Management Cooperative
Activity Time Line - CY2005

January

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

February

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

March

- Treat selected tip moth impact plots with insecticides.
- Monitor tip moth and weevil populations and rainfall for tip moth studies.
- Make selection of study sites and trees for Bark Beetle and Seed Orchard Injection studies.
- Treat study trees (slash pine) with injection treatments for Seed Orchard Injection Study.
- Evaluate weevil damage.

April

- Flag 6-10 branches/tree and record number of conelets and cones on all treatment and check trees for Injection Trial at each seed orchard.
- Treat study trees with injection treatments for Bark Beetle and Seed Orchard Injection Study.
- 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.
- Evaluate weevil damage.

May

- Evaluate tip moth damage after 1^{st} generation for all tip moth studies; photograph damage.
- Evaluate termite damage to log cookies; photograph damage.
- Treat study trees with standard foliar treatment for Seed Orchard Injection Study.
- Fell trees, 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.
- Evaluate weevil damage.

June

- Treat study trees with standard foliar treatment for Seed Orchard Injection Study.
- Collect and evaluate bolts and traps SPB Injection Study.
- Evaluate tip moth damage after 2^{nd} 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.

July

- Treat study trees with standard foliar treatment for Seed Orchard Injection Study.
- Fell trees, deploy bolts, traps and bark beetle pheromones for *Ips* Bark Beetle Injection Study.
- Treat nursery seedlings with in-furrow treatments.
- Treat selected tip moth impact plots with insecticides.
- Monitor tip moth populations and rainfall for tip moth studies.
- Evaluate weevil damage.

Western Gulf Forest Pest Management Cooperative
Activity Time Line - CY2005

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.
- Treat study trees with injection treatments for Western Bark Beetle 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 weevil damage.
- 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).
- Fell trees, deploy bolts, traps and bark beetle pheromones for *Ips* Bark Beetle Injection Study.
- Evaluate tip moth damage after 4th generation for all tip moth studies; photograph damage.
- Treat nursery seedlings with in-furrow treatments.
- Monitor tip moth populations and rainfall for tip moth studies.
- Collect acorns from sample trees for Seed Orchard studies.
- Evaluate weevil damage.

October
- Treat selected tip moth impact plots with insecticides.
- Collect and evaluate bolts and traps Ips Bark Beetle Injection Study.
- Collect all cones from sample trees for Seed Orchard studies.
- Evaluate coneworm damage for systemic injection rate and Denim® studies.
- Collect acorns from sample trees for 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 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.

2005 Proposed Budget

The proposed budget for CY 2005 totals $179,331 (Table 1). The proposed budget includes an increase of $26,961 for salaries and fringe benefits due to the anticipated hiring of a full-time Research Specialist (9 months in 2005), shifting time-share of the staff forester, and the need for 2 seasonal technicians (4.5 months each). Monies budgeted for operating expenses were increased by about 26% to a total of $22,328 compared to actual CY2004 operating expenses. The increase is in anticipation of additional travel and vehicle use and maintenance expenses. Current membership dues plus a CY2004 surplus of $11,860 in the WGFPMC account plus $1,350 for seed analysis work for WGTIP will provide $71,710 (40%). An additional $57,689 (32%) is available from a BASF gift ($50,000), and funds available in the FSPIAP (fipronil) and Griffin LLC grants and from WGTIP for seed analysis. The remaining (28%) 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 2004 is given in Table 2.

2006 Proposed Budget

A proposed budget for CY 2006 is given in Table 3 by source of funding. A total of $196,403 is proposed for CY 2006. Assuming that membership dues will remains stable at $8,000 per full member in CY 2006 (4 years after the last increase) (Fig. 1), and membership remains at 8, $68,500 (35%) would be provided by membership dues, utilization of 1/3 ($8,000) of the surplus GL account funds and anticipated funds from WGTIP for seed analysis. The remainder (65%) 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 2006 is given in Table 4. We anticipate that one or more small projects will terminate at the end of CY 2005, allowing the funding of one new applied research or technology transfer project in CY 2006.

Table 1. WGFPMC Proposed Budget by Source of Funding - CY 2005

	Source: WGFPMC	Source: TFS and Others*	Total	% of Total
A. Salaries and Wages				
Principal Investigator (Grosman) (100%)	$ 18,457 (33%)	$ 37,474 (67%)	$ 55,931	
Research Specialist (New hire **) (100%)	4,650 (20%)	18,600 (80%)	23,250	
Staff Forester (Upton) (75%)	15,998 (40%)	13,998 (35%)	29,996	
2 Seasonal Technician (4.5 mo.)	9,000	9,000	18,000	
Total Salaries and Wages	$ 48,105	$ 79,072	$ 127,177	
B. Fringe Benefits (26% of Salaries & 8% of Wages)	$ 10,887	$ 18,939	$ 29,826	
	58,992	98,011	157,003	88%
C. Operating Expenses				
Supplies	$ 2,748	$ 2,500	$ 5,248	
Vehicle Use and Maintainance	5,770	1,510	7,280	
Travel	2,000	1,950	3,950	
Telecommunications (15% of PCS)	0	350	350	
Utilities (15% of PCS)	0	1,300	1,300	
Other Services (rentals, publications, postage, etc.)	2,200	2,000	4,200	
Total Operating Expenses	$ 12,718	$ 9,610	$ 22,328	12%
Grand Total	$ 71,710 ***	$ 107,621	$ 179,331	
% of Total	40%	60%	100%	100%

* includes $50,000 BASF gift and any new members or federal grants.

** New Research Specialist expected to be hired by April 1.

*** member dues at $8,000/yr for seven members; $2,500/yr for one member, $11,860 CY04 surplus,and $1,350 for WGTIP seed analysis = $71,710.

Table 2. WGFPMC Proposed Budget by Source of Project - CY 2005

	Activity					
	Administration	Tip Moth Studies		Systemic	LCA and	
	Site Visits/Service	(Impact & HR)	(Systemic Trt)	Injection Studies	Weevil Studies	Total
A. Salaries and Wages						
Entomologist III (100%)	$ 27,966 (50%)	$ 5,593 (10%)	$ 5,593 (10%)	$ 11,186 (20%)	$ 5,593 (10%)	$ 55,931
Research Specialist (100%)	0	6,975 (30%)	6,975 (30%)	6,975 (30%)	2,325 (10%)	23,250
Staff Forester (75%)	0	5,999 (15%)	7,999 (20%)	11,999 (30%)	3,999 (10%)	29,996
2 Seasonal Technician (4.5 mos.)	0	4,500 (25%)	6,300 (35%)	5,400 (30%)	1,800 (10%)	18,000
B. Fringe Benefits (26% of Salaries) 8% of Wages)	$ 7,271	$ 5,187	$ 5,851	$ 8,274	$ 3,242	$ 29,826
C. Operating Expenses						
Travel and Vehicle Use	$ 2,950	$ 2,070	$ 2,070	$ 2,820	$ 1,320	$ 11,230
Supplies & Postage	2,306	1,040	1,250	1,250	500	6,346
Other Operating Expenses	1,540	812	800	800	800	4,752
Grand Total	$ 42,033	$ 32,176	$ 36,838	$ 48,704	$ 19,579	$ 179,331

Table 3. WGFPMC Proposed Budget by Source of Funding - CY 2006

		Source			% of
		WGFPMC	TFS and Others*	Total	Total
A.	**Salaries and Wages**				
	Principal Investigator (Grosman) (100%)	$ 17,618 (30%)	$ 41,109 (70%)	$ 58,727 ***	
	Research Specialist (New hire from '05) (100%)	6,200 (20%)	24,800 (80%)	31,000	
	Staff Forester (Upton) (75%)	12,398 (31%)	17,598 (44%)	29,996	
	2 Seasonal Technician (4.5 mo.)	9,000	9,000	18,000	
	Total Salaries and Wages	$ 45,216	$ 92,507	$ 137,723	
B.	**Fringe Benefits (26% of Salaries & 8% of Wages)**	$ 10,136	$ 22,432	$ 32,568	
		55,352	114,939	170,291	88%
C.	**Operating Expenses**				
	Supplies	$ 2,700	$ 2,700	$ 5,400	
	Vehicle Use and Maintainance	4,998	2,000	6,998	
	Travel	3,050	1,250	4,300	
	Telecommunications (15% of PCS)	0	350	350	
	Utilities (15% of PCS)	0	1,300	1,300	
	Other Services (rentals, publications, postage, etc.)	2,400	2,000	4,400	
	Total Operating Expenses	$ 13,148	$ 9,600	$ 22,748	12%
	Grand Total	$ 68,500 **	$ 124,539	$ 193,039	
	% of Total	35%	65%	100%	100%

* includes $50,000 BASF gift and any new members or federal grants.

** includes 5% salary increase

*** member dues at $8,000/yr for seven members; $2,500/yr for one member, $8,000 GL Acct surplus,and $2,000 for WGTIP seed analysis. = $68,500

Table 4. WGFPMC Proposed Budget by Source of Project - CY 2006

	Activity					
	Administration	Tip Moth Studies		Systemic		
	Site Visits/Service	(Impact & HR)	(Systemic Trt)	Injection Studies	Other Study	Total
A. Salaries and Wages						
Entomologist III (100%)	$ 23,491 (40%)	$ 8,809 (15%)	$ 8,809 (15%)	$ 8,809 (15%)	$ 8,809 (15%)	$ 58,727
Research Specialist (100%)	0	9,300 (30%)	9,300 (30%)	9,300 (30%)	3,100 (10%)	31,000
Staff Forester (75%)	0	5,999 (15%)	7,999 (20%)	11,999 (30%)	3,999 (10%)	29,996
2 Seasonal Technician (4.5 mos.)	0	4,500 (25%)	6,300 (35%)	5,400 (30%)	1,800 (10%)	18,000
B. Fringe Benefits (26% of Salaries)	$ 6,108	$ 6,628	$ 7,292	$ 8,260	$ 4,280	$ 32,568
C. Operating Expenses						
Travel and Vehicle Use	$ 3,000	$ 2,000	$ 2,400	$ 2,500	$ 1,398	$ 11,298
Supplies & Postage	2,400	900	1,100	1,100	1,100	6,600
Other Operating Expenses	1,440	850	850	850	860	4,850
Grand Total	$ 36,439	$ 38,986	$ 44,050	$ 48,218	$ 25,346	$ 193,039

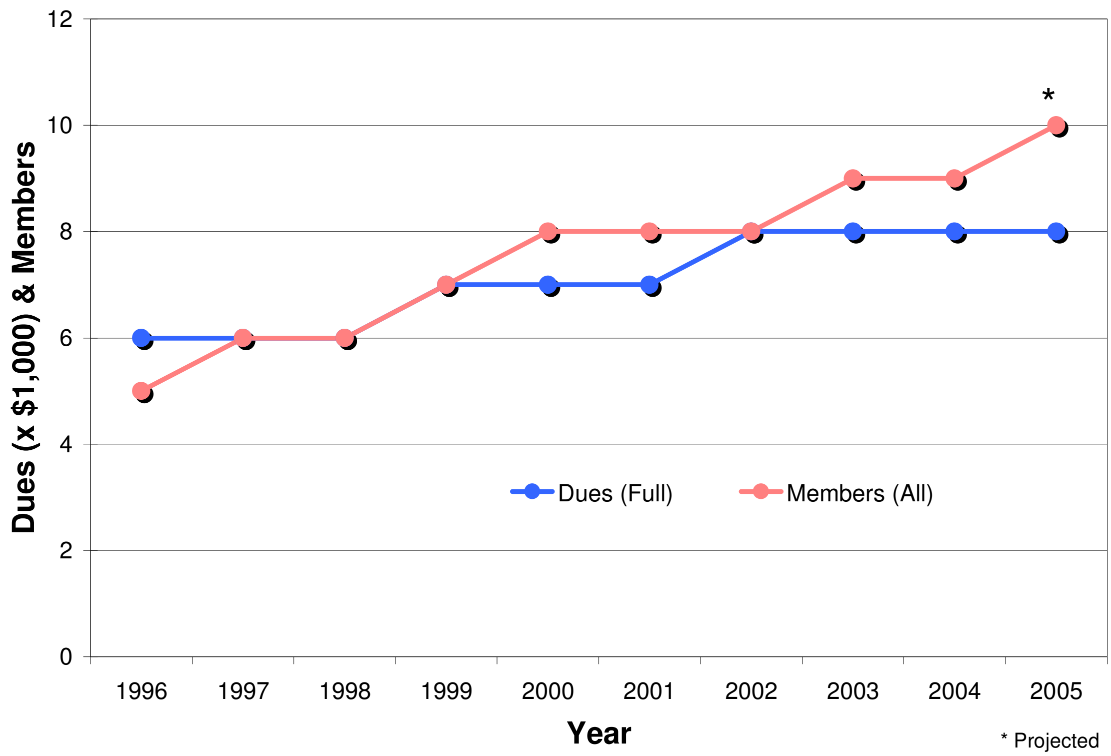

Figure 1. Dues and membership levels in the Western Gulf Forest Pest Management Cooperative from 1996 to 2005 (projected).

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