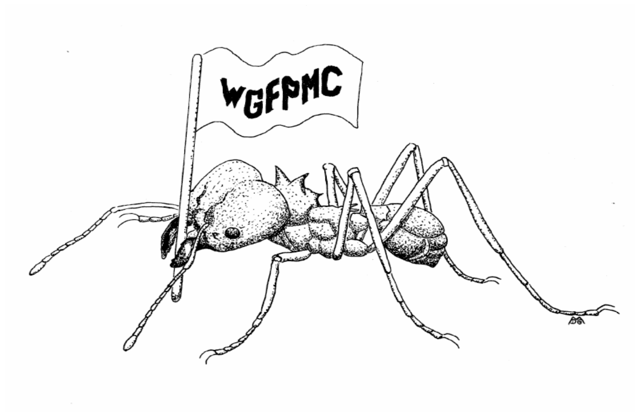
Western Gulf Forest Pest Management Cooperative



Report on
Research Accomplishments in 2005

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2005 WGFPMC Members:

Anthony Forest Products Company
Forest Investment Associates
International Paper Company
Plum Creek Timber Company, Inc.
Potlatch Corporation
Temple-Inland Forest Products Corporation
Texas Forest Service
U.S.D.A. Forest Service - Forest Health Protection R8
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Executive Summary

The Western Gulf Forest Pest Management Cooperative (WGFPMC) made significant strides in 2005. A brief summary of WGFPMC activities is given below. Two primary research projects (systemic injection studies and tip moth impact/hazard/control) were continued from 2004. These projects contained sixteen smaller studies that were initiated, continued and/or completed. Separate detailed reports for each study are attached. The purpose of this report is to provide executive committee members with an update on research findings and a basis for evaluating the merits of the attached 2006 Project Proposals.

Membership in the WGFPMC did not change in 2005. **Thank you for your continued support!**

Jason Helvey was hired in April as our new full-time research specialist. He is providing assistance in the management of the tip moth projects. William Upton has taken over the field management of the leaf-cutting ant, weevil and systemic injection trials. Seasonal technicians Jeff Cruse, Dustin Hollowell, and Gregg Cheney were hired to provide assistance with field and lab studies. Southern Pine Beetle Prevention Specialists Allen Smith and Mike Murphrey, provided assistance with cone evaluations and GPS/GIS work. We appreciate the help provided by Vladimir Cizek, another visiting forester from the Czech Republic, with several projects in April. We also greatly appreciate the time and effort provided by member representatives on the various projects. They are acknowledged in each report.

Service to members continues to be an important part of the WGFPMC. To this end, four issues of the *PEST* newsletter were prepared and distributed. Also, 7 presentations, 13 meeting requests, and 99 phone/e-mail requests were addressed relating to the following topics: leaf-cutting ants, pine tip moth, reproduction weevils, bark beetles (southern pine beetle, *Ips* and black turpentine beetle), and cone and seed insects (coneworms and seed bugs).

Although the citrus pulp bait containing the active ingredient fipronil (Blitz®, Bayer Environmental Science) was found to be highly effective against leaf-cutting ants, Bayer has decided not to support the registration of the product in the U.S. Bayer cited insufficient market size as its primary reason. In the mean time, a small study was completed in spring 2005 to evaluate the effectiveness of a "new" product called Amdro® Ant Block. It is reported to have generally the same formulation as the old Amdro® leaf-cutting ant bait except is contains more sugars to improve attractiveness. Although none of the Amdro®-treated colonies were killed, the activity level of all colonies after 33 weeks post-treatment was significantly reduced (63%) compared to their initial activity.

What a turn around! In contrast to 2004, where rainfall was more than 30 inches above normal (46+ inches) in Lufkin, rainfall was more than 12 inches below average in 2005. Most areas in the Western Gulf Region also received below average rainfall. Northeast Texas was one of the hardest hit areas. Several other areas had a relatively short period of drought in August and September.

Populations and damage caused by several lepidopteran defoliators, including oak leaf roller and walnut caterpillars, increased in several areas of Central and East Texas, respectively. Pine tip moth damage levels were generally higher than in previous years; several locations averaged >60% infested shoots by mid-summer. After an outbreak year in 2004, coneworm and seed bug pressure declined considerably in 2005. Also on the positive side, no infestations of the southern pine beetle were reported in Texas, Louisiana, Arkansas or Oklahoma in 2005. However, 92 southern pine beetle infestations were reported to have developed on state and national forests in Mississippi. Due to intensifying drought conditions, *Ips* engraver beetles populations began building in east Texas in the late summer and caused considerable tree mortality.

Progress continues on the evaluation and development of systemic insecticides and injection systems. With the discovery in 2004 that emamectin benzoate and fipronil were both effective in preventing the mortality of pine trees by bark beetles, new formulations of both chemicals were developed for testing in 2005. One trial was established in Texas to evaluate the efficacy of these new formulations against *Ips* engraver beetles. The results again indicate that emamectin benzoate and fipronil are highly effective against bark beetles and wood borers. Also, we are interested in determining if these chemicals are effective against more aggressive *Dendroctonus* species. Additional trials were established in Mississippi for southern pine beetle on loblolly pine, in California for western pine beetle on ponderosa pine, in Utah for spruce beetle on Englemann spruce, and in Idaho and British Columbia for mountain pine beetle on lodgepole pine. All trials are on-going, but preliminary data for MS and CA trials indicate that emamectin benzoate and fipronil are both effective in reducing tree mortality by bark beetles. A manuscript entitled “Efficacy of systemic insecticides for protection of single trees against southern pine engraver beetles (Coleoptera: Curculionidae, Scolytinae) and wood borers (Coleoptera: Cerambycidae)” and based on the 2004 trial was accepted for publication in the Journal of Economic Entomology. Evaluations of injected trees from 2004 indicate that emamectin benzoate and fipronil protected wood from termites, wood borers and *Ips* bark beetles for 10 – 14 months after the trees were felled.

The new emamectin benzoate and fipronil formulations also were tested in several seed orchards in 2005. Trials were established in two loblolly pine, two slash pine, one Douglas-fir and a cherrybark oak seed orchard. Data collected, so far, from the two loblolly and one slash pine orchards indicate again that emamectin benzoate had significantly reduced levels of coneworm damage. Seed analysis for seed bug damage is ongoing.

The tip moth project, established in 2001, to evaluate the true impact of pine tip moth on the growth of loblolly pine and identify site characteristics that influence the occurrence and severity of pine tip moth infestations, was further expanded in 2005. Forty-four impact plots on 29 sites are now established in the Western Gulf Region. An additional 4 hazard-rating plots were established in 2005, bringing the total to 76. The analysis of impact data indicates that protected trees continue to grow at an accelerated rated through the fifth year after establishment. A preliminary hazard-rating model developed by Mr. Andy Burrow indicates that two site characteristics - site index and proportion of sand in the soil - have the greatest influence on the occurrence and severity of tip moth damage.

Systemic insecticide trials revealed that single applications of fipronil continued to affect pine tree growth through the third growing season. Additional fipronil trials initiated in 2003 to evaluate application techniques and rates showed that root dips and plant hole treatments continued to reduce tip moth damage through the third growing season. Three fipronil technique and rate refinement trials were established on 14 sites across the South in 2004. All trials again showed that fipronil applied by root soaks and dips and in plant holes provided excellent protection during the second year after planting. Operational planting trials on four sites showed that larger plantation areas containing fipronil-treated seedlings continued to experience less tip moth damage and greater improvements in tree growth in the third year after planting compared to untreated areas.

A pilot test was established on two sites in 2004 to evaluate the potential efficacy of tablets containing different rates of imidacloprid plus or minus fertilizer. Although most insecticide treatments did reduce tip moth damage levels, the effects on growth were marginal. Three trials were established in 2005. One trial found that fipronil applied in furrow next to seedlings in nursery beds was not effective in reducing tip moth damage. A second trial found that fipronil applied to planted seedlings by a soil injector apparatus was very effective in reducing tip moth damage later in the year. The final trial appeared to show that fipronil also can reduce the level of seedling mortality caused by regeneration weevils. In light of the above results, BASF has indicated that they will pursue EPA registration of fipronil for protection of pine seedlings against pine tip moth.

LEAF-CUTTING ANT

Amdro® Ant Block Bait Trial - East Texas

Highlights:

- The production and sale of Volcano® Leafcutter Ant Bait was discontinued in 2003 after DuPont acquired Griffin LLC. DuPont does not plan to resume production of Volcano®.
- Bayer Environmental Science has decided not to support the registration of "BES-100," citing insufficient market size.
- A 'new' ant bait, Amdro® Ant Block, was registered in TX and LA in late 2004. A small trial was initiated in March 2005 to evaluate its efficacy against the Texas leaf-cutting ant. The bait was ineffective in halting ant activity after 16 weeks, but did reduce activity by an average of 63%.

Justification: 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. Ambrands, Atlanta, GA, recently acquired the rights to the 'old' Amdro® leaf-cutting ant bait. They are now marketing this same bait under the name 'Amdro® Ant Block.' This bait was approved for registration in TX in the fall 2004. Ambrands reported that this bait differs from the old Amdro® in that it contains more sugars and should be more attractive to Texas leaf-cutting ants.

Objective: Evaluate the efficacy of the hydramethylnon/corn grit bait formulation (Amdro® Ant Block) in reducing activity in Texas leaf-cutting ant colonies.

Study Sites: Active colonies (15) were located in East Texas on lands owned by Temple-Inland Forest Products and private landowners.

Insecticide:

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

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

Research Approach:

Application rates were based on the label recommendation of ¾ lb per colony. A cyclone spreader was used to evenly spread measured amounts of hydramethylnon bait over the central nest area (CAN).

Bait - Loose bait spread evenly over entire CNA at ¾ lb per colony in March 2005.
Check - untreated colonies

Application Dates:

Treatments applied to 10 colonies in early March 2005.

Data Collection: The number of active entrance/exit mounds was counted prior to treatment and periodically following treatment at 2, 8, 16 and 33 weeks. Five untreated colonies were included as checks and monitored to account for possible seasonal changes in ant activity. For each colony, the percent of initial activity was calculated as the current number of active mounds at each post-treatment check (X 100) divided by the initial number of active mounds.

Results:

Efficacy Trial: - The bait treatment quickly reduced ant activity (61%) on treated colonies compared to initial activity within 2 weeks after treatment (Table 1). It appeared that a number of treated colonies had become inactive (5 out of 10 after 8 weeks and 8 out of 10 after 16 weeks). Unfortunately, a reassessment 33 weeks post-treatment found that all treated colonies were still active, although at a reduced level (63%) compared to initial levels. The inactivity of some of the colonies (16 weeks post treatment) may have been due, in part, to prevailing drought conditions. Under these conditions leaf-cutting ant colonies tend to go dormant. The reduced ant activity 33 weeks post treatment suggests that the bait was effective in killing a few, but not all, of the queens in each colony. It is possible that the efficacy of the bait may be improved if it were applied in the winter when little green plant material is available.

Acknowledgements: Thanks go to Temple-Inland and several private landowners who provided access to ant colonies. We appreciate the donation of ant bait made by Ambrands, Atlanta, GA for the trial.

Table 1. Efficacy of hydramethylnon (Amdro®) applied by spreader to control the Texas leaf-cutting ant (*Atta texana*) in east Texas (Winter - Summer 2005).

Treatment	No. of Colonies Treated	Mean Nest Area (ft^2)	Mean # Mounds @ Trt.	Mean % initial activity a (% inactive colonies):											
				2 wk			8 wk			16 wk			33 wk		
				N			N			N			N		
Hydramethylnon (Amdro® Ant Block)	10	733	88	10	38.5	(10)	10	10.7	(50)	10	----	(80)	9	37.3	(0)
Check (no treatment)	5	515	87	5	110.8	(0)	5	92.4	(0)	5	----	(0)	5	100.0	(0)
Total	15														

Summary and Registration Status of Leaf-cutting Ant Control Options

Based on our previous experience with leaf-cutting ant baits, marginally effective baits (including the "old" Amdro® and Grant's baits) can significantly reduce worker ant populations and activity for 4 to 12 weeks after treatment. However, if the active ingredient is not passed onto all the queens, the surviving queens will ultimately repopulate the colony. The data collected during the 2005 Amdro® trial indicates that ant activity in most colonies had not recovered to the initial level. This suggests that the Amdro® Ant Block bait was somewhat effective in reducing the number of queens in each treated colony and preventing the colony's population from recovering fully.

Evaluations conducted by the WGFPMC in 1996 on Amdro® leaf-cutting ant bait revealed that two or more factors were likely responsible for the generally poor bait performance.

1) Storage length/temperature. Baits stored for longer than 3 months after opening and/or stored at high temperatures (>90^{o}F) have a tendency to go stale or turn rancid. Once rancid, the bait is unattractive to the ants.
2) Bait particle size. The bait was originally developed for fire ants – a much smaller ant compared to leaf-cutting ants. Most leaf-cutting ant foragers will pick up particles >2 mm in diameter. However, more than 50% of the Amdro® bait particles are < 2 mm in diameter and is likely to be 'lost' to the ants when spread over the central nest area.
3) Bait carrier preference. Dr. Scott Cameron, IP, had conducted much of the early development work that showed that leaf-cutting ants prefer a carrier like citrus pulp. However, American Cyanamid had already formulated the Amdro® fire ant bait using corn grit and was reluctant to switch carriers. Their solution was to make the corn grit bait more attractive to leaf-cutting ants by adding an attractant, perhaps sugar. However, even with this addition, the bait is not very attractive to leaf-cutting ants.

It seems unlikely that storage length and/or high temperatures are to blame for the recent bait failure as the bait was reported to be 'fresh'. More likely, the bait's particle size and unattractive carrier ingredient are the primary factors leading to poor bait performance. I seems possible that better efficacy could be obtained with the Amdro® Ant Block bait if it were applied in the winter when little green plant material is available and the bait would be more attractive to the ant.

Note: It was recently brought to my attention that the language on the Amdro® Ant Block label states that "this product is not for use on crops, **timber**, . . ." It suggests that the bait cannot be used in reforestation sites. This has led to one or more forest industries deciding to discontinue use of the product. I have contacted Ambrands and they have indicated they will work to change language to include "timber" or "forested sites" on the label. It is not known at this time when the new language will go into effect.

The future availability of Volcano® is very limited due to the persistence of sulfluramid in the environment (e.g., chemicals related to sulfluramid have been found in the blood of factory workers). EPA and Griffin L.L.C. reached an agreement in 2001 to halt production of technical sulfluramid. Griffin was permitted to produce and sell Volcano® until their supply of technical sulfluramid has been utilized. In 2001, Griffin estimated that Volcano® would be available for the next 7 - 10 years before phase out in 2008 - 2011. Another provision of the EPA/Griffin agreement was that the use language would be changed from “Pine Forest Sites” to “Pine Reforestation Sites - within and immediately surrounding the site.” This new use language restricts application to ant colonies in harvested areas being replanted in pine and includes areas directly adjacent to these sites. In late 2003, Griffin became a subsidiary company of DuPont Chemical Company. In 2004, Dupont/Griffin indicated they wished to sell their remaining technical sulfluramid (enough to make 6 years worth of bait at 5,000 lbs/year) to Red River Specialties. Red River has indicated that they would make arrangements with FMC to have the bait made in Mexico. Unfortunately, at the last second, DuPont decided, for legal reasons, not sell the technical material to Red River Specialties. At the same time, DuPont indicated that they have no plans to resume production or sale of the Volcano bait.

In early 2002, Bayer Environmental Science (previously Aventis) submitted a registration package to the Environmental Protection Agency (EPA) to register the Blitz® formulation in the U.S. under the new product name “BES 100.” The site uses are to be expanded to include all forested areas, including those around residential and commercial sites. The sale and use of the BES-100 bait was to be restricted to licensed applicators. After four years, EPA had yet to approve the registration of BES-100. Recently, EPA implemented a pay-for-services program to quicken the registration process. The cost to register BES-100 would be $20,000. Due to the small potential market (estimated at $500,000 sales per year) and the fact that the bait would have to be purchased from a BASF-owned Brazilian plant and shipped to the U.S., Bayer decided in August they “will not be progressing with commercialization (of BES-100) because the limited market size would not offset the extensive internal costs to set up a new product in their supply chain.”

In the mean time, landowners have no safe <u>and</u> effective means of controlling leaf-cutting ants. The use of methyl bromide for control of leaf-cutting ants was phased out at the end of 2005. The Grants’ Total Ant Killer bait and new Amdro® Ant Block bait are safe but, more often than not, are ineffective with a single application. If a landowner elects to use one of these products, we advise that they follow two primary rules to insure the best possible results: 1) apply the bait when the ants first become active (foraging and/or building mounds) during the day. In the winter, this usually occurs in the late morning when temperature rises above 50°F. In the summer, this is in the late evening when temperatures cool below 85°F. 2) apply the bait when the ground is dry and rain or heavy dew is not expected for 24 hrs. If the ground is wet, the bait will absorb the moisture and become unattractive to the ants.

SYSTEMIC INSECTICIDE INJECTION TRIALS

Emamectin Benzoate and Fipronil Tree Injections for Cone and Seed Insect Control in Southern and Western Seed Orchards – TX, LA, AL, FL & OR

Highlights:

- Tree IV injections of emamectin benzoate reduced coneworm damage by 77 - 92% at three orchards in 2005. Fipronil was slightly less effective at two orchards (74% and 90%), but markedly less effective (32% reduction) at a third orchard.
- Seed analysis to determine treatment effect on seed bug damage is ongoing.

Justification: Trials conducted from 1998 – 2004 at the TFS Magnolia Spring seed orchard showed that both emamectin benzoate (Arise® and Denim®) and fipronil (experimental EC) were effective in reducing damage caused by coneworms and seed bugs. New formulations of these chemicals were developed during the winter of 2004/05 and need to be evaluated for their efficacy against cone and seed insect pests.

Objectives: 1) Evaluate the efficacy of new formulations of emamectin benzoate and fipronil, applied by the Arborjet™ Tree IV injector for control of coneworms, seed bugs and/or flower thrips in loblolly and slash pine orchards and coneworms, seed bugs and cone midge in a Douglas-fir seed orchard.

Cooperators:

Mr. Jim Smith	Plum Creek Timber Company, OR
Mr. Jerry Watkins	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. Alex Mangini	US Forest Service, FHP R8, LA
Dr. David Cox	Syngenta, Modesta, CA
Dr. Harold Quicke	BASF, Auburn, AL
Mr. Joseph Doccola	Arborjet, Inc., Worchester, MA

Study Sites:

Loblolly pine:

Plum Creek's Hebron orchard near Chatham, LA (Jackson Parish)
International Paper's Bellamy orchard near Marianna, FL (Jackson Co.)

Slash pine:

Temple-Inland's Forest Lake orchard near Spurger, TX (Jasper Co.)
Smurfit-Stone's Brewton orchard near Brewton, AL (Escambia Co.)

Douglas-fir:

Plum Creek's Cottage Grove orchard near Cottage Grove, OR (Lane Co.)

Insecticides:

Emamectin benzoate (Ava-jet, Arborjet, Inc.) -- avermectin derivative

Fipronil (experimental BAS 350 UB I) -- a phenyl pyrazole insecticide that has shown systemic activity against other Lepidoptera (tip moth)

Design: Randomized complete block with clones as blocks. 3-4 treatments X 5-6 clones = 62 ramets used per study site.

Treatments:

1) Emamectin benzoate (Ava-jet, Arborjet Inc.) at 5 - 10 ml (0.2 – 0.4g AI) per inch tree diameter at breast height (DBH) by Tree IV injector
2) Fipronil (BAS 350 UB I) at 1.7 - 3.4 ml (0.2 – 0.4g AI) per inch tree DBH by Tree IV injector
3) Asana® XL, Capture®, Warrior®, Mimic®, Guthion®, or Imidan® (foliar standard) applied operationally by air to foliage 3-4 times per year at label rate beginning in April.
8) Check (untreated)

Application Methods:

In March (AL, OR & TX) and April (FL & LA), at least four holes, 3/8 in diameter and 5-8 cm (2-3 in) deep, were drilled about 30 cm high at cardinal points on the tree bole. Arborplugs were installed in each hole. The Arborjet™ Tree IV system was used to inject a predetermined amount of product into each hole (Figures 1A & B). The rate also increased with 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. The length of time to inject each varied from 5-40 min and was dependent on tree, species, location and weather.

The foliar spray treatment (Capture®, Mimic®, or Warrior® standard) was applied at one orchard (Bellamy) to foliage beginning in April 2005 using a hydraulic sprayer at 10 gal/tree. The distance between test trees will be ≥20 m to minimize the effects of drift. At one orchard (Forest Lake) where hydraulic spray equipment was not available, a rough comparison was made between treatment efficacies on injected trees to operationally sprayed trees in another block.

Data Collection:

Conelet and Cone Survival – Six to ten branches were tagged per sample tree (minimum of 50 conelets and 50 cones) in April 2005; conelets and cones were reevaluated for damage and survival in late September.

***Dioryctria* Attacks** -- All cones that could be reached by bucket truck were picked in September; cones were categorized as small dead, large dead, green infested, with other insect or disease damage, or healthy.

Seed Bug Damage -- 10 healthy cones were picked "at random" from all healthy cones collected from each ramet; seeds were extracted and radiographed (X-ray); seeds were categorized as full seed, empty, seed bug-damaged, 2nd year abort, seedworm-damaged, and other damage.

Results:

The cone crops were lost at the Oregon Douglas-fir orchard due to frost and at the Alabama slash pine orchard due to hurricane winds.

The study orchard block at the Hebron orchard (Plum Creek, LA) had not been sprayed since establishment, whereas, the study orchard blocks at the Forest Lake (Temple, TX) and Bellamy (IP, FL) were sprayed operationally in 2004 - suggesting that pressure from coneworms and seed bugs would likely be higher at the Hebron orchard compared to the Forest Lake and Bellamy orchards. This was confirmed for coneworms by 31% damage on check cones in at the Hebron orchard (Table 6). This contrasts with the 6% and 4% damage on the same trees in the Forest Lake and Bellamy orchards, respectively. Relatively high numbers of both leaffooted and shieldbacked pine seed bugs were observed in the trees at the Bellamy orchard (Tim Slichter, personal communication). The ongoing seed analysis should allow us to confirm these observations.

<u>Treatment Effect on Conelet and Cone Survival</u>: Cones and conelets on tagged branches were examined in April and September. The emamectin benzoate treatment significantly improved survival of conelets and cones compared to check trees in LA (Table 2, Figures 2 & 3). In contrast, none of the treatments improved survival of conelets or cones in FL or TX.

<u>Treatment Effect on Coneworm Damage</u>: Both injection treatments (emamectin benzoate and fipronil) significantly reduced early and late coneworm damage compared to the checks in FL and TX (Table 3, Figure 4). Damage levels observed at these sites were markedly lower than those observed in LA. At the LA site, only emamectin benzoate provided significant protection against early and late-season coneworm damage and improved percentage of healthy cones. Overall, the emamectin benzoate treatment applied by the Arborjet injector provided the greatest reductions in total coneworm damage (76 - 92%) compared to the check (Figure 4).

<u>Treatment Effect on Seed Bug Damage:</u> Analysis of seed lots from the LA, FL and TX sites is on-going.

Conclusions: As in past trials, the results obtained in 2005 confirm that emamectin benzoate is highly effective against coneworm. Fipronil also showed good efficacy in the FL and TX orchards, but only moderate effects at the LA orchard. Drought conditions at the Hebron orchard may have slowed the movement and dispersal of fipronil throughout the treated trees as was observed in 2003. However, the TX orchard also experienced drought conditions - yet the efficacy of fipronil at this orchard was not affected.

The duration of emamectin benzoate and fipronil treatment efficacy is of considerable interest. Cone crops at each orchard will be monitored in 2006.

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Table 2. Mean percentages (± SE) of surviving conelets and cones on branches of loblolly pine, slash pine or Douglas-fir protected with systemic injection of emamectin benzoate, fipronil or foliar treatments, 2005.

Site	Tree Spp.	Treatment	Application Technique, Treatment Date(s)	N	Mean Survival (%) Conelets	Mean Survival (%) Cones
LA	Loblolly pine	Emamectin benzoate	Tree IV - Apr., '05	12	86.6 ± 3.5 **b**†	77.7 ± 5.6 **b**
		Fipronil	Tree IV - Apr., '05	12	58.9 ± 5.2 **a**	65.3 ± 5.8 **a**
		Check		12	48.9 ± 7.8 **a**	56.0 ± 6.7 **a**
FL	Loblolly pine	Emamectin benzoate	Tree IV - Apr., '05	12	90.9 + 2.7 **a**	97.9 + 1.0 **a**
		Fipronil	Tree IV - Apr., '05	12	93.4 + 1.2 **a**	98.5 + 1.0 **a**
		Foliar Spray	Hydraulic 5X	12	90.8 + 2.5 **a**	97.2 + 2.1 **a**
		Check		12	95.4 + 1.4 **a**	97.4 + 1.0 **a**
TX	Slash pine	Emamectin benzoate	Tree IV - Apr., '05	10	88.0 + 2.9 **a**	96.1 + 1.8 **a**
		Fipronil	Tree IV - Apr., '05	10	89.6 + 2.4 **a**	94.9 + 1.6 **a**
		Foliar spray	Aerial 4X	10	90.6 + 2.3 **a**	91.6 + 2.9 **a**
		Check		10	88.2 + 4.4 **a**	94.7 + 1.6 **a**
AL	Slash pine	Emamectin benzoate	Tree IV - Apr., '05	10	**Data not available due to hurricane damage to cone crop**	
		Fipronil	Tree IV - Apr., '05	10		
		Check		10		
OR	Douglas fir	Emamectin benzoate	Tree IV - Apr., '05	10	**Data not available due to frost damage to cone crop**	
		Fipronil	Tree IV - Apr., '05	10		
		Check		10		

† Means followed by the same letter in each column of the same year are not significantly different at the 5% level based on Fishe LSD.

Table 3. Mean percentages (± SE) of cones killed early and late by coneworms, other-damaged cones, and healthy cones on loblolly pine, slash pine or Douglas-fir protected with systemic injections of emamectin benzoate (EB) or fipronil (FIP), 2005.

					Mean Coneworm Damage (%)				
Site	Tree Spp.	Treatment	Application Technique, Treatment Date(s)	N	Early (small dead)	Late (large dead and infested)	Total	Mean Other Damage (%) *	Mean Healthy (%)
LA	Loblolly pine	EB	Tree IV - Apr., '05	12	1.0 ± 0.4 **a†**	1.8 ± 0.9 **a**	2.9 ± 1.2 **a**	34.3 ± 4.6 **b**	62.9 ± 5.1 **b**
		FIP	Tree IV - Apr., '05	12	11.2 ± 2.1 **b**	10.2 ± 2.8 **b**	21.3 ± 3.3 **b**	33.7 ± 4.3 **b**	44.9 ± 5.2 **a**
		Check		12	16.2 ± 3.5 **b**	15.1 ± 3.4 **b**	31.3 ± 4.9 **b**	24.9 ± 2.2 **a**	43.8 ± 5.7 **a**
FL	Loblolly pine	EB	Tree IV - Apr., '05	12	0.1 ± 0.1 **a**	0.8 ± 0.3 **a**	0.9 ± 0.3 **a**	2.4 ± 0.5 **a**	96.7 ± 0.7 **a**
		FIP	Tree IV - Apr., '05	12	0.2 ± 0.1 **a**	0.8 ± 0.3 **a**	1.0 ± 0.3 **a**	2.0 ± 0.4 **a**	96.9 ± 0.7 **a**
		Spray	Hydraulic - 5X	12	1.1 ± 0.3 **b**	2.1 ± 0.5 **b**	3.2 ± 0.6 **b**	1.4 ± 0.4 **a**	95.4 ± 0.9 **a**
		Check		12	1.8 ± 0.9 **b**	1.9 ± 0.4 **b**	3.8 ± 1.1 **b**	1.9 ± 0.6 **a**	94.3 ± 1.3 **a**
TX	Slash pine	EB	Tree IV - Mar. - Apr., '05	10	0.1 ± 0.1 **a**	0.4 ± 0.3 **a**	0.5 ± 0.4 **a**	5.6 ± 1.3 **a**	93.9 ± 1.5 **a**
		FIP	Tree IV - Mar. - Apr., '05	10	0.2 ± 0.1 **a**	0.4 ± 0.3 **a**	0.6 ± 0.3 **a**	4.4 ± 1.3 **a**	95.0 ± 1.2 **a**
		Spray	Aerial - 5X	10	0.0 ± 0.0 **a**	3.6 ± 0.9 **b**	3.6 ± 0.9 **b**	3.0 ± 0.5 **a**	93.4 ± 1.3 **a**
		Check		10	0.5 ± 0.2 **b**	5.5 ± 1.5 **b**	6.0 ± 1.5 **b**	3.3 ± 0.9 **a**	90.7 ± 2.2 **a**
AL	Slash pine	EB	Tree IV - Mar. - Apr., '05	10					
		FIP	Tree IV - Mar. - Apr., '05	10	**No data available due to hurricane damage to cone crop**				
		Check		10					
OR	Douglas fir	EB	Tree IV - Mar. - Apr., '05	10					
		FIP	Tree IV - Mar. - Apr., '05	10	**No data available due to frost damage to cone crop**				
		Check		10					

* Mortality or wounds caused by drought, pitch canker, squirrel, midge, or mechanical damage.

† Means followed by the same letter in each column of the same year are not significantly different at the 5% level based on Fisher's Protected LSD.

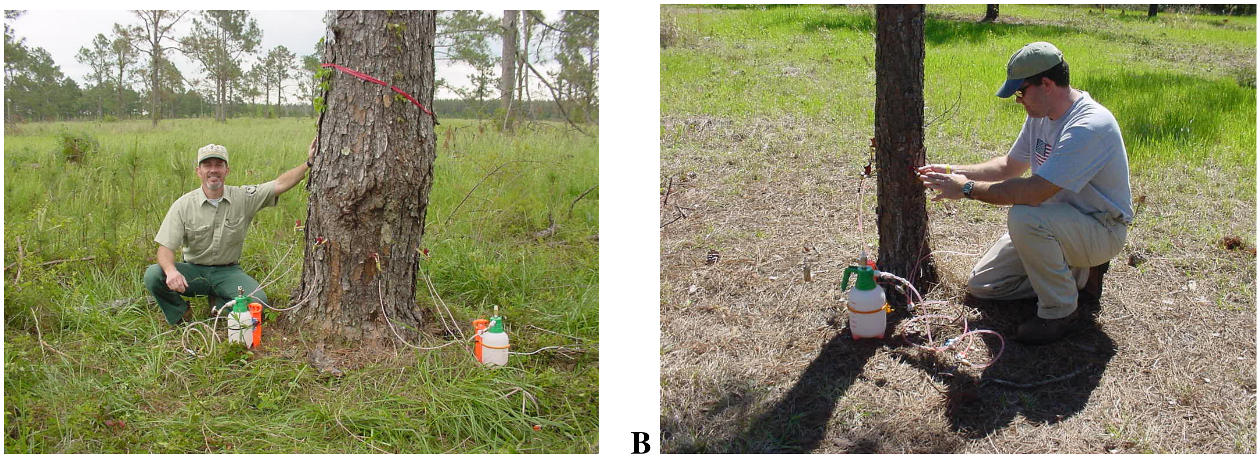
A  B

Figure 1. Arborjet™ Tree IV system being used to inject slash pine in Alabama (A) and loblolly pine in Florida (B) in 2005.

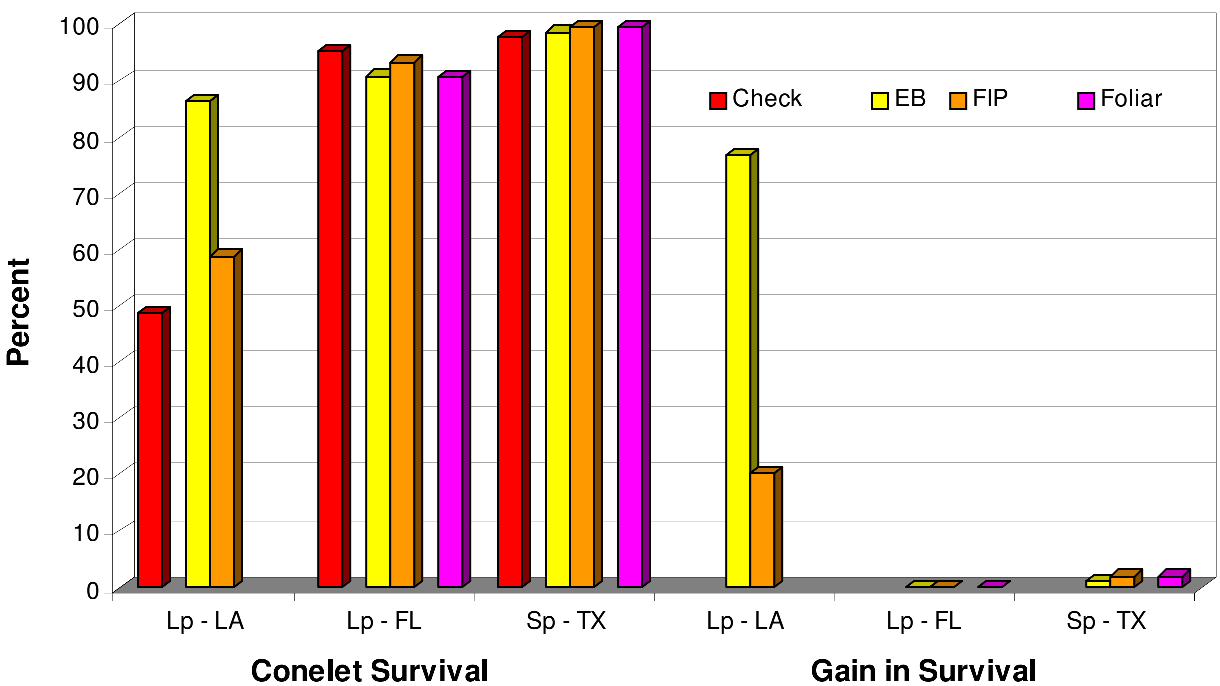


Figure 2. Percent survival and gain in survival of loblolly pine (Lp) or slash pine (Sp) conelets protected with injections of emamectin benzoate or fipronil or foliar treatments in Louisiana (LA), Florida (FL) or Texas (TX), 2005.

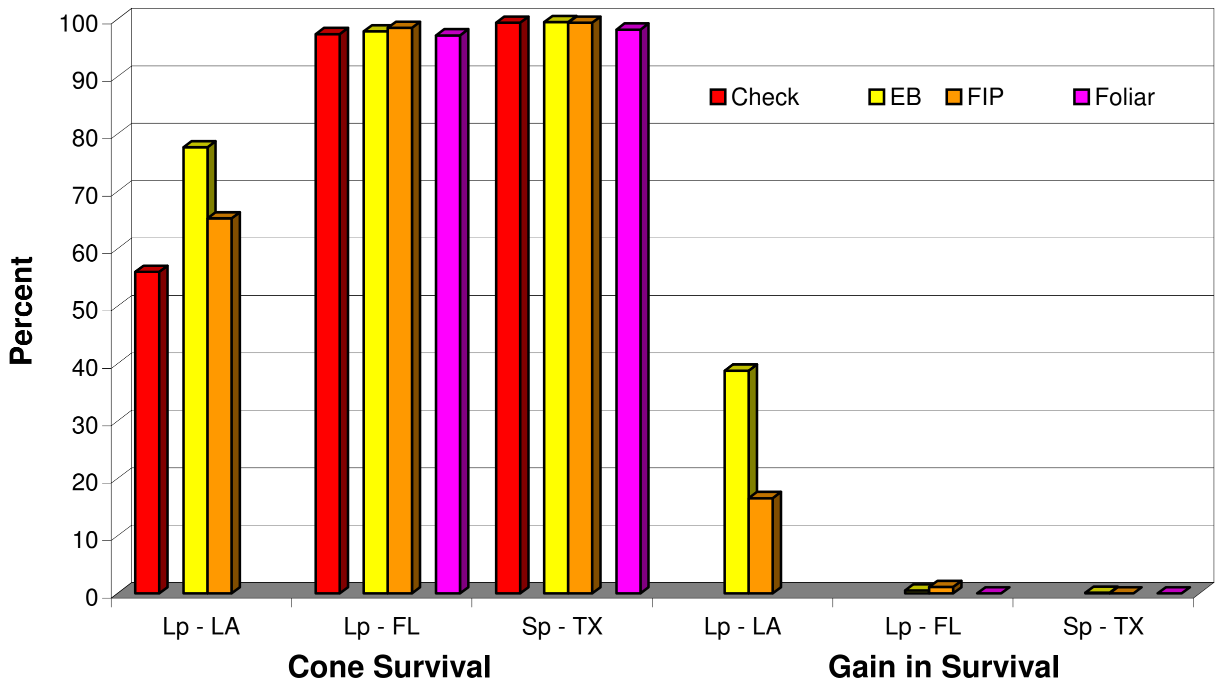


Figure 3. Percent survival and gain in survival of loblolly pine (Lp) or slash pine (Sp) cones protected with injections of emamectin benzoate or fipronil or foliar treatments in Louisiana (LA), Florida (FL) or Texas (TX), 2005.

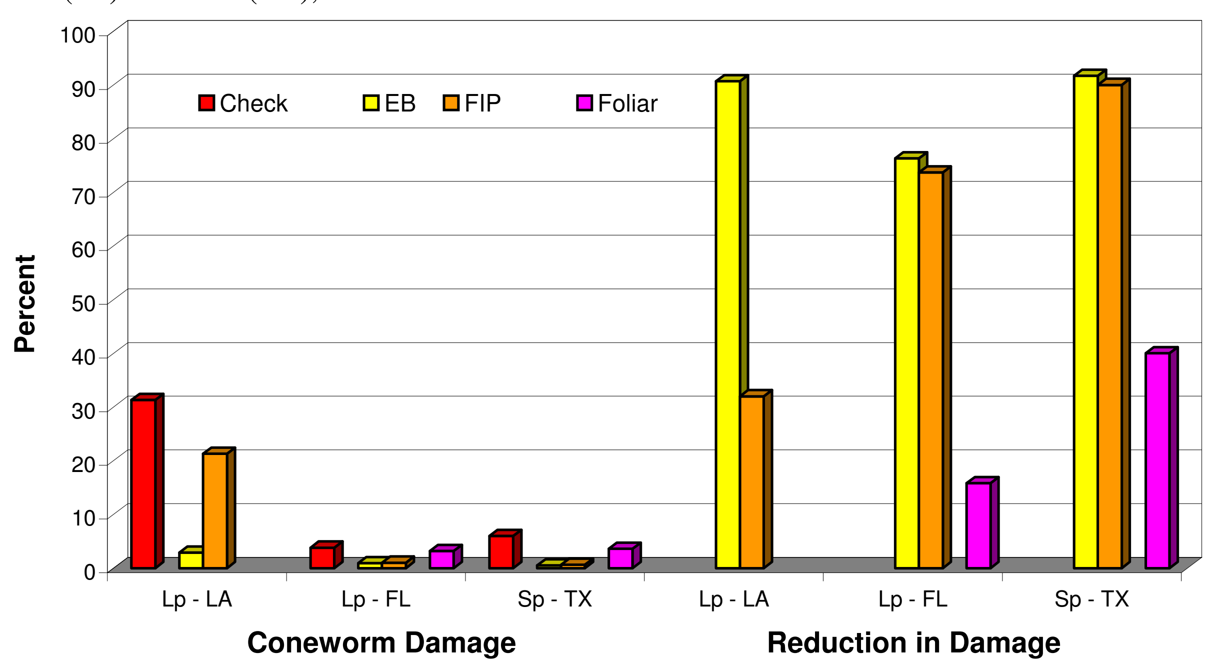


Figure 4. Percent coneworm (*Dyrictria* spp.) damage and reduction in damage on second-year loblolly pine (Lp) or slash pine (Sp) cones protected with injections of emamectin benzoate or fipronil or foliar treatments in Louisiana (LA), Florida (FL) or Texas (TX), 2005.

SYSTEMIC INSECTICIDE INJECTION TRIALS

Protection of Live and Cherrybark Acorn Crops from Acorn Weevil – Hudson, TX

Highlights:

- Nearly all live oak and cherrybark oak study trees have very poor crops in 2005. The data collected from the few acorns that fell from 9 of 30 cherrybark oaks indicate that neither emamectin benzoate nor fipronil had any effect on acorn weevil damage levels.

Objective: 1) Evaluate the potential for systemic injections of emamectin benzoate, imidacloprid or fipronil in reducing acorn crop losses in live oak or cherrybark oak seed orchards.

Cooperators:

Mr. Joe Hernandez	Western Gulf Tree Improvement Program, College Station, TX
Dr. Harold Quicke	BASF, Auburn, AL
Dr. David Cox	Syngenta, Modesta, CA
Mr. Joseph Doccola	Arborjet, Inc., Worchester, MA

Study Site: two 3 acre orchard block containing 10 - 20 year-old live oak and cherrybark oak -- Texas Forest Service Hudson Hardwood Seed Orchard, Angelina Co., TX.

Insecticides:

Emamectin benzoate (Denim® or Avajet) -- avermectin derivative

Imidacloprid -- a highly systemic neonicotinoid insecticide with known activity against Coleoptera

Fipronil (experimental BAS 350 UB I) -- a phenyl pyrazole insecticide that has shown systemic activity against other Coleoptera (bark beetles)

Design:

Live Oak - randomized complete block with clones as blocks. 4 treatments X 5-7 clones = 26 ramets used for study.

Cherrybark Oak - randomized complete block with clones as blocks. 3 treatments X 10 clones = 30 ramets used for study.

Application Methods:

In late May 2004 (live oak) and late April 2005 (cherrybark oak), study trees were selected and measured for DBH to determine volume of insecticide to be injected. Four holes, 3/8 in diameter and 4 cm (1.5 in) deep, were drilled about 0.5 m high at cardinal points on the tree bole. Arborplugs were installed in each hole. The Arborjet™ Tree IV system was used to inject a predetermined amount of product into each hole.

Treatments:

Live Oak Trial

1) Emamectin benzoate (Denim®, 2.15% ai) mixed 2:1:1 with methanol and water and applied at 18.6 ml of solution per inch tree diameter at breast height (DBH) (0.2g active per inch DBH) (N = 5)
2) Emamectin benzoate (Denim®, 2.15% ai) mixed 1:1 with methanol and applied at 18.6 ml of solution per inch tree DBH (= 0.2g active per inch DBH) (N = 7)
3) Imidacloprid (IMA-jet, 5% ai) mixed 1:3 with ADD-jet and applied at 16 ml of solution per inch tree DBH (= 0.2g active per inch DBH) (N = 7)
4) Check (untreated) (N = 7)

Cherrybark Oak Trial

1) Emamectin benzoate (Ava-jet) mixed 1:1 with water and applied at 10 ml of solution per inch tree DBH (= 0.2g active per inch DBH) (N = 10)
2) Fipronil (BAS350I) mixed 2:1:1 with methanol and water and applied at 8 ml of solution per inch tree DBH (= 0.2g active per inch DBH) (N = 10)
3) Check (untreated) (N = 10)

Data Collection:

Starting in early September, the study trees were checked weekly for acorn ripeness. When acorns began to drop (September 17), 25 acorns that had dropped within a 6 foot radius of each tree trunk were to be collected once per week. Acorns were to be collected until mid-December when acorn drop ceased. After each collection all acorns were to be dried for 24 hrs, counted and stored temporarily in refrigerators or coolers.

Collected acorns were split in half. The interior of each half was evaluated for the presence of weevil larvae and/or feeding damage in excess of 5% of the acorn meat.

Results: In both orchard blocks, all treatments had been quickly injected into study trees using Arborjet's Tree IV system – often in less than 5 minutes. Unfortunately, in 2004, the Denim® treatment was found to have caused the bark to split on several smaller-diameter, fast-growing trees. Nearly all cracks ran from the injection points up the trunk to large branches. On one tree, the dead bark was removed to reveal a long, narrow lesion where the phloem layer had died. At that time, callus tissue had already begun to form and was folding over the damaged tissue. None of the treatments appear to cause any discoloration or lose of foliage. No additional damage was found in 2005. The new formulation of emamectin benzoate did not cause the bark to split on any of the cherrybark oak study trees.

The acorns crops on nearly all of the live oaks and most of the cherrybark oaks were poor or nonexistent in 2005. However, some cherrybark oak acorns were collected in late October from 4 EB, 2 FIP and 3 Checks.

Treatment Effect on Weevil Damage: Based on the limited data, none of the injection treatments significantly reduced weevil damage compared to the check (Table 4).

Conclusions: Data collected in 2004 and 2005 suggest that chemicals such as emamectin benzoate, imidacloprid and possibly fipronil, may not be transported into the embryonic tissue of the acorn and does not provide protection against acorn weevils. However, moderate to severe drought conditions in TX in 2005 may have dramatically slowed the movement of the chemicals within the trees. Both the live oaks and cherrybark oaks will be monitored again in 2006 to determine if any of the chemicals have efficacy against acorn weevils.

Acknowledgements: Thanks go to Joe Hernandez for providing assistance with the project. We appreciate the chemical donations and injection equipment loans made by Arborjet, Inc., BASF and Syngenta.

Table 4: Acorn weevil damage on cherrybark oak acorns collected between Oct. 22 and Nov. 4 following trunk injection of trees with emamectin benzoate or fipronil in May 2005, Hudson, Angelina Co., Texas.

		Mean Percent of Acorns	
Treatment	N	Weeviled	Healthy
Emamectin benzoate	4	33.5 **a**	66.5 **a**
Fipronil	2	50.0 **a**	50.0 **a**
Check (untreated)	3	40.0 **a**	60.0 **a**

† Means followed by the same letter in each column of the same year are not significantly different at the 5% level based on Fisher's Protected LSD.

SYSTEMIC INSECTICIDE INJECTION TRIALS

Fipronil and Emamectin Benzoate Dose Rate and Volume for Single Tree Protection from Southern *Ips* Engraver Beetles – Zavalla, TX

Highlights:

- We evaluated the efficacy of new formulations of fipronil, emamectin benzoate, nemadectin and moxidectin for preventing attacks and brood production of *Ips* engraver beetles and wood borers on bolt sections of loblolly pine in East Texas.
- All injection treatments of fipronil and emamectin benzoate were highly effective in preventing engraver beetles and associated wood borers from successfully colonizing pine bolt sections. Neither one of two fipronil basal bark spray treatment was effective against bark beetles or wood borers. The nemadectin treatment was moderately effective against bark beetles, but not wood borers, late in the season. Moxidectin did not appear to affect either insect group.
- The new formulation of emamectin benzoate did not cause lesions in the sapwood / phloem interface.

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 (Coleoptera: Curculionidae). 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 by *Ips* engraver beetles and wood borers (Coleoptera: Cerambycidae) and the mortality of standing trees (see 2004 Accomplishment Report). New formulations of fipronil and emamectin benzoate were developed by BASF and Arborjet, respectively. It is unknown if the performance of the new insecticide formulations will differ from that observed for Denim® and fipronil EC in 2004.

Nemadectin and moxidectin (Fort Dodge Animal Health) are closely related to emamectin benzoate. Nemadectin is reported to be similarly effective against nematodes in Japanese pine.

Objectives: 1) Evaluate the efficacy of systemic injections of new formulations of fipronil emamectin benzoate, nemadectin and moxidectin in reducing success of pine bark beetles and wood borer attacks on loblolly pine; 2) evaluate the chemicals applied at different rates and volumes using Arborjet's Tree IV™ pressurized injection system or as a basal bark spray; and 3) determine the duration of treatment efficacy.

Cooperators:

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

Study Site: A 20-year-old, recently thinned loblolly pine plantations were selected on land owned by Temple-Inland Forest Products about 15 miles east of Diboll, Texas. Trees in one plantation were injected for use in a bolt study. A staging area also was set up in the plantation where bolts were exposed to bark beetles and wood borers.

Population Monitoring:
Three unbaited multiple-funnel traps were positioned within the staging area to monitor arrival of bark beetles and wood borer adults. The traps were left in place for two weeks.

Insecticides:
Emamectin benzoate (Avajet) – an avermectin derivative
Fipronil (experimental BAS 350 UBI) -- a phenyl pyrazole insecticide that has shown systemic activity against other Coleoptera (bark beetles)
Nemadectin – fermentation product of *Streptomyces cyanogriseus noncyanogenus*
Moxidectin – a nemadectin derivative

Treatments:

Trt #	Chemical	Formulation	Application Technique	Rate (g ai/inch dbh)	Volume (ml/inch dbh)	No of Trees Treated	Felling Dates
1	Untreated					31	May, Jul, Sep & Oct '05, May '06 & '07
2	Fipronil	BAS 350UB 120EC	Injection	0.1	8	15	May, Jul & Sep '05
3	Fipronil	BAS 350UB 120EC	Injection	0.2	8	15	May, Jul & Sep '05
4	Fipronil	BAS 350UB 120EC	Injection	0.4	8	15	May, Jul & Sep '05
5	Fipronil	BAS 350UB 120EC	Injection	0.1	16	15	May, Jul & Sep '05
6	Fipronil	BAS 350UB 120EC	Injection	0.2	16	15	May, Jul & Sep '05
7	Fipronil	BAS 350UB 120EC	Injection	0.4	16	15	May, Jul & Sep '05
8	Fipronil	Regent 2.5EC	Injection	0.2	8	15	May, Jul & Sep '05
9	Fipronil	BAS 350OY 50ME	Injection	0.2	8	10	May, Jul & Sep '05
10	Fipronil	BAS 350UB 120EC	Basal bark spray	?		15	May, Jul & Sep '05
11	Fipronil	BAS 320UI 120DC	Basal bark spray	?		15	May, Jul & Sep '05
12	Emamectin benzoate	Avajet	Injection	0.2	5	20	May & Jul '05 & May '06 & '07
13	Emamectin benzoate	Avajet	Injection	0.4	5	20	May & Jul '05 & May '06 & '07
14	Nemadectin		Injection	0.2	16.5	6	Oct '05
15	Moxidectin		Injection	0.2	20	6	Oct '05

Treatment Methods and Evaluation:
Loblolly pine trees (220), 15 – 20 cm diameter at breast height (DBH), were selected in March 2005. Fifteen trees were injected or sprayed with one of ten fipronil treatments. Twenty trees were each injected with one of two emamectin benzoate treatments. Each injection treatment (1-9 and 12 & 13) consisted of a single insecticide formulation injected into four cardinal points about 0.3 m above the ground on each tree in April using the new Arborjet Tree IV™ microinfusion system (Arborjet, Inc. Woburn, MA). The nemadectin and moxidectin treatments (14 & 15) were applied in August using the same method. Treatments 10 & 11 were applied by backpack sprayer to bark surface from ground level to height of 5 feet.

After 1 (May), 3 (July) and 5 (September) months post-injection, 5 trees of each fipronil and emamectin benzoate treatment were felled and one 1.5 m-long bolts were removed from the 3 m and 8 m heights of the bole. The six nemadectin and moxidectin-treated trees were felled 2 months (October) after injection. The bolts were transported to another area of the plantation that was recently thinned and contained fresh slash material. Each bolt was 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) were attached separately to three 1 m stakes evenly spaced in the study area.

Each series of bolts was retrieved about 3 weeks after deployment, after we observed many cerambycid egg niches on the bark surface of most bolts. In the laboratory, two 10 cm X 50 cm samples (total = 1000 cm^2) of bark were removed from each bolt. The following measurements were 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 was determined by comparing *Ips* beetle attacks, *Ips* egg gallery length and cerambycid feeding for each treatment. The data were 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.

At the time of tree felling for the first and second series, the bark was removed around the injection points of trees injected with emamectin benzoate or higher rates of fipronil to determine if any damage had resulted from the installation of plugs and/or injection of chemicals. If damage was found, the length and width of any discolored areas (lesions) on the surface of the xylem were measured.

Results:

Fipronil/Emamectin Benzoate trial: Arborjet's Tree IV system was successfully used to inject all chemical formulations. The installation of the system on each tree (drilling holes, installing plugs, pressurizing the system, and installing needles) usually took about 5 minutes when using 3 systems in tandem. Most injections were completed in just a few minutes.

Evaluation of the phloem and xylem around the injection points for each of the first two series of bolts revealed no lesions extending more than 2 cm from any of the injection points.

Signs of beetle attack (boring dust) were usually visible on several bolts in just a few days after the bolts had been moved to the staging area and the pheromone baits deployed. Within 2 weeks, several *Ips* attacks and numerous cerambycid egg niches were evident on the bark surface of most bolts. Because of concern that if logs were left too long in the feed, cerambycid larvae feeding activity would obscure or obliterate the *Ips* galleries, each series of bolts were retrieved 3 weeks after deployment. Retrieved bolts were stored temporarily in a TFS seedling cooler (~45^{o}F) to slow cerambycid development until the bolts could be evaluated.

Ips Attack Success –The total number of attacks (nuptial chambers constructed) by male *Ips* engraver beetles differed among the treatments in the first series but not among treatments in the second and third series (Table 5). In the first series, the number of attacks was reflective of the success of the attack. A significantly greater number of nuptial chambers was present on check and basal bark sprayed bolts compared to most other treatments. For all three series, nearly all nuptial chambers were successfully constructed on untreated bolts - with at least one egg gallery radiating from each nuptial chamber. In contrast, on emamectin benzoate-treated bolts evaluated in May, most attacks were unsuccessful (81 - 88%) and all (100%) attacks were unsuccessful in July and September. It appeared that nearly all attacks were aborted or the beetles died as soon as they penetrated into the phloem region. Fipronil-injected trees showed similar trends, except that the efficacy of most treatments, particularly in May, was reduced compared that of emamectin benzoate. This again indicates, like in 2004, that fipronil requires more time to disperse throughout the tree than does emamectin benzoate. Treatment efficacy was not influenced by chemical formulation or rate or solution volume. Both basal bark spray treatments were ineffective in reducing bark beetle attack success.

In May, emamectin benzoate treatments (0.2g and 0.4g) sharply reduced the total number (96% and 100%) and length (99% and 100%) of egg galleries compared to check trees (Table 6 & 7). All fipronil injection treatments also significantly reduced the number and length of egg galleries but not to the same extent as emamectin benzoate. In July and September, emamectin benzoate completely prevented the construction of egg galleries in nearly all bolts. Fipronil injection treatments were nearly equal in its efficacy in the second and third series. Although a few egg galleries were constructed, almost none had developing brood. The basal bark sprays were ineffective in preventing the production of bark beetle brood.

Cerambycid Larval Feeding – The attack level of wood borers (egg niches) was variable among treatments in May. However, there were no differences in July and September. In May, cerambycid larvae were found to have fed upon 6% of the phloem area on untreated bolts during the 3 weeks period between tree felling and bolt evaluation (Table 8). In contrast, very little larval feeding or development was found on either emamectin benzoate-treated bolts. Overall, the 0.2g and 0.4g treatments reduced feeding damage on bolts by 97% and 100%, respectively. Most fipronil injection treatments significantly reduced feeding on bolts. However, fipronil was ineffective when applied as a basal bark spray. Cerambycid larvae fed upon 18 - 41% of the phloem area on untreated bolts taken in July and September, respectively (Table 8). In contrast, all emamectin benzoate and fipronil injection treatments significantly reduced or prevented feeding in both series.

Nemadectin/Moxidectin trial:
Ips Attack Success –The total number of attacks (nuptial chambers constructed) by male *Ips* engraver beetles did not differ among the treatments (Table 9). Most of the nuptial chambers were successfully constructed on untreated bolts - with at least one egg gallery radiating from each nuptial chamber. In contrast, the nemadectin -treated bolts had significantly fewer nuptial

chambers with egg galleries. The moxidectin-treated logs did not differ from the checks. The nemadectin treatment reduced the total number (33%) and length (87%) of egg galleries compared to check trees (Table 10).

Cerambycid Larval Feeding – The attack level of wood borers (egg niches) did not differ among treatments. Very little cerambycid feeding occurred on untreated bolts during the 3 weeks period between tree felling and bolt evaluation (Table 11).

Conclusions:

All chemical formulations were quickly injected into the study trees for both trials using the Arborjet Tree IV system. Evaluation of the phloem and xylem surrounding the injection points revealed that none of the formulations caused the development of lesions.

As in 2004, emamectin benzoate was highly effective in preventing successful attacks by *Ips* bark beetles and cerambycids one, three and five months after injection. On the bolts, at least, those male *Ips* that initiated attacks were either deterred or killed upon penetration into the phloem layer and exposure to the active ingredient. It is surmised that any pheromone production by males as they burrow through the bark was halted prematurely. Without these pheromones, very few, if any, females were attracted to the host material or entered the nuptial chamber to mate and begin construction of egg galleries. Even when females did arrive on a few of the logs of the first series and began construction of galleries, the galleries were very short and brood did not developed beyond the initial larval instars. Assuming that this scenario also occurred in the standing trees, the halting of pheromone production upon male contact with the phloem layer also halted the attraction of additional males, thus preventing the mass attack of the host tree. Five additional treated trees each will be felled in 2006 and 2007 to determine the duration of treatment efficacy.

Fipronil injections (all formulations, rates and volumes) also showed good activity against bark beetles and cerambycids in the bolt trial. However, the diffusion of fipronil throughout the tree appeared to be slower than that of emamectin benzoate and thus was incomplete 4 weeks after injection as indicated by the strips of clean, uncolonized phloem. With additional time (3+ months), the chemical had dispersed enough in the tree to provide full protection from beetle attack as indicated by the final results from the standing tree trial and second and third series of bolts.

Moxidectin and nemadectin , in particular, appeared to show some limited effect against bark beetles. However, the lateness of the injections and reduced bark beetle and cerambycid populations in the fall made it difficult to discern the true efficacy of these chemicals. Further evaluation of these chemicals is warranted in 2006.

Takai (et al. 2003a, 2003b) demonstrated that injected emamectin benzoate protected Japanese black and red pines from pine wood nematode infection for 3 years. Also, recent injection trials (1999 – 2004) conducted by the authors in pine seed orchards indicate single injections of emamectin benzoate and fipronil in loblolly pine can provide protection of cone crops from coneworms for more than 6 years and 2 years, respectively (Grosman, unpublished data). It is conceivable that single injections of these chemicals also may protect trees against bark beetles for several years as well. Duration trials using *Ips* or SPB are needed to validate this hypothesis.

The emamectin benzoate dose (0.2 g ai / inch of tree diameter) used in 2004 and 2005 has been found to prevent successful attack by *Ips* engravers. If a lower dose were to be injected in trees threatened by southern pine beetle (SPB) infestations, the injected trees may serve as trap trees, i.e., allow successful mass attack, gallery construction and egg laying by adult SPB, but the larvae would not develop and no brood adults would be produced. If the treatment proved successful, it is conceivable that local populations of SPB would decline and the progression of the infestation would stop. Trials are needed to determine the dosage level necessary to allow adult beetle attack but prevent development of progeny. Subsequently, trials are needed to test the efficacy of using emamectin benzoate-injected trap trees for managing active SPB infestations.

Acknowledgements: Many thanks go to Temple-Inland Forest Products and Emily Goodwin for providing a thinned stand for the project. We appreciate the chemical donations and injection equipment loans made by Arborjet, Inc, BASF, and Syngenta and field assistance of Vladimir Cizek.

Table 5: Attack success and gallery construction of *Ips* engraver beetles on loblolly pine bolts cut one, three, and five months after trunk injection or basal bark spray with different rates, volumes, and formulations of fipronil and emamectin benzoate; Lufkin, Texas - 2005.

			Number of Nuptial Chambers				
			Without Egg Galleries		With Egg Galleries		
Evaluation period	Treatment	N	No.	% of total	No.	% of total	Total No.
1 Month Post-Injection (May)	FIP 350UB 120EC 0.1g 8ml	5	2.6 **a***	61.9	1.6 **ab**	38.1	4.2 **ab**
	FIP 350UB 120EC 0.2g 8ml	5	3.2 **a**	44.4	4.0 **bcd**	55.6	7.2 **ab**
	FIP 350UB 120EC 0.4g 8ml	5	2.6 **a**	81.3	0.6 **ab**	18.8	3.2 **a**
	FIP 350UB 120EC 0.1g 16ml	5	0.8 **a**	19.0	3.4 **abcd**	81.0	4.2 **a**
	FIP 350UB 120EC 0.2g 16ml	5	2.8 **a**	73.7	1.0 **ab**	26.3	3.8 **a**
	FIP 350UB 120EC 0.4g 16ml	5	1.8 **a**	50.0	1.8 **ab**	50.0	3.6 **a**
	FIP Regent 2.5EC 0.2g	5	2.0 **a**	62.5	1.2 **ab**	37.5	3.2 **a**
	FIP 350OY 50ME 0.2g + Meth 8ml	5	2.2 **a**	50.0	2.2 **abc**	50.0	4.4 **ab**
	FIP 350UB 120EC Basal Bark 1	5	1.0 **a**	13.9	6.2 **cde**	86.1	7.2 **b**
	FIP 320UI 120DC Basal Bark 2	4	0.3 **a**	3.8	7.5 **de**	96.2	7.8 **b**
	EB 0.2g 20ml	5	2.6 **a**	81.3	0.6 **ab**	18.8	3.2 **a**
	EB 0.4g 20ml	5	1.4 **a**	87.5	0.2 **a**	12.5	1.6 **a**
	Check	6	2.5 **a**	18.2	11.2 **e**	81.8	13.7 **b**
3 Months Post-Injection (July)	FIP 350UB 120EC 0.1g 8ml	5	1.2 **a***	75.0	0.4 **a**	25.0	1.6 **a**
	FIP 350UB 120EC 0.2g 8ml	5	2.2 **a**	84.6	0.4 **a**	15.4	2.6 **a**
	FIP 350UB 120EC 0.4g 8ml	5	0.8 **a**	80.0	0.2 **a**	20.0	1.0 **a**
	FIP 350UB 120EC 0.1g 16ml	5	2.6 **a**	86.7	0.4 **a**	13.3	3.0 **a**
	FIP 350UB 120EC 0.2g 16ml	5	2.4 **a**	100.0	0.0 **a**	0.0	2.4 **a**
	FIP 350UB 120EC 0.4g 16ml	5	3.2 **a**	100.0	0.0 **a**	0.0	3.2 **a**
	FIP Regent 2.5EC 0.2g	5	1.8 **a**	90.0	0.2 **a**	10.0	2.0 **a**
	FIP 350OY 50ME 0.2g + Meth 8ml	4	1.3 **a**	100.0	0.0 **a**	0.0	1.3 **a**
	FIP 350OY 50ME 0.2g 8ml	1	1.0 **a**	100.0	0.0 **a**	0.0	1.0 **a**
	FIP 350UB 120EC Basal Bark 1	5	1.0 **a**	21.1	3.9 **b**	82.1	4.8 **a**
	FIP 320UI 120DC Basal Bark 2	5	1.0 **a**	19.6	4.6 **b**	90.2	5.1 **a**
	EB 0.2g 20ml	5	2.6 **a**	100.0	0.0 **a**	0.0	2.6 **a**
	EB 0.4g 20ml	5	1.6 **a**	100.0	0.0 **a**	0.0	1.6 **a**
	Check	5	0.7 **a**	18.4	3.2 **b**	84.2	3.8 **a**
5 Months Post-Injection (Sept.)	FIP 350UB 120EC 0.1g 8ml	5	3.2 **a**	84.2	0.6 **a**	15.8	3.8 **a**
	FIP 350UB 120EC 0.2g 8ml	4	0.5 **a**	100.0	0.0 **a**	0.0	0.5 **a**
	FIP 350UB 120EC 0.4g 8ml	5	2.0 **a**	90.9	0.2 **a**	9.1	2.2 **a**
	FIP 350UB 120EC 0.1g 16ml	5	1.6 **a**	88.9	0.2 **a**	11.1	1.8 **a**
	FIP 350UB 120EC 0.2g 16ml	5	2.6 **a**	81.3	0.6 **a**	18.8	3.2 **a**
	FIP 350UB 120EC 0.4g 16ml	5	3.8 **a**	95.0	0.2 **a**	5.0	4.0 **a**
	FIP Regent 2.5EC 0.2g	5	2.6 **a**	100.0	0.0 **a**	0.0	2.6 **a**
	FIP 350OY 50ME 0.2g + Meth 8ml	1	2.0 **a**	100.0	0.0 **a**	0.0	2.0 **a**
	FIP 350OY 50ME 0.2g 8ml	2	2.5 **a**	83.3	0.5 **a**	16.7	3.0 **a**
	FIP 350UB 120EC Basal Bark 1	5	1.0 **a**	23.8	3.2 **b**	76.2	4.2 **a**
	FIP 320UI 120DC Basal Bark 2	3	0.7 **a**	10.5	5.7 **c**	89.5	6.3 **a**
	EB 0.2g 20ml	2	2.0 **a**	100.0	0.0 **a**	0.0	2.0 **a**
	EB 0.4g 20ml	2	1.5 **a**	100.0	0.0 **a**	0.0	1.5 **a**
	Check	7	0.1 **a**	2.5	5.6 **c**	97.5	5.7 **a**

* Means followed by the same letter are not significantly different at the 5% level based on Fisher's Protected LSD.

Table 6: Mean number of egg galleries constructed by *Ips* engraver beetles in loblolly pine bolts cut one, three, and five months after trunk injection or basal bark spray with different rates, volumes, and formulations of fiproni and emamectin benzoatel; Lufkin, Texas - 2005.

Evaluation period	Treatment	N	Without Larvae No.	Without Larvae % of total	With Larvae No.	With Larvae % of Total	Total No.
1 Month Post-Injection (May)	FIP 350UB 120EC 0.1g 8ml	5	2.8 **bcd***	82.4	0.6 **ab**	17.6	3.4 **abc**
	FIP 350UB 120EC 0.2g 8ml	5	6.2 **cde**	68.9	2.8 **ab**	31.1	9.0 **bc**
	FIP 350UB 120EC 0.4g 8ml	5	1.6 **abc**	100.0	0.0 **a**	0.0	1.6 **ab**
	FIP 350UB 120EC 0.1g 16ml	5	3.4 **bcd**	29.3	8.2 **b**	70.7	11.6 **bc**
	FIP 350UB 120EC 0.2g 16ml	5	1.0 **ab**	22.7	3.4 **ab**	77.3	4.4 **abc**
	FIP 350UB 120EC 0.4g 16ml	5	2.4 **abc**	54.5	2.0 **ab**	45.5	4.4 **bc**
	FIP Regent 2.5EC 0.2g	5	2.8 **abc**	77.8	0.8 **ab**	22.2	3.6 **abc**
	FIP 350OY 50ME 0.2g + Meth 8ml	5	4.2 **cde**	100.0	0.0 **a**	0.0	4.2 **abc**
	FIP 350UB 120EC Basal Bark 1	5	7.2 **de**	33.6	14.2 **c**	66.4	21.4 **d**
	FIP 320UI 120DC Basal Bark 2	4	4.0 **cde**	21.6	14.5 **c**	78.4	18.5 **cd**
	EB 0.2g 20ml	5	1.0 **abc**	100.0	0.0 **a**	0.0	1.0 **ab**
	EB 0.4g 20ml	5	0.0 **a**		0.0 **a**		0.0 **a**
	Check	6	13.2 **e**	47.9	14.3 **c**	52.1	27.5 **d**
3 Months Post-Injection (July)	FIP 350UB 120EC 0.1g 8ml	5	0.6 **a**	100.0	0.0 **a**	0.0	0.6 **ab**
	FIP 350UB 120EC 0.2g 8ml	5	1.6 **ab**	100.0	0.0 **a**	0.0	1.6 **b**
	FIP 350UB 120EC 0.4g 8ml	5	0.2 **a**	100.0	0.0 **a**	0.0	0.2 **ab**
	FIP 350UB 120EC 0.1g 16ml	5	0.8 **a**	100.0	0.0 **a**	0.0	0.8 **ab**
	FIP 350UB 120EC 0.2g 16ml	5	0.0 **a**		0.0 **a**		0.0 **a**
	FIP 350UB 120EC 0.4g 16ml	5	0.0 **a**		0.0 **a**		0.0 **a**
	FIP Regent 2.5EC 0.2g	5	0.4 **a**	100.0	0.0 **a**	0.0	0.4 **ab**
	FIP 350OY 50ME 0.2g + Meth 8ml	4	0.0 **a**		0.0 **a**		0.0 **a**
	FIP 350OY 50ME 0.2g 8ml	1	0.0 **a**		0.0 **a**		0.0 **a**
	FIP 350UB 120EC Basal Bark 1	5	5.2 **c**	36.6	9.0 **b**	63.4	14.2 **c**
	FIP 320UI 120DC Basal Bark 2	5	2.3 **b**	16.8	11.4 **c**	83.2	13.7 **c**
	EB 0.2g 20ml	5	0.0 **a**		0.0 **a**		0.0 **a**
	EB 0.4g 20ml	5	0.0 **a**		0.0 **a**		0.0 **a**
	Check	5	4.2 **c**	36.2	7.4 **b**	63.8	11.6 **c**
5 Months Post-Injection (Sept.)	FIP 350UB 120EC 0.1g 8ml	5	1.2 **ab**	100.0	0.0 **a**	0.0	1.2 **ab**
	FIP 350UB 120EC 0.2g 8ml	4	0.0 **a**		0.0 **a**		0.0 **a**
	FIP 350UB 120EC 0.4g 8ml	5	0.2 **a**	100.0	0.0 **a**	0.0	0.2 **a**
	FIP 350UB 120EC 0.1g 16ml	5	0.2 **a**	100.0	0.0 **a**	0.0	0.2 **a**
	FIP 350UB 120EC 0.2g 16ml	5	0.4 **a**	100.0	0.0 **a**	0.0	0.4 **a**
	FIP 350UB 120EC 0.4g 16ml	5	0.2 **a**	100.0	0.0 **a**	0.0	0.2 **a**
	FIP Regent 2.5EC 0.2g	5	0.0 **a**		0.0 **a**		0.0 **a**
	FIP 350OY 50ME 0.2g + Meth 8ml	1	0.0 **a**		0.0 **a**		0.0 **a**
	FIP 350OY 50ME 0.2g 8ml	2	0.5 **a**	100.0	0.0 **a**	0.0	0.5 **ab**
	FIP 350UB 120EC Basal Bark 1	5	3.0 **bc**	23.4	9.8 **b**	76.6	12.8 **c**
	FIP 320UI 120DC Basal Bark 2	3	3.3 **c**	21.3	12.3 **c**	78.7	15.7 **c**
	EB 0.2g 20ml	2	0.0 **a**		0.0 **a**		0.0 **a**
	EB 0.4g 20ml	2	4.0 **c**	100.0	0.0 **a**	0.0	4.0 **b**
	Check	7	2.4 **bc**	12.3	17.3 **d**	87.7	19.7 **c**

* Means followed by the same letter in each column are not significantly different at the 5% level based on Fisher's Protected LSD.

Table 7: Mean length of egg galleries constructed by *Ips* engraver beetles in loblolly pine bolts cut one, three, and five months after trunk injection or basal bark spray with different rates, volumes, and formulations of fipronil; Lufkin, Texas - 2005.

			Length of Egg Galleries				
			Without Larvae		With Larvae		
Evaluation period	Treatment	N	cm	% of Total	cm	% of Total	Total Length
1 Month Post-Injection (May)	FIP 350UB 120EC 0.1g 8ml	5	13.2 **bcde**	76.5	4.1 **ab**	23.5	17.3 **bc**
	FIP 350UB 120EC 0.2g 8ml	5	23.4 **de**	33.6	46.2 **bc**	66.4	69.6 **cd**
	FIP 350UB 120EC 0.4g 8ml	5	3.0 **abc**	100.0	0.0 **a**	0.0	3.0 **ab**
	FIP 350UB 120EC 0.1g 16ml	5	18.3 **cde**	22.5	63.0 **bc**	77.5	81.3 **cd**
	FIP 350UB 120EC 0.2g 16ml	5	2.0 **ab**	16.0	10.7 **ab**	84.0	12.7 **abc**
	FIP 350UB 120EC 0.4g 16ml	5	9.1 **abcd**	25.4	26.9 **ab**	74.6	36.1 **cd**
	FIP Regent 2.5EC 0.2g	5	10.7 **abcd**	70.0	4.6 **ab**	30.0	15.2 **abc**
	FIP 350OY 50ME 0.2g + Meth 8ml	5	14.2 **cde**	100.0	0.0 **a**	0.0	14.2 **bc**
	FIP 350UB 120EC Basal Bark 1	5	36.6 **ef**	20.2	144.3 **d**	79.8	180.8 **e**
	FIP 320UI 120DC Basal Bark 2	4	33.0 **def**	20.4	128.9 **cd**	79.6	161.9 **de**
	EB 0.2g 20ml	5	2.5 **ab**	100.0	0.0 **a**	0.0	2.5 **ab**
	EB 0.4g 20ml	5	0.0 **a**		0.0 **a**		0.0 **a**
	Check	6	100.3 **f**	41.6	141.0 **d**	58.4	241.3 **e**
3 Months Post-Injection (July)	FIP 350UB 120EC 0.1g 8ml	5	2.5 **a**	100.0	0.0 **a**	0.0	2.5 **ab**
	FIP 350UB 120EC 0.2g 8ml	5	4.6 **a**	100.0	0.0 **a**	0.0	4.6 **b**
	FIP 350UB 120EC 0.4g 8ml	5	0.5 **a**	100.0	0.0 **a**	0.0	0.5 **ab**
	FIP 350UB 120EC 0.1g 16ml	5	3.6 **a**	100.0	0.0 **a**	0.0	3.6 **ab**
	FIP 350UB 120EC 0.2g 16ml	5	0.0 **a**		0.0 **a**		0.0 **a**
	FIP 350UB 120EC 0.4g 16ml	5	0.0 **a**		0.0 **a**		0.0 **a**
	FIP Regent 2.5EC 0.2g	5	1.0 **a**	100.0	0.0 **a**	0.0	1.0 **ab**
	FIP 350OY 50ME 0.2g + Meth 8ml	4	0.0 **a**		0.0 **a**		0.0 **a**
	FIP 350OY 50ME 0.2g 8ml	1	0.0 **a**		0.0 **a**		0.0 **a**
	FIP 350UB 120EC Basal Bark 1	5	49.3 **c**	36.5	85.6 **b**	63.5	134.9 **c**
	FIP 320UI 120DC Basal Bark 2	5	12.2 **b**	7.4	151.9 **c**	92.6	164.1 **c**
	EB 0.2g 20ml	5	0.0 **a**		0.0 **a**		0.0 **a**
	EB 0.4g 20ml	5	0.0 **a**		0.0 **a**		0.0 **a**
	Check	5	35.1 **c**	27.0	95.0 **b**	73.0	130.0 **c**
5 Months Post-Injection (Sept.)	FIP 350UB 120EC 0.1g 8ml	5	6.4 **ab**	100.0	0.0 **a**	0.0	6.4 **a**
	FIP 350UB 120EC 0.2g 8ml	4	0.0 **a**		0.0 **a**		0.0 **a**
	FIP 350UB 120EC 0.4g 8ml	5	1.0 **a**	100.0	0.0 **a**	0.0	1.0 **a**
	FIP 350UB 120EC 0.1g 16ml	5	0.6 **a**	100.0	0.0 **a**	0.0	0.6 **a**
	FIP 350UB 120EC 0.2g 16ml	5	1.4 **a**	100.0	0.0 **a**	0.0	1.4 **a**
	FIP 350UB 120EC 0.4g 16ml	5	0.6 **a**	100.0	0.0 **a**	0.0	0.6 **a**
	FIP Regent 2.5EC 0.2g	5	0.0 **a**		0.0 **a**		0.0 **a**
	FIP 350OY 50ME 0.2g + Meth 8ml	1	0.0 **a**		0.0 **a**		0.0 **a**
	FIP 350OY 50ME 0.2g 8ml	2	2.0 **ab**	100.0	0.0 **a**	0.0	2.0 **a**
	FIP 350UB 120EC Basal Bark 1	5	13.2 **bc**	12.3	94.0 **b**	87.7	107.2 **b**
	FIP 320UI 120DC Basal Bark 2	3	16.0 **c**	11.7	121.0 **c**	88.3	137.0 **b**
	EB 0.2g 20ml	2	0.0 **a**		0.0 **a**		0.0 **a**
	EB 0.4g 20ml	2	3.0 **ab**	100.0	0.0 **a**	0.0	3.0 **a**
	Check	7	9.4 **bc**	4.7	192.0 **d**	95.3	201.4 **b**

* Means followed by the same letter in each column are not significantly different at the 5% level based on Fisher's Protected LSD.

Table 8: Extent of feeding by cerambycid larvae in loblolly pine bolts cut one, three, and five months after trunk injection or basal bark spray with different rates, volumes, and formulations of fipronil or emamectin benzoate; Lufkin, Texas - 2005.

	No. of cerambycid egg niches on bark			Percent phloem area consumed by larvae		
Treatment	1 month post injection (May)	3 months post injection (July)	5 months post injection (Sept.)	1 month post injection (May)	3 months post injection (July)	5 months post injection (Sept.)
FIP 350UB 120EC 0.1g 8ml	4.4 **bcd***	3.8 **a**	5.6 **a**	1.4 **ab**	0.0 **a**	0.0 **a**
FIP 350UB 120EC 0.2g 8ml	4.2 **bcd**	7.4 **a**	1.3 **a**	6.0 **bc**	1.8 **a**	0.0 **a**
FIP 350UB 120EC 0.4g 8ml	2.6 **bc**	3.4 **a**	5.0 **a**	1.4 **ab**	0.0 **a**	0.8 **a**
FIP 350UB 120EC 0.1g 16ml	2.4 **bc**	4.8 **a**	5.0 **a**	0.8 **ab**	0.0 **a**	0.0 **a**
FIP 350UB 120EC 0.2g 16ml	1.2 **ab**	6.6 **a**	6.6 **a**	0.0 **a**	0.0 **a**	0.0 **a**
FIP 350UB 120EC 0.4g 16ml	5.8 **bc**	4.8 **a**	4.4 **a**	0.0 **a**	0.0 **a**	0.0 **a**
FIP Regent 2.5EC 0.2g	1.6 **ab**	1.6 **a**	5.8 **a**	1.8 **ab**	0.0 **a**	0.0 **a**
FIP 350OY 50ME 0.2g + Meth 8ml	0.0 **a**	3.8 **a**	2.0 **a**	0.0 **a**	0.8 **a**	0.0 **a**
FIP 350OY 50ME 0.2g 8ml		3.0 **a**	1.5 **a**		0.0 **a**	0.0 **a**
FIP 350UB 120EC Basal Bark 1	8.2 **d**	5.4 **a**	9.8 **a**	10.2 **c**	14.8 **b**	15.4 **b**
FIP 320UI 120DC Basal Bark 2	3.5 **bcd**	5.6 **a**	7.7 **a**	4.0 **ab**	19.0 **b**	31.7 **c**
EB 0.2g 20ml	1.8 **abc**	5.0 **a**	4.5 **a**	0.2 **a**	0.0 **a**	0.0 **a**
EB 0.4g 20ml	3.0 **bc**	2.2 **a**	14.0 **a**	0.0 **a**	0.0 **a**	0.0 **a**
Check	5.0 **cd**	8.6 **a**	6.4 **a**	6.2 **bc**	17.8 **b**	41.3 **c**

* Means followed by the same letter are not significantly different at the 5% level based on Fisher's Protected LSD.

Table 9: Attack success and gallery construction of *Ips* engraver beetles on loblolly pine bolts cut two months after trunk injection with nemadectin and moxidectin; Lufkin, Texas - 2005.

Evaluation period	Treatment	Mean # of nuptial chambers without egg galleries		Mean # of nuptial chambers with egg galleries		Mean total # of nuptial chambers
		No.	% of total	No.	% of total	
2 Month Post-Injection (Oct.)	Nemadectin 3.6%, 0.2gai, 16.5ml	1.2 **a***	48	1.3 **a**	52	2.5 **a**
	Moxidectin 1%, 0.2gai, 20.0ml	1.5 **a**	31	3.3 **b**	69	4.8 **a**
	Check	0.7 **a**	15	3.7 **b**	85	4.3 **a**

* Means followed by the same letter are not significantly different at the 5% level based on Fisher's Protected LSD.

Table 10: Mean number and length of egg galleries constructed by *Ips* engraver beetles in loblolly pine bolts cut two months after trunk injection with nemadectin and moxidectin; Lufkin, Texas - 2005.

		Number of egg galleries					Length of egg galleries				
		Without larvae		With larvae			Without larvae		With larvae		
Evaluation period	Treatment	No.	% of total	No.	% of Total	Total #	cm	% of Total	cm	% of Total	Total length
2 Month Post-Injection (Oct.)	Nemadectin 3.6%, 0.2gai, 16.5ml	3.3 **a***	91	0.3 **a**	9	3.7 **a**	12.3 **a**	85	2.2 **a**	15	14.5 **a**
	Moxidectin 1%, 0.2gai, 20.0ml	7.8 **a**	76	2.5 **a**	24	10.3 **a**	33.8 **a**	60	22.5 **a**	40	56.3 **b**
	Check	4.0 **a**	36	7.2 **a**	64	11.2 **a**	28.2 **a**	25	84.3 **b**	75	112.5 **b**

* Means followed by the same letter in each column are not significantly different at the 5% level based on Fisher's Protected LSD.

Table 11: Extent of feeding by cerambycid larvae in loblolly pine bolts cut two months after trunk injection with nemadectin and moxidectin; Lufkin, Texas - 2005.

Treatment	No of cerambycid egg niches on bark	Percent phloem area consumed by larvae
Nemadectin 3.6%, 0.2gai, 16.5ml	2.0 **a***	0.5 **a**
Moxidectin 1%, 0.2gai, 20.0ml	0.8 **a**	0.0 **a**
Check	2.0 **a**	1.0 **a**

* Means followed by the same letter in each column are not significantly different at the 5% level based on Fisher's Protected LSD.

SYSTEMIC INSECTICIDE INJECTION TRIALS

Emamectin Benzoate and Fipronil for Protection of High-Value Southern and Western Conifers from Bark Beetles – MS, CA, ID, UT & BC

Highlights:

- We evaluated the efficacy of the new formulations of fipronil and emamectin benzoate, for preventing mortality of conifers by *Dendroctonus* beetles (Coleoptera: Curculionidae, Scolytinae) in Mississippi, California, Idaho, Utah and British Columbia.
- Preliminary results indicate that fipronil and emamectin benzoate were effective in preventing tree mortality by southern pine beetle and western pine beetle in MS and CA, respectively.

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. 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.

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*, and coneworms, *Dioryctria* spp. Fipronil also is efficacious against coneworms as well as the Nantucket pine tip moth, *Rhyacionia frustrana*. 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.

Objectives: 1) Evaluate the efficacy of systemic injections of new formulations of fipronil and emamectin benzoate for preventing mortality of conifers by *Dendroctonus* bark beetles found in the southeastern and western regions of the United States; 2) evaluate affect of injection timing on treatment efficacy, and 3) determine the duration of treatment efficacy.

Cooperators:

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

Study Sites: The study is being conducted at five sites: 1) DeSoto National Forest, Chickasawhay Ranger District in Wayne and Green Co. Mississippi with southern pine beetle (SPB) attacking loblolly pine, 2) private timberland owned by Sierra Pacific Industries (SPI) in Calaveras Co. California, with western pine beetle (WPB) attacking ponderosa pine; 3) Challis National Forest, Yankee Ranger District in Custer Co. Idaho, with mountain pine beetle (MPB) attacking lodgepole pine; 4) Manti-LaSal National Forest , Sanpete Ranger District in Carbon and Emery Counties, Utah with spruce beetle (SB) attacking Engelmann spruce and 5) provincial timberland near 100 Mile House, British Columbia with mountain pine beetle (MPB) attacking lodgepole pine.

Treatments:

1) Emamectin benzoate injection at 0.08 – 0.16 g AI per cm (0.2 – 0.4 g AI per in) DBH,
2) Fipronil injection at 0.08 – 0.16 g AI per cm (0.2 – 0.4 g AI per in) DBH,
3) carbaryl or bifenthrin bole spray (standard) at 0.06% AI or 2.0% AI, respectively(*)
4) Untreated (control) - used to assess beetle pressure during each summer (2005 - 2007)

(*) The standard treatment was excluded in Mississippi, Utah and British Columbia.

Treatment Methods and Evaluation:

Each insecticide (injection or spray) treatment was applied to 30-35 randomly assigned trees. A similar number of trees were/will be used for each set of the untreated checks (3 sets (by year) total). Test trees will be located in areas with recent beetle activity, spaced >100m apart, 23 to 52 cm dbh, and within 75m of an access road to facilitate treatment.

Each systemic insecticide treatment was/will be injected with Arborjet Tree IV™ microinfusion system (Arborjet, Inc. Woburn, MA) into 4 cardinal points 0.3 m above the ground. The injected trees are generally allowed one to two months (depending on water availability) to translocate chemicals prior to being challenged by the application of synthetic pheromone baits. Due to the short season because elevation, the trees in Utah will not be baited until 2006 (Table 12). One group of trees in British Columbia was injected in the fall 2005. A second set of trees also will be in jected in the spring 2006.

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

All test trees and the first set of untreated check trees were/will be baited with appropriate species-specific lures (Phero Tech Inc., Delta, BC) for 2 to 4 weeks in 2005 or 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 and 2007.

The only criterion used to determine the effectiveness of the insecticide treatment was/will be whether or not individual trees succumb to attack by bark beetles. Tree mortality will be assessed in 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 ≥60% of the untreated control trees die from beetle attack during each year. Insecticide treatments will be considered efficacious if <7 treated trees die as a result of bark beetle attacks. 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 (Shea et al., 1984).

Results:

The Tree IV system (Arborjet Inc.) was successfully used to inject all chemical formulations (Figures 5A, B, C & D). The installation of the system on each tree (drilling holes, installing plugs, pressurizing the system, and installing needles) usually took about 5 minutes when using 3 systems in tandem. At most sites injections were completed in just a 10-20 minutes. However, in British Columbia where drought conditions prevailed and temperatures often hovered around the freezing point, injections averaged 60 minutes per tree.

Southern Pine Beetle on loblolly pine (MS) Although the pheromone baits were left on the study trees for several weeks, relatively few bark beetle attacks were observed on most trees. Based on this observation we concluded that SPB populations were likely insufficient to cause 60% or better mortality of the check trees. Each tree was ranked as to the level of SPB attacks and tree mortality. Check trees had a much greater number of trees with high levels of attack and mortality than did emamectin benzoate- or fipronil-treated trees (Figure 6). Given that SPB populations were relatively low in 2005, it was surprising that two each of the emamectin benzoate- and fipronil-treated trees had died. All dead trees were cut down to determine the cause of tree mortality. In contrast to the check trees that were killed by SPB, the colonization of injected trees by SPB was unsuccessful (no galleries or brood were produced). Instead tree mortality appeared to be caused by the introduction of blue stain fungus by the unsuccessful SPB and possibly attack by ambrosia beetles.

Western Pine Beetle on ponderosa pine (CA) Nearly all baited trees, except for those sprayed with bifenthrin, were heavily attacked by WPB within 3 weeks. A preliminary assessment of potential tree mortality was conducted in October. At that time, better than 53% the check trees exhibited fading crown or was so heavily attacked by bark beetles it was presumed that the trees would die (Figure 7). In contrast, 20%, 13% and 3% of fipronil-, emamectin benzoate- and bifenthrin-treated trees had faded or were expected to die. A final assessment will be conducted in 2006.

Mountain Pine Beetle on lodgepole pine (ID) Bark beetle populations were exceptionally high in the study site area. In a matter of just 5 days after baits were deployed, nearly all check and injected trees were heavily attacked. In contrast, very few carbaryl-sprayed trees were attacked. Due to the short season, a final assessment of treatment efficacy can not be made until 2006.

Spruce Beetle on Engelmann spruce (UT). Treated and untreated trees will be baited in April 2006. However, due to the extremely short season at high elevations in Utah, the final assessment will not be made until 2007.

Mountain Pine Beetle on lodgepole pine (BC) One set of trees were treated in fall 2005. A second set will be treated in May 2006. Treated and untreated trees will be baited in July 2006. However, due to the short season in British Columbia, the final assessment will not be made until 2007.

Conclusions: Preliminary data indicates that as of fall 2005, the western pine beetle attack levels in CA appear to be high enough to cause 53% mortality of check trees. In contrast, emamectin and fipronil-treated tree so far exhibit only 13% and 20% mortality, respectively. Although the check mortality was not quite up to the 60% required to demonstrate true efficacy, it is apparent that the injection treatments are reducing tree mortality.

Although there was insufficient southern pine beetle pressure in MS to cause required amount of check tree mortality, the level of attack on check trees was markedly greater than that on injected trees, suggesting that the treatments had an affect on SPB attraction and attack success

The baiting of trees with pheromones causes a false extended attack on trees. Under natural conditions (without baits) it is surmised that female WPB and SPB that initiate attacks would be either deterred or killed upon penetration into the phloem layer and exposure to the active ingredient. Any pheromone production by females as they burrow through the bark is halted prematurely. Without these pheromones, very few, if any, males were attracted to the host material or entered the galleries to mate. The halting of pheromone production upon female contact with the phloem layer also halted the attraction of additional females, thus preventing the mass attack of the host tree.

Acknowledgements: Many thanks go to our cooperators: Chris Fettig, Steve Clarke, Steve Munson, Carl Jorgensen, and Leo Rankin for their efforts on the project. We appreciate the chemical donations and injection equipment loans made by Arborjet, Inc, BASF, and Syngenta and field assistance of Chris Dabney, Robert Borys, Jason Helvey, Teresa Krause, Doris Oberlander, Genie Michiel and Blake Smith. These trials were supported by funds from the WGFPMC, Western Bark Beetle Initiative, Southern Pine Beetle Initiative and BASF.

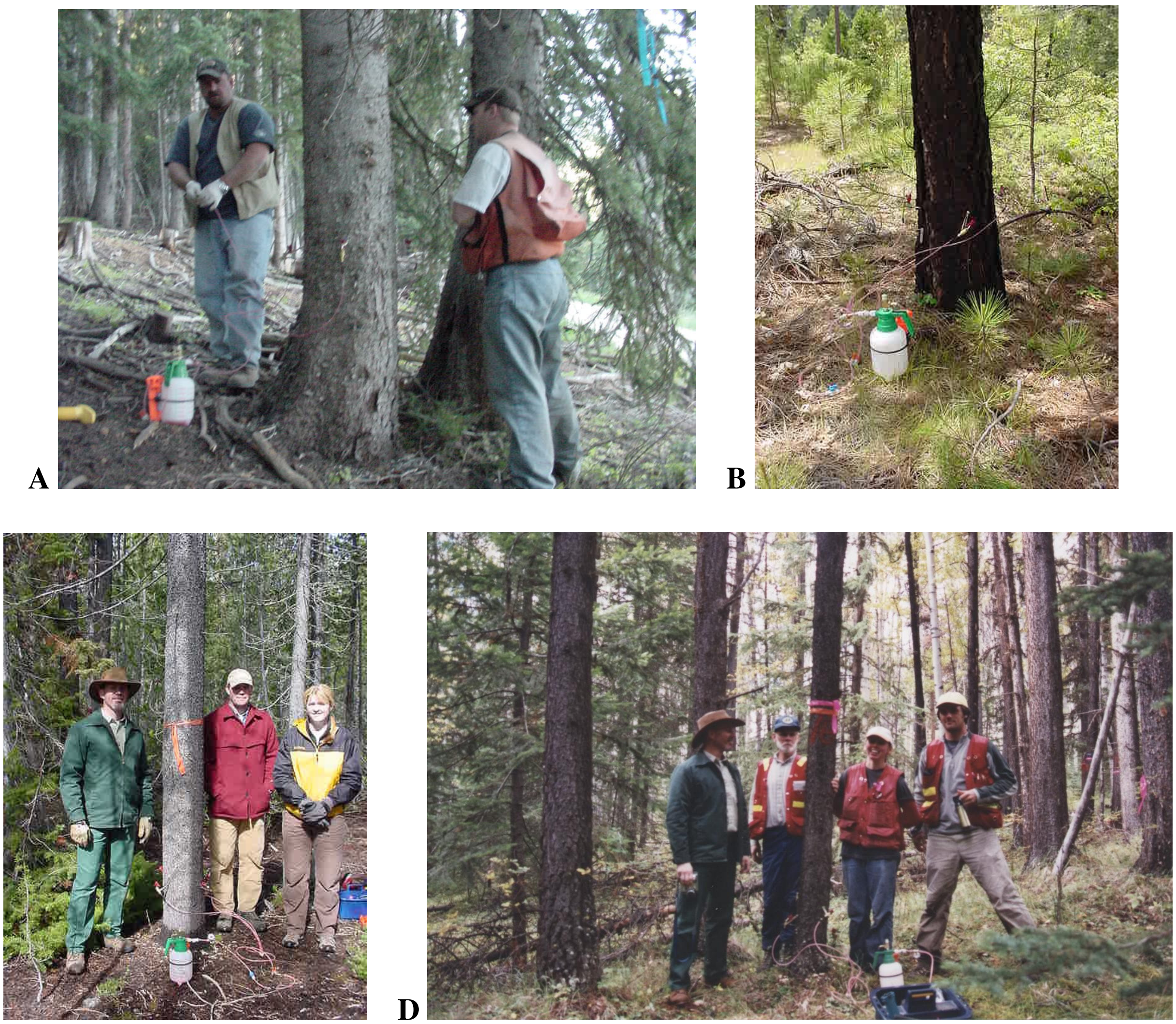


Figure 5. Systemic injections on A) Engelmann spruce in UT with Chris Fettig and Chris Dabney, B) ponderosa pine in CA, C) lodgepole pine in ID with Carl Jorgensen and Teresa Krause, and D) lodgepole pine in BC with Leo Rankin, Genie Michiel and Blake Smith.

Table 12. Scheduled Injection, Baiting and Evaluation Dates for Five *Dendroctonus* Bark Beetle Trials

	Southern Pine Beetle (MS)	Western Pine Beetle (CA)	Mountain Pine Beetle (ID)	Spruce Beetle (UT)	Mountain Pine Beetle (BC)
Injection Dates	April 11 - 13, 2005	May 16 - 18, 2005	May 31 - June 2, 2005	August 29 - 31, 2005	September 19 - 21, 2005 May 16 - 18, 2006
Baiting Period	May 17 - Jun 23, 2005	July 5 - August 15, 2005	July 13 - 27, 2005	April - July 2006	July 13 - 27, 2006
Prelim Evaluation	August 2005	October 2005			
Final Evaluation	December 2005	June 2006	August 2006	August 2007	August 2006

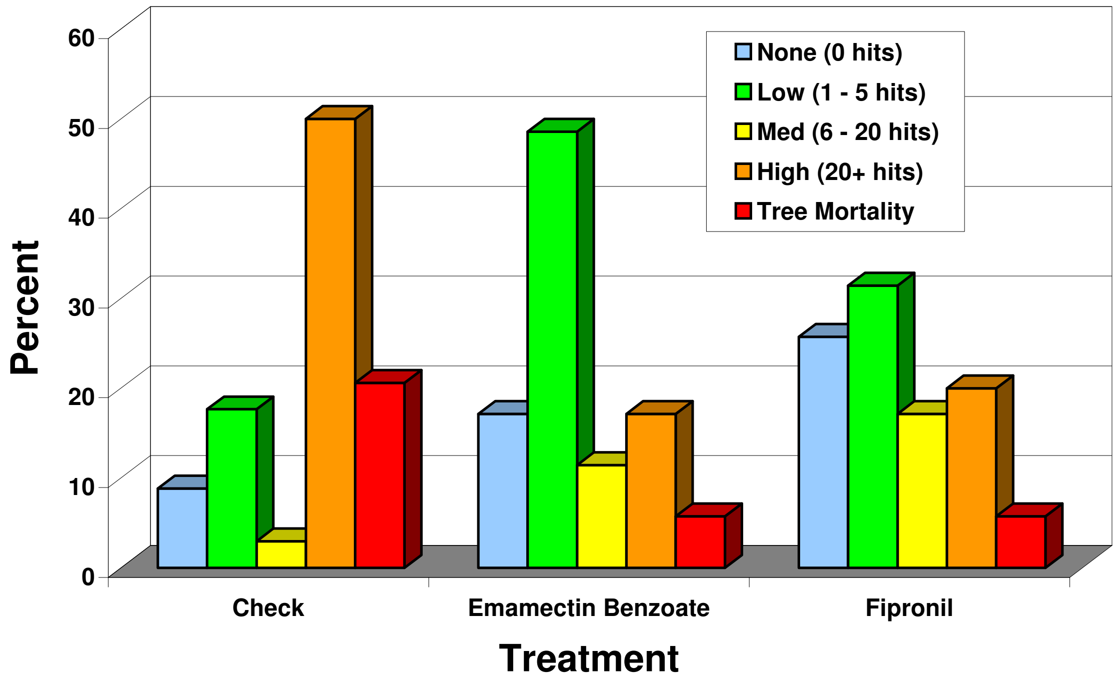


Figure 6. Effects of injection treatments on southern pine beetle attack levels on standing loblolly pine as of December 2005, Chickasawhay, Ranger District, DeSoto National Forest, MS.

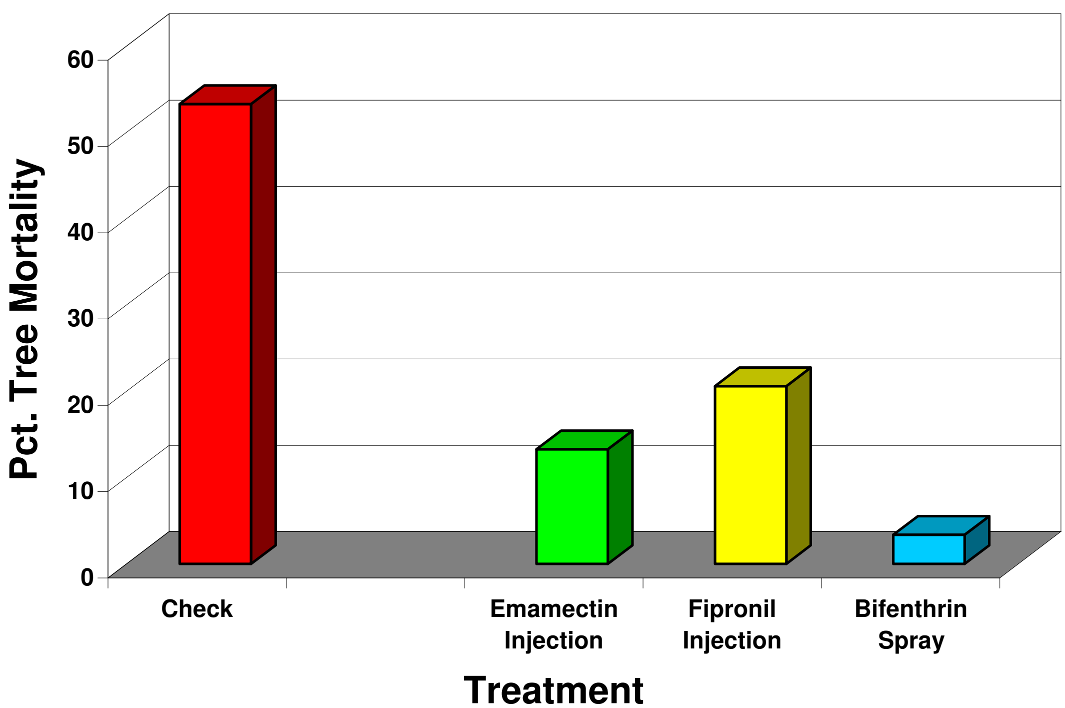


Figure 7. Preliminary effects of injection treatments on tree mortality caused by western pine beetle attack on standing ponderosa pine as of October 2005; Sierra Pacific Industries (SPI) land in Calaveras Co., California.

SYSTEMIC INSECTICIDE INJECTION TRIALS

Protection of Pine Wood Against Termites – Wells, TX

Highlights:

- The trial was initiated in November 2004 and is on-going.
- Preliminary data indicates that both fipronil- and emamectin benzoate-treated logs had reduced termite activity compared to untreated logs 10-14 months after the treated trees were felled.

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 cut from most untreated study trees and left on the ground were being colonized by termites and wood boring insects within the 3 to 5 months.

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® will be 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 will be 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 1 m 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 were evaluated for termite damage. Ratings made at the location of the most extensive damage as follows:

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

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

Results: Due to moderate drought conditions, no termite activity was observed on or around the wood cookies in May 2005. The cookies were transported to another area in the stand that appeared to have more termite activity. However, no appreciable termite activity was observed on or around the wood cookies in November 2005. The cookies were left in place and will be reevaluated in May 2006.

In July, 2 m logs from the 1-3 m height of each emamectin benzoate, fipronil and check tree were debarked and ranked as to the level of termite, bark beetle, and/or wood borer damage present on each log. These logs had been laying flat on the ground for 10 – 14 months. Termite damage was ranked as follows: 0 = none, 1 = light surface activity, 2 = moderate surface activity, 3 = moderate activity, 4 = moderate to heavy mining, 5 = extensive mining of xylem. *Ips* engraver beetle and wood bore damage were each ranked as: 0 = none, 1 =slight, 2 =moderate, 3 = considerable.

Termite damage did not differ among treatments in logs cut in May (1 month after injection), but did differ in logs from July and September (Table 13, Figure 8). Fipronil significantly reduced termite damage in July compared to check logs, while emamectin benzoate reduced damage in September.

Emamectin benzoate was highly effective in reducing bark beetle colonization of logs in all series (May, July and September) (Table 13, Figure 9). The level of *Ips* engraver damage on logs was significantly reduced compared to check logs only in those cut in September.

Emamectin benzoate also was effective in reducing wood borer damage in all log series compared to check logs (Table 13, Figure 10). Initially in May, fipronil was ineffective against borers. However, by September this chemical was equal to emamectin benzoate in efficacy.

Conclusions: Both emamectin benzoate and fipronil continued to protect logs against bark beetles and wood bores for extended periods (10 –14 months) after the trees were felled. Additionally, both chemicals showed activity against termites by significantly reducing the level of colonization compared to check logs. What is unknown is how deep into the wood does the chemicals penetrate.

Acknowledgements: Special thanks go to French Wynne, Potlatch Corp., for asking the question that prompted this trial. Thanks also go to Temple-Inland and Emily Goodwin for providing thinned stands for the project. We appreciate the chemical donations and injection equipment loans made by Arborjet, Inc, BASF, and Syngenta. Advise on the experimental design and protocol was provided by Dr. Harry Quicke, BASF.

Table 13: Mean termite, *Ips* engraver and wood-borer (cerambycid) activity ranking in loblolly pine bolts cut one, three and five months after trunk injection with two systemic insecticides; Lufkin, Texas. Post-fell evaluation conducted July, 2005.

	Mean (+ SE) Termite Damage Ranking*			Mean (+ SE) *Ips* Damage Ranking**			Mean (+ SE) Borer Damage Ranking***		
Treatment	1 month post injection (May)	3 months post injection (July)	5 months post injection (Sept.)	1 month post injection (May)	3 months post injection (July)	5 months post injection (Sept.)	1 month post injection (May)	3 months post injection (July)	5 months post injection (Sept.)
Emamectin	2.8 ± 0.9 **a**	1.8 ± 0.7 **b**	0.6 ± 0.4 **a**	0.2 ± 0.2 **a**	0.3 ± 0.2 **a**	0.4 ± 0.2 **a**	0.8 ± 0.4 **a**	0.6 ± 0.4 **a**	1.6 ± 0.5 **a**
Fipronil	1.8 ± 0.6 **a**	0.6 ± 0.4 **a**	1.2 ± 0.6 **b**	1.8 ± 0.6 **b**	2.4 ± 0.4 **b**	0.4 ± 0.2 **a**	2.2 ± 0.6 **b**	1.4 ± 0.5 **a**	1.6 ± 0.2 **a**
Check	3.4 ± 0.5 **a**	2.6 ± 0.4 **b**	2.4 ± 0.4 **b**	3.0 ± 0.0 **c**	2.4 ± 0.4 **b**	3.0 ± 0.0 **b**	3.0 ± 0.0 **b**	3.0 ± 0.0 **b**	3.0 ± 0.0 **b**

* Termite ranking: 0= none, 1= light surface activity, 2= moderate surface activity, 3= moderate activity, 4= moderate to heavy mining, 5= extensive mining of xylem
** Ips ranking: 0= none, 1=slight, 2=moderate, 3= considerable
*** Wood borer ranking: 0= none, 1=slight, 2=moderate, 3= considerable

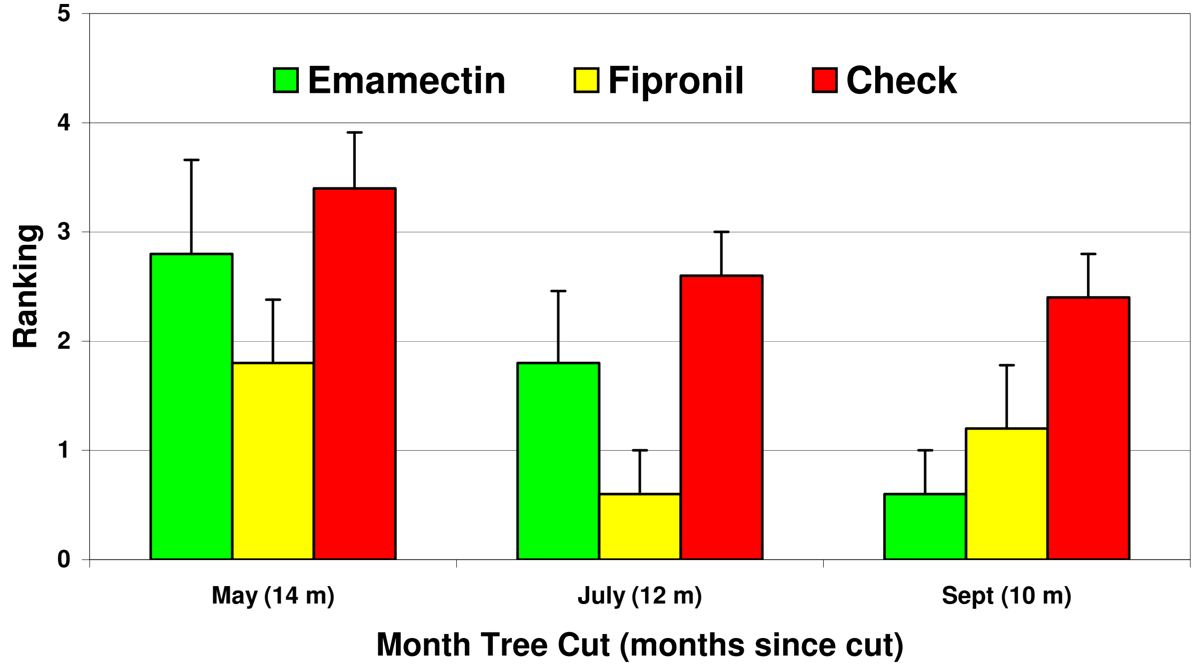


Figure 8. Mean termite activity ranking on emamectin benzoate- and fipronil-treated loblolly pine bolts 10 - 14 months after being cut; Lufkin, Texas. Post-fell evaluation conducted July, 2005. Ranking: 0 = none, 1 = light surface activity, 2 = moderate surface activity, 3 = moderate activity, 4 = moderate to heavy mining, 5 = extensive mining of xylem.

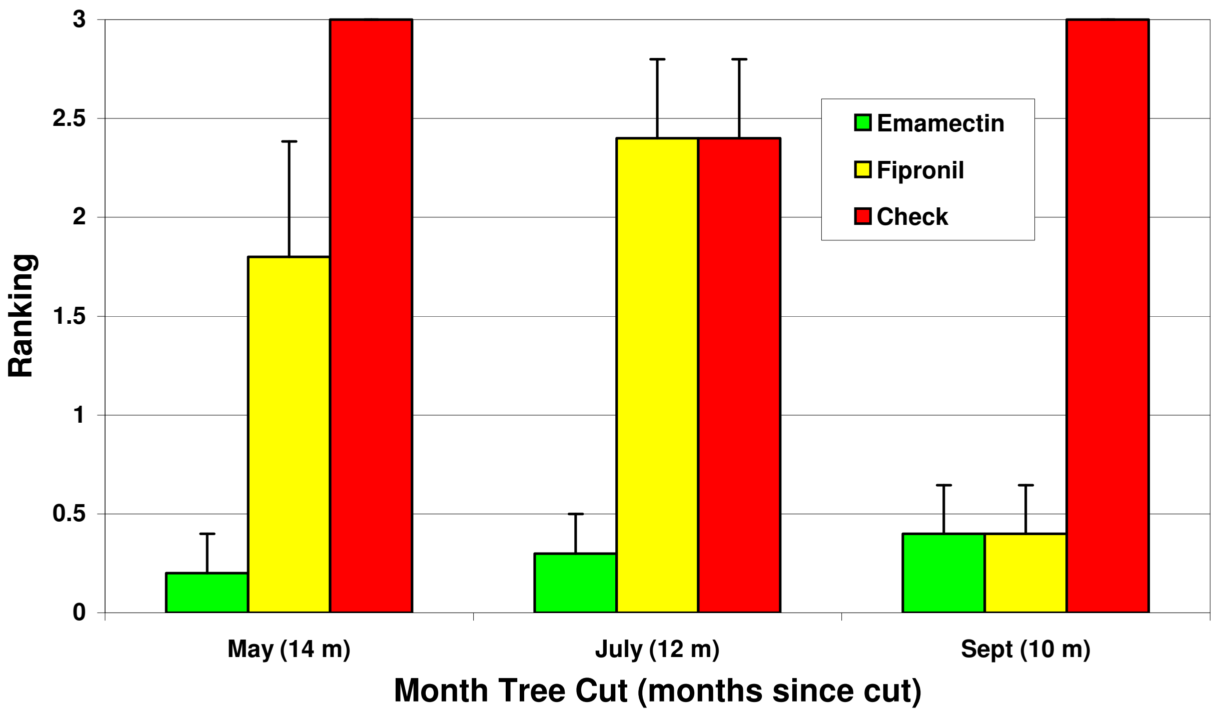


Figure 9. *Ips* engraver beetle activity ranking on emamectin benzoate- and fipronil-treated loblolly pine bolts 10 - 14 months after being cut; Lufkin, Texas. Post-fell evaluation conducted July, 2005. Ranking: 0 = none, 1 =slight, 2 =moderate, 3 = considerable.

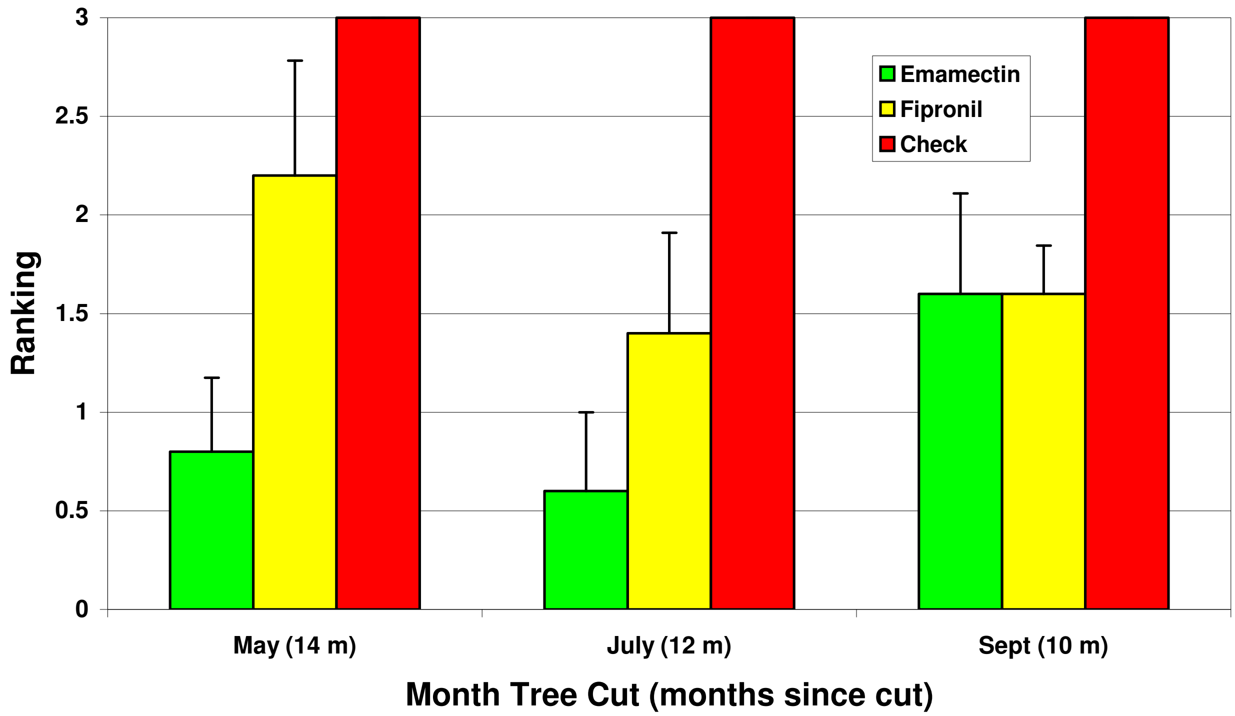


Figure 10. Mean wood borer (cerambycid) activity ranking on emamectin benzoate- and fipronil-treated loblolly pine bolts 10 - 14 months after being cut; Lufkin, Texas. Post-fell evaluation conducted July, 2005. Ranking: 0 = none, 1 =slight, 2 =moderate, 3 = considerable.

SYSTEMIC INSECTICIDE INJECTION TRIALS

Summary and Registration Status of Tested Systemic Insecticides

One of the initial goals of the Western Gulf Forest Pest Management Cooperative (WGFPMC) was to develop alternative control options for cone and seed insects in light of the potential lose of registered foliar pesticides (e.g. Guthion®). Individual tree injections in seed orchards offer several advantages. Control efforts can be allocated to clones on the basis of inherent susceptibility to insect attacks, genetic worth, and high potential for seed production. With these criteria, only 10 – 25% of the ramets in an orchard might need to be protected with insecticides. In turn, the pesticide load (amount of pesticide per acre) produced by conventional application techniques could be substantially reduced. Potential environmental concerns from insecticides in runoff water could be virtually eliminated because insecticides would be contained in the tree. Specific situations where systemic injections may be particularly useful include protecting seeds on trees with control pollinated crosses, protecting selected ramets of genetically-valued clones in early-generation orchards after emphasis shifts to newer orchards, and providing insect control in orchards located in environmentally-sensitive sites where conventional air and ground sprays may be hazardous.

Protection of individual trees from bark beetles has historically involved insecticide applications to the tree bole using hydraulic sprayers. However, this control option can be expensive, time-consuming, of high risk for worker exposure and drift, and detrimental to natural enemies. The use of a newly developed injection technology to deliver systemic insecticides could reduce or eliminate many of the limitations associated with hydraulic spray applications.

Emamectin Benzoate - Over a six years period, emamectin benzoate (Arise SL®), injected as part of the initial Seed Orchard Duration trial, exhibited excellent protection in pine seed orchards against coneworms, with a mean reduction damage of 80% compared to checks. The data suggest that a single injection of emamectin benzoate can protect trees against coneworm for 72 months or longer. A second injection is not necessary during the second growing season to improve efficacy. It has not been as effective against seed bugs. Single injections are capable of significantly reducing seed bug damage, but only for about 18 months. The work by the WGFPMC has proven that emamectin benzoate is highly effective in protecting cone crops. Unfortunately, because seed orchard use constitutes a very small market (only ~8,000 acres in the South), Syngenta had been reluctant to support an injection use registration in the U.S.

Since 2002, an attempt had being made to expand the forestry market of emamectin benzoate through trials with other tree and pest species. Recently, in 2004, injected emamectin benzoate (Denim®) was tested for efficacy against southern pine engraver beetles. Emamectin benzoate was found to be highly effective in preventing the colonization and mortality of stressed loblolly pine by southern pine engraver beetles (see Bark Beetle Report).

In light of the large potential market for emamectin benzoate, particularly as it relates to protection of high-value trees from bark beetles, Syngenta has shown considerably more interest in pursuing registration of this chemical for injection use. Unfortunately, the Denim® formulation had several negative characteristics that limited its potential use as an injectable formulation. Syngenta reached an agreement with Arborjet, Inc. during the winter of 2004/2005 to develop a new injectable formulation of emamectin benzoate. Arborjet created a non-toxic, low viscosity "Ava-jet" formulation for injection use (Joe Doccola, Arborjet™, personal communication).

Three WGFPMC trials were established in 2005 to evaluate the new Ava-jet formulation of emamectin benzoate for 1) efficacy against cone and seed insects in loblolly pine, slash pine and Douglas-fir seed orchards, 2) efficacy of different rates and duration against *Ips* engraver beetles, and 3) efficacy against aggressive bark beetles in the South (southern pine beetle) and West (mountain pine beetle, western pine beetle and spruce beetle). All trials showed that Ava-jet could be quickly injected into trees, was non-toxic, and, where results were available, effective against different species of coneworms and bark beetles. Arborjet also has ongoing trials to test the new formulation for control of emerald ash borer, Asian longhorned beetle, forest tent caterpillar and red gum lerp psyllid. Assuming that the 2005 trials continue to show that the new emamectin benzoate formulation is effective against these insects, Syngenta has agreed to cover the cost of EPA required toxicology tests. Arborjet will then submit a package to EPA in 2006 for label registration.

Fipronil – In light of the discovery that fipronil has systemic activity in loblolly pine against pine tip moth in 2002 (see Tip Moth trials), an experimental EC formulations of fipronil was injected into trees as part of the Denim®/fipronil trial (2003) and Bark Beetle trial (2004). The EC formulation reduced overall coneworm damage by 80% and was highly effective in preventing the colonization and mortality of stressed loblolly pine by southern pine bark beetles (see Bark Beetle Report). Although this formulation had not been found to cause stem necrosis in injected trees, BASF elected to develop and test several new formulations of fipronil for injection use. These were available for comparison with the new formulation of emamectin benzoate in the three 2005 WGFPMC trials mentioned above. Although fipronil tends to require more time to move throughout the tree, it is nearly as effective as emamectin benzoate in most trials.

The BAS 350 UB formulation, developed by BASF in 2005, requires the addition of methanol to improve uptake of the chemical by trees. This would be undesirable when sold for commercial use. Thus, BASF has decided to develop a new formulation in 2006 that already contains a solvent and is injection ready.

Thiamethoxam - Thiamethoxam (Novartis 293) was tested in combination with emamectin benzoate in 1999-2000 and 2001 (Duration Trial and Rate Trial, respectively) to improve protection of cone crops against seed bugs and coneworms. The addition of thiamethoxam did significantly reduce seed bug damage compared to emamectin benzoate alone in the first year in both trials, but generally showed little or inconsistent effects against coneworms. Thiamethoxam provided some extended protection (18 mo.), but not as extensive as was found for emamectin benzoate against coneworms. Protection did improved significantly with a second injection of thiamethoxam in 2000 (Duration Trial). However, cost (manpower and excessive tree wounding) makes yearly injections unattractive. Therefore, a search should begin for an alternative chemical that has a greater effect on seed bugs when injected alone or in combination with emamectin benzoate.

Imidacloprid – Imidacloprid is another neonictinoid chemical tested by the WGFPMC in our seed orchard trials at low (2ml, Pointer® w/ Wedgle Tip injector in 1997) and high (30 ml, Admire® w/ STIT injector in 1999-2000) volumes. Generally, low volume injections were ineffective against coneworms and seed bugs. High volume injections of imidacloprid did significantly reduce coneworm damage (45%), but was not nearly as effective as emamectin benzoate (94%) in the first year after injection. In contrast, imidacloprid was more effective against seed bugs (82% reduction) than was emamectin benzoate (34% reduction). However, there was considerable variability in the efficacy against both groups of pests. As observed with thiamethoxam, imidacloprid efficacy against both coneworms and seed bugs declined markedly in the second year.

Protection against seed bugs, but not coneworms, improved significantly with a second injection of imidacloprid in 2000 (Duration Trial). This suggests that yearly injections of imidacloprid are needed for protection against seed bugs. Again, the cost (manpower and excessive tree wounding) makes yearly injections unattractive. In addition, imidacloprid has a low solubility in water (0.4g/L). Thus, mixing currently-registered products (Merit® and Admire®) in water to create an injectable solution at an effective concentration that is easily injected is difficult. For these reasons, we elected to discontinue our evaluation of imidacloprid after 2000. Recently, Arborjet has developed a new formulation of 5% injectable imidacloprid (Ima-jet™). This formulation alone or combined with their new emamectin benzoate formulation may provide the solution for both pest groups and needs to be tested, perhaps in 2006.

Dinotefuran - Dinotefuran (Valent) is a "3rd generation" neonicotinoid insecticide with primary activity against sucking insects as well as Coleoptera (beetles). Although dinotefuran (0.2g/DBH") was not found to be active against bark beetles in our 2004 trial, it was found by Arborjet (at 0.4g/DBH") to be as effective as imidacloprid against emerald ash borer. One advantage dinotefuran has over imidacloprid is that it is 100X more water soluble (40g/L vs 0.4g/L). Thus, higher concentrations can be developed that translocate more quickly compared to imidacloprid. Arborjet is currently developing a formulation of dinotefuran that may be combined with emamectin benzoate for seed orchard use. A trial should be initiated, perhaps in 2006, to evaluate the potential of this chemical against seed and cone insects.

Nemadectin - Nemadectin (Fort Dodge Animal Health) is a fermentation product of *Streptomyces cyanogriseus noncyanogenus* and closely related to emamectin benzoate. A preliminary trial was conducted in 2005 to determine if nemadectin has similar efficacy against bark beetle. The results suggest some activity, but treatment and evaluation earlier in the year should provide more conclusive evidence.

PINE TIP MOTH TRIALS

Impact Study – Western Gulf Region

Highlights:

- Four new impact plots were established in 2005, bringing the total to 44 plots established since 2001.
- Nantucket pine tip moth damage levels on first-year check trees were moderate (13%) in 2005, the highest level since 2001 (22%). Damage levels on second-year check trees in 2005 were moderately high (18%).
- Periodic applications of Mimic® to first- and second-year trees in 2005 provided good protection against tip moth, reducing damage by 87 and 89 percent, respectively, compared to untreated checks.
- Mimic-treated trees in all age groups (1-5 years old) continued to show improved differences in growth measurements compared to untreated checks. Fifth-year trees, previously treated with Mimic®, were on average 43 cm (1.4 ft) taller in height, had 0.77 cm (0.3 in) greater diameter and 12,867 cm^3 (0.455 ft^3) greater volume compared to check trees.

Objectives: 1) Evaluate 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.

Study Sites: Most WGFPMC members had established 4 or more impact study sites by 2004. In most plantation sites, two areas were selected and divided into 2 plots each - each plot containing 126 trees (9 rows X 14 trees). Tip moth populations were monitored on TFS sites in East Texas.

Population Monitoring: Tip moth populations were monitored on TFS sites in East Texas. In the Lufkin area, 3 Phericon 1C wing traps with Trece septa lures (Great Lakes IPM) were monitored at each of 7 sites. Traps were generally positioned 50 to 100 m apart and at tree terminal height. Sticky trap bottoms were collected and replaced weekly starting in early December 2004 and monitored until late November 2005 (Fig. 22). Lures were changed at 4 - 6 week intervals, depending on mean temperatures.

Insecticide:
Mimic® 2F (tebufenozide) - molting stimulant specific to Lepidoptera.

Design: 28 sites X 1-2 plots X 2 treatments X 50 trees = 4,400 monitored trees.

Treatments:
1) Mimic® 2F applied once per generation at 0.08 oz. / gal.
2) Check

Application Methods: Treatments were randomly assigned to each plot pair at the establishment of each site. Pesticides were applied by backpack sprayer or spray bottle to all 126 trees to within the designated Mimic® plot (treatment area) on first- and second-year sites. Application dates were based on Fettig's optimal spray period predictions for locations near each study site (Fettig et al. 2003), generally every 7-8 weeks starting in late February and ending in late August.

Tip Moth Damage Survey: Tip moth infestation levels were determined in each plot by surveying the internal 50 trees within each plot during the pupal stage of each tip moth generation for the first two years after establishment. Each tree was ranked on the extent of tip moth damage including: 1) tree identified as infested or not, 2) if infested, the proportion of tips infested on the top whorl and terminal was calculated, and 3) separately, the terminal was identified as infested or not. Trees also were surveyed a final time in November or December. At this time, data also were collected on tree height and diameter at 6 inches above the ground. Tree height, diameter at breast height (DBH) and form data were collected on third-year and fifth-year sites. Tree form was evaluated based on number of forks occurring on each tree: 0 = no forks, 1 = one fork, 2 = two to four forks and 3 = five or more forks. A fork is defined by the presence of a lateral branch that is more than half the diameter of the main stem at its base.

Results: Figure 11 shows the mean number of pine tip moths captured in traps per day at several one- to three-year-old sites surrounding Lufkin, TX from 2000- 2005. For the sixth year in row, trap catches in the Lufkin, TX area indicate four full generations with at least a partial fifth generation developing late in the summer. The optimal spray periods in east Texas (near Lufkin) for the first four generations are predicted to be March 22-26, May 21-25, July 10-14, and Aug 19-23 (Fettig et al. 2003). Based on previous years trap data (Figure 11), a fifth spray period was calculated to be September 29 to October 3. In contrast, optimal spray periods for southern Arkansas sites (near Crossett) are April 6-10, June 5-9, July 30-August 3, and Sept. 13-17.

Four new impact plots were established in 2005; bringing the total number of plots established since 2001 to 44. Figure 12 shows the distribution of the 44 first- thru fifth-year impact study sites in the Western Gulf Region.

<u>Group 1 - Fifth-year sites (11)</u>:
Three years after the last Mimic® spray, the difference in growth (height, diameter and volume) between Mimic-treated and untreated trees continues to expand (Table 15, Figures 13-15). After five years, Mimic-treated trees are on average 43 cm (1.7 ft) taller, had 0.77 cm greater diameter at breast height and 12,867 cm^3 (0.455 ft^3) greater volume compared to check trees. It is apparent from the data collected so far that the differences in height, diameter and volume between treated and untreated trees become greater with each year even after Mimic® treatments are discontinued (Figure 13-15).

<u>Group 2 - Fourth-year sites (7)</u>:
Trees on these sites were not measured in 2005. Their next measurements are scheduled for 2006.

<u>Group 3 - Third-year sites (8)</u>:
As with fifth year sites, the difference in growth (height, diameter and volume) between Mimic-treated and untreated trees continues to expand even after Mimic-sprays are halted (Table 15). After three years, Mimic-treated trees were on average 34 cm (1.1 ft) taller, had 0.62 cm greater diameter at breast height and 1503 cm^3 (0.0532 ft^3) greater volume compared to check trees.

These "large" differences in growth, after only 3 years, are likely the result of better protection against tip moth both in the first and second years (Table 14).

Group 4 - Second-year sites (5): Tip moth infestation levels on untreated second-year trees was greater (17% of shoots infested) in 2005 compared to similar aged trees in 2004 (12% of shoots infested) (Table 14). Overall protection of second-year trees was good, with Mimic® reducing damage to shoots by 89%. Combined, these factors have resulted in a dramatic improvement in the height (20%), diameter (9%) and volume (25%) of Mimic®-treated trees compared to check trees (Table 15).

Group 5 - First-year sites (4): Overall, tip moth infestation levels on untreated first-year seedlings were moderate (13% of shoots infested) in 2005 compared to the high (22% of shoots infested) in 2001 and low (7% of shoots infested) in 2002 (Table 14). Mimic® protection during the first generation was good throughout the year (87% average) with reductions in damage not dropping below 75%. Mimic®-treated trees on 3 of 4 sites show significant gains in height, diameter and volume compared to untreated check trees. Overall, Mimic®-treated seedlings saw gains in height, diameter and volume of 20%, 35% and 116%, respectively compared to check trees (Table 15).

Conclusions: Overall tip moth populations and damage levels increased in 2005 relative to the previous three years. This increase was largely due to the extensive drought conditions that occurred in the Western Gulf Region through most of 2005. Multiple applications of Mimic® again were able to significantly reduced tip moth infestation levels on both one- and two-year old sites in 2005. Whereas, Mimic® treatments did significantly improve tree growth on first-year sites in 2001, 2003 & 2005 and second-year sites in 2002 and 2005, they did not improve tree growth on first-year sites in 2002 or second-year sites in 2003. One reason may be that tip moth populations were too low (below some threshold) to impact the growth of untreated trees on first and second-year sites in 2002 and 2003, respectively. In contrast, tip moth populations were apparently high enough on second-year sites to significantly impact growth of unprotected trees. It is conservatively estimated that yearly mean tip moth damage levels (percent shoots infested) need to exceed 10% before there is a significant impact on tree growth in a given year.

Fettig (et al. 2000) concluded that tip moth damage occurring during the first generation has the greatest impact on growth. This may be true on second-year sites when first generation damage is fairly high. However, very little damage has occurred recently in the Western Gulf region on first year sites during the first generation: 1) because the moth is just beginning to colonize the area and populations are very low, and 2) the first flush of growth after transplant is usually much shorter than future flushes. During the first year, the effects of second and third tip moth generations appear to be most crucial. This supported by the fact that first year trees in 2002 had good protection (85% reduction) from Mimic® during the first generation, while only moderate protection (68% and 59% reduction) was obtained during the second and third generations, respectively. The result was that the treatments over the course of the year had no impact on tree growth. In contrast, first year trees in 2003 had relatively poor protection (49% reduction) during the first generation, but excellent protection the second and third generation (90% reduction for both generations). The result was significant growth gains with Mimic® treatments. Regression analysis is on going to determine the damage threshold for impact on tree growth. Also, analysis will be conducted to determine the relationship between time and extent of tip moth protection and tree growth.

Given the disparity in tip moth population levels over the past three years, it is suggested that additional impact sites be established in 2006. Also it is important to continue treatments on second-year sites and monitor tip moth damage and impact on third- and fifth-year sites in 2006.

Acknowledgments: We greatly appreciate the efforts of Emily Goodwin, Temple-Inland, Valerie Sawyer, Weyerhaeuser, Al Cook, independent contractor for International Paper and Plum Creek, and Nick Chappell, Potlatch, and Greg Kelley, contractor for Forest Investment Associates, for establishing, spraying and monitoring the impact plots. Many thanks go to Andy Burrows, Temple-Inland, for volunteering his time to assist us in the analysis of the impact data.

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Fettig, C.J., K.W. McCravy and C.W. Berisford. 2000. Effects of Nantucket pine tip moth insecticide spray schedules on loblolly pine seedlings. So. J. Appl. For. 24(2):106 – 111.

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

Table 14: Mean percent of pine shoots (in top whorl) infested by Nantucket pine tip moth on one- and two-year old loblolly pine trees following treatment with Mimic® after 4 - 5 generations; Arkansas, Lousiana and Texas sites, 2001 - 2005.

	Planted 2001 (N =16)		Planted 2002 (N = 7)		Planted 2003 (N= 10)		Planted 2004 (N= 7)	(N= 5)	Planted 2005 (N= 4)		Mean Year 1	Mean Year 2
Treatment	Year 1	Year 2	Year 1	Year 2	Year 1	Year 2	Year 1	Year 2	Year 1	Year 2	(N= 44)	(N= 38)
Mimic®	1.7	3.8	1.5	3.8	1.2	1.2	1.4	2.0	1.7		1.5	2.9
Check	22.4	21.9	7.5	15.5	12.2	12.0	10.3	17.9	12.7		14.9	17.6
% Reduction	92	83	80	75	90	90	87	89	87		90	84

Table 15: Mean tree height, diameter and volume index and percent growth gain and actual difference in growth of one-, two-, three- and five-year old loblolly pine following treatment with Mimic® after 4 - 5 generations; Arkansas, Lousiana and Texas sites - 2001 to 2005.

	Planted 2001 (N =16)				Planted 2002 (N = 7)			Planted 2003 (N= 10)			Planted 2004 (N= 5-7)		Planted 2005 (N= 4)		Mean			
Treatment	Yr 1	Yr 2	Yr 3	Yr 5	Yr 1	Yr 2	Yr 3	Yr 1	Yr 2	Yr 3	Yr 1	Yr 2	Yr 1	Yr 2	Year 1 (N= 44)	Year 2 (N= 38)	Year 3 (N= 33)	Year 5 (N= 16)
Height (cm)																		
Mimic®	62.2	157	299	617	58.0	149	282	63.1	171	270	40.3	110	73.4		59.3	153	287	617
Check	48.7	142	272	574	59.2	147	270	55.6	153	236	41.7	94	61.0		51.9	139	261	574
Pct. Gain Compared to Check	28	11	10	7	-2	1	5	13	12	14	-3	17	20		14	10	10	7
Actual Diff. In Growth (cm)	14	15	27	43	-1	2	12	8	19	34	-1	16	12		7	14	26	43
Diameter (cm)																		
Mimic®	1.30	3.27	3.84	9.21	1.27	3.53	4.93	1.09	3.13	2.50	0.74	1.51	1.40		1.17	3.05	3.66	9.21
Check	1.16	2.92	3.27	8.44	1.29	3.57	4.79	0.96	2.85	1.88	0.79	1.47	1.07		1.07	2.83	3.17	8.44
Pct. Gain Compared to Check	12	12	17	9	-2	-1	3	14	10	33	-6	3	31		9	8	16	9
Actual Diff. In Growth (cm)	0.14	0.35	0.57	0.77	-0.02	-0.04	0.14	0.13	0.28	0.62	-0.05	0.04	0.33		0.10	0.22	0.49	0.77
Volume Index (cm^3)																		
Mimic®	201	2824	6465	60808	131	2343	8187	141	2445	3161	22	356	209		148	2311	5829	60808
Check	138	2053	4680	47941	149	2393	7242	113	2091	1658	21	299	103		112	1895	4308	47941
Pct. Gain Compared to Check	46	38	38	27	-12	-2	13	25	17	91	6	19	103		32	22	35	27
Actual Diff. In Growth (cm)	63	771	1785	12867	-18	-50	945	28	353	1503	1	58	106		36	416	1521	12867

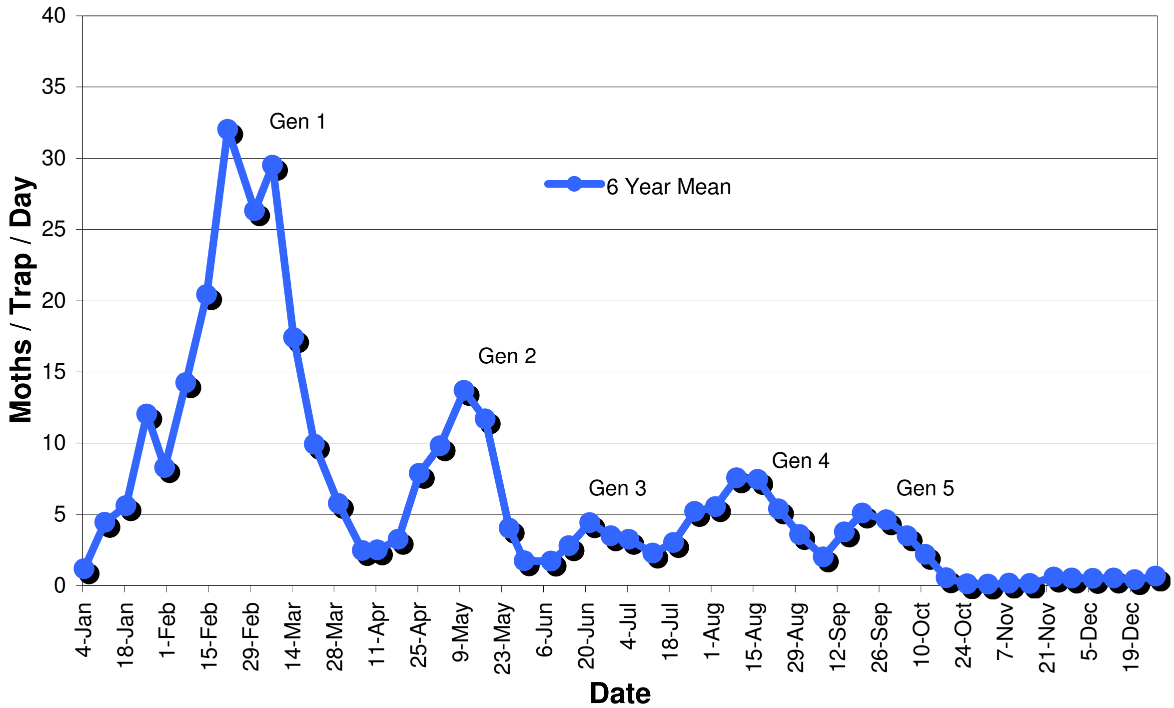

Figure 11. Mean number of pine tip moth adults captured per trap per day in the Lufkin, TX area (2000 - 2005).

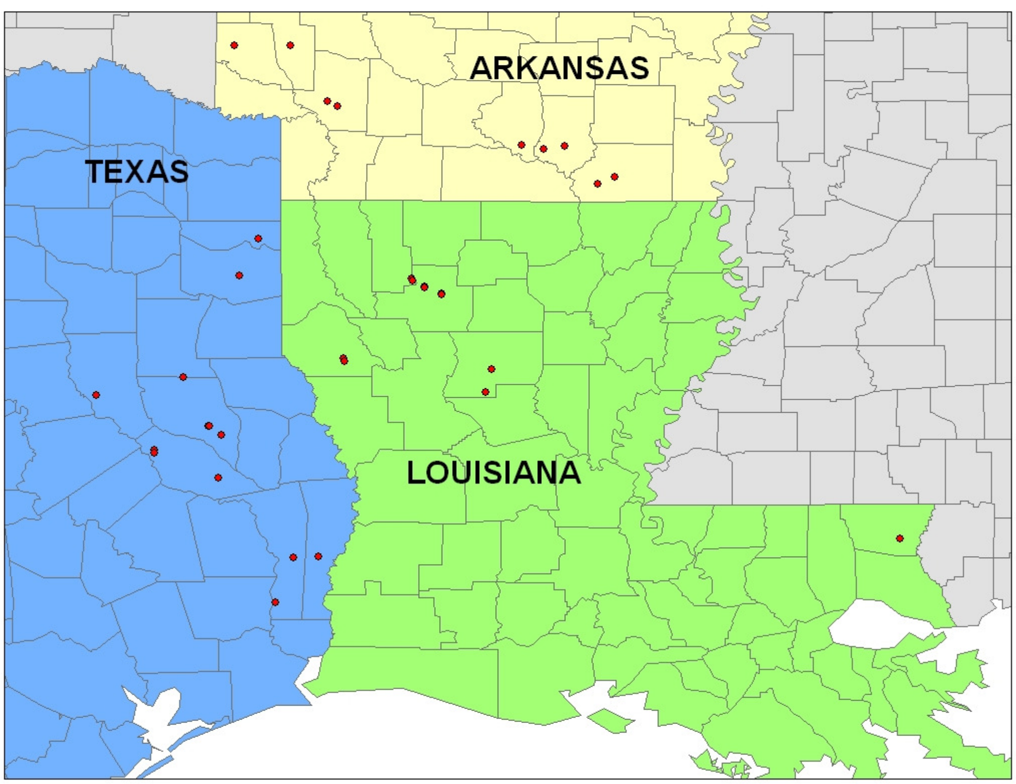

Figure 12. Distribution of 44 one- to five-year old impact sites (●) from 2001 – 2005 in the Western Gulf Region.

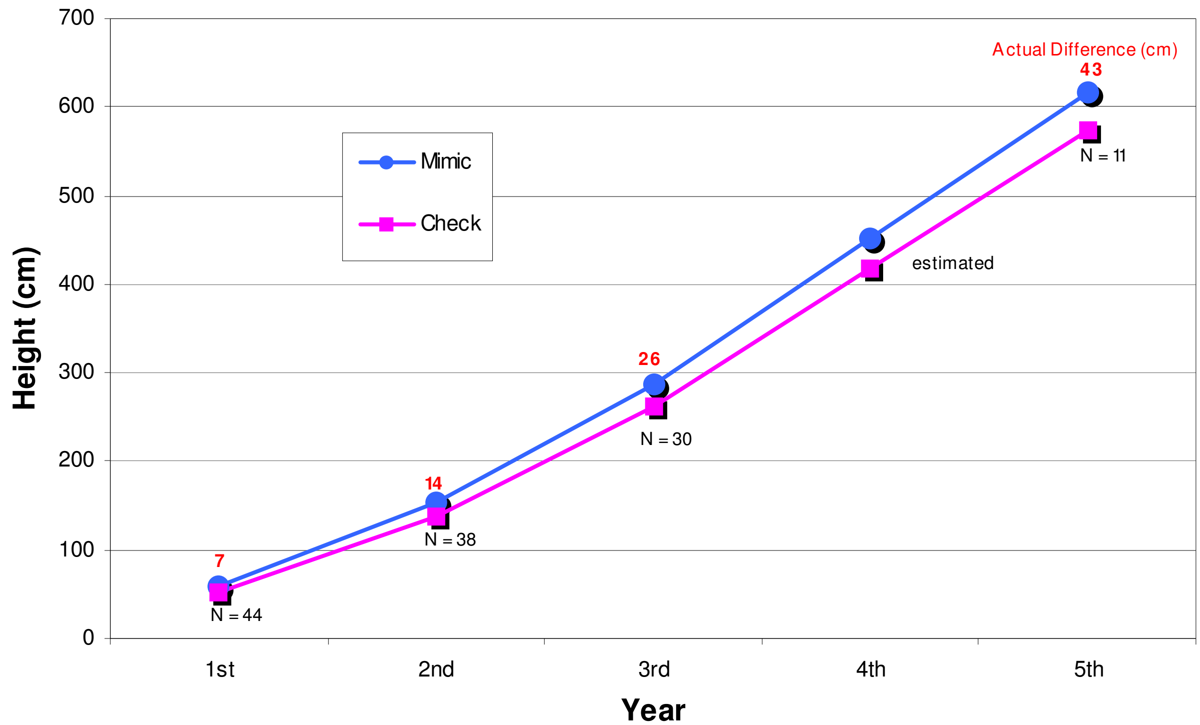

Figure 13. Mean height (cm) of one- to five-year old loblolly pine treated with Mimic® compared to untreated trees on all Western Gulf sites: 2001 – 2005.

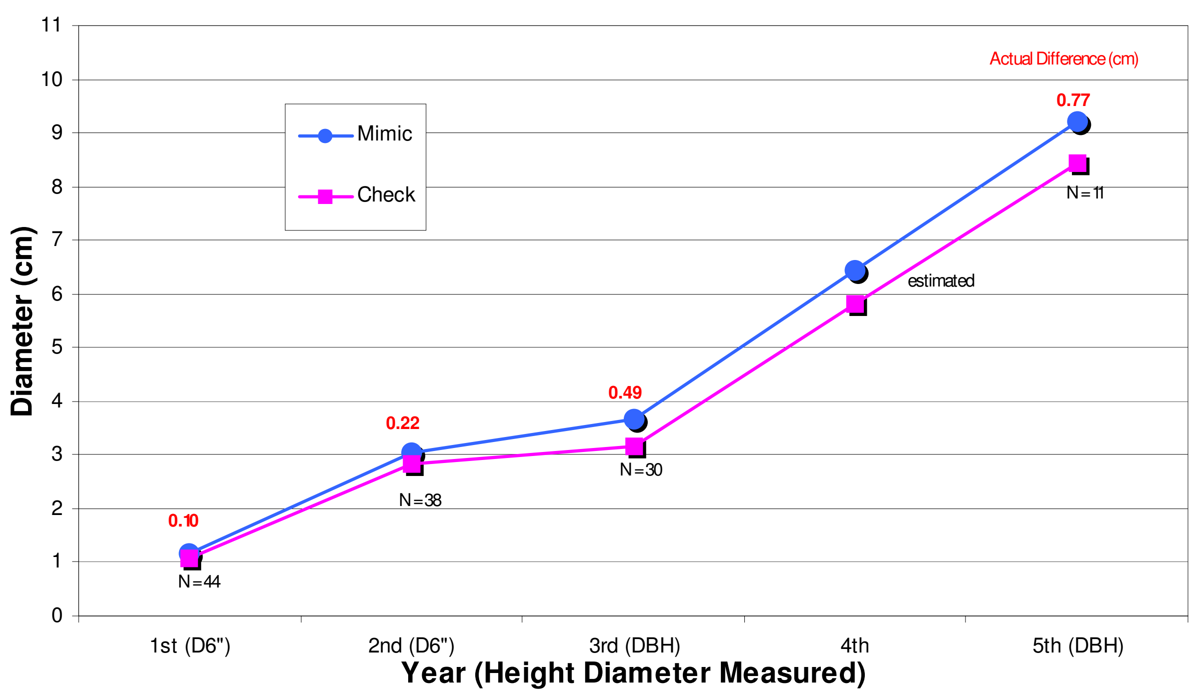

Figure 14. Mean diameter (cm) of one- to five-year old loblolly pine treated with Mimic® compared to untreated trees on all Western Gulf sites: 2001 – 2005.

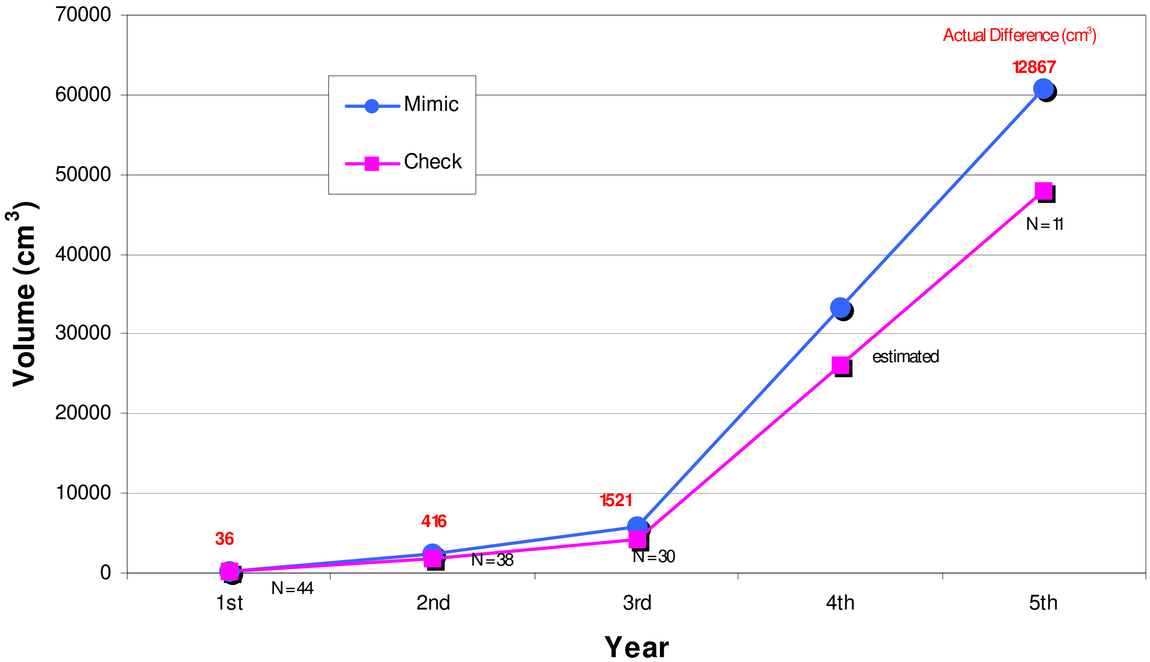

Figure 15. Mean volume index (cm^3) of one- to five-year old loblolly pine treated with Mimic compared to untreated trees on all Western Gulf sites: 2001 – 2005.

PINE TIP MOTH TRIALS

Hazard Rating Study – Western Gulf Region

Highlights:

- Data on site characteristics were collected from 14 plots (4 - first-year and 10 - second-year) in the Western Gulf Region in 2005. In total, 76 hazard-rating plots have been established since 2001.
- A hazard-rating model developed by Andy Burrow indicates that site index and soil texture have the greatest influence on tip moth occurrence and severity.
- In the Western Gulf Region, sites having site indices of less than 65 and sand making up more than 30% of the soil component are at high risk for tip moth damage.

Objective: Identify abiotic factors that influence the occurrence and severity of Nantucket pine tip moth infestations.

Cooperators: Western Gulf Forest Pest Management Coop. members
Dr. C. Wayne Berisford, University of Georgia
Mr. Andy Burrow, Temple-Inland Forest Products

Study Sites: WGFPMC members selected from one or two new first-year plantations in 2004. Several were the same as those used in the Impact Study. When associated with the Impact Study, the untreated Impact plot was also used to collect tip moth and site characteristics data for the Hazard Rating Study. In this situation, a plot area within each plantation was selected - each plot containing 126 trees (9 rows X 14 trees). The internal 50 trees were evaluated for tip moth damage. For plantations with Hazard Rating plots alone, a plot area representative of the plantation was selected and contained 50 trees (5 rows X 10 trees).

Site Characteristics Data: Site characteristics data collected from 14 Western Gulf plots (4 - first-year and 10 - second-year) in 2005 included:

Soil - Texture and drainage
Soil description/profile: depth of 'A' and to 'B' horizons; color and texture of 'B' Horizon
Depth to hard-pan or plow-pan
Depth to gleying
Soil sample (standard analysis plus minor elements and pH)

Tree - Age (1-2)
Percent tip moth infestation of terminal and top whorl shoots – 1st, 2nd, 3rd, and last generation
Height and diameter at 6 inch above ground

Site - Previous stand history
Site index (base 25 years)
Silvicultural prescription (for entire monitoring period)
Slope, aspect, and position (ridge, side-slope, bottom, flat)
Competing vegetation: 5 random samples within each plot to determine proportion of bare ground, grasses, forbes and non arborescent woody stems after 2nd and last tip moth generation.

Rainfall (on sight or from nearest weather station)
Estimate of the acreage of susceptible loblolly stands in the 2-5 year age class (< 15 ft tall) adjacent to or within 1/2 mile of study stand boundary

Tip Moth Damage Survey: Tip moth infestation levels were determined in each plot by surveying the internal 50 trees during the pupal stage of the first, second and last tip moth generation. Each tree was ranked on the extent of tip moth damage including: 1) tree identified as infested or not, 2) if infested, the proportion of tips infested on the top whorl and terminal was calculated, and 3) separately, the terminal was identified as infested or not. On second-year sites, the 50 sample trees were measured after the last generation for height and diameter at 6 inches and assessed for the occurrence of fusiform rust galls. Incidence of fusiform rust was 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.

Data Analysis: Mr. Andy Burrow, Temple Inland, volunteered in 2004 to help develop the model. With a Masters in Biometrics and minor in statistics, Mr. Burrows has the expertise the WGFPMC needs to get the job done. The data (four years' worth) was consolidated and sent to Mr. Burrows by the end of March 2005. The data was analyzed using Classification and Regression Tree analysis to create a classification tree (STATISTICA, 2005, StatSoft, Inc.)

Results: Figure 16 shows the distribution of all 76 hazard-rating sites established in the Western Gulf Region from 2001 to 2005.

Mr. Burrow's analyses have resulted in a working model that indicates that, individually, site index, soil texture, soil drainage class, depth to 'B' horizon and stand history are the five important factors that influence the occurrence and severity of pine tip moth on a site. However, the two factor model that included site index and soil texture provide the best explanation of site variability. Specifically, "good" sites with site indices > 65 are low hazard for tip moth damage (mean annual percent of shoots infested < 10%) (Figures 17 & 18). On these sites, soil nutrients and water are usually at levels that encourage good growth and allow the trees to resist tip moth attack.

If the site is "fair or poor", with site indices less than 65, the hazard for tip moth occurrence and damage becomes moderate (11 – 20% shoots infested). If the soil on the same site also has > 30% sand, the site becomes a high hazard for tip moth damage (> 20% shoots infested). Trees growing on such sites are more likely to experience stressful conditions, e.g., poor nutrient availability or drought conditions. A stressed tree would be less able to resist tip moth attack. Thus tip moth damage levels would be higher and impact on growth and form greater.

The model needs to be validated. Additional sites should be installed in 2006 on sites with high and low site indices and sand components.

Acknowledgments: We greatly appreciate the efforts of Emily Goodwin, Temple-Inland, Valerie Sawyer, Weyerhaeuser, Al Cook for International Paper and Plum Creek, and Nick Chappell, Potlatch, and Greg Kelley for Forest Investment Associates, for establishing and monitoring the hazard-rating plots. Many thanks go to Andy Burrows, Temple-Inland, for volunteering his time to assist in the development of a hazard-rating model.

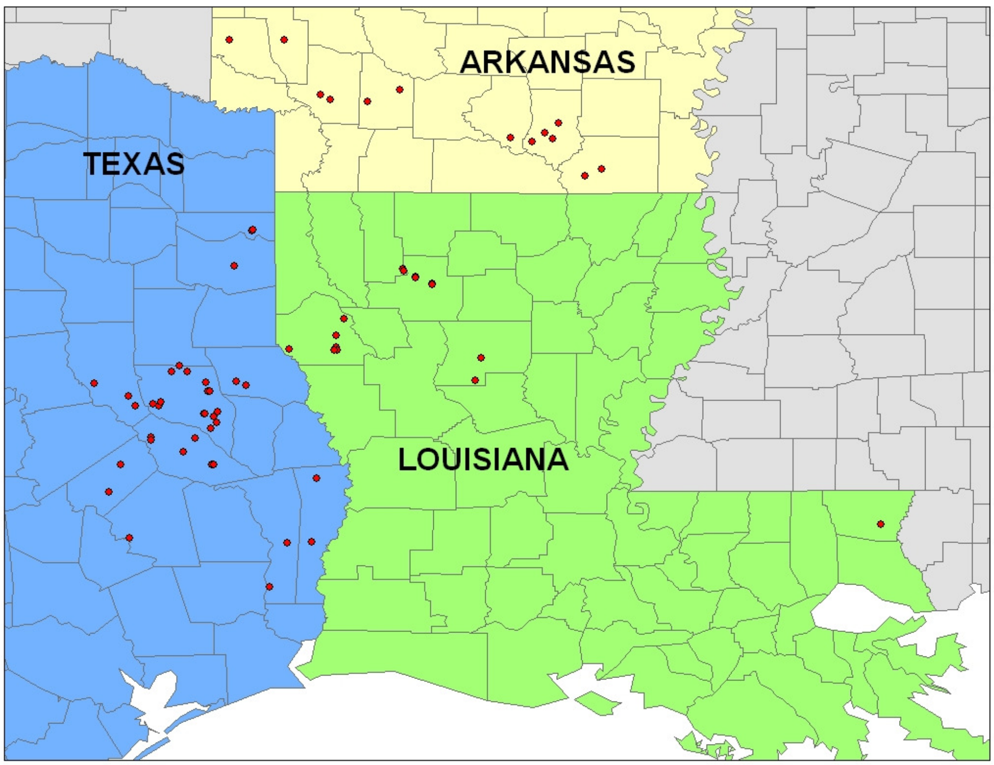

Figure 16. Distribution of 76 hazard-rating plots (●) established from 2001 - 2005 in the Western Gulf Region.

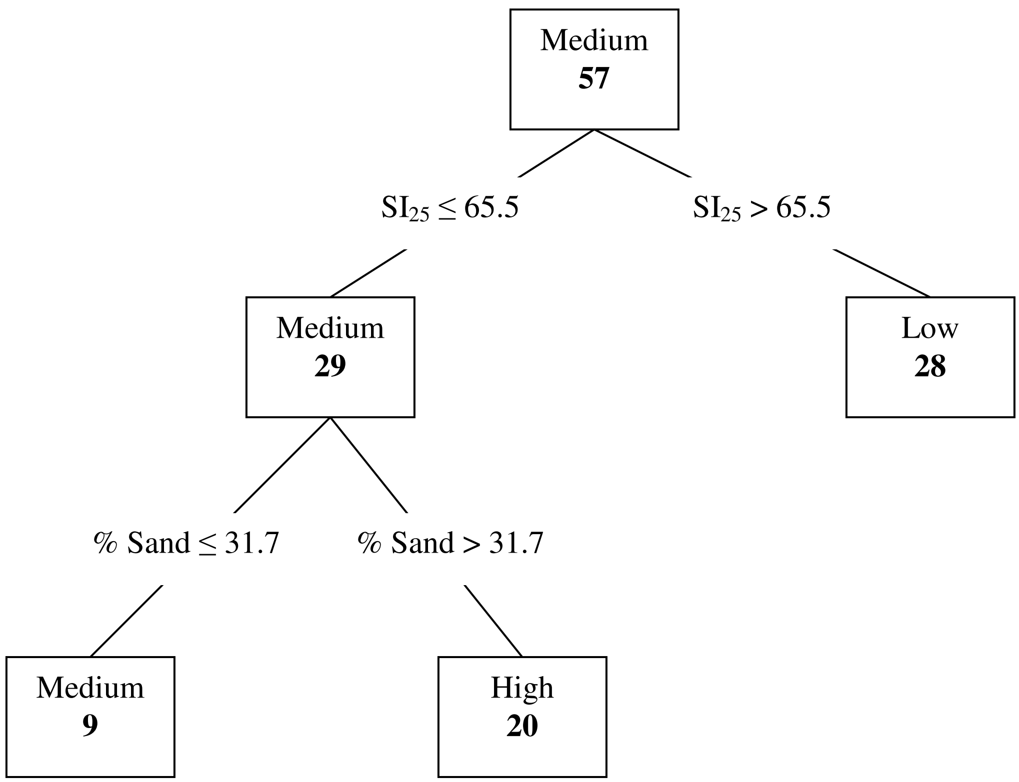

Figure 17. Classification tree describing a hazard rating system for tip moth infestation in one (1) and two (2) year old pine plantations. Bold numbers represent the number of sample points at each node.

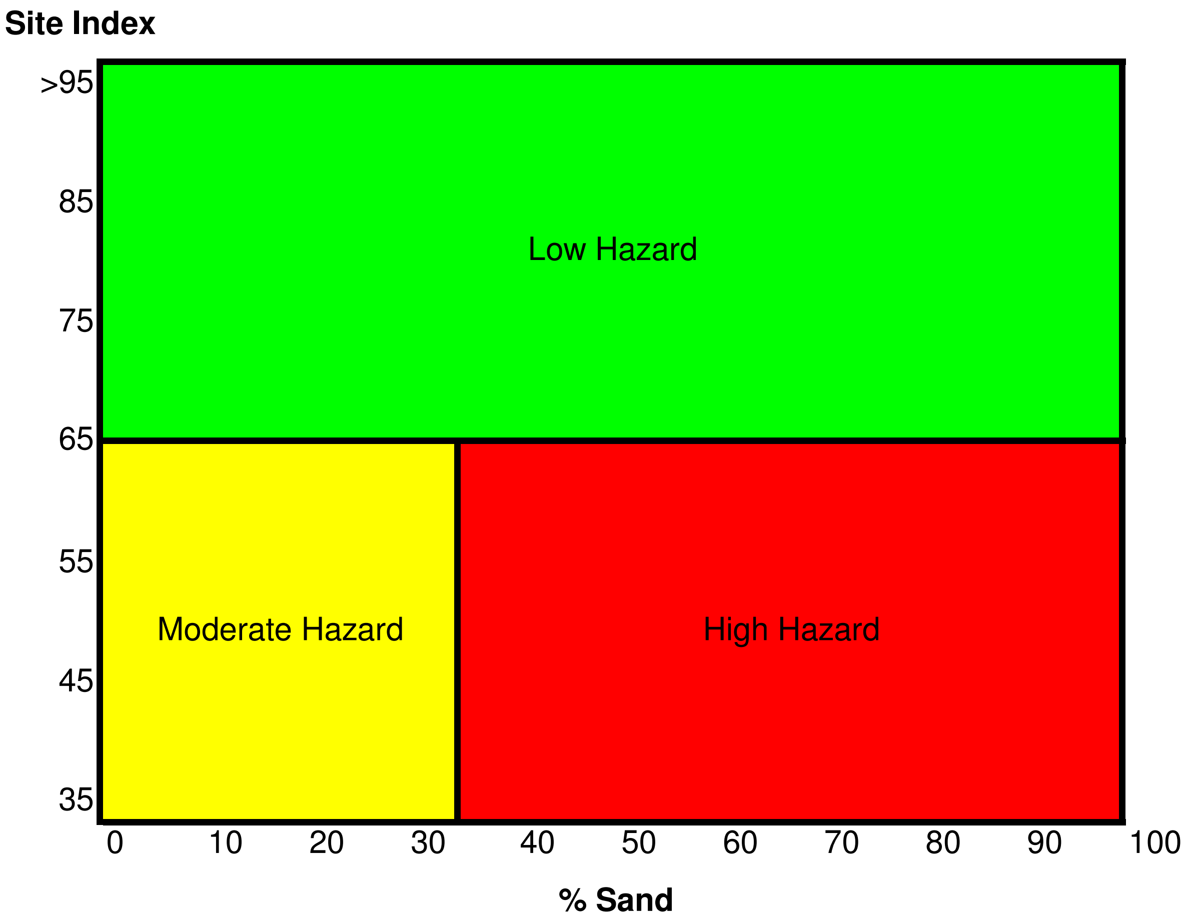

Figure 18. Tip moth hazard-rating graph for Western Gulf Region sites.

PINE TIP MOTH TRIALS
Seedling Treatment Study – Rusk Co., TX

Highlights:

- Four years after treatment and planting, fipronil-treated trees have surpassed those treated with Mimic® as the treatment with the greatest mean height and volume index.
- Fipronil trees continued to show increasing gains in diameter and volume growth compared to check trees in 2005. In contrast, the gains made by seedlings treated with Mimic® or imidacloprid continued to decline in the fourth year after planting.

Objectives: 1) Continue evaluating the efficacy of several systemic insecticides (emamectin benzoate, imidacloprid and fipronil) in reducing tip moth damage on loblolly pine seedlings; and 2) determine the duration of treatment efficacy.

Study Sites: Two second-year plantations were selected in the Fairchild State Forest (Cherokee Co.) in East Texas (Figure 19). One research plot, containing 350 trees (5 rows X 70 trees), was established in 2002 in each plantation.

Insecticides:

Proclaim® (emamectin benzoate) - an avermectin derivative with activity against Lepidoptera.
Termidor® (fipronil) – a pheny pyrazole with some systemic activity against Lepidoptera.
Imidacloprid – highly systemic neonictinoid with activity against Lepidoptera.
Actera® (thiamethoxam) – a related neonicotinoid with high systemic activity.
Mimic® (tebufenozide) – molting stimulant with specific activity against Lepidoptera.

Design: Randomized complete block design at each site with beds or site areas serving as blocks, i.e., each treatment was randomly selected for placement along a bed. Ten seedlings from each treatment were planted on each of five beds. Plots 1 & 2: 2 sites X 7 treatments X 50 trees = 700 monitored trees.

Treatments:

Plot 1 & 2: Chemical Effect:

1) Emamectin benzoate (Proclaim®) solution (0.12%) root soak **(discontinued after 2004)**
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 **(discontinued after 2004)**
5) Tebufenozide (Mimic®, 0.8 oz/gal) foliar spray (5X) prior to each generation in 2002 and 2003
6) Check (untreated)

Treatment Evaluation in 2005: Tip moth damage was not evaluated in 2005, as most trees were too tall to evaluate from the ground. Each tree was measured for diameter (at breast height) and height and evaluated for form (occurrence of forks) in December 2005.

Results: In 2002, all root-soak treatments had shown significantly lower tip moth damage levels after the first two tip moth generations compared to check trees (Table 16). However, only fipronil and Mimic® continued to reduce damage levels through the fifth generation. The fipronil treatment (90% reduction) was comparable to the standard, Mimic® foliar treatment (92%). The fipronil, imidacloprid and thiamethoxam treatments each resulted in significant (or nearly significant) gains in tree height, diameter and volume growth compared to check trees (Table 17 & 18).

In 2003, damage levels on check trees averaged nearly 50% lower than 2002 levels (Table 16). Activity of all root-soak treatments also declined compared to the previous year. However, the fipronil treatment consistently had the lowest level of tip moth damage of all root-soak treatments. Tip moth damage on fipronil-treated trees was significantly lower than the check during the fourth and fifth generations. Overall, fipronil reduced damage by 27% in 2003 and by 58% over the past two years. The fipronil, imidacloprid and Mimic® treatments each resulted in significant gains in tree diameter and volume growth compared to check trees (Table 17 & 18). However, only Mimic®-treated trees continued to be significantly taller in height than check trees. The fipronil and Mimic® treatments both resulted in significantly lower levels of forking compared to the other root-soak treatments and the check.

In 2004, fipronil, imidacloprid, thiamethoxam and Mimic®-treated trees continued to show significant gains in tree diameter growth compared to check trees (Table 17). However, only fipronil and Mimic®-treated trees continued to be both significantly taller in height and larger in volume than check trees (Table 17 & 18). The fipronil-treated trees have maintained a stable volume growth rate relative to the check trees over the past two years (Figures 20 & 21). In contrast, the growth rate of Mimic®-, imidacloprid- and thiamethoxam-treated trees declined from 2003 to 2004, indicating that these treatments no longer had a significant effect on tip moth control. Only the Mimic® treatment resulted in significantly lower levels of forking compared to the other root-soak treatments and the check.

In 2005, fipronil-, imidacloprid-, and Mimic®-treated trees continued to show significant gains in tree diameter growth compared to check trees (Table 17). In contrast, only fipronil- and Mimic®-treated trees continued to be both significantly taller in height and larger in volume than check trees. The fipronil-treated trees continues to improve in volume growth rate relative to the check trees over the past 4 years (Figures 20 & 21). In contrast, the growth rate of Mimic®-, and imidacloprid-treated trees has declined markedly from 2003 to 2005, indicating that fipronil is continuing to affect growth while the other treatments are not.

Acknowledgment: We thank Harry Vanderveer and Ted Moore for providing assistance at the nursery and the Texas Forest Service for donating the seedlings. We appreciate the chemical donations made by BASF, Bayer Cropscience, Certis and Syngenta.

References:

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

Table 16. Effect of systemic chemical treatments on pine tip moth infestation of loblolly pine shoots (top whorl) after each generation during two growing seasons on **Plots 1 & 2**, Evans Tract, Fairchild State Forest, Cherokee Co., TX, 2002 - 2003.

		CY 2002 — Mean Percent Shoots Infested by Tip Moth (Pct. Reduction Compared to Check)										Mean % Infested Yr. 1	Mean Pct. Red. (All 5 Gen)
Treatment §	N	Gen 1		Gen 2		Gen 3		Gen 4		Gen 5			
EB (0.12% ai)	100	2.5 **a** *	(84)	14.7 **c**	(49)	26.2 **c**	(16)	49.4 **c**	(6)	62.8 **c**	(16)	31.1	**34**
FIP (0.146% ai)	100	1.3 **a**	(92)	0.0 **a**	(100)	6.8 **a**	(78)	0.9 **a**	(98)	13.4 **b**	(82)	4.5	**90**
IMID (0.532% ai)	100	1.3 **a**	(92)	5.1 **b**	(82)	27.9 **c**	(10)	47.6 **c**	(10)	71.7 **d**	(4)	30.7	**40**
THIA (0.17% ai)	100	0.0 **a**	(100)	5.0 **ab**	(83)	18.3 **b**	(41)	36.0 **b**	(32)	55.8 **c**	(25)	23.0	**56**
Mimic® (foliar)	100	1.8 **a**	(89)	0.3 **ab**	(97)	7.6 **a**	(76)	1.1 **a**	(98)	1.5 **a**	(98)	2.5	**92**
Check	100	15.4 **b**		28.6 **d**		31.1 **c**		52.8 **c**		74.5 **d**		40.5	

		CY 2003 — Mean Percent Shoots Infested by Tip Moth (Pct. Reduction Compared to Check)										Mean % Infested Yr. 1	Mean Pct. Red. (All 5 Gen)	Mean Pct. Red. (2 Yr Avg)
Treatment §	N	Gen 1		Gen 2		Gen 3		Gen 4		Gen 5				
EB (0.12% ai)	100	10.6 **b** *	(7)	9.8 **b**	(-4)	19.7 **c**	(-16)	18.0 **b**	(35)	29.6 **c**	(18)	17.5	**8**	**21**
FIP (0.146% ai)	100	8.8 **b**	(23)	8.1 **b**	(14)	13.4 **b**	(21)	16.0 **b**	(42)	24.4 **b**	(33)	14.1	**27**	**58**
IMID (0.532% ai)	100	11.9 **bc**	(-4)	9.1 **b**	(4)	17.1 **bc**	(-1)	25.1 **c**	(9)	30.2 **d**	(17)	18.7	**5**	**22**
THIA (0.17% ai)	100	17.4 **c**	(-52)	11.3 **b**	(-19)	21.8 **c**	(-28)	16.1 **b**	(42)	31.2 **c**	(14)	19.5	**-9**	**24**
Mimic® (foliar)	100	1.4 **a**	(88)	0.0 **a**	(100)	1.7 **a**	(90)	1.2 **a**	(96)	1.1 **a**	(97)	1.1	**94**	**93**
Check	100	11.4 **bc**		9.5 **b**		17.0 **bc**		27.7 **c**		36.3 **d**		20.4		

§ EB = emamectin benzoate, FIP = fipronil, IMID = imidacloprid, THIA = Thiamethoxam.

* Means followed by the same letter in each column are not significantly different at the 5% level based on Fisher's Protected LSD.

Table 17. Effect of systemic chemical treatments on loblolly pine height and diameter growth on Plots 1 & 2, Evans Tract, Fairchild State Forest, Cherokee Co., TX, 2002 - 2005.

		Mean Tree Measurements (**Growth Difference (cm) Compared to Check**)															
		Height (cm)								Diameter (cm)							
Treatment §	N	2002		2003		2004		2005		2002 (D @ 6")		2003 (D @ 6")		2004 (DBH)		2005 (DBH)	
Emamectin	100	47.1 *	**-4.6**	145	**-5**	286	**-9**			0.69	**-0.06**	2.6	**-0.1**	3.5	**-0.1**		
Fipronil	100	56.3 *	**4.6**	157	**7**	314 *	**20**	481 *	**22**	0.82	**0.07**	3.0 *	**0.3**	4.0 *	**0.4**	6.5 *	**0.7**
Imidacloprid	100	55.2	**3.5**	157	**6**	311 *	**16**	467	**7**	0.85 *	**0.10**	3.1 *	**0.3**	4.0 *	**0.4**	6.3 *	**0.5**
Thiamethoxam	100	55.1	**3.4**	158	**7**	306	**12**			0.84 *	**0.09**	3.0 *	**0.2**	4.0 *	**0.3**		
Mimic® (foliar)	100	59.9 *	**8.2**	174 *	**23**	324 *	**30**	479 *	**19**	0.91 *	**0.16**	3.3 *	**0.5**	4.3 *	**0.7**	6.5 *	**0.7**
Check	100	51.7		150		294		460		0.75		2.7		3.6		5.8	

§ Concentrations: EB = 0.12%, FIP = 0.15%, IMID = 0.53%, THIA = 0.17%.
* Means followed by astriks in each column are not significantly different from the check at the 5% level based on Fisher's Protected LSD.

Table 18. Effect of systemic chemical treatments on loblolly pine volume growth on **Plots 1 & 2**, Evans Tract, Fairchild State Forest, Cherokee Co., TX, 2002 - 2005.

Treatment §	N	Volume (cm^3) (**Growth Difference (cm^3) Compared to Check**)							
		2002		2003		2004		2005	
Emamectin	100	27.3	**-10**	1083	**-229**	4072	**-559**		
Fipronil	100	47.6	**10.1**	1678 *	**366**	5933 *	**1302**	23241 *	**5823**
Imidacloprid	100	47.6	**10.1**	1688 *	**375**	5504	**874**	19606	**2188**
Thiamethoxam	100	47.4	**9.9**	1552	**239**	5373			
Mimic® (foliar)	100	60.6 *	**23.1**	2190 *	**878**	6993 *	**2362**	22888 *	**5470**
Check	100	37.5		1312		4631		17418	

§ Concentrations: EB = 0.12%, FIP = 0.15%, IMID = 0.53%, THIA = 0.17%.
* Means followed by astriks in each column are not significantly different from the check at the 5% level based on Fisher's Protected LSD.

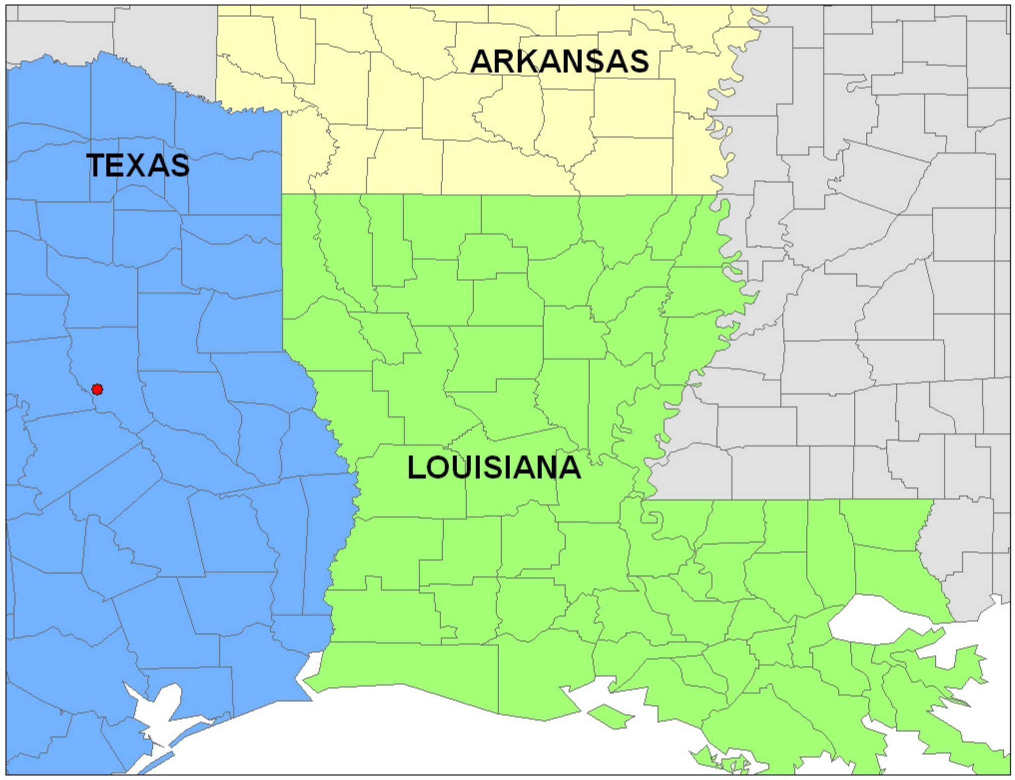

Figure 19. Site of the initial tip moth control plots (●) established in 2002 in the Fairchild State Forest, Cherokee Co., TX.

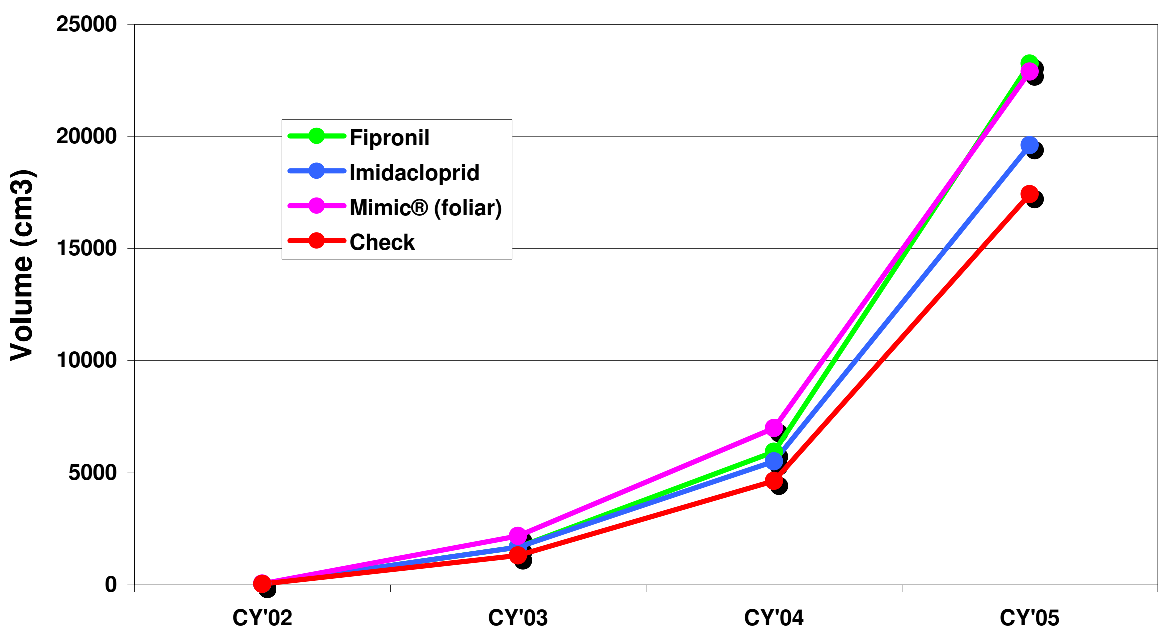

Figure 20. Volume (cm^3) growth of loblolly pine treated with systemic or foliar insecticides relative to untreated trees, Fairchild State Forest, 2002 -2005.

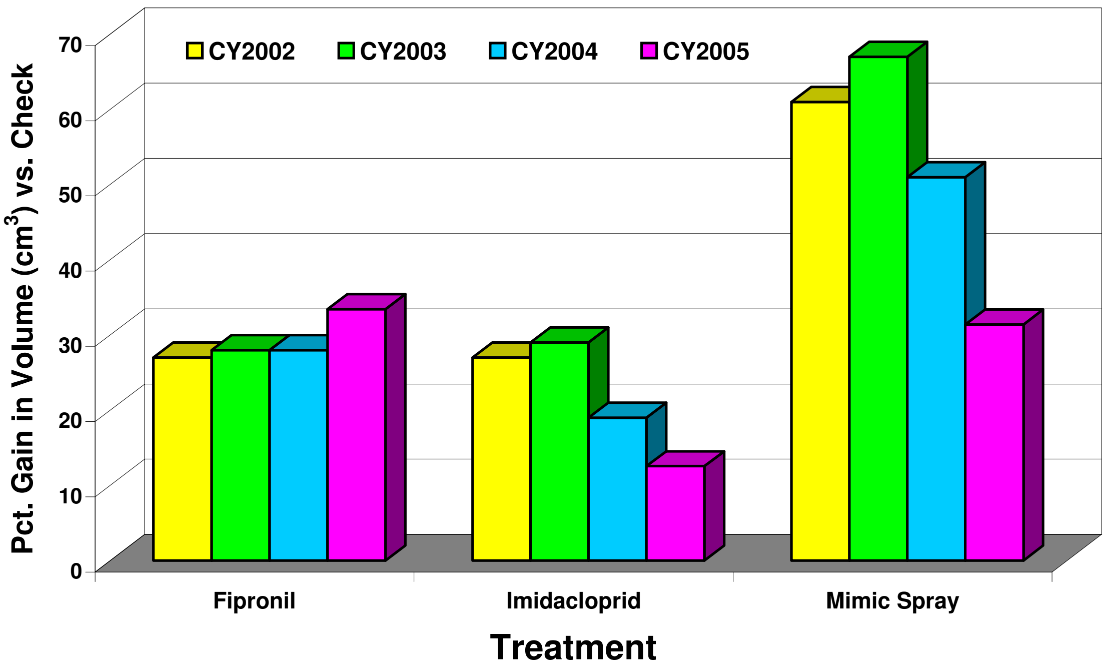

Figure 21. Percent gain in volume (cm^3) growth of loblolly pine treated with systemic or foliar insecticides relative to untreated trees, Fairchild State Forest, 2002 -2005.

PINE TIP MOTH TRIALS

Fipronil Technique and Rate Study – Western Gulf and East Coast

Highlights:

- The plant hole (Termidor®) treatment still provided good protection against tip moth in the third-growing season, reducing damage by 58% in one TX site compared to untreated check trees. No other treatment significantly reduced tip moth damage.
- Third-year trees that had been treated in plant holes (6.5% Regent®) now have the greatest height, diameter and volume parameters compared to check trees. Root-dipped trees slipped to second for all growth parameters. Trees soaked with Regent® were a close third.

Objectives: 1) Determine the efficacy of fipronil applied at different rates to nursery beds, lifted bare root seedlings, and plant holes in reducing pine tip moth infestation levels on loblolly pine seedlings, and 2) determine the duration of chemical activity.

Study Sites: Eight second-year plantations were selected in late 2002. Three sites (TX1, TX2, TX3) were in 5 tip moth generation areas near Wells, Woden and Huntington, Texas (Angelina and Nacogdoches Co., see Figure 21); two sites (GA1, GA2) were in 4 generation areas in Burke Co., Georgia; and three sites (VA1, NC1 and NC2) were in 3 generation areas in Sussex Co., Virginia, Beaufort Co. and Bertie Co., North Carolina, respectively. All plots contained at least 9 treatments and 450 trees (5 rows X 90 trees).

Population Monitoring: Tip moth populations were monitored in Texas sites by placing 3 Phericon 1C wing traps with Trece septa lures (Great Lakes IPM) at each site. Traps were generally positioned 50 to 100 m apart and at tree terminal height. Sticky trap bottoms were collected and replaced weekly starting in early December 2003 and monitored until the end of 2004. Lures were changed at 4 - 6 week intervals, depending on mean temperatures.

Insecticides:
Termidor® and Regent® (fipronil) – a phenyl pyrazole with some systemic activity against Lepidoptera.

Design: Randomized complete block design at each site with beds or site areas serving as blocks, i.e., each treatment was randomly selected for placement along a bed. Ten seedlings from each treatment were planted on each of five beds. TX sites: 3 sites X 9 treatments X 50 trees = 1,350 monitored trees. GA, NC & VA sites: 5 sites X 7 treatments X 50 trees = 1,750 monitored trees.

Treatments:

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.

Treatment Methods: Texas Forest Service (Advanced Generation, Indian Mounds Nursery, Alto, TX) loblolly pine seedlings were used on Texas sites; International Paper seedlings were used on Georgia and Virginia sites; and Weyerhaeuser seedlings were used on North Carolina sites. Lateral root pruning equipment was used to apply Treatments 1 and 2 (described above) to a nursery bed section in October and December 2002. For all treatments, 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 to be used for Treatment 3 - 7 were warmed at room temperature (~70^{o}F) for 3 hours. For each of Treatments 3 - 6, 150 seedlings were soaked in 9.5 liters (2.5 gal) of insecticide solution for 2 hours. For Treatment 7, the same number of seedlings were dipped in the fipronil/TerraSorb®(*) solution. After treatment, all seedlings were dipped in TerraSorb®(*) solution, rebagged and placed in cold storage until the following day. Fifty seedlings from each treatment were planted 1.8 X 3 m (= 6 X 10 ft) spacing on each of the eight plantation sites. **Note:** Treatments 1 & 2 were only evaluated on TX and GA sites.

Treatment Evaluation: Tip moth damage was evaluated after each tip moth generation (3-4 weeks after peak moth flight; 5 generations in TX, 4 generations in GA, and 3 generations in NC and VA) in 2003 and 2004 by 1) identifying if the tree was infested or not, 2) if infested, the proportion of tips infested on the top whorl and terminal were calculated; and 3) separately, the terminal was identified as infested or not. One TX site also was monitored for tip moth damage after each generation in 2005. Each tree was measured for diameter (at 6") in winter 2003/2004 and 2004/2005 and for diameter at breast height (DBH) in winter 2005/2006. Tree height also was measured in each winter.

Results:

<u>Tip Moth Infestation</u>: In 2003, all treatments showed relatively similar patterns of performance at each of the eight sights. Although neither in-furrow treatment performed particularly well in TX and GA, the single in-furrow treatment tended to reduce tip moth infestation levels more than the double half dose treatment (Table 19). In both states, the single in-furrow treatment reduced damage levels to the greatest extent during the middle generations (second or third). Neither in-furrow treatment had any consistent effect on tip moth damage levels in TX in 2004.

All higher rate ($\geq$ 0.3%) dip, soak and plant hole treatments generally performed well in reducing tip moth damage during the first generation. However, there was a marked improvement in treatment efficacy during the second and/or third generations compared to the 1st on TX and GA sites. This indicates that fipronil moved slowly in the seedlings and may require 3+ months before chemical concentrations reach effective levels in pine shoots. In contrast, the VA site's first generation occurs later (late April) then on 4 (late March – early April) and 5 (mid-March) generation sites. Thus, the highest level of treatment efficacy on the VA site occurred during the first generation. With the exception of the plant hole treatment, all treatments tended to show reductions in efficacy during the last generation(s). Overall, pine seedlings treated with fipronil (Termidor®) using plant hole, root dip with Terrasorb™, and root soak (0.3%) techniques, reduced tip moth damage by 89%, 86%, and 78%, respectively, compared to untreated check trees (Table 19). The performance of the Regent® formulation did not differ from that of Termidor® at the same rate (0.3%).

In 2004, the plant hole treatment continued to perform very well throughout the year with overall reductions in damage averaging 93% in TX and 91% in NC (Table 19). The root dip with Terrasorb™ treatment also significantly reduced tip moth damage through the first four generations in TX and all generations in NC. However, in both areas, treatment efficacy had declined markedly by the last generation. Overall, pine seedlings treated by root dip with Terrasorb™ reduced tip moth damage in TX and NC by 39% and 30%, respectively, compared to check trees (Table 19). Both high rate (0.3%) root soak treatments (Termidor® and Regent®) showed moderate activity in NC, but neither treatment had any effect in TX.

In 2005, damage assessments were made after each generation on one TX (Huntington) site. The plant hole treatment continued to perform well throughout the year with overall reductions in damage averaging 58% (Table 19). No other treatment was able to significantly reduce damage compared to checks.

Tree Growth: In 2003, seedlings treated by root-soak (0.3% Regent®) and root dip (0.3% Termidor® + Terrasorb™) consistently had the some of the greatest improvement in height, diameter and volume index compared to check trees (Table 20). There were no differences in tree growth between seedlings soaked with 0.3% Regent® and those soaked in Termidor® at the same rate. The effect of fipronil dose rate on growth was inconsistent in TX. However, on 3 and 4 generation sites, where pressure and impact of tip moth was much greater on check trees, treated seedlings on most sites showed improved growth with increasing concentration of fipronil.

In 2004, trees that had been treated by root soak (0.3% Regent®) still had consistent gains in height, diameter and volume index compared to check trees (Table 20). Trees with plant hole treatments had some of the best improvements in growth in NC, but, surprisingly, there were insignificant gains in TX. In contrast, trees that had received a root dip (0.3% Termidor® + Terrasorb™) treatment had the greatest improvements in growth in TX, while NC trees saw relatively minor gains in growth. The effect of fipronil rate on growth again was inconsistent in TX. However, on NC sites where pressure and impact of tip moth was much greater on check trees, there were consistant improvements in seedling growth with increasing fipronil concentration.

In 2005, trees were measured on 7 of the 8 original sites. Trees with plant hole treatments had the greatest improvement in growth in 2005. This treatment surpassed root dip (0.3% Termidor® + Terrasorb™) as the treatment having the greatest mean height, diameter (DBH) and volume index (Table 20, Figure 22). Trees treated by root dip and root soak (0.003 – 0.3% Termidor and 0.3% Regent®) still had consistent gains in height, diameter and volume index compared to check trees. In contrast, trees with in-furrow treatments and check trees had declining improvements in growth relative to 2004 means. This indicates that fipronil applied by root dip, root soak and plant hole continued to impact tree growth through the third year after establishment.

Acknowledgments: Thanks go to Temple-Inland and Emily Goodwin for providing research sites in TX. We greatly appreciate the efforts Jimmy Seckinger and Dr. Scott Cameron, International Paper, and Wilson Edwards, Weyerhaeuser, made to establish, spray and monitor additional research sites on the East Coast. We thank Harry Vanderveer and Ted Moore for providing assistance at the nursery and the Texas Forest Service for donating seedlings. We also thank Dr. Harry Quicke, BASF, for providing the fipronil formulations, Regent® and Termidor®, for the project.

Table 19. Effect of fipronil application technique and rate on pine tip moth infestation of loblolly pine shoots (top whorl) after 3, 4 or 5 generations on 8 sites in Virginia, North Carolina, Georgia & Texas, 2003 - 2005.

		Mean Percent Top Whorl Shoots Infested by Tip Moth (**Pct. Reduction Compared to Check**)												
	Treatment §	3 Gen Sites			4 Gen Sites			5 Gen Sites				Overall Mean		
2003	T Fip Furrow 1	---	---		43.7	**7**		15.0	**19**	*		26.4	**-2**	
	T Fip Furrow 1+1	---	---		44.1	**6**		17.6	**5**			28.4	**-9**	
	T Fip + TerraSorb Dip	2.0	**95**	*	6.8	**85**	*	3.3	**82**	*		3.6	**86**	*
	T Fip Soak 0.003%	36.0	**5**		39.6	**15**	*	16.7	**10**			26.1	**1**	
	T Fip Soak 0.03%	14.7	**61**	*	18.9	**60**	*	13.1	**29**	*		14.0	**47**	*
	T Fip Soak 0.3%	2.7	**93**	*	8.5	**82**	*	7.1	**62**	*		5.8	**78**	*
	R Fip Soak 0.3%	3.0	**92**	*	10.8	**77**	*	5.0	**73**	*		5.6	**79**	*
	T Fip Plant Hole 6.5%	0.6	**99**	*	8.1	**83**	*	0.6	**97**	*		2.8	**89**	*
	Check	38.0			46.9			18.5			A	26.5		
											B	26.0		
2004	T Fip Furrow 1	---	---		20.5	**2**		15.2	**5**			17.3	**0**	
	T Fip Furrow 1+1	---	---		21.1	**-1**		15.4	**4**			17.7	**-2**	
	T Fip + TerraSorb Dip	28.1	**30**	*	11.6	**45**	*	9.8	**39**	*		17.2	**28**	*
	T Fip Soak 0.003%	37.9	**5**		18.5	**12**		14.9	**7**			25.4	**-7**	
	T Fip Soak 0.03%	38.6	**4**	*	15.4	**26**	*	16.1	**0**			25.0	**-5**	
	T Fip Soak 0.3%	28.7	**28**	*	13.4	**36**	*	15.8	**2**			21.5	**10**	
	R Fip Soak 0.3%	32.2	**20**	*	14.5	**30**	*	20.3	**-26**	*		22.3	**6**	
	T Fip Plant Hole 6.5%	3.8	**91**	*	7.4	**65**	*	1.2	**93**	*		5.4	**77**	*
	Check	40.1			20.9			16.1			A	23.8		
											B	17.3		
2005	T Fip Furrow 1	---	---		---	---		11.7	**16**					
	T Fip Furrow 1+1	---	---		---	---		11.8	**15**					
	T Fip + TerraSorb Dip	---	---		---	---		15.6	**-12**					
	T Fip Soak 0.003%	---	---		---	---		13.9	**-1**					
	T Fip Soak 0.03%	---	---		---	---		15.7	**-13**					
	T Fip Soak 0.3%	---	---		---	---		13.0	**6**					
	R Fip Soak 0.3%	---	---		---	---		13.0	**6**					
	T Fip Plant Hole 6.5%	---	---		---	---		5.8	**58**	*				
	Check	---			---			13.8						

§ T = Termidor, R = Regent.
* Means followed by an asterik are significantly different from checks at the 5% level based on Fisher's Protected LSD.
= treatment reduced damage by >75% compared to check.
Check A - 3, 4 and 5 Generation Mean; Check B - 4 and 5 Generation Mean
Note: Tip moth damage assessments were conducted on 8 sites in 2003 and 2004, but only 1 TX site in 2005

Table 20. Effect of fipronil application technique and rate on loblolly pine height and dia growth after three years on eight sites in Virginia, North Carolina, Georgia and Texas, 2003 - 2005.

		Mean Tree Measurements (**Growth Difference (cm or cm^3) Compared to Check**)																	
		Height (cm)						Diameter (cm)						Volume (cm^3)					
Treatment §		2003		2004		2005		2003 (D at 6")		2004 (D at 6")		2005 (DBH)		2003		2004		2005	
T Fip Furrow 1		51.5 *	**3**	152 *	**11**	280 *	**22**	1.08 *	**0.07**	3.4 *	**0.3**	3.1 *	**0.5**	85	**14**	2225 *	**369**	3470 *	**928**
T Fip Furrow 1+1		48.2	**-1**	143	**2**	273 *	**14**	1.00	**-0.01**	3.2	**0.0**	2.8	**0.2**	66	**-5**	1854	**-2**	2957	**415**
T Fip + TerraSorb Dip		60.6 *	**13**	162 *	**25**	302 *	**43**	1.23 *	**0.21**	3.4 *	**0.5**	3.5 *	**0.8**	120 *	**50**	2407 *	**773**	4812 *	**2270**
T Fip Soak 0.003%		49.7	**2**	146 *	**9**	283 *	**24**	1.07	**0.05**	3.0	**0.1**	3.0 *	**0.4**	72	**2**	1656	**22**	3555 *	**867**
T Fip Soak 0.03%		54.5 *	**7**	146 *	**9**	283 *	**24**	1.12 *	**0.11**	3.1	**0.1**	3.1 *	**0.4**	90 *	**21**	1885 *	**251**	3843 *	**1155**
T Fip Soak 0.3%		54.6 *	**7**	151 *	**14**	289 *	**30**	1.15 *	**0.14**	3.2 *	**0.2**	3.1 *	**0.5**	101 *	**32**	1962 *	**328**	4008 *	**1320**
R Fip Soak 0.3%		59.5 *	**12**	160 *	**23**	301 *	**42**	1.25 *	**0.23**	3.4 *	**0.4**	3.4 *	**0.8**	134 *	**64**	2364 *	**730**	4812 *	**2124**
T Fip Plant Hole 6.5%		57.4 *	**10**	161 *	**24**	309 *	**50**	1.14 *	**0.13**	3.2 *	**0.3**	3.6 *	**1.0**	112 *	**43**	2180 *	**546**	5454 *	**2766**
Check	A	47.4		137		259		1.02		2.9		2.7		69		1634		2688	
	B	48.8		141		259		1.01		3.2		2.7		71		1856		2542	

§ T = Termidor, R = Regent.

* Means followed by an asterik are significantly different from checks at the 5% level based on Fisher's Protected LSD.

Check A - 3, 4 and 5 Generation Mean; Check B - 4 and 5 Generation Mean

Note: 2003 & 2004 tree measurement means were collected from 8 sites; 2005 means were collected from 7 sites.

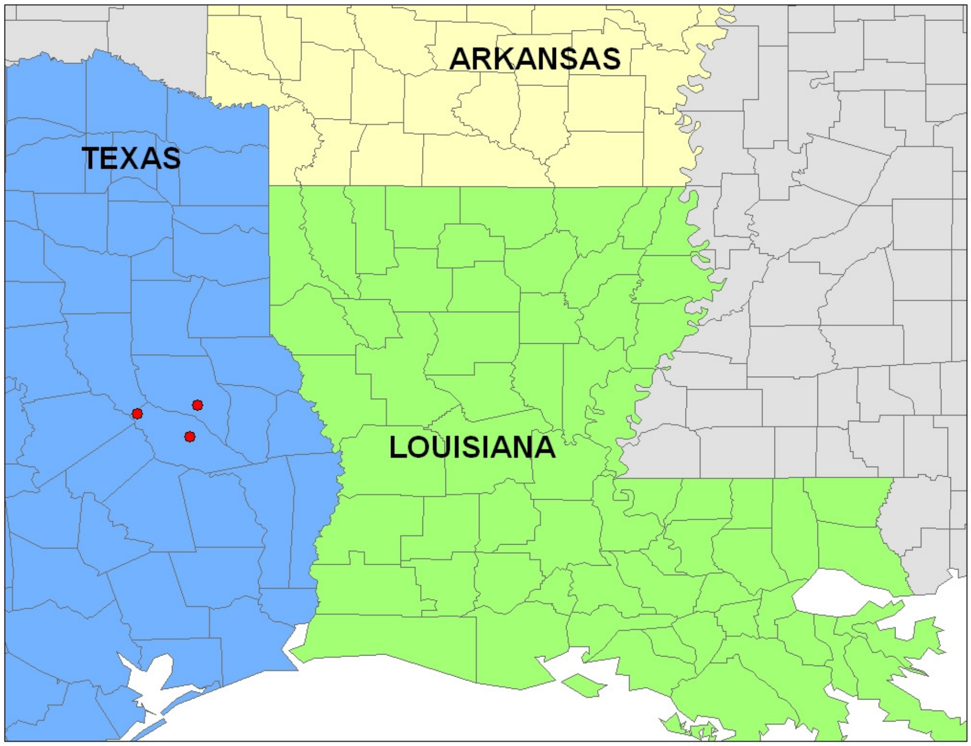

Figure 21. Sites of the Fipronil Technique and Rate Trail (●) established in 2003 in Angelina and Nacogdoches Counties, TX.

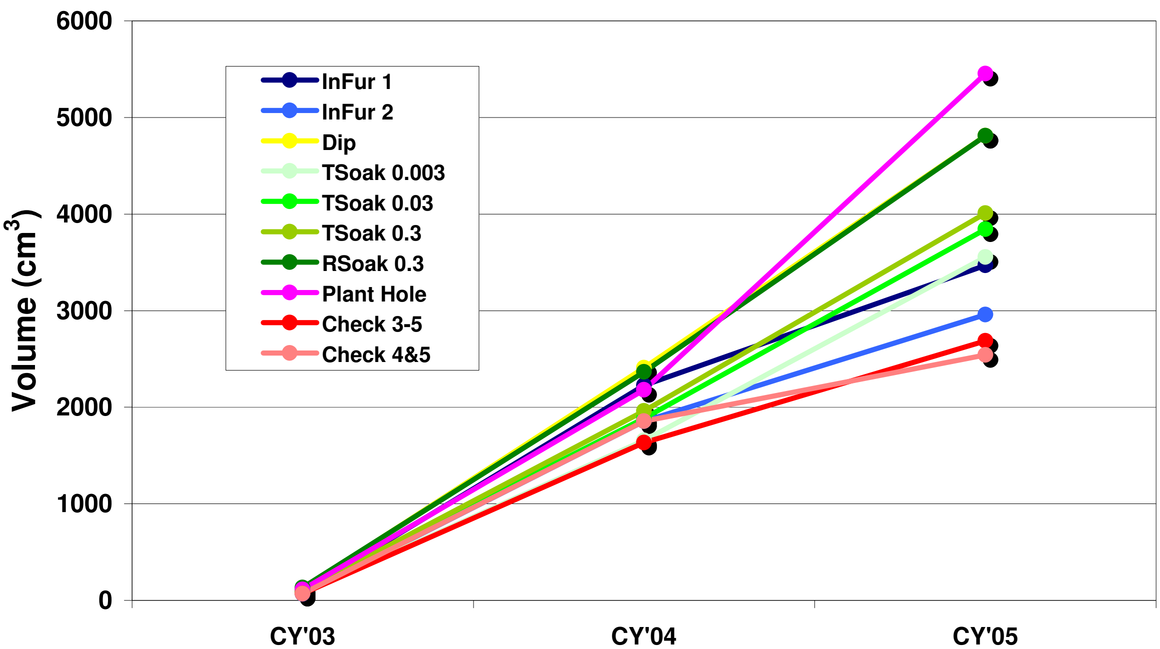

Figure 22. Mean volume (cm^3) growth of loblolly pine treated with fipronil relative to untreated trees, on seven of eight sites in GA, NC, TX & VA, 2003 -2005.

PINE TIP MOTH TRIALS

Fipronil Technique and Rate Refinement Study: Western Gulf and East Coast

Highlights:

- All fipronil treatments applied to plant holes significantly reduced tip moth damage during all five generations in the second year. Overall damaged was reduced by 85 – 93% compared to check trees. Most plant hole treatments significantly improved height and volume growth.
- Higher rate (3%) root soak treatments applied to all types of seedlings (bare root, containerized and rooted cuttings) significantly reduced tip moth damage throughout the whole second growing season. Overall damaged was reduced by 79 - 86% compared to check trees. Treatment efficacy was improved with concentration. The addition of methanol negatively affected treatment efficacy. Root soak treatments of containerized seedlings provided greater improvements in height, diameter and volume growth than did treatments of bare root seedlings.
- All root-dip treatments (excluding methanol) applied to bare root seedlings significantly reduced tip moth damage throughout the whole second growing season. Overall damaged was reduced by 49 – 92% compared to check trees. However, only trees treated with 1% Regent + clay had significant gains in height, diameter and volume compared to check trees. The addition of methanol had a negative effect on treatment efficacy.

Objectives: 1) Determine the efficacy of fipronil applied at different rates to nursery beds, containerized and lifted bare root seedlings, and plant holes in reducing pine tip moth infestation levels on loblolly pine seedlings, and 2) determine the duration of chemical activity.

Study Sites: Eleven second-year plantations were selected in Arkansas, Louisiana or East Texas (see Figure 23). Four additional sites were established in Georgia or North Carolina. Second-year plantations were used in the study because tip moth populations are usually well established at this age and would ensure that significant tip moth pressure would be placed on treated seedlings. Most plots contained 11 treatments and 550 trees (5 rows X 110 trees).

Population Monitoring: Tip moth populations were monitored on TFS sites in East Texas. Three Phericon 1C wing traps with Trece septa lures (Great Lakes IPM) at 3 sites near Evadale, Groveton, and Mayflower. Traps were generally positioned 50 to 100 m apart and at tree terminal height. Sticky trap bottoms were collected and replaced weekly starting in early February 2004 and monitored until the end of the year. Lures were changed at 4 - 6 week intervals, depending on mean temperatures.

Insecticides and Root Coatings:
Regent® or Icon® (fipronil) – a phenyl pyrazole with some systemic activity against Lepidoptera.
Terrasorb™, Driwater™ or Clay – root coating to retain moisture.

Design: Randomized complete block design at each site with beds or site areas serving as blocks, i.e., each treatment was randomly selected for placement along a bed. Ten seedlings from each treatment were planted on each of five beds. All sites had at least 11 treatments X 50 trees = 550 monitored trees.

Treatments:

Trial 1: In-furrow (December) alone or combined with plant hole treatment

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)

Extra Treatment for TFS Site

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)

Trial 2: Root soak of containerized and bare root seedlings

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)

Extra Treatments for TFS Site

12) Root soak (1.0% = 157 ml Icon® in 9.26 liters of water) of bare root seedling
13) Root soak (2.0% = 340 ml Icon® in 9.16 liters of water) of bare root seedling

Trial 3: Root dip of bare root seedlings

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)

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. For Trial 1, lateral root pruning equipment was used to create 8" deep furrows between drills in a nursery bed section in early December 2003. Immediately afterwards, treatment solutions (as described below for Treatments 1 - 4) 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 Trial 2.

When ready, the bundles of bare-root seedlings to be used for Trial 2, Treatment 5 – 8, 12 and 13 were soaked in 9.5 liters (2.5 gal) of insecticide solution for 2 hours. For Trial 1, Treatment 12 and Trial 3, Treatments 1 - 7 & 9 - 11, bundles of seedlings were dipped in the fipronil plus one of three root coatings 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 Trial 2, Treatments 1 – 4 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.

Fifty seedlings from each treatment and were planted (spacing variable) on each of 3 - 4 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 and cooperators were:

Western Gulf sites (see Fig. 25)
Trial 1: Four sites (Anthony Forest Products, International Paper, Texas Forest Service & Weyerhaeuser)
Trial 2: Four sites (Forest Investment Associates, Plum Creek, Temple-Inland Forest Products & Texas Forest Service)
Trial 3: Three sites (Potlatch, Temple-Inland Forest Products & Texas Forest Service)

East Coast sites
Trial 2: Two sites (International Paper & Weyerhaeuser)
Trial 3: Two sites (International Paper & Weyerhaeuser)

Treatment Evaluation: Tip moth damage was evaluated after each tip moth generation (3-4 weeks after peak moth flight) by 1) identifying if the tree was infested or not, 2) if infested, the proportion of tips infested on the top whorl and terminal were calculated; and 3) separately, the terminal was identified as infested or not. Observations also were made as to the occurrence and extent of damage caused by other insects, i.e., aphids, weevils, coneworm, etc. Each tree was measured for diameter and height (at 6") in the fall or winter (November - January) following planting.

Data were analyzed by GLM and the Tukey's Compromise test using Statview or SAS statistical programs.

Results:

Trial 1: Nursery Bed and Plant Hole Treatments**:** In 2004**,** tip moth populations were quite low on all four sites during the first generation with an average of only 4% of the shoots infested on check trees. As a result of the low tip moth pressure, only two treatments (In-furrow 2X and the combination in-furrow 4x + root dip + plant hole treatment) reduced tip moth infestation of top whorl shoots by >75% compared to the check during the first generation (Table 21). There did not appear to be any pattern of treatment efficacy. In contrast, all five treatments that included plant hole treatments (plant hole alone or combined with in-furrow) provided excellent protection during the second through the fifth generation, reducing damaged by 82 – 100% (83 – 99% overall). This suggests that the full effects of the chemical treatments were not expressed until after the first generation. An increased concentration of fipronil applied to nursery bed furrows had no apparent effect on tip moth damage levels. This may be due to the late application of the treatments (December). None of the fipronil treatments negatively affected seedling survival after 5 generations. The addition of methanol to one in-furrow treatment did not appear to improve fipronil uptake or performance. Seedlings receiving applications of fipronil in plant holes (0.3% Regent®) consistently had some of the greatest improvement in height, diameter and volume index compared to check trees (Tables 22).

In 2005**,** tip moth populations were higher on all four sites during the first generation with an average of 8% of the shoots infested on check trees (Table 21). All five treatments that included plant hole treatments (plant hole alone or combined with in-furrow) continued to provide excellent protection during all five generations, reducing damaged by 82 – 97% (85 – 93% overall). The nursery bed furrow treatments again had no apparent effect on tip moth damage levels. None of the fipronil treatments negatively affected seedling survival after 5 generations; in fact, one treatment

(In-furrow 2X + plant hole) had significantly better survival compared to the check. As in 2004, seedlings receiving applications of fipronil in plant holes (0.3% Regent®) consistently had some of the greatest improvement in height, diameter and volume index compared to check trees (Tables 22).

<u>Trial 2: Root Soak of Bare Root and Containerized Seedlings</u>**:** In 2004, damage levels from first-generation tip moth populations to bare root check trees on five of six sites were nearly twice as high as those observed in Trial 1. However, only containerized seedlings soaked in 1% and 3% Regent® reduced tip moth damage by > 75% compared to checks (Table 23). In contrast, nearly all concentrations significantly reduced damage to shoots of both bare root and containerized seedlings during the remaining tip moth generations. The addition of methanol to 0.3% Regent® reduced the efficacy of fipronil on all three types of seedlings (bare root, containerized and rooted cuttings) and significantly reduced seedling survival of bare root and containerized seedlings. On one site, 1% and 2% Icon® treatments of bare root seedlings were highly effective (>80%) in reducing tip moth damage during each of the first 4 generations (Table 24). On another site, fipronil treatments of rooted cuttings provided excellent protection in the middle of the year (third and fourth generations) but efficacy was generally slow to develop and quick to fade. Only the high rate (3%) treatment maintained good efficacy through the last generation. Root soak treatments of containerized seedlings provided greater improvements in height, diameter and volume growth than did treatments of bare root seedlings (Table 25).

In 2005, average tip moth damage levels on bare root and containerized check trees were much higher during the first generation than in 2004 (Table 23&24). All fipronil treatments (except those with methanol) on both bare root and containerized trees significantly reduced damage levels compared to the check. However, only trees soaked in 3% Regent® showed a reduction in tip moth damage of > 75% during most of the generations compared to checks (Table 23 & 24). On one site, 1% and 2% Icon® treatments of bare root seedlings were still moderately effective (>44%) in reducing tip moth damage through the second year. On another site, fipronil treatments of rooted cuttings provide good protection the second year. Tip moth protection on both containerized and rooted cutting was improved with higher rates of fipronil. Root soak treatments of containerized seedlings continued to produce greater improvements in height, diameter and volume growth than did treatments of bare root seedlings (Table 25).

<u>Trial 3: Root Coating Evaluation</u>**:** In 2004, tip moth damage to top whorl shoots on four of five sites was low on all checks (range: 3 – 5%) during the first generation (Table 31). Treatment efficacy was inconsistent among the rates and root coatings during the first generation; only 1% Regent® in Driwater™, 3% Regent® in clay and 1% Regent® + methanol in Terrasorb™ significantly reduced damage compared to checks. Efficacy of nearly all treatments improved through the fifth or last generation (based on three sites). Overall reductions in damage for all root dip treatments (excluding the methanol treatment) ranged from 90% to 95%. The addition of methanol to one treatment had a negative effect on treatment efficacy and tree survival. Surprisingly, survival of trees treated with a high rate (3%) of fipronil combined with Terrasorb™ and Driwater™ had significantly lower survival compared to check trees. Based on combined data from two of five sites, none of the root dip treatments significantly improved height, diameter or volume growth compared to check trees (Table 32).

In 2005, mean first generation tip moth damage to top whorl shoots was about 4X higher on second-year checks (range: 12 – 22%) compared to 2004 (range: 3 – 5%) (Table 26 - 27). All 1% and 3% Regent treatments significantly reduced damage throughout the second year compared to checks. Overall reductions in damage for these treatments ranged from 49% to 94% (Table 27). Treatment efficacy improved when the rate of fipronil was increased. Based on combined data from five sites, trees treated with lower rates of Regent tended to have greater gains in height, diameter and volume compared to check trees (Table 28).

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Table 21. Effect of fipronil application technique and rate (Trial 1) on pine tip moth infestation of loblolly pine shoots (top whorl) after each of 5 generations on four sites in in the Western Gulf Region, 2004 - 2005.

			Mean Percent Top Whorl Shoots Infested by Tip Moth (Pct. Reduction Compared to Check)																	
Year	Treatment §	N	Gen 1			Gen 2			Gen 3			Gen 4			Gen 5			Overall Mean		
2004	Furrow 2x R	200	1.0	**76**	*	3.0	**55**	*	18.1	**9**		28.8	**19**	*	24.6	**-3**		15.0	**18**	*
	Furrow 4x R	200	1.6	**61**	*	7.6	**-13**		16.5	**18**		29.2	**18**	*	26.0	**-8**		16.2	**11**	
	Furrow 4x R + meth	200	1.0	**75**	*	3.3	**51**	*	17.2	**14**		30.3	**15**	*	33.6	**-40**	*	17.6	**3**	
	Furrow 8x R	200	3.4	**15**		8.1	**-21**		16.8	**16**		29.6	**17**	*	21.7	**9**		16.3	**11**	*
	Furrow 2x R + PH	200	3.4	**16**		1.2	**82**	*	3.2	**84**	*	3.6	**90**	*	3.9	**84**	*	3.0	**84**	*
	Furrow 4x R + PH	200	2.5	**39**		0.4	**94**	*	0.0	**100**	*	0.5	**98**	*	0.6	**97**	*	0.8	**96**	*
	Furrow 4x R + meth + PH	200	2.3	**44**		0.2	**97**	*	0.0	**100**	*	0.1	**100**	*	0.0	**100**	*	0.5	**97**	*
	Furrow 8x R + PH	200	1.6	**59**	*	0.7	**90**	*	0.0	**100**	*	0.4	**99**	*	0.0	**100**	*	0.6	**97**	*
	Plant Hole only	200	2.7	**32**		0.0	**100**	*	0.2	**99**	*	0.3	**99**	*	0.0	**100**	*	0.6	**97**	*
	Mimic spray	200	1.7	**57**	*	0.3	**96**	*	1.0	**95**	*	0.3	**99**	*	0.8	**97**	*	0.9	**95**	*
	Check	200	4.0			6.7			20.0			35.5			24.0			18.2		
	Furrow 4x R + RD + PH	50	1.0	**86**		2.4	**86**	*	0.0	**100**	*	0.0	**100**	*	0.0	**100**	*	0.4	**99**	*
	Check (TFS)	50	7.3			17.2			36.7			54.4			47.5			33.5		
2005	Furrow 2x R	200	10.4	**-26**		12.5	**22**		16.5	**-7**		56.7	**-12**		48.4	**16**	*	28.9	**2**	
	Furrow 4x R	200	7.5	**9**		15.7	**2**		17.8	**-15**		54.2	**-7**		50.7	**12**	*	29.1	**1**	
	Furrow 4x R + meth	200	9.6	**-16**		9.0	**44**	*	17.9	**-16**		54.0	**-6**		40.4	**30**	*	26.1	**11**	*
	Furrow 8x R	200	8.3	**0**		10.5	**34**	*	19.3	**-25**	*	50.7	**0**		36.9	**36**	*	25.3	**14**	*
	Furrow 2x R + PH	200	0.8	**90**	*	0.8	**95**	*	2.6	**83**	*	9.0	**82**	*	7.4	**87**	*	4.1	**86**	*
	Furrow 4x R + PH	200	0.1	**99**	*	1.7	**90**	*	2.8	**82**	*	9.1	**82**	*	8.1	**86**	*	4.3	**85**	*
	Furrow 4x R + meth + PH	200	0.6	**92**	*	1.1	**93**	*	1.8	**88**	*	6.7	**87**	*	5.9	**90**	*	3.2	**89**	*
	Furrow 8x R + PH	200	1.3	**85**	*	0.6	**96**	*	0.5	**97**	*	6.3	**88**	*	8.3	**86**	*	3.4	**89**	*
	Plant Hole only	200	1.5	**82**	*	0.2	**99**	*	1.3	**92**	*	5.1	**90**	*	3.0	**95**	*	2.2	**93**	*
	Mimic spray	200	1.1	**87**	*	0.7	**96**	*	0.8	**95**	*	2.2	**96**	*	1.7	**97**	*	1.3	**96**	*
	Check	200	8.3			16.0			15.4			50.7			57.5			29.5		
	Furrow 4x R + RD + PH	50	3.7	**64**	*	3.1	**91**	*	0.0	**100**		0.0	**100**	*	1.2	**98**	*	0.4	**99**	*
	Check (TFS)	50	10.3			34.1			6.3			41.3			60.5			33.5		

§ R = Regent, PH = Plant Hole, RD = Root Dip

* Means followed by an asterik are significantly different from checks at the 5% level based on Fisher's Protected LSD.

= treatment reduced damage by >75% compared to check.

Table 22. Effect of fipronil application technique and rate (Trial 1) on loblolly pine growth parameters and tree survival after the first and second year on three sites in the Western Gulf Region, 2004 - 2005.

		Mean End of Season Loblolly Pine Seeding Growth Measurements (**Growth Difference (cm or cm^3) Compared to Check**)												Mean % Tree Survival (**Pct. Gain Compared to Check**)			
		Height (cm)				Diameter (cm)				Volume (cm^3)							
Treatment §	N	2004		2005		2004		2005		2004		2005		2004		2005	
Furrow 2x R	150	38.6	**2**	76.6	**0**	0.59	**0.04**	1.56	**0.05**	18.4	**2**	284.3	**7**	83	**5**	79	**5**
Furrow 4x R	150	39.5 *	**3**	72.5	**-4**	0.63 *	**0.08**	1.50	**-0.01**	19.4	**3**	233.9	**-43**	78	**-2**	72	**-4**
Furrow 4x R + meth	150	39.1 *	**3**	77.9	**1**	0.60	**0.05**	1.52	**0.00**	20.2	**4**	299.7	**22**	82	**3**	79	**5**
Furrow 8x R	150	38.1	**2**	72.7	**-4**	0.60	**0.05**	1.45	**-0.06**	18.4	**2**	227.2	**-50**	79	**-1**	77	**3**
Furrow 2x R + PH	150	43.0 *	**7**	88.4 *	**12**	0.68 *	**0.13**	1.73	**0.21**	29.5 *	**13**	445.9 *	**169**	88	**11**	85 *	**13**
Furrow 4x R + PH	150	45.5 *	**9**	91.5 *	**15**	0.71 *	**0.16**	1.83 *	**0.32**	37.5 *	**21**	546.9 *	**270**	72	**-9**	69	**-8**
Furrow 4x R + meth + PH	150	41.9 *	**6**	85.2 *	**9**	0.65 *	**0.10**	1.63	**0.12**	26.0 *	**9**	369.0	**92**	84	**6**	83	**11**
Furrow 8x R + PH	150	42.7 *	**6**	83.1	**7**	0.63 *	**0.08**	1.58	**0.07**	25.9 *	**9**	337.4	**60**	81	**3**	78	**4**
Plant Hole only	150	42.7 *	**6**	81.7	**5**	0.63 *	**0.08**	1.61	**0.10**	26.9 *	**10**	374.3	**97**	75	**-5**	71	**-5**
Mimic spray	150	37.8	**2**	77.9	**1**	0.55	**0.00**	1.45	**-0.06**	14.6	**-2**	227.1	**-50**	78	**-2**	75	**0**
Check	150	36.2		76.5		0.55		1.51		16.6		277.3		79		75	
Furrow 4x R + RD + PH	50	43.3 *	**7**	88.9 *	**15**	0.74 *	**0.13**	1.80	**0.20**	33.5 *	**11**	434.8	**126**	76	**-3**	76	**-3**
Check (TFS)	50	35.8		74.0		0.61		1.60		22.3		308.7		78		78	

§ R = Regent, PH = Plant Hole, RD = Root Dip
* Means followed by an asterik are significantly different from checks at the 5% level based on Fisher's Protected LSD.

Table 23. Effect of fipronil application technique and rate (Trial 2) on pine tip moth infestation of loblolly pine shoots (top whorl) after 3 to 5 generations on six sites in the Western Gulf Region and East Coast - 2004.

			Mean Percent Top Whorl Shoots Infested by Tip Moth (Pct. Reduction Compared to Check)																	
Year	Treatment §	N	Gen 1 (6)			Gen 2 (6)			Gen 3 (5)			Gen 4 (2)			Gen 5 (6)			Overall Mean		
2004	0.3% R BR RS	300	2.9	**67**	*	2.3	**88**	*	3.1	**84**	*	10.3	**72**	*	8.9	**72**	*	4.6	**79**	*
	0.3% R + meth BR RS	250	2.9	**67**	*	2.8	**86**	*	5.1	**74**	*	17.4	**53**	*	5.2	**84**	*	5.0	**78**	*
	1.0% R BR RS	350	3.1	**65**	*	1.6	**92**	*	1.8	**91**	*	7.5	**79**	*	7.6	**76**	*	3.8	**83**	*
	3.0% R BR RS	250	2.8	**68**	*	0.3	**98**	*	0.5	**97**	*	2.5	**93**	*	1.5	**95**	*	1.4	**94**	*
	BR Mimic or Pounce Spray	300	6.0	**33**	*	5.6	**72**	*	5.2	**73**	*	15.3	**58**	*	8.5	**74**	*	7.6	**66**	*
	Check Bare Root	300	8.9			20.1			19.5			36.6			32.3			22.3		
	0.3% R Cont. RS	250	1.5	**81**	*	1.0	**92**	*	1.5	**92**	*	2.3	**94**	*	3.4	**89**	*	1.8	**91**	*
	0.3% R + meth Cont. RS	200	1.7	**78**	*	1.0	**93**	*	8.7	**51**	*	15.5	**63**	*	4.7	**85**	*	5.0	**75**	*
	1.0% R Cont. RS	250	0.7	**91**	*	0.3	**98**	*	0.1	**99**	*	3.5	**91**	*	0.5	**98**	*	0.7	**97**	*
	3.0% R Cont. RS	200	0.0	**100**	*	0.0	**100**	*	0.0	**100**	*	0.4	**99**	*	0.3	**99**	*	0.1	**100**	*
	Check Containerized	250	8.0			13.5			17.7			41.4			32.0			19.9		
			Gen 1 (3)			Gen 2 (3)			Gen 3 (3)			Gen 4 (2)			Gen 5 (3)			Overall Mean		
2005	0.3% R BR RS	150	23.4	**23**	*	21.4	**29**	*	19.8	**42**	*	15.5	**40**	*	38.8	**8**		27.0	**24**	*
	0.3% R + meth BR RS	100	16.7	**45**	*	30.1	**0**		16.7	**52**	*	17.9	**31**		26.5	**37**	*	22.2	**37**	*
	1.0% R BR RS	150	20.4	**33**	*	24.9	**17**		20.8	**40**	*	10.8	**58**	*	38.2	**9**		26.5	**25**	*
	3.0% R BR RS	100	4.8	**84**	*	5.2	**83**	*	5.4	**84**	*	7.9	**70**	*	13.8	**67**	*	7.5	**79**	*
	BR Mimic or Pounce Spray	150	2.1	**93**	*	1.4	**95**	*	0.9	**97**	*	1.6	**94**	*	10.3	**75**	*	3.7	**90**	*
	Check Bare Root	150	30.5			30.1			34.5			26.0			42.0			35.3		
	0.3% R Cont. RS	150	19.3	**48**	*	10.8	**70**	*	11.3	**57**	*	12.9	**37**	*	17.2	**63**	*	14.8	**59**	*
	0.3% R + meth Cont. RS	100	15.6	**58**	*	21.8	**39**	*	14.5	**44**	*	20.6	**0**		19.6	**58**	*	18.4	**49**	*
	1.0% R Cont. RS	150	14.7	**60**	*	3.5	**90**	*	4.2	**84**	*	7.2	**65**	*	13.0	**72**	*	9.0	**75**	*
	3.0% R Cont. RS	100	13.7	**63**	*	3.1	**91**	*	2.8	**89**	*	3.4	**84**	*	2.8	**94**	*	5.2	**86**	*
	Check Containerized	150	37.0			35.5			26.0			20.6			46.5			36.1		

§ R = Regent, BR = Bare Root, RS = Root Soak, Cont. = Containerized, Cut. = Cuttings
* Means followed by an asterik are significantly different from checks at the 5% level based on Fisher's Protected LSD.
= treatment reduced damage by >75% compared to check.

Table 24. Effect of fipronil application technique and rate (Trial 2) on pine tip moth infestation of loblolly pine shoots (top whorl) after 4 to 5 generations on one sites in the Western Gulf Region or East Coast, 2004 - 2005.

			Mean Percent Top Whorl Shoots Infested by Tip Moth (**Pct. Reduction Compared to Check**)					
Year	Treatment §	N	Gen 1	Gen 2	Gen 3	Gen 4	Gen 5	Overall Mean
2004	0.03% R BR RS	50	9.7 **45**	2.1 **95** *	15.2 **56** *		51.7 **31** *	19.7 **54** *
	0.03% R + meth BR RS	50	5.4 **69** *	3.8 **91** *	11.7 **66** *		56.5 **24** *	19.4 **55** *
	1.0% R BR QuickDip	50	3.3 **81** *	1.7 **96** *	5.4 **84** *		46.5 **38** *	14.3 **67** *
	Check Bare Root (IP)	50	17.7	44.0	34.3		74.8	42.7
	1.0% Icon BR RS	50	1.3 **81** *	0.0 **100** *	0.0 **100** *	2.7 **94** *	0.0 **100** *	0.9 **96** *
	2.0% Icon BR RS	50	0.8 **88** *	0.0 **100** *	0.0 **100** *	2.3 **95** *	0.9 **98** *	0.9 **96** *
	Check Bare Root (TFS)	50	6.8	6.6	10.9	43.4	37.6	22.3
	0.03% R Cont. RS	50	8.1 **71** *	1.1 **97** *	0.0 **100** *		13.6 **82** *	5.7 **87** *
	0.03% R + meth Cont. RS	50	19.7 **30** *	3.7 **90** *	1.4 **96** *		30.4 **60** *	13.9 **69** *
	Check Containerized (IP)	50	28.2	37.5	35.0		76.8	44.4
	0.3% R Cut. RS	50	3.4 **71** *	13.4 **-222** *	5.0 **80** *	4.7 **85** *	7.2 **55**	6.7 **62** *
	0.3% R + meth Cut. RS	50	4.2 **64** *	12.1 **-190**	9.5 **62** *	15.9 **48** *	12.2 **23**	10.8 **38** *
	1.0% R Cut. RS	50	4.8 **59**	0.7 **84**	0.0 **100** *	0.0 **100** *	4.4 **73** *	2.0 **89** *
	3.0% R Cut. RS	50	3.6 **70** *	4.7 **-12**	4.7 **81** *	0.0 **100** *	0.0 **100** *	2.5 **86** *
	Check (TI)	50	11.8	4.2	24.9	30.6	15.8	17.5
2005	0.03% R BR RS	50	61.6 **-7**	48.2 **-2**	46.7 **26** *		70.7 **5**	56.8 **6**
	0.03% R + meth BR RS	50	52.5 **9**	53.3 **-13**	56.9 **10**		73.7 **1**	59.1 **2**
	1.0% R BR QuickDip	50	54.1 **6**	48.8 **-3**	49.7 **21** *		78.0 **-5**	57.6 **5**
	Check Bare Root (IP)	50	57.7	47.2	62.9		74.5	60.6
	1.0% Icon BR RS	50	2.1 **80** *	6.3 **50**	4.6 **4**	13.3 **43**	9.1 **63** *	7.2 **52** *
	2.0% Icon BR RS	50	9.6 **9**	7.7 **38**	2.8 **41**	11.0 **52**	6.2 **74** *	8.4 **44** *
	Check Bare Root (TFS)	50	10.6	12.5	4.7	23.1	24.2	15.0
	0.03% R Cont. RS	50	44.9 **33** *	41.4 **25** *	35.6 **32** *		83.6 **-2**	51.4 **20** *
	0.03% R + meth Cont. RS	50	48.8 **27** *	41.7 **25** *	44.7 **15**		84.2 **-3**	54.8 **15** *
	Check Containerized (IP)	50	67.3	55.5	52.5		81.8	64.3
	0.3% R Cut. RS	50	7.5 **66** *	3.3 **78** *	10.1 **54** *	8.7 **66** *	20.2 **38** *	10.0 **58** *
	0.3% R + meth Cut. RS	50	11.0 **50** *	23.2 **-51**	23.1 **-4**	27.1 **-7**	27.8 **15**	22.4 **5**
	1.0% R Cut. RS	50	2.3 **90** *	2.9 **81** *	1.6 **93** *	5.9 **77** *	9.1 **72** *	4.3 **82** *
	3.0% R Cut. RS	50	1.2 **95** *	0.0 **100** *	2.0 **91** *	1.7 **93** *	4.9 **85** *	1.6 **93** *
	Check (TI)	50	21.8	15.3	22.2	25.3	32.8	23.6

§ R = Regent, BR = Bare Root, RS = Root Soak, Cont. = Containerized, Cut. = Cuttings
* Means followed by an asterik are significantly different from checks at the 5% level based on Fisher's Protected LSD.
= treatment reduced damage by >75% compared to check.

Table 25. Effect of fipronil application technique and rate (Trial 2) on loblolly pine seedling growth parameters in the first two years after planting on five sites in east Texas, Georgia and North Carolina, 2004 - 2005.

		Mean End of Season Loblolly Pine Seedling Growth Measurements (**Growth Difference (cm or cm^3) Compared to Check**)											
		Height (cm)				Diameter (cm)				Volume (cm^3)			
Treatment §	N	2004		2005		2004		2005		2004		2005	
0.03% R BR RS	50	67.8 *	**7.6**	144 *	**22**	1.03 *	**0.17**	2.8 *	**0.5**	86.6 *	**31**	1370 *	**534**
0.03% R + meth BR RS	50	65.5 *	**5.2**	140 *	**19**	1.01 *	**0.15**	2.7 *	**0.4**	76.5 *	**20**	1231 *	**395**
1.0% R BR QuickDip	50	71.1 *	**10.8**	143 *	**21**	0.99 *	**0.13**	2.6 *	**0.3**	79.1 *	**23**	1107 *	**271**
Check Bare Root (IP)	50	60.3		122		0.9		2.3		56.1		836	
0.3% R BR RS	250	59.1 *	**4.4**	142 *	**13**	0.89	**0.05**	2.5 *	**0.2**	68.4	**14**	1180 *	**235**
0.3% R + meth BR RS	200	49.3 *	**-5.4**	125	**-4**	0.71 *	**-0.13**	2.2	**-0.1**	36.9 *	**-18**	786	**-159**
1.0% R BR RS	300	58.8	**4.0**	142 *	**13**	0.89	**0.05**	2.5 *	**0.2**	68.0	**13**	1187 *	**242**
3.0% R BR RS	200	54.4	**-0.4**	140 *	**11**	0.87	**0.03**	2.5 *	**0.2**	59.4	**5**	1182 *	**237**
BR Mimic or Pounce Spray	250	61.3 *	**6.6**	155 *	**26**	0.96 *	**0.12**	2.7 *	**0.4**	82.9 *	**28**	1501 *	**556**
Check Bare Root	250	54.7		129		0.84		2.3		54.6		945	
1.0% Icon BR RS	50	52.0	**0.0**	143	**3**	1.02	**-0.05**	3.1	**-0.1**	92.0	**-9**	1844	**-114**
2.0% Icon BR RS	50	40.4 *	**-11.5**	125	**-15**	0.72 *	**-0.35**	2.4 *	**-0.7**	34.3 *	**-67**	971	**-987**
Check Bare Root	50	52.0		140		1.07		3.1		101.3		1958	
0.03% R Cont. RS	50	89.7 *	**10.4**	169 *	**26**	1.32	**0.00**	3.3	**0.3** *	171.0	**16**	2150 *	**632**
0.03% R + meth Cont. RS	50	82.8	**3.5**	157 *	**14**	1.28	**-0.05**	3.2	**0.2**	144.9	**-10**	1752 *	**234**
Check Containerized (IP)	50	79.3		143		1.32		3.0		154.6		1518	
0.3% R Cont. RS	200	59.6 *	**7.4**	145 *	**24**	0.95 *	**0.09**	2.7 *	**0.3**	90.1 *	**32**	1495 *	**578**
0.3% R + meth Cont. RS	150	46.8 *	**-5.5**	121	**0**	0.78 *	**-0.08**	2.2	**-0.1**	44.5 *	**-13**	949 *	**32**
1.0% R Cont. RS	200	59.6 *	**7.4**	150 *	**29**	0.98 *	**0.11**	2.8 *	**0.4**	83.5 *	**26**	1509 *	**592**
3.0% R Cont. RS	150	49.1	**-3.1**	128	**7**	0.82	**-0.04**	2.4	**0.0**	51.3	**-6**	1007	**90**
Check Containerized	200	52.2		121		0.86		2.4		57.8		917	
0.3% R Cut. RS	50	57.6	**-4.1**	138	**10**	0.68	**-0.11**	2.2	**0.0**	39.1	**-15**	921	**112**
0.3% R + meth Cut. RS	50	51.5 *	**-10.2**	116	**-13**	0.61 *	**-0.19**	2.0	**-0.2**	27.1 *	**-27**	662	**-147**
1.0% R Cut. RS	50	62.3	**0.6**	137	**8**	0.79	**0.00**	1.8 *	**-0.4**	57.9	**4**	592	**-217**
3.0% R Cut. RS	50	69.1 *	**7.4**	148 *	**20**	0.89	**0.10**	2.0	**-0.2**	79.8	**26**	725	**-84**
Check Cuttings	50	61.7		128		0.79		2.2		53.8		809	

§ R = Regent, BR = Bare Root, RS = Root Soak, Cont. = Containerized, Cut. = Cuttings

* Means followed by an asterik are significantly different from checks at the 5% level based on Fisher's Protected LSD.

Table 26. Effect of fipronil application technique and rate (Trial 3) on pine tip moth infestation of loblolly pine shoots (top whorl) after each of 5 generations on three sites in the Western Gulf Region and East Coast - 2004.

		Mean Percent Top Whorl Shoots Infested by Tip Moth (Pct. Reduction Compared to Check)																	
		Gen 1			Gen 2			Gen 3			Gen 4			Gen 5			Overall Mean		
Treatment §	N	(4 sites)			(4 sites)			(3 sites)			(2 sites)			(3 sites)			(3 sites)		
1.0% R & TS RD	200	2.6	**23**		0.8	**94**	*	0.0	**100**	*	0.0	**100**	*	2.2	**93**	*	1.4	**93**	*
1.0% R + meth & TS RD	200	3.3	**2**		4.7	**64**	*	3.8	**70**	*	0.0	**100**	*	1.4	**96**	*	4.0	**79**	*
3.0% R & TS RD	200	2.1	**38**		0.8	**94**	*	0.6	**95**	*	0.0	**100**	*	0.7	**98**	*	1.0	**95**	*
TS RD & Mimic Spray	200	3.3	**3**		2.6	**80**	*	1.1	**92**	*	14.1	**55**	*	15.2	**52**	*	8.6	**56**	*
TS RD Check	200	3.4			13.1			12.8			31.3			31.5			19.4		
1.0% R & DW RD	200	0.4	**90**	*	0.6	**94**	*	0.0	**100**	*	0.0	**100**	*	3.3	**87**	*	1.2	**93**	*
3.0% R & DW RD	200	4.0	**0**		2.1	**80**	*	0.8	**94**	*	2.2	**93**	*	0.8	**97**	*	1.8	**90**	*
DW RD Check	200	4.0			10.9			14.9			31.5			25.6			17.1		
1.0% R & Clay RD	200	1.7	**68**	*	0.9	**94**	*	1.1	**95**	*	0.4	**99**	*	3.1	**90**	*	2.0	**91**	*
3.0% R & Clay RD	200	0.7	**85**	*	0.0	**100**	*	0.5	**97**	*	0.0	**100**	*	2.5	**92**	*	1.2	**95**	*
Clay RD Check	200	5.1			14.7			20.2			32.3			31.1			22.2		

§ R = Regent, TS = Terrasorb, RD = Root Dip, DW = Driwater.

* Means followed by an asterik are significantly different from checks at the 5% level based on Fisher's Protected LSD.

= treatment reduced damage by >75% compared to check.

Table 27. Effect of fipronil application technique and rate (Trial 3) on pine tip moth infestation of loblolly pine shoots (top whorl) after each of 5 generations on three sites in the Western Gulf Region and East Coast - 2005.

		Mean Percent Top Whorl Shoots Infested by Tip Moth (Pct. Reduction Compared to Check)																	
Treatment §	N	Gen 1 (4 sites)			Gen 2 (4 sites)			Gen 3 (3 sites)			Gen 4 (2 sites)			Gen 5 (3 sites)			Overall Mean (3 sites)		
0.03% R & IPB RD (IP)	50	59.1	**-14**		42.0	**6**		53.1	**-4**					81.8	**-2**		59.0	**-4**	
0.03% R + meth & IPB RD (IP)	50	55.6	**-8**		42.6	**4**		44.6	**13**					76.4	**5**		54.8	**4**	
0.3% R & IPB RD (IP)	50	51.6	**0**		42.2	**5**		37.0	**28**	*				79.0	**2**		52.5	**8**	
1.0% R & IPB RD (IP)	50	53.1	**-3**		34.7	**22**		31.1	**39**	*				69.2	**14**		47.0	**17**	*
IPB RD Check (IP)	50	51.7			44.4			51.1						80.4			56.9		
1.0% R & TS RD	200	1.9	**85**	*	0.2	**98**	*	0.3	**99**	*	1.0	**95**	*	3.0	**84**	*	1.2	**94**	*
1.0% R + meth & TS RD	200	1.4	**89**	*	0.0	**100**	*	1.0	**97**	*	2.9	**86**	*	1.5	**92**	*	1.5	**93**	*
3.0% R & TS RD	200	2.3	**81**	*	1.7	**87**	*	0.2	**99**	*	1.2	**95**	*	2.6	**86**	*	1.6	**92**	*
TS RD & Mimic Spray	250	2.6	**79**	*	1.6	**88**	*	1.8	**94**	*	2.3	**89**	*	10.2	**45**	*	4.1	**79**	*
TS RD Check	200	12.1			13.5			30.4			21.2			18.6			19.6		
1.0% R & DW RD	200	2.7	**82**	*	2.7	**80**	*	3.7	**85**	*	2.2	**89**	*	8.3	**45**	*	3.9	**78**	*
3.0% R & DW RD	200	0.6	**96**	*	2.1	**84**	*	2.6	**90**	*	1.7	**91**	*	1.4	**91**	*	1.8	**90**	*
DW RD Check	200	14.8			13.5			24.7			19.6			15.2			18.0		
0.03% R & Clay RD (IP)	50	52.8	**-1**		49.2	**1**		53.3	**3**					73.1	**4**		57.1	**2**	
0.3% R & Clay RD (IP)	50	54.1	**-4**		42.9	**14**		44.1	**20**	*				81.9	**-7**		55.8	**4**	
1.0% R & Clay RD	250	16.4	**26**	*	12.2	**47**	*	10.8	**66**	*	0.7	**96**	*	21.7	**42**	*	15.1	**49**	*
3.0% R & Clay RD	200	2.3	**90**	*	2.1	**91**	*	4.7	**85**	*	4.8	**76**	*	3.3	**91**	*	3.5	**88**	*
Clay RD Check (IP)	50	52.0			49.9			54.9						76.3			58.3		
Clay RD Check	250	22.3			23.0			31.3			20.2			37.4			29.4		

§ R = Regent, TS = Terrasorb, RD = Root Dip, DW = Driwater.

* Means followed by an asterik are significantly different from checks at the 5% level based on Fisher's Protected LSD.

= treatment reduced damage by >75% compared to check.

Table 28. Effect of fipronil application technique and rate (Trial 3) on loblolly pine growth parameters and tree survival during the first and second season after planting on one to five sites in the Western Gulf Region and East Coast, 2004 & 2005.

		Mean End of Season Loblolly Pine Seeding Growth Measurements (**Growth Difference (cm or cm^3) Compared to Check**)												Mean % Tree Survival			
		Height (cm)				Diameter (cm)				Volume (cm^3)							
Treatment §	N	2004		2005		2004		2005		2004		2005		2004		2005	
0.03% R & IPB RD (IP)	50	78.8 *	**14**	151	**18**	1.16 *	**0.18**	2.9 *	**0.4**	128.3 *	**56**	1375 *	**449**	100	**0**	100	**0**
0.03% R + meth & IPB RD (IP)	50	60.7	**-4**	126	**-7**	0.81 *	**-0.16**	2.3	**-0.2**	47.4 *	**-25**	825	**-101**	100	**0**	100	**0**
0.3% R & IPB RD (IP)	50	74.9 *	**10**	143	**10**	0.95	**-0.02**	2.6	**0.2**	79.3	**7**	1082	**156**	98	**-2**	98	**-2**
1.0% R & IPB RD (IP)	50	70.7	**6**	149	**16**	0.86 *	**-0.12**	2.6	**0.2**	61.4	**-11**	1089	**163**	100	**0**	100	**0**
IPB RD Check (IP)	50	64.7		133		0.98		2.4		72.3		926		100		100	
1.0% R & TS RD	200	52.9	**-1**	118	**-2**	0.82	**-0.06**	1.9	**-0.1**	59.4	**-5**	686	**14**	84 *	**-13**	75 *	**-18**
1.0% R + meth & TS RD	200	50.8	**-3**	129	**8**	0.78	**-0.11**	1.9	**0.0**	40.7	**-24**	701	**29**	39 *	**-59**	33 *	**-64**
3.0% R & TS RD	200	46.5 *	**-8**	101 *	**-20**	0.68 *	**-0.20**	1.6 *	**-0.3**	31.8 *	**-33**	415 *	**-257**	79 *	**-17**	76 *	**-16**
TS RD & Mimic Spray	250	58.8 *	**5**	134 *	**13**	0.91	**0.03**	2.1	**0.2**	68.0	**3**	875 *	**203**	97	**1**	94	**3**
TS RD Check	200	54.0		121		0.88		1.9		64.5		672		96		91	
1.0% R & DW RD	200	57.2	**4**	131 *	**14**	0.91	**0.06**	1.8	**0.0**	72.8	**17**	717	**126**	95	**1**	85	**-1**
3.0% R & DW RD	200	54.1	**1**	122	**5**	0.83	**-0.01**	1.9	**0.0**	56.3	**1**	698	**107**	83 *	**-12**	79 *	**-8**
DW RD Check	200	52.7		117		0.85		1.9		55.5		591		95		86	
0.03% R & Clay RD (IP)	50	64.7 *	**7**	127	**14**	0.93	**0.07**	2.5 *	**0.4**	70.4	**15**	875 *	**307**	100	**0**	100	**0**
0.3% R & Clay RD (IP)	50	74.4 *	**17**	147 *	**35**	1.07 *	**0.20**	2.8 *	**0.7**	97.9 *	**42**	1222 *	**654**	100	**0**	100	**0**
1.0% R & Clay RD	250	57.8 *	**7**	131 *	**20**	0.86	**0.06**	2.1 *	**0.3**	61.1 *	**15**	780 *	**246**	94	**-2**	94	**3**
3.0% R & Clay RD	200	53.1	**3**	127 *	**16**	0.83	**0.03**	1.8	**-0.1**	60.5 *	**15**	572	**38**	93	**-3**	83	**-9**
Clay RD Check (IP)	50	57.5		112		0.87		2.0		55.8		568.0		100		100	
Clay RD Check	250	50.4		111		0.80		1.9		45.6		534.0		96		91	

§ R = Regent, TS = Terrasorb, RD = Root Dip, DW = Driwater.

* Means followed by an asterik are significantly different from checks at the 5% level based on Fisher's Protected LSD.

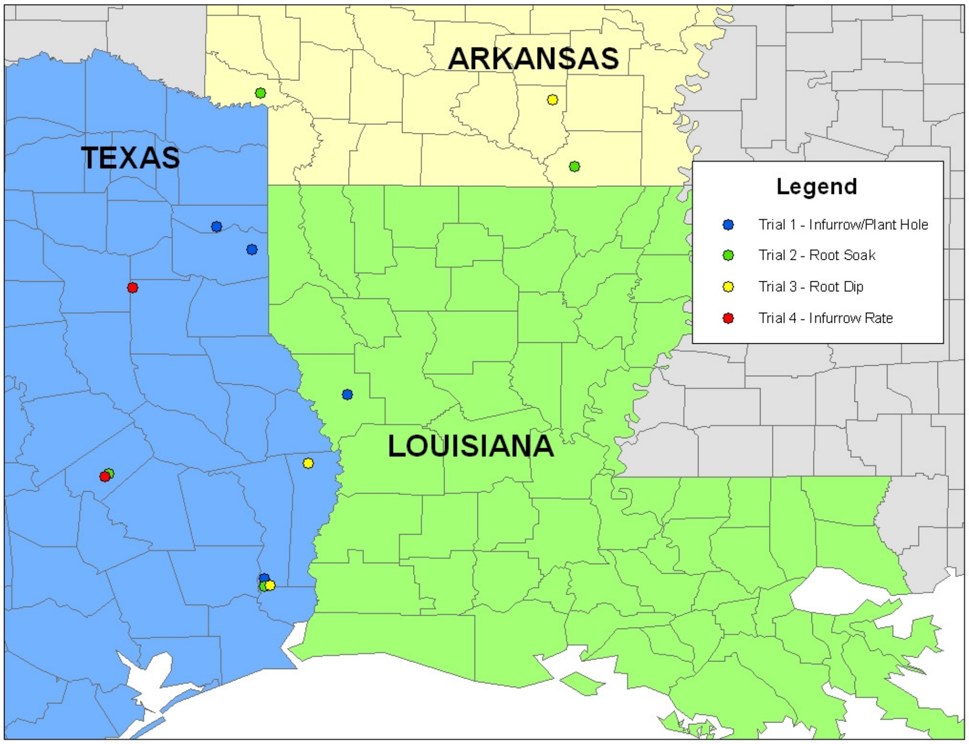

Figure 23. Sites of the four Technique and Rate Refinement Trials (●) established in 2004 and 2005 in the Western Gulf Region.

PINE TIP MOTH TRIALS

Fipronil In-Furrow Treatment Study - Western Gulf and East Coast

Highlights:

- All fipronil treatments applied in-furrow to nursery beds were generally ineffective in reducing tip moth damage through most of the year and had no effect on tree growth.
- Fipronil applied in plant holes or by soil injection after planting significantly reduced tip moth damage after the first generation and improved volume growth.

Objectives: 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.

Study Sites: Two second-year plantations were selected in Texas (see Fig. 25). One additional site was established in South Carolina. Second-year plantations were used in the study because tip moth populations are usually well established at this age and would ensure that significant tip moth pressure would be placed on treated seedlings. Most plots contained 12 treatments and 600 trees (5 rows X 110 trees).

Population Monitoring: Tip moth populations were monitored on TFS sites in East Texas. Three Phericon 1C wing traps with Trece septa lures (Great Lakes IPM) at 3 sites near Evadale, Groveton, and Mayflower. Traps were generally positioned 50 to 100 m apart and at tree terminal height. Sticky trap bottoms were collected and replaced weekly starting in early February 2004 and monitored until the end of the year. Lures were changed at 4 - 6 week intervals, depending on mean temperatures.

Insecticides:
Regent® (fipronil) – a phenyl pyrazole with some systemic activity against Lepidoptera.

Design: Randomized complete block design at each site with beds or site areas serving as blocks, i.e., each treatment was randomly selected for placement along a bed. Ten seedlings from each treatment were planted on each of five beds. 3 sites X 12 treatments X 50 trees = 550 monitored trees.

Treatments:

1) In-furrow (2X - 0.026%, 0.62 ml Regent®/liter of water) applied at 7ml solution/ft of furrow in July (TX seedlings planted in TX & SC)
2) In-furrow (4X - 0.051%, 1.24 ml/liter) applied at 7ml solution/ft of furrow in July (TX seedlings planted in TX & SC)
3) In-furrow (8X - 0.102%, 2.48 ml/liter) applied at 7ml solution/ft of furrow in July (TX seedlings planted in TX only)
4) In-furrow (16X – 0.204%, 4.96 ml/liter) applied at 7ml solution/ft of furrow in July (TX seedlings planted in TX only)

5) In-furrow (2X - 0.0256%, 0.62 ml/liter) applied at 7ml solution/ft of furrow in September (TX seedlings planted in TX & SC)
6) In-furrow (4X - 0.0512%, 1.24 ml/liter) applied at 7ml solution/ft of furrow in September (TX seedlings planted in TX & SC)
7) In-furrow (8X - 0.1%, 2.48 ml/liter) applied at 7ml solution/ft of furrow in September (TX seedlings planted in TX only)
8) In-furrow (2X - 0.026%, 0.62 ml Regent® + 2.25g DriWater™ /liter of water) applied at **14ml** solution/ft of furrow in September (TX seedlings planted in TX & SC)
9) Plant Hole - 30 ml (0.267%, 6.8 ml Regent®/liter) applied to plant hole (TX seedlings planted in TX only)
10) Soil Injection - 30 ml (0.267%, 6.8 ml Regent®/liter) applied to soil after planting (TX seedlings planted in TX & SC)
11) Foliar application (5X) of pine seedlings with Mimic® 2LV or Pounce (0.6 ml / liter of water) (TX seedlings planted in TX & SC)
12) Check (lift and plant) (TX seedlings planted in TX & SC)
13) In-furrow (1X - 0.013%, 0.32 ml Regent®/liter of water) applied at 7ml solution/ft of furrow in September (SC seedlings planted in SC only)
14) In-furrow (2X - 0.0256%, 0.62 ml/liter) applied at 7ml solution/ft of furrow in September (SC seedlings planted in SC only)
15) Soil Injection - 3 ml (2.67%, 68 ml Regent®/liter) applied to soil after planting (SC seedlings planted in SC only)
16) Check (lift and plant) (SC seedlings planted in SC only)

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 above 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.

When ready, fifty seedlings from each treatment (1 – 12) were planted (spacing variable) on each of 2 second-year TX plantation sites. Additionally, fifty seedlings from treatments 1, 2, 5, 6, 8, 10 - 16 also were planted on a SC site. 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) Zavalla, TX (Temple-Inland provided and Texas Forest Service monitored)
3) Unknown site, SC (International Paper provided and monitored)

Treatment Evaluation: Tip moth damage was evaluated after each tip moth generation (3-4 weeks after peak moth flight) by 1) identifying if the tree was infested or not, 2) if infested, the proportion of tips infested on the top whorl and terminal were calculated; and 3) separately, the terminal was identified as infested or not. Observations also were made as to the occurrence and extent of damage caused by other insects, i.e., aphids, weevils, coneworm, etc. Each tree was measured for diameter and height (at 6”) in the fall or winter (November - January) following planting.

Data were analyzed by GLM and the Fisher’s protected LSD test using Statview or SAS statistical programs.

Results:

Tip moth populations were quite low on both TX sites during the first generation with an average of only 0.3% of the shoots infested on check trees. As a result of the low tip moth pressure, none of the treatments reduced tip moth infestation of top whorl shoots compared to the check during the first generation (Table 29). In contrast, first generation damage on the SC site check trees was considerable (47%) and all treatments had significantly less damage (Table 30). All in-furrow treatments, regardless of rate or timing, showed little or no consistent effect on reducing tip moth damage levels through the remainder of the year (Tables 29 &30). In contrast, all soil treatments (injection and plant hole) provided good to excellent protection during the second through the fifth generation, reducing damaged by 52 – 98% (63 – 88% overall). This again suggests that the full effects of the chemical treatments were not expressed until after the first generation. None of the fipronil treatments negatively affected seedling survival after 5 generations. Seedlings receiving applications of fipronil by injection or in plant holes consistently had the greatest improvement in height, diameter and volume index compared to check trees (Tables 31 & 32).

Acknowledgments: We greatly appreciate the efforts by Jimmy Seckinger and Dr. Scott Cameron, International Paper Company to establish, spray and monitor research plots in SC. Thanks also go to Temple-Inland Forest Products for providing additional research sites in TX. We thank Harry Vanderveer and Ted Moore for providing assistance at the nursery and the Texas Forest Service for donating the seedlings. We also thank Dr. Harry Quicke, BASF, for providing the fipronil formulation, Regent®, for the project.

Table 29. Effect of fipronil application technique, rates and timing on pine tip moth infestation of loblolly pine shoots (top whorl) after each of 5 generations on two TX sites in the Western Gulf Region - 2005.

Treatment §	N	Mean Percent Top Whorl Shoots Infested by Tip Moth (Pct. Reduction Compared to Check)																	
		Gen 1			Gen 2			Gen 3			Gen 4			Gen 5			Overall Mean		
IF 2x-July	100	1.0	**-292**		7.1	**18**		10.3	**50**	*	23.4	**25**		59.5	**-348**	*	20.6	**-42**	*
IF 4x-July	100	1.8	**-602**		13.1	**-52**		14.9	**27**		23.2	**25**		29.7	**-124**	*	16.9	**-16**	
IF 8x-July	100	2.3	**-801**		9.8	**-14**		9.4	**54**	*	32.5	**-4**		49.7	**-274**	*	20.9	**-44**	*
IF 16x-July	100	1.6	**-546**		9.5	**-10**		11.1	**46**	*	23.9	**23**		42.9	**-223**	*	18.0	**-23**	
IF 2x-Sept	100	5.8	**-2182**	*	22.1	**-156**	*	12.0	**41**	*	30.2	**3**		39.2	**-195**	*	21.7	**-49**	*
IF 4x-Sept	100	0.5	**-100**		8.1	**6**		6.8	**67**	*	20.3	**35**		35.4	**-167**	*	14.3	**2**	
IF 8x-Sept	100	0.6	**-133**		9.0	**-4**		17.4	**15**		26.9	**14**		26.6	**-101**	*	16.3	**-12**	
IF 2x+DW-Sept	100	1.4	**-452**		10.2	**-19**		18.3	**11**		23.0	**26**		11.8	**11**		13.1	**10**	
Injection 30 ml	100	3.7	**-1352**	*	3.5	**60**		3.5	**83**	*	1.5	**95**	*	1.7	**87**	*	2.8	**81**	*
Plant Hole 30 ml	100	3.1	**-1118**		1.7	**80**	*	3.0	**85**	*	3.4	**89**	*	0.3	**98**	*	2.0	**86**	*
Mimic spray	100	0.0	**100**		0.8	**91**	*	1.8	**91**	*	5.5	**82**	*	0.0	**100**	*	1.5	**90**	*
Check	100	0.3			8.6			20.5			31.2			13.3			14.6		

§ IF = In-Furrow, DW = Driwater

* Means followed by an asterik are significantly different from checks at the 5% level based on Fisher's Protected LSD.

= treatment reduced damage by >75% compared to check.

Table 30. Effect of fipronil application technique, rates and timing on pine tip moth infestation of loblolly pine shoots (top whorl) after each of 4 generations on one site in the East Coast Region - 2005.

Treatment §	N	Gen 1			Gen 2			Gen 3			Gen 4			Overall Mean		
		Mean Percent Top Whorl Shoots Infested by Tip Moth (**Percent Reduction Compared to Check**)														
IF 2x-July	50	6.6	**86**	*	45.2	**-13**		15.1	**11**		32.2	**-22**		23.9	**29**	*
IF 4x-July	50	14.0	**70**	*	56.1	**-40**	*	16.9	**1**		31.3	**-19**		29.6	**12**	
IF 2x-Sept	50	12.2	**74**	*	40.9	**-2**		17.0	**0**		16.4	**38**		22.0	**35**	*
IF 4x-Sept	50	9.5	**80**	*	43.9	**-9**		18.4	**-7**		24.2	**8**		24.1	**29**	*
IF 2x+DW-Sept	50	12.9	**73**	*	46.0	**-15**		13.4	**22**		26.8	**-2**		24.3	**28**	*
Injection 30 ml	50	7.3	**85**	*	5.4	**87**	*	1.9	**89**	*	1.5	**94**	*	4.1	**88**	*
Pounce spray	50	0.0	**100**	*	2.1	**95**	*	0.4	**98**	*	0.7	**97**	*	0.8	**98**	*
Check	50	47.4			40.1			17.1			26.3			33.7		
IF 1X-Sept (SC)	50	6.6	**51**		39.4	**-33**		22.9	**1**		37.6	**16**		26.6	**4**	
IF 2X-Sept (SC)	50	10.0	**26**		33.4	**-13**		22.1	**5**		34.6	**23**		25.7	**7**	
Injection 3ml (SC)	50	11.6	**13**		14.2	**52**	*	6.5	**72**	*	7.7	**83**	*	10.2	**63**	*
Check (SC)	50	13.4			29.6			23.2			44.9			27.6		

§ IF = In-Furrow, DW = Driwater

* Means followed by an asterik are significantly different from checks at the 5% level based on Fisher's Protected LSD.

[shaded box] = treatment reduced damage by >75% compared to check.

Table 31. Effect of fipronil application technique, rate and timing on loblolly pine growth parameters and tree survival after the first year on three sites in the Western Gulf Region - 2005.

Treatment §	N	Mean End or Season Loblolly Pine Seeding Growth Measurements (**Growth Difference (cm or cm^3) Compared to Check**) Height (cm)			Diameter (cm)			Volume (cm^3)			Mean % Tree Survival (**Pct. Gain Compared to Check**)	
IF 2x-July (TX&SC)	150	44.1		**0.8**	0.76		**0.05**	30.9		**1**	82	**44**
IF 4x-July (TX&SC)	150	45.7		**2.5**	0.72		**0.01**	29.9		**0**	83	**46**
IF 8x-July (TX)	100	45.3		**2.1**	0.76		**0.05**	33.5		**4**	85	**49**
IF 16x-July (TX)	100	41.7		**-1.5**	0.69		**-0.03**	25.3		**-4**	77	**35**
IF 2x-Sept (TX&SC)	150	44.6		**1.4**	0.72		**0.00**	27.5		**-2**	76	**33**
IF 4x-Sept (TX&SC)	150	42.5		**-0.8**	0.69		**-0.03**	26.3		**-3**	74	**30**
IF 8x-Sept (TX)	100	43.6		**0.4**	0.71		**0.00**	27.6		**-2**	86	**51**
IF 2x+DW-Sept (TX&SC)	150	42.7		**-0.6**	0.75		**0.03**	34.7		**5**	81	**42**
Injection 30 ml (TX&SC)	150	46.4		**3.2**	0.80		**0.08**	40.4		**11**	87	**53**
Plant Hole 30 ml (TX)	100	46.4		**3.2**	0.82	*	**0.11**	43.1	*	**13**	81	**42**
Foliar spray (TX&SC)	150	40.9		**-2.3**	0.70		**-0.01**	25.3		**-4**	52	**-9**
Check (TX)	100	43.2			0.71			29.7			57	

§ IF = In-Furrow, DW = Driwater

* Means followed by an asterik are significantly different from checks at the 5% level based on Fisher's Protected LSD.

Table 32. Effect of fipronil application technique, rate and timing on loblolly pine growth parameters and tree survival after the first year on three sites in the Western Gulf Region - 2005.

Treatment §	N	Mean End or Season Loblolly Pine Seeding Growth Measurements (**Growth Difference (cm or cm^3) Compared to Check**)									Mean % Tree Survival (**Pct. Gain Compared to Check**)	
		Height (cm)			Diameter (cm)		Volume (cm^3)					
IF 2x-July	50	48.4		**-8.4**	0.73	**-0.12**	31.4	*	**-17**		90	**7**
IF 4x-July	50	50.8		**-6.0**	0.85	**0.00**	46.0		**-3**		98	**17**
IF 2x-Sept	50	53.8		**-3.0**	0.82	**-0.03**	43.2		**-5**		88	**5**
IF 4x-Sept	50	52.8		**-4.0**	0.80	**-0.05**	39.9		**-9**		84	**0**
IF 2x+DW-Sept	50	51.8		**-4.9**	0.82	**-0.03**	39.0		**-10**		82	**-2**
Injection 30 ml	50	57.7		**4.0**	0.79	**-0.02**	47.1		**4**		96	**14**
Pounce spray	50	68.8	*	**12.1**	0.94	**0.10**	71.4	*	**23**		90	**7**
Check	50	56.8			0.85		48.7				84	
IF 1X-Sept (SC)	50	59.6		**-0.6**	0.80	**-0.05**	47.1	*	**-14**		98	**7**
IF 2X-Sept (SC)	50	60.2		**0.1**	0.84	**-0.01**	53.2		**-8**		92	**0**
Injection 3ml (SC)	50	60.2		**0.1**	0.89	**0.04**	68.2		**7**		92	**0**
Check (SC)	50	60.2			0.85		61.4				92	

§ IF = In-Furrow, DW = Driwater

* Means followed by an asterik are significantly different from checks at the 5% level based on Fisher's Protected LSD.

PINE TIP MOTH TRIALS

Fipronil Soil Injection Treatment Study – East Texas

Highlights:

- All fipronil soil injection treatments significantly reduced overall tip moth damage after the third generation. Overall damage was reduced by 55-73% compared to check trees.
- None of the treatments significantly improved tree growth.

Objectives: 1) Determine the efficacy of fipronil applied post-plant by soil injection in reducing pine tip moth infestation levels on loblolly pine seedlings, and 3) determine the duration of chemical activity.

Study Sites: Two first-year plantations were selected in Texas (see Fig. 24). The plots contained 5 treatments and 250 trees (5 rows X 50 trees).

Population Monitoring: Tip moth populations were monitored on TFS sites in East Texas. Three Phericon 1C wing traps with Trece septa lures (Great Lakes IPM) at 3 sites near Evadale, Groveton, and Mayflower. Traps were generally positioned 50 to 100 m apart and at tree terminal height. Sticky trap bottoms were collected and replaced weekly starting in early February 2004 and monitored until the end of the year. Lures were changed at 4 - 6 week intervals, depending on mean temperatures.

Insecticides:

Fipronil – Regent® 4SC (4.0 lbs ai/gal),
Regent 2.5 EC (2.5 lbs ai/gal,
BAS350 UB 120EC (1.0 lb ai/gal)

Design: Randomized complete block design at each site with beds or site areas serving as blocks, i.e., each treatment was randomly selected for placement along a bed. Ten seedlings from each treatment were planted on each of five beds. 2 sites X 5 treatments X 50 trees = 250 monitored trees.

Treatments:

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

Treatment Methods: Temple Inland Forest Product loblolly pine seedlings were planted in January 2005 at 605 trees per acre (6' X 12' spacing). All soil injection treatments were applied in May using the Kioritz soil injector (Figure 25). The injector point was positioned about 4 inches from each seedling and forced into the soil at an angle to a depth of 5 inches. Once the fipronil solution was applied the injector was removed and hole was covered with soil to prevent root desiccation.

Treatment Evaluation: Tip moth damage was evaluated after each tip moth generation (3-4 weeks after peak moth flight; 4 generations in TX, by 1) identifying if the tree was infested or not, 2) if infested, the proportion of tips infested on the top whorl and terminal were calculated; and 3) separately, the terminal was identified as infested or not. Each tree was measured for diameter (at 6") and height in winter 2005/2006.

Results: Tip moth populations were low during the second generation with an average of <6% of the shoots infested on check trees. As a result of the low tip moth pressure, none of the treatments significantly reduced tip moth infestation of top whorl shoots compared to the check during this generation (Table 33). The 350 UB treatment initially provided good protection against tip moth but appeared to fade by the fifth generation. In contrast, both Regent 4 SC treatments started off slow but improved with each generation. This again suggests that the full effects of the chemical treatments were not expressed until about 3 months after application. None of the fipronil treatments negatively affected seedling survival after 4 generations. None the treatments significantly improved tree growth parameters (height, diameter or volume index) compared to check trees (Tables 34).

Acknowledgments: Thanks go to Emily Goodwin and Temple-Inland Forest Products for providing research sites in TX. We also thank Dr. Harry Quicke, BASF, for providing the fipronil formulation, Regent®, for the project.

Table 33. Effect of different fipronil formulations and volumes on pine tip moth infestation of loblolly pine shoots (top whorl) after each of 4 generations on two Texas sites - 2005.

Treatment	N	Mean Percent Top Whorl Shoots Infested by Tip Moth (Pct. Reduction Compared to Check) Gen 1	Gen 2	Gen 3	Gen 4	Gen 5	Overall Mean
Regent 4SC 3ml	100		4.9 **15**	5.0 **40**	17.5 **49** *	10.6 **75** *	11.7 **58** *
Regent 4SC 30ml	100		1.9 **67**	4.6 **45**	15.1 **56** *	3.0 **93** *	7.2 **74** *
Regent 2.5EC 3ml	100		2.3 **60**	3.9 **53** *	16.3 **53** *	9.4 **78** *	10.2 **63** *
BAS350 UB 3ml	100		2.3 **60**	1.8 **78** *	16.8 **51** *	16.9 **60** *	12.2 **55** *
Check	100		5.8	8.3	34.6	42.5	27.5

* Means followed by an asterik are significantly different from checks at the 5% level based on Fisher's Protected LSD.
= treatment reduced damage by >75% compared to check.

Table 34. Effect of different fipronil formulations applied by soil injection on loblolly pine growth parameters and tree survival after the first year on two sites in the Western Gulf Region - 2005.

Treatment §	N	Mean End or Season Loblolly Pine Seeding Growth Measurements (**Growth Difference (cm or cm^3) Compared to Check**) Height (cm)	Diameter (cm)	Volume (cm^3)	Mean % Tree Survival (**Pct. Gain Compared to Check**)
Regent 4SC 3ml	100	70.9 * **-7.0**	1.45 * **-0.16**	210.5 * **-48.9**	97 **-2**
Regent 4SC 30ml	100	77.5 **-0.4**	1.64 **0.03**	256.6 **-2.8**	97 **-2**
Regent 2.5EC 3ml	100	76.2 **-1.7**	1.60 **-0.01**	249.5 **-9.9**	94 **-5**
BAS350 UB 3ml	100	70.9 * **-7.0**	1.46 * **-0.16**	203.3 * **-56.1**	90 **-9**
Check	100	77.9	1.62	259.4	99

§ R = Regent, PH = Plant Hole, RD = Root Dip
* Means followed by an asterik are significantly different from checks at the 5% level based on Fisher's Protected LSD.

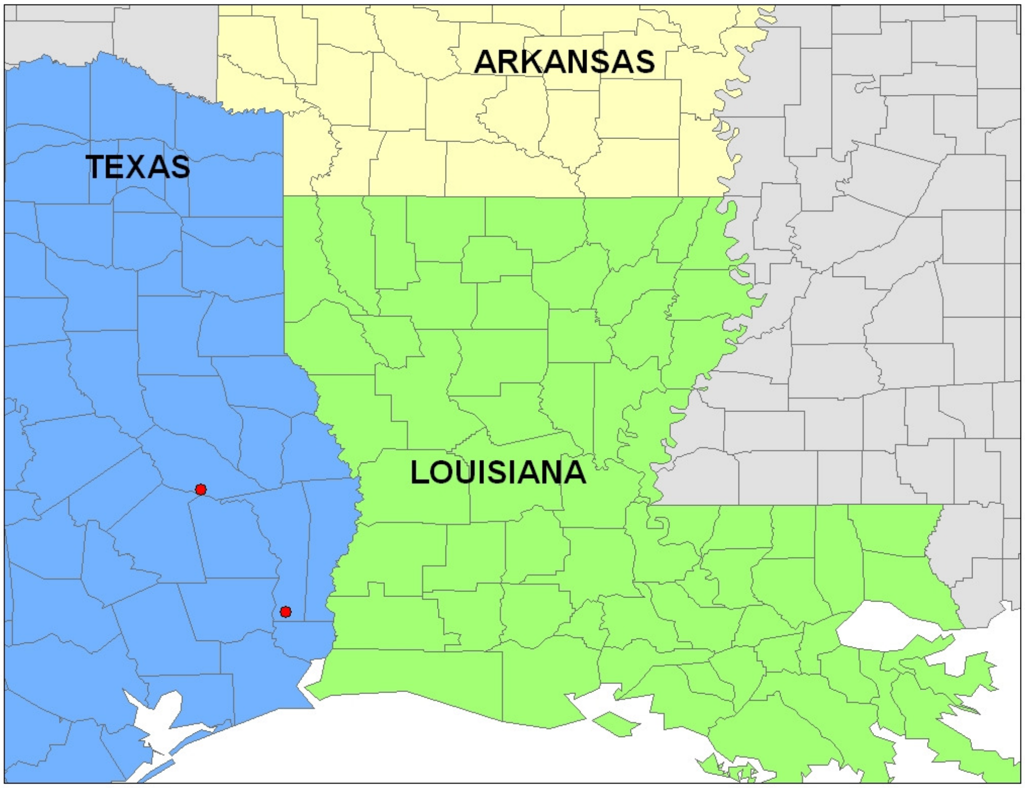

Figure 24. Sites of the Soil Injection Trial (●) established in 2005 in Angelina and Jasper Counties, TX.

Figure 25. Jason Helvey with Kioritz soil injector.

PINE TIP MOTH TRIALS

Fipronil Operational Planting Study – TX and LA

Highlights:
- The ability of fipronil to reduce tip moth damage faded out in the third year in the large half areas, but the chemical still appears to be active in the 100 tree plots.
- Some anomalies appeared in the 2005 tree measurement analysis. Reevaluation of the data is ongoing.

Objectives: 1) Evaluate the efficacy of fipronil in reducing pine tip moth infestation levels in loblolly pine plantations and 2) determine the duration of chemical activity.

Study Sites: Four first-year plantations were selected in 2003, three in East Texas [near Linden (Anthony), Camden (IP) and Zavalla (Temple)] and one in north Louisiana [Deer Rd near Sailes (Weyerhaeuser)]. The plantations ranged in size from 19 – 38 acres.

Population Monitoring: Tip moth populations were monitored at the Camden and Zavalla sites in 2004 with 3 Phericon 1C wing traps with Trece septa lures (Great Lakes IPM) at each site. Traps were generally positioned 50 to 100 m apart and at tree terminal height. Sticky trap bottoms were collected and replaced weekly starting in early January 2004 and monitored until the end of the year. Lures were changed at 4 - 6 week intervals, depending on mean temperatures.

Insecticides:

Termidor® (fipronil) – a pheny pyrazole insecticide with some systemic activity against Lepidoptera.

Design: The four plantations were divided in half. Half of the plantation was planted with treated seedlings and the other half with untreated seedlings. Ten 10-tree plots were evenly spaced throughout each half. Also in each half, a 100-tree plot was established with the reverse treatment.

Treatments:
1) Root soak of bare root seedlings for 2 hours in 0.3% fipronil (Termidor® SC) solution.
2) Check - bare root seedling (lift and plant)

Treatment Methods: A single family (Advanced Generation) of bare root loblolly pine seedlings was used from the Texas Forest Service Indian Mounds Nursery at Alto, TX. The seedlings (~20,000) were lifted in January 2003 in a manner to cause the least breakage of roots. The seedlings were culled of small and large caliper seedlings, bagged and placed briefly in cold storage. When ready, half the cold-stored seedlings were warmed at room temperature (~70^{o}F) for 3 hours. These seedlings were soaked in two 190-liter (50 gal) tanks of fipronil (0.3% ai) solution for 2 hours. All seedlings (treated and untreated) were dipped in TerraSorb™ solution, rebagged and placed in cold storage until the following day. Seedlings were hand-planted on three sites (Camden, Linden and Deer Rd) and machine-planted on the fourth (Zavalla). The spacing was variable and dependent on the preference of participating members.

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 the treated half contained untreated seedlings, while the plot in the untreated half contained treated seedlings. Ten 10-tree plots were evenly spaced within each of the half tracts (20 – 10 tree plots / whole tract) to evaluate tip moth damage levels in this area. The plantations were treated with herbicide after planting when necessary to minimize herbaceous and/or woody competition.

Treatment Evaluation: Tip moth damage was evaluated in each 100- and 10-tree plots after each tip moth generation (3-4 weeks after peak moth flight) on 4 sites in 2003 and 2004 and 3 sites in 2005 by 1) identifying if the tree was infested or not, 2) if infested, the proportion of tips infested on the top whorl and terminal were calculated; and 3) separately, the terminal was identified as infested or not. Observations also were made as to the occurrence and extent of damage caused by other insects, i.e., weevils, coneworms, aphids, sawflies, etc. Each tree was measured for height and diameter (at breast height) in late December 2005.

Results: Generally, similar patterns of treatment performance against tip moth were found on all four sites. As a result, data from the four sites were pooled for analysis.

Tip Moth Infestation: In 2003, tip moth populations were fairly low on all four first-year plantation sites; damage levels never exceeded 25% of the shoots infested on any of the sites. All treatments showed relatively similar tip moth infestation levels (2 – 3% of shoots) after the first generation (Fig. 27, Table 33). The two fipronil treatment areas showed improvements in damage reduction during the second and/or third generations compared to the first. This again (like the Technique and Rate Study) indicates that fipronil molecules move slowly in the seedlings and may require 5+ months before chemical concentrations reach maximum levels in pine shoots during the third generation. However, both fipronil treatment areas showed some reductions in efficacy after five generations. Overall, the fipronil-treated areas (half and plot) had significantly less tip moth damage compared to the check areas in 2003 with reductions ranging from 83% to 85% (Table 35).

In 2004, tip moth damage again started off very light (2%), but increased markedly by the third generation. Although damage levels in fipronil areas (half and plot) tended to increase as the year progressed, they were nearly always lower than their contrasting check area. Overall, the fipronil treatments reduced damage levels from 11% to 44% (Fig. 28, Table 35).

In 2005, tip moth damage again started off light (5 - 9%), but increased markedly by the fifth generation. Fipronil areas (half and plot) tended to have lower damage levels than their contrasting check area early in the year, but levels became significantly higher in the half area late in the year (Table 35).

Tree Growth: In 2003, seedlings treated with fipronil were significantly taller than check trees, with gains ranging from 5 – 16% (Table 36). In contrast, only fipronil-treated seedlings planted within the check area (Fipronil 100) had significantly greater diameters and volumes. Gains for these parameters were 19% and 47%, respectively. There were no differences in tree survival among the treatment areas.

In 2004, fipronil treatments provided even greater gains in tree height, diameter and volume compared to check areas (Table 36).

In 2005, the differences in height and volume in the fipronil 100 tree plot compared to the check 100 tree plots continued to expand. However, differences in growth parameters (height, diameter and volume) between treatments has declined dramatically since 2004 (Table 36). The reason is unknown at this time, but perhaps the diameters of trees on one or more sites were measured at 6" while at others sites diameters were measured at breast height (DBH). The data will be reanalyzed and sites revisited if necessary.

Acknowledgments: We greatly appreciate the efforts of Valerie Sawyer, Weyerhaeuser Company, to establish and monitor research plots. Thanks also go to Temple-Inland Forest Products and International Paper for providing additional research sites in TX. We thank Harry Vanderveer and Ted Moore for providing assistance at the nursery and the Texas Forest Service for donating the seedlings. We also thank Dr. Harry Quicke, BASF, for providing the fipronil formulation, Termidor®, for the project.

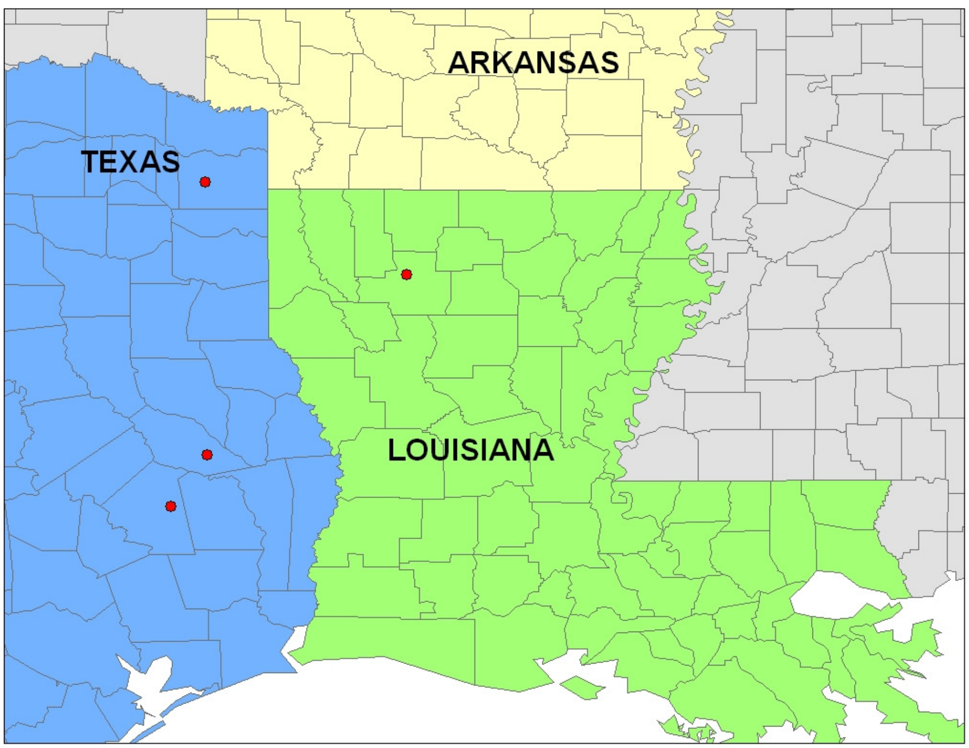

Figure 26. Sites of the Operational Planting Trial (●) established in 2003 in Texas and Louisiana.

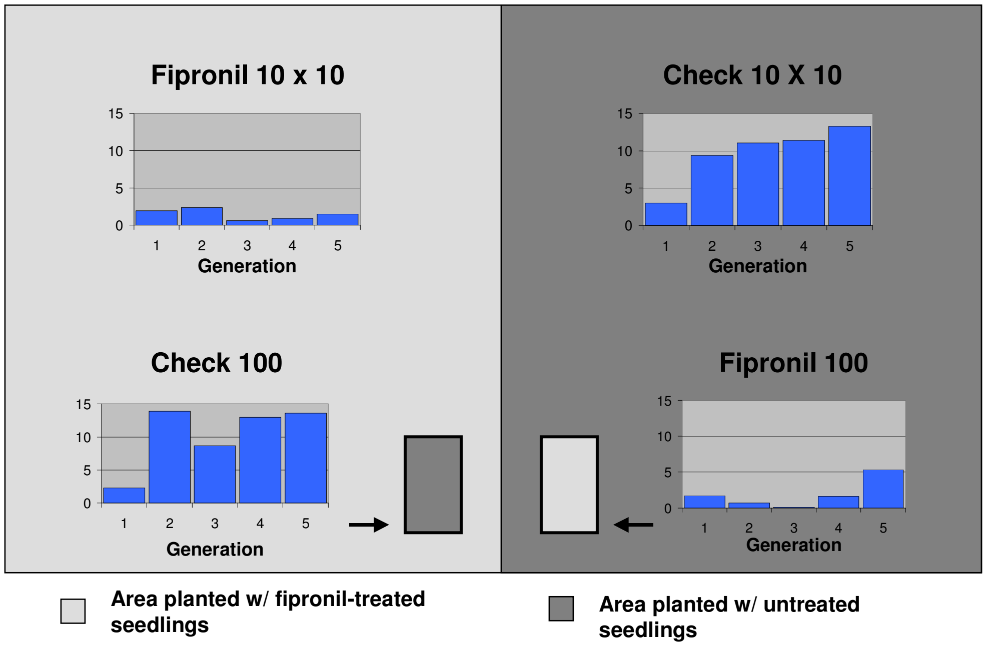

Figure 27. Mean percent of pine shoots (top whorl) infested by pine tip moth during each of 5 generations on four operational planting sites in East Texas (3) and Louisiana (1) – 2003.

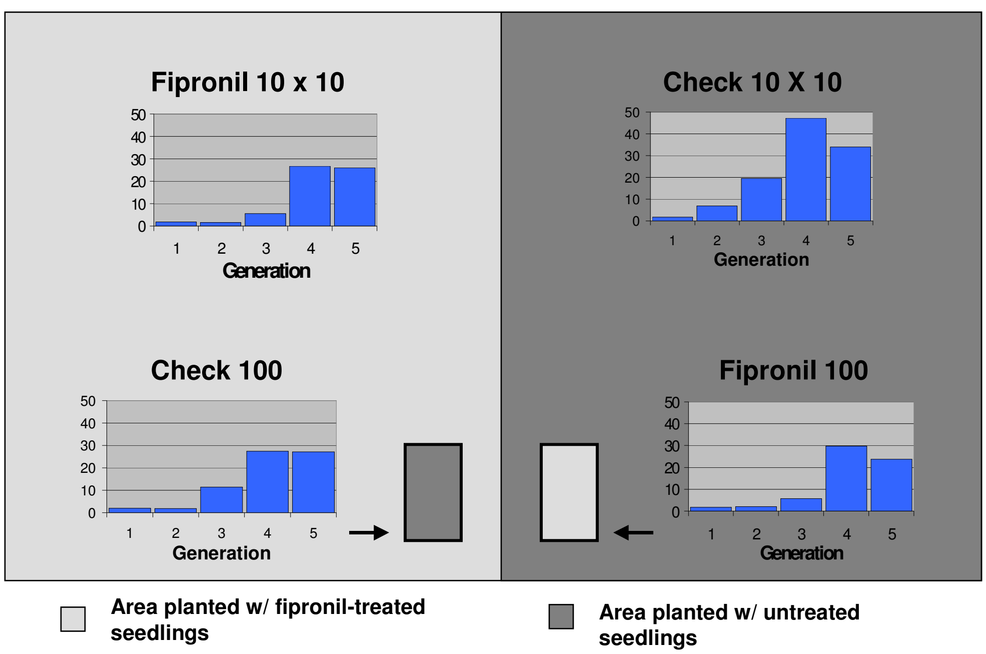

Figure 28. Mean percent of pine shoots (top whorl) infested by pine tip moth during each of 5 generations on four operational planting sites in East Texas (3) and Louisiana (1) – 2004.

Table 35. Effect of operational planting of fipronil-treated seedlings on pine tip moth infestation of loblolly pine shoots (top whorl) on four sites in east Texas or Louisiana, 2003 - 2005.

Year	Treatment	N	Mean Percent Top Whorl Shoots Infested by Tip Moth					Overall	Pct
			Gen 1	Gen 2	Gen 3	Gen 4	Gen 5	Mean	Red.
2003	Fipronil 10 X 10	400	1.9 **a** *	2.4 **a**	0.8 **a**	0.9 **a**	1.5 **a**	1.5	**84.6**
	Check 10 X 10	400	3.0 **a**	9.4 **b**	11.8 **b**	11.5 **b**	13.3 **c**	9.8	
	Fipronil 100	400	1.7 **a**	0.7 **a**	0.1 **a**	1.4 **a**	5.3 **b**	1.8	**83.0**
	Check 100	400	2.3 **a**	13.9 **c**	10.8 **b**	13.3 **b**	13.6 **c**	10.8	
2004	Fipronil 10 X 10	364	1.8 **a**	1.5 **a**	5.6 **a**	26.7 **a**	26.0 **a**	12.2 **a**	**44.0**
	Check 10 X 10	386	1.7 **a**	6.8 **b**	19.6 **c**	47.2 **b**	34.0 **b**	21.8 **c**	
	Fipronil 100	333	1.8 **a**	2.1 **a**	5.7 **a**	29.8 **a**	23.7 **a**	12.5 **ab**	**10.9**
	Check 100	392	2.1 **a**	1.9 **a**	11.5 **b**	27.5 **a**	27.1 **a**	14.0 **b**	
2005	Fipronil 10 X 10	297	7.2 **ab**	3.0 **ab**	9.0 **b**	40.8 **b**	42.8 **c**	20.6 **c**	**-24.3**
	Check 10 X 10	299	8.9 **b**	5.3 **bc**	9.9 **b**	32.9 **a**	25.7 **b**	16.6 **b**	
	Fipronil 100	218	5.7 **a**	1.6 **a**	5.3 **a**	32.1 **a**	15.7 **a**	12.1 **a**	**52.1**
	Check 100	236	5.1 **a**	6.5 **c**	11.1 **b**	48.8 **c**	55.9 **d**	25.4 **d**	

* Means followed by a different letter in each year are significantly different at the 5% level based on Fisher's Protected LSD.

Table 36. Effect of operational planting of fipronil-treated seedlings on loblolly pine growth and survival after three seasons on four sites in east Texas or Louisiana, 2003 - 2005.

			Mean End or Season Loblolly Pine Seeding Growth Measurements (**Growth Difference (cm or cm^3) Compared to Check**)					
Year	Treatment	N	Height (cm)		Diameter (cm) [a]		Volume (cm^3)	
2003	Fipronil 10 X 10	400	49.1 **b** *	2.4	0.86 **a**	0.01	57.5 **bc**	6.8
	Check 10 X 10	399	46.7 **a**		0.85 **a**		50.7 **ab**	
	Fipronil 100	405	52.3 **c**	7.2	0.94 **b**	0.13	64.7 **c**	20.3
	Check 100	419	45.1 **a**		0.81 **a**		44.4 **a**	
2004	Fipronil 10 X 10	400	142 **bc**	6.1	2.88 **c**	0.2	1517 **b**	255
	Check 10 X 10	399	136 **b**		2.69 **b**		1261 **a**	
	Fipronil 100	405	148 **c**	26.8	3.15 **d**	0.7	1819 **c**	836
	Check 100	419	121 **a**		2.43 **a**		983 **a**	
2005	Fipronil 10 X 10	391	217 **b**	-19.1	2.01 **b**	-0.3	1518 **b**	-424
	Check 10 X 10	387	236 **c**		2.31 **c**		1942 **c**	
	Fipronil 100	320	244 **c**	50.7	2.54 **d**	0.9	2258 **d**	1284
	Check 100	342	194 **a**		1.64 **a**		974 **a**	

* Means followed by the same letter in each column are not significantly different at the 5% level based on Fisher's Protected LSD.

[a] Diameter taken at 6" above ground in 2003 and 2004; at breast height in 2005.

PINE TIP MOTH TRIALS

Imidacloprid (Spike & Tablet) Studies – East Texas

Highlights:

- The effects of imidacloprid plus fertilizer and disulfoton plus fertilizer spikes on tip moth damage have disappeared completely in the third growing season. However, differences between treated and untreated trees for height, diameter and volume continued to expand.
- Imidacloprid tablet treatments ($\geq$10%), with and without fertilizer, applied in 2004, continued to provide moderate protection against tip moths through most of the year; reducing damage levels by 32 – 49%. There was a rate effect with higher rates providing better protection. However, none of the tablet treatments improved height or diameter growth.
- All imidacloprid tablet treatments, with and without fertilizer, applied in 2005, provided good protection against tip moths during the latter part of the year; reducing overall damage levels by 88 – 100%. However, only the 20% imidacloprid + fertilizer + Merit spray treatment improved height or diameter growth.

Objectives: 1) Determine 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.

Study Sites: In 2003, one second-year plantation was selected near Huntington, TX as part of the Fipronil Technique and Rate Trial (see Fig. 25). In 2004, two second-year plantations were selected at Groveton and Overton, Texas. In 2005, a second year site was selected near Zavalla, TX. Second-year plantations were used in the study because tip moth populations are usually well established at this age, increasing the likelihood that significant tip moth pressure would be placed on treated seedlings. The plots contained 11 treatments and 550 trees (5 rows X 110 trees) in 2004. **Note:** Scott Cameron, International Paper Co., also established study plots on the East Coast in 2004. The plot contained 7 treatments and 350 trees (5 rows X 70 trees) in 2005.

Population Monitoring: Three Phericon 1C wing traps with Trece septa lures (Great Lakes IPM) were placed at the Groveton site to monitor tip moth populations. Traps were generally positioned 50 to 100 m apart and at tree terminal height. Sticky trap bottoms were collected and replaced weekly starting in early February 2005 and monitored until the end of the year. Lures were changed at 4 - 6 week intervals, depending on mean temperatures.

Insecticides:

Imidacloprid – highly systemic neonictinoid with activity against Lepidoptera.
Disufoton – systemic organophosphate with activity against Lepidoptera.

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

Year & Treatments:

2003	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	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
2005	A =	10% imidacloprid tablet -	1 tablet in plant hole
	B =	20% imidacloprid tablet -	1 tablet in plant hole
	C =	20% imidacloprid tablet + Fertilizer-	1 tablet in plant hole
	C =	20% imidacloprid tablet + Fertilizer + single Merit® spray	1 tablet in plant hole
	D =	Pounce® Foliar -	Apply Pounce® (0.6 ml/L water) 1X / season
	E =	Merit® Foliar -	Apply Merit® (0.6 ml/L water) 1X / season
	F =	Bare root Check -	Treat w/ Terrasorb™ and plant bare root

Research Approach:

In 2003, 2004 and 2005, a single family 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, culled of small and large caliper seedlings, treated with Terrasorb™ root coating, bagged and stored briefly in cold storage.

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. In 2005, a single tablet was dropped into the plant hole just prior to placement of the seedling in the plant hole.

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

Results:

Insecticide/fertilizer spikes

In 2003, fertilizer spikes containing imidacloprid or disulfoton were effective in significantly reducing tip moth damage for three and two generations, respectively (Table 37). By the fifth generation, the damage level of neither treatment differed from the check. Overall, imidacloprid and disulfoton reduced damage levels by 52 and 15%, respectively. Disulfoton and imidacloprid plus fertilizer spike treatments both resulted in marked improvements in all growth parameters compared to check trees (Table 38). Both insecticide/fertilizer spike treatments significantly improved survival compared to check trees.

In 2004, the imidacloprid plus fertilizer treatment continued to reduce tip moth damage levels, particularly in the second, third and fourth generations. Overall, this treatment reduced damage by 18% compared to check trees (Table 37). Seedlings receiving insecticide/fertilizer treatments again had significantly greater height, diameter and volume growth compared to check trees. Percent gains in these parameters were larger in 2004 compared to 2003; indicating that the treatment effects on growth had not declined.

In 2005, the effects of both treatments on tip moth damage have faded completely in the third growing season (Table 37). Seedlings receiving insecticide/fertilizer treatments again had significantly greater height, diameter and volume growth compared to check trees. The differences between treated trees and checks in height, diameter and volume continued to expand, indicating that the treatment effects on growth had not declined.

Imidacloprid Tablets (2004)

In 2004, tip moth populations were quite low on both sites during the first generation with an average of only 5% of the shoots infested on check trees. As a result of the low tip moth pressure, none of treatments significantly reduced tip moth infestation levels compared to the check during the first generation (Table 39). In contrast, nearly all treatments containing imidacloprid or fertilizer alone or combined provided moderate to excellent protection during the second through the fifth generations, reducing damaged by 30 – 100% (39 – 84% overall). An increase in imidacloprid concentration in the tablets had no apparent effect on tip moth damage levels. Seedling survival was generally poor for most treatments with averages for the two sites ranging from 55 – 72% compared to 69% survival for check trees. Only trees treated with the 15% imidacloprid only tablets had significantly lower survival than the check. None of the treatments, including the Mimic® spray, significantly improved height and diameter growth compared to the checks (Tables 40). Only seedlings receiving a 5% imidacloprid + fertilizer tablet had significantly greater volume index compared to check trees.

In 2005, tip moth populations were again low on both sites during the first generation with an average of only 6% of the shoots infested on check trees. As a result of the low tip moth pressure, none of treatments significantly reduced tip moth infestation levels compared to the check during the first generation (Table 39). Treatments containing imidacloprid or fertilizer alone or combined provide low to moderate protection during the second through the fifth generations, reducing overall damage by 3 – 49%. Increasing imidacloprid concentration in the tablets tended to improve protection against tip moth damage. None of the treatments, including the Mimic® spray, significantly improved height, diameter or volume growth compared to the checks (Tables 40 & 41).

Imidacloprid Tablets (2005)
Tip moth populations were very low on the single site during the first, second and fourth generations with averages of 0.8%, 1.7% and 0% of the shoots infested on check trees, respectively. As a result of the low tip moth pressure, none of treatments significantly reduced tip moth infestation levels compared to the check during these generations (Table 42). In contrast, all treatments containing imidacloprid or fertilizer alone or combined provided excellent protection during the third and fifth generations, reducing damaged by 91 – 100% (88 – 100% overall). The addition of fertilizer or increase in imidacloprid concentration in the tablets had no apparent effect on tip moth damage levels. Only seedlings receiving a 20% imidacloprid + fertilizer tablet + Merit spray had significantly greater diameter and volume index compared to check trees (Table 43).

Acknowledgments: We greatly appreciate the efforts of Eric Taylor, Texas Cooperative Extension, to establish, spray and monitor the research plot. Thanks also go to Temple-Inland Forest Products and Texas Cooperative Extension for providing additional research sites in TX. We thank Harry Vanderveer and Ted Moore for providing assistance at the nursery and the Texas Forest Service for donating the seedlings. We also thank Nate Royalty, Bayer Cropscience, for providing the imidacloprid tablets for the project.

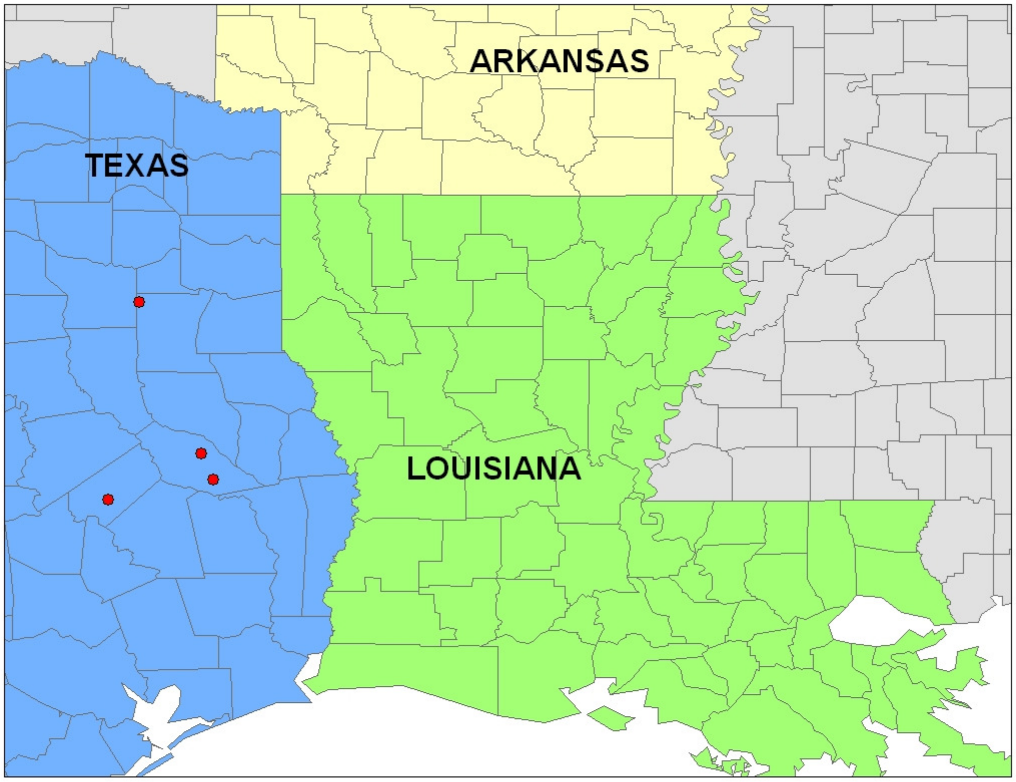

Figure 29. Sites of the Imidacloprid spike and tablet trials (●) established in 2003 -2005 in Angelina, Rusk and Trinity Counties, TX.

Table 37. Effect of imidacloprid + fertilizer or disolfoton + fertilizer plant spikes on pine tip moth infestation of loblolly pine shoots (top whorl) on one site in east Texas, 2003 - 2005.

			Mean Percent Top Whorl Shoots Infested by Tip Moth (Pct. Reduction Compared to Check)																	
Year	Treatment §	N	Gen 1			Gen 2			Gen 3			Gen 4			Gen 5			Overall Mean		
2003	Imidacloprid + Fert.	50	1.0	**74**		1.2	**90**	*	0.0	**100**	*	21.9	**53**	*	41.7	**22**		13.2	**52**	*
	Disulfoton + Fert.	50	3.1	**19**		5.0	**59**	*	4.2	**81**	*	45.3	**2**		60.0	**-12**		23.4	**15**	
	Check	100	3.9			12.3			22.6			46.1			53.4			27.5		
2004	Imidacloprid + Fert.	50	17.3	**-37**		4.7	**57**	*	10.3	**53**	*	22.9	**50**	*	67.7	**-15**		24.4	**18**	*
	Disulfoton + Fert.	50	21.6	**-71**		12.4	**-14**		15.9	**27**		22.2	**51**	*	66.0	**-12**		27.8	**7**	
	Check	100	12.6			10.9			21.9			45.5			59.2			29.8		
2005	Imidacloprid + Fert.	50	21.6	**-69**		6.5	**-67**		1.2	**14**		34.9	**-13**		25.7	**-31**		18.0	**-30**	
	Disulfoton + Fert.	50	17.9	**-41**		2.1	**46**		1.4	**1**		51.8	**-68**	*	34.8	**-77**	*	21.6	**-56**	*
	Check	100	12.8			3.9			1.4			30.8			19.7			13.8		

* Means followed by an asterik are significantly different from checks at the 5% level based on Fisher's Protected LSD.
= treatment reduced damage by 75% or better compared to check.

Table 38. Effect of imidacloprid + fertilizer or disolfoton + fertilizer plant spikes on loblolly pine growth on one site in east Texas, 2003 - 2005.

			Mean End of Season Loblolly Pine Seeding Growth Measurements (**Growth Difference (cm or cm^3) Compared to Check)**						
Year	Treatment	N	Height (cm)		Diameter (cm) [a]		Volume (cm^3)		Mean Percent Tree Survival
2003	Imidacloprid + Fert.	50	58.8 *	**9.0**	1.21 *	**0.15**	101.4 *	**29.3**	98 *
	Disulfoton + Fert.	50	54.5 *	**4.7**	1.21 *	**0.16**	95.4 *	**23.3**	96 *
	Check	100	49.8		1.06		72.1		90
2004	Imidacloprid + Fert.	50	161 *	**31**	3.6 *	**0.5**	2223 *	**698**	94
	Disulfoton + Fert.	50	152 *	**22**	3.6 *	**0.6**	2314 *	**790**	94
	Check	100	129		3.0		1525		87
2005	Imidacloprid + Fert.	50	282 *	**44**	3.4 *	**0.9**	3566 *	**1542**	94
	Disulfoton + Fert.	50	271	**33**	3.2 *	**0.7**	3267 *	**1243**	92
	Check	100	238		2.5		2024		87

[a] Diameter taken at 6" above ground in 2003 and 2004; at breast height in 2005.

* Means followed by an asterik are significantly different from checks at the 5% level based on Fisher's Protected LSD.

Table 39. Effect of tablets containing imidacloprid alone or combined with fertilizer at different rates on pine tip moth infestation of loblolly pine shoots (top whorl) after each of 5 generations on two sites in the Western Gulf Region - 2004 & 2005.

			Mean Percent Top Whorl Shoots Infested by Tip Moth (Pct. Reduction Compared to Check)															
Year	Treatment §	N	Gen 1		Gen 2			Gen 3 **			Gen 4			Gen 5			Overall Mean		
2004	5% Imid.	100	6.2	**-22**	4.6	**76**	*	7.1	**72**	*	6.1	**77**	*	9.2	**67**	*	6.6	**68**	*
	10% Imid.	100	7.9	**-56**	0.9	**95**	*	0.0	**100**	*	4.3	**84**	*	8.2	**70**	*	4.3	**79**	*
	15% Imid.	100	5.2	**-2**	2.7	**86**	*	5.9	**77**	*	8.6	**68**	*	8.0	**71**	*	6.1	**71**	*
	20% Imid.	100	6.2	**-22**	2.2	**88**	*	5.5	**79**	*	4.8	**82**	*	14.9	**47**	*	6.7	**68**	*
	5% Imid. + Fert.	100	6.1	**-20**	8.7	**54**	*	12.0	**53**	*	13.5	**49**	*	23.6	**15**		12.8	**39**	*
	10% Imid. + Fert.	100	7.0	**-39**	6.5	**66**	*	5.8	**77**	*	6.9	**74**	*	11.9	**57**	*	7.6	**63**	*
	15% Imid. + Fert.	100	4.6	**10**	3.2	**83**	*	0.7	**97**	*	1.7	**94**	*	6.4	**77**	*	3.3	**84**	*
	20% Imid. + Fert.	100	3.4	**34**	2.6	**86**	*	1.4	**94**	*	8.2	**69**	*	14.1	**49**	*	5.9	**72**	*
	Fert. only	100	9.7	**-92**	7.5	**60**	*	13.1	**49**	*	17.0	**36**	*	15.4	**45**	*	12.6	**40**	*
	Mimic spray	100	8.2	**-62**	2.8	**85**	*	0.5	**98**	*	6.9	**74**	*	3.1	**89**	*	4.3	**79**	*
	Check	100	5.1		18.9			25.6			26.5			27.8			20.8		
2005	5% Imid.	100	9.3	**-51**	11.0	**48**	*	21.0	**5**		31.5	**-31**		29.5	**9**		21.0	**3**	
	10% Imid.	100	6.3	**-2**	13.5	**36**		17.4	**21**		25.0	**-4**		9.3	**71**	*	14.8	**32**	*
	15% Imid.	100	5.2	**16**	9.1	**57**	*	10.9	**50**	*	18.5	**23**		24.9	**23**		13.5	**37**	*
	20% Imid.	100	5.5	**12**	11.7	**44**	*	10.1	**54**	*	13.2	**45**	*	13.7	**58**	*	11.0	**49**	*
	5% Imid. + Fert.	100	12.5	**-102**	10.2	**52**	*	14.3	**35**	*	25.2	**-5**		26.0	**20**		17.9	**17**	
	10% Imid. + Fert.	100	6.7	**-9**	16.5	**22**		11.7	**47**	*	14.9	**38**		20.7	**36**	*	14.3	**34**	*
	15% Imid. + Fert.	100	5.8	**7**	15.3	**27**		8.4	**62**	*	18.3	**24**		18.2	**44**	*	13.3	**39**	*
	20% Imid. + Fert.	100	9.2	**-48**	17.8	**16**		7.2	**67**	*	15.7	**35**		14.3	**56**	*	13.3	**38**	*
	Fert. only	100	4.4	**29**	20.6	**3**		10.3	**53**	*	16.9	**30**		19.3	**40**	*	14.9	**31**	*
	Mimic spray	100	6.1	**1**	4.9	**77**	*	3.6	**84**	*	2.2	**91**	*	3.0	**91**	*	4.0	**82**	*
	Check	100	6.2		21.1			22.0			24.1			32.5			21.6		

* Means followed by an asterik are significantly different from checks at the 5% level based on Fisher's Protected LSD.

= treatment reduced damage by >75% compared to check.

Table 40. Effect of tablets containing imidacloprid alone or combined with fertilizer at different rates on loblolly pine growth and tree survival after one season on two sites in east Texas, 2004 & 2005.

		Mean End of Season Tree Measurements (**Growth Difference (cm) Compared to Check**)											
		Height (cm)						Diameter (cm)					
Treatment	N	2004			2005			2004			2005		
5% Imid.	100	48.8		**-2.1**	125.7		**-8.1**	0.75	*	**-0.2**	2.27		**-0.2**
10% Imid.	100	48.3		**-2.5**	115.6	*	**-18.1**	0.80		**-0.1**	2.09		**-0.4**
15% Imid.	100	43.8	*	**-7.1**	117.2	*	**-16.6**	0.68	*	**-0.2**	2.00		**-0.5**
20% Imid.	100	50.0		**-0.9**	130.8		**-3.0**	0.89		**0.0**	2.51		**0.0**
5% Imid. + Fert.	100	54.8		**3.9**	141.7		**8.0**	1.03		**0.1**	2.89		**0.4**
10% Imid. + Fert.	100	45.0		**-5.8**	121.0		**-12.7**	0.72	*	**-0.2**	2.12		**-0.3**
15% Imid. + Fert.	100	39.4	*	**-11.4**	105.7	*	**-28.0**	0.60	*	**-0.3**	1.86		**-0.6**
20% Imid. + Fert.	100	50.5		**-0.4**	138.7		**5.0**	0.88		**0.0**	2.08		**-0.4**
Fert. only	100	42.9	*	**-8.0**	117.9		**-15.8**	0.75	*	**-0.2**	2.50		**0.0**
Mimic spray	100	47.8		**-3.1**	135.7		**2.0**	0.85		**-0.1**	2.59		**0.1**
Check	100	50.9			133.7			0.93			2.47		

* Means followed by an asterik are significantly different from checks at the 5% level based on Fisher's Protected LSD.

Table 41. Effect of tablets containing imidacloprid alone or combined with fertilizer at different rates on loblolly pine growth and tree survival after one season on two sites in east Texas, 2004 & 2005.

		Mean Volume (cm^3) (**Growth Difference (cm^3) Compared to Check**)						Mean % Tree Survival			
Treatment	N	2004			2005			2004		2005	
5% Imid.	100	49.9	**-18.9**		1039	**-235**		70	**1**	66	**3**
10% Imid.	100	60.6	**-8.1**		992	**-282**		61	**-12**	55	**-14**
15% Imid.	100	31.9	**-36.8**	*	758	**-516**		55	**-20**	50	**-22**
20% Imid.	100	89.1	**20.3**		1639	**365**		64	**-7**	59	**-8**
5% Imid. + Fert.	100	104.6	**35.9**	*	1798	**524**		70	**1**	64	**0**
10% Imid. + Fert.	100	40.7	**-28.0**		966	**-308**		60	**-13**	56	**-13**
15% Imid. + Fert.	100	34.2	**-34.5**		815	**-459**		58	**-16**	52	**-19**
20% Imid. + Fert.	100	81.7	**13.0**		1077	**-197**		67	**-3**	59	**-8**
Fert. only	100	43.3	**-25.4**		1222	**-52**		58	**-16**	55	**-14**
Mimic spray	100	58.7	**-10.1**		1534	**260**		72	**4**	70	**9**
Check	100	68.8			1274			69		64	

* Means followed by an asterik are significantly different from checks at the 5% level based on Fisher's Protected LSD.

Table 42. Effect of tablets containing imidacloprid alone or combined with fertilizer at different rates on pine tip moth infestation of loblolly pine shoots (top whorl) after each of 5 generations on one site in the Western Gulf Region - 2005.

		Mean Percent Top Whorl Shoots Infested by Tip Moth (**Pct. Reduction Compared to Check**)																	
Treatment §	N	Gen 1			Gen 2			Gen 3			Gen 4			Gen 5			Overall Mean		
10% Imid.	50	0.0	**100**		0.6	**66**		0.0	**100**	*	0.0	**####**		0.0	**100**	*	0.0	**100**	*
20% Imid.	50	0.7	**18**		0.8	**53**		0.0	**100**	*	0.0	**####**		0.0	**100**	*	0.2	**96**	*
20% Imid. + Fert.	50	0.0	**100**		0.0	**100**		0.0	**100**	*	0.0	**####**		0.0	**100**	*	0.0	**100**	*
20% Imid. + Fert. + Merit spray	50	0.4	**52**		1.4	**17**		1.0	**91**	*	0.0	**####**		0.0	**100**	*	0.7	**88**	*
Merit® spray	50	0.5	**40**		0.4	**74**		0.4	**96**	*	6.6	**####**	*	5.4	**62**	*	2.8	**53**	
Pounce® spray	50	6.0	**-619**	*	2.4	**-40**		4.1	**64**	*	2.9	**####**		6.5	**54**		4.2	**29**	
Check	50	0.8			1.7			11.2			0.0			14.0			5.9		

* Means followed by an asterik are significantly different from checks at the 5% level based on Fisher's Protected LSD.

= treatment reduced damage by >75% compared to check.

Table 43. Effect of tablets containing imidacloprid alone or combined with fertilizer at different rates on loblolly pine growth and tree survival after one season on one site in east Texas, 2005.

Treatment	N	Mean End of Season Tree Measurements (**Growth Difference (cm or cm^3) Compared to Check**)								Mean % Tree Survival (**Pct. Gain Compared to Check**)	
		Height (cm)		Diameter (cm)			Volume (cm^3)				
10% Imid.	50	32.5	**1.4**	0.52		**0.04**	10.8		**0.8**	68	**-3**
20% Imid.	50	32.1	**1.0**	0.50		**0.02**	10.1		**0.1**	54	**-23**
20% Imid. + Fert.	50	31.0	**-0.1**	0.44		**-0.04**	6.9		**-3.1**	58	**-17**
20% Imid. + Fert. + Merit spray	50	33.1	**2.0**	0.56	*	**0.08**	12.8	*	**2.8**	74	**6**
Merit® spray	50	30.7	**-0.5**	0.50		**0.02**	9.3		**-0.7**	74	**6**
Pounce® spray	50	30.6	**-0.5**	0.47		**-0.01**	8.1		**-1.9**	62	**-11**
Check	50	31.1		0.48			10.0			70	

* Means followed by an asterik are significantly different from checks at the 5% level based on Fisher's Protected LSD.

PINE TIP MOTH TRIALS

Summary and Registration Status of Tested Systemic Insecticides

Over the past 8 years (1998 – 2005), the WGFPMC has been monitoring and assessing the impact of pine tip moth on pine tree growth. It has been well established through our impact, hazard-rating and control trials that this insect significantly impacts growth and form, at least in the short term. However, several questions remain to be answered in their entirety, particularly 1) What is the long term impact of tip moth on tree growth and 2) what are the primary factors that influence the occurrence and severity of tip moth infestations? During the past four years we have established 44 impact plots and 76 hazard-rating plots in the Western Gulf Region and accumulated a large pool of data from which to address these two questions. Regression analyses continue to determine the damage threshold for impact on tree growth and relationship between time and extent of tip moth protection and tree growth. Andy Burrows, Temple-Inland, developed a preliminary hazard-rating model that has identified site index and soil texture composition as the two primary factors that influence the occurrence and severity of pine tip moth damage. This models needs to be validated with data from various sites. It is important that evaluations and data collections continue on already established impact and hazard-rating sites in 2006 and beyond and that new sites be established.

Fipronil: Over the past four years (2002 – 2005), 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 and 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 Termidor® formulation of fipronil was initially used as part of the Seedling Treatment Trial (2002). Although the results were good, subsequent trials with Regent®-treated seedlings consistently have had less tip moth damage and better volume growth compared to seedlings treated with Termidor® at the same rate. Regent® may have other advantages; it is already registered for in-furrow use and it has a much larger market than Termidor®.

The treatment of pine seedlings in the nursery, prior to lifting, would 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. The hope had been that because many pine seedling nurseries grow seedlings on a four-year rotation (two years in seedlings and two years in cover crops), EPA might 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 2004 and 2005 trials by applying fipronil at 2X, 4X, 8X and 16X the annual rate. Unfortunately, none of the treatments was found to be effective in reducing tip moth damage.

Three methods of treating bare root seedlings after lifting were evaluated in 2003 and 2004: root soak, root dip or plant hole treatment. All three treatment techniques proved to be effective in reducing tip moth damage at least through the first year. The root dip and plant hole treatments provide extended protection into the second year, but only the high rate plant hole treatment significantly reduced damage through the third year. However, there was concern about the potential for excessive chemical exposure when treating or handling treated bare root seedlings. Given these concerns and limitations, it was decided to focus on the development of treatments made at or post plant of seedlings.

A soil injection trial established in 2005 again showed that this application technique is consistently effective in reduce pine tip moth damage.

At least one forest industry has experimented with a ‘puddle planter”, developed by Mr. Kevin Darrow (formerly with Pelton Reforestation Inc.), that ‘injects’ water or fertilizer solutions into plant furrows while machine planting seedlings. This would seem to be a safe and time-efficient way of treating bare root seedlings with fipronil. Mr. Darrow has provided some guidance in the development of an application system that would be attached to a machine planter and allow treatment of seedlings with fipronil while they are planted.

Fipronil treatments with containerized seedlings and rooted cuttings also were highly effective in reducing tip moth damage in 2004. As this segment of the seedling market is continuing to build, a safe and efficient method of treating these containerized and rooted cutting seedlings in trays should be developed.

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. Additional planting trials will be needed in the future to evaluate the operational use of Regent® in combination with different application techniques.

BASF has shown considerable interest in the potential market of fipronil for treating pine seedlings. This is apparent by their generous gifts ($50,000 in 2005 and $24,000 in 2006) to support the WGFPMC research projects. Dr. Harry Quicke has indicated that BASF will submit a package to EPA to register a formulation of fipronil for use to protect conifers against pine tip moth in 2006. **BASF anticipates that product registration will take about 18 months so the product should be available for use for the winter 2007/2008 planting season.**

Imidacloprid: Imidacloprid has been shown in the past to be highly effective in reducing tip moth damage levels on treated seedlings. However, the cost of treatment per seedling had been a deterrent to its registration for forestry use (Scott Cameron, personal communication). Recently, Bayer Environmental Science has registered imidacloprid/fertilizer spikes (Advance Garden™ 2-in-1 plant spikes) for residential use against tip moth. Although the plant spikes have performed well in a single trial replicates (Technique and Rate Trial, 2003-2004), again the cost of treatment per seedling for operational forestry use would be prohibitive.

Bayer Environmental Science also is looking at the potential market for an imidacloprid tablet. One area of interest is the protection of seedlings against tip moth. The 2004 and 2005 trials indicate the tablets show considerable promise. In addition to providing good protection against tip moth in the first year after planting, it is possible that these tablets could be mass-produced at relatively low cost. However, one problem arose in 2004 and 2005. There was an absence of treatment effect during the first tip moth generation. This suggests that concentrations of imidacloprid had not reached high enough levels in the shoots to reduce damage levels until after the first generation. One reason may be that the tablets were too tightly packed, thus preventing a quick release of chemical early in the year. 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 2006. In addition, a new trial is planned for 2006 that will evaluate several new tablet, granular and gel formulations. Bayer is encouraged by the results of these trials as well as other trials on the East Coast. **They have indicated tentative plans to submit a proposal for registration of the imidacloprid tablets to EPA by the fall of 2006 (Nate Royalty, Bayer, personal communication).**

REGENERATION WEEVILS

Fipronil for Protection of Pine Seedlings – East Texas

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.

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.

Study Sites: Two first-year plantations were selected near Quitman and Livingston, Texas.

Population Monitoring: Regeneration weevil were 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.

Insecticides:
Fipronil – Regent® 4SC (4.0 lbs ai/gal),

Design: Randomized complete block design at each site with beds or site areas serving as blocks, i.e., each treatment was randomly selected for placement along a bed. Ten seedlings from each treatment were planted on each of five beds. 2 sites X 4 treatments X 100 trees = 800 monitored trees.

Treatments:

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).

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 consisted 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 served as a check.

Treatment Evaluation: All seedlings were evaluated monthly for weevil feeding damage from February through November. The amount of damage on each seedling was 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)

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

Results:

Severe drought conditions in the northern (Quitman) site caused significant mortality of seedlings planted early in the year (i.e. check and soil injected). Plus the landowner used a brushhog to create a hunting lane through one or more of the plots. Thus, this site was not included in the data analysis.

In the southern (Livingston) site, weevils began to emerge and cause damage to seedlings in March. At first there were no differences among treatments in the level of weevil-caused damage or mortality. However, from April through the remainder of the year, seedlings treated with fipronil by soil injection experienced significantly less mortality than those of the other treatments (Figure 30). Survival of seedlings with any fipronil treatment was significantly greater than the check (Figure 31).

Conclusions:

Data from this study as well as the operational trial (2003) indicates that fipronil has some activity against regeneration weevils. Both trials indicate that survival of seedlings can be improved with fipronil treatments, but not prevented. The fact remains that the weevils need to chew through the bark and feed on the cambial tissue of the seedling in order to be exposed to the fipronil within the seedling. If weevil populations are high, enough feeding damage can occur on seedlings to cause mortality to a portion of the trees. Fipronil can be used to reduce potential mortality, but it is the author's opinion that better protection of seedlings will nearly always be obtained from the use of contact poisons such as permethrin.

Acknowledgments: Thanks go to Jeff Waits and International Paper Co. for providing the research sites in TX. We thank Harry Vanderveer and Ted Moore for providing assistance at the nursery and the Texas Forest Service for donating the seedlings. We also thank Harold Quicke, BASF, for providing the fipronil for the project.

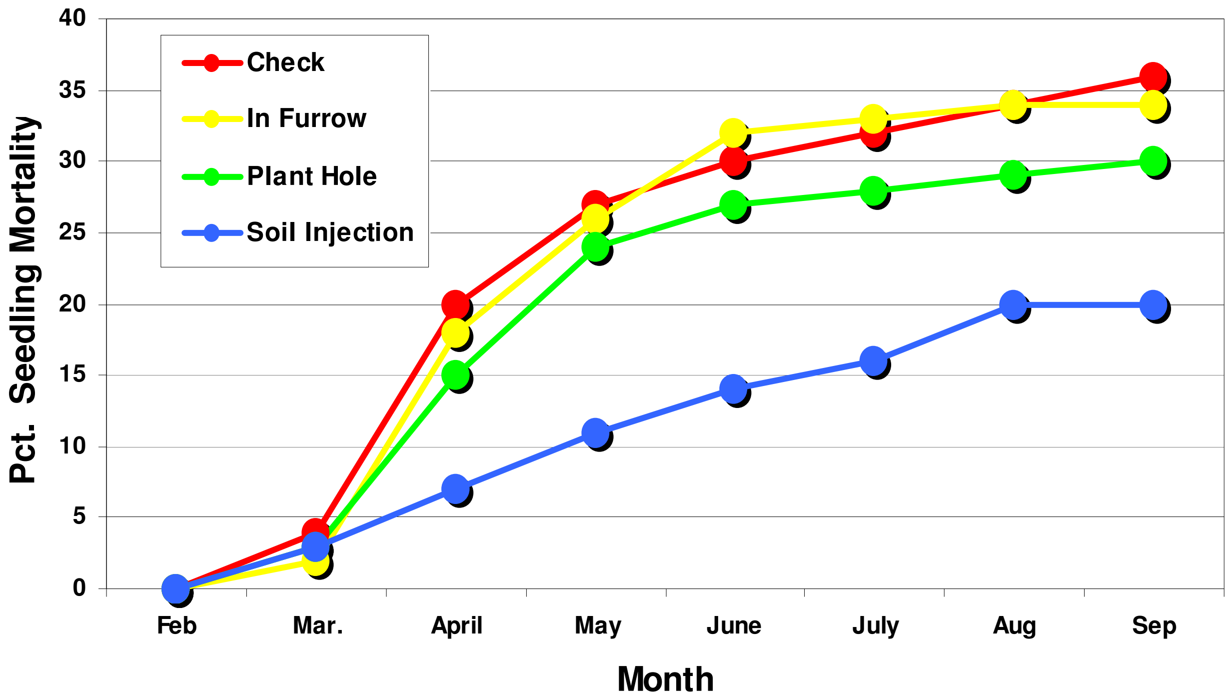

Figure 30. Progression of pine seedling mortality caused by pine regeneration weevils; Livingston, Texas, 2005.

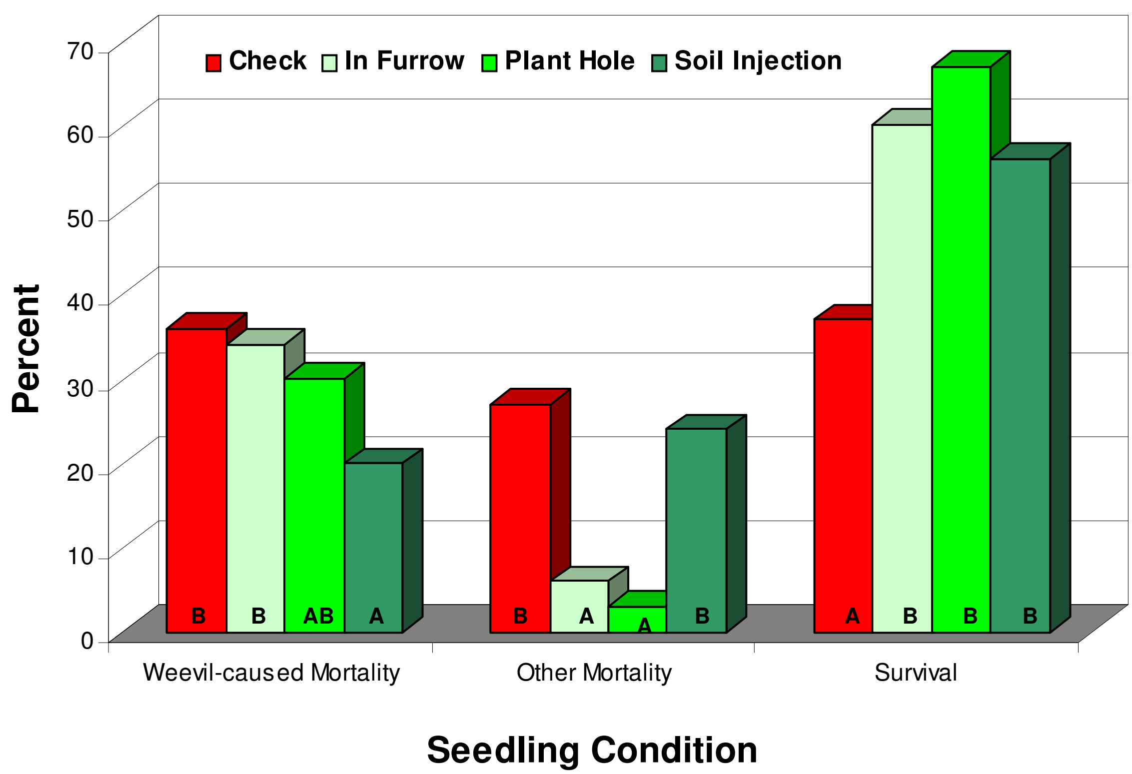

Figure 31. Condition of pine seedlings in September 2005 after attack by pine regeneration weevils; Livingston, Texas, 2005.

2005 Expenditures vs. Budget

Expenditures to operate the WGFPMC for CY 2005 totaled $187,575 (Table 44). This was $8,244 more than the projected $179,331 budget (Table 45 and 46) due to the hiring of a research specialist (Jason Helvey) in April. Sources of funding to cover expenses were derived from membership dues (39%), the SPBI federal grants for systemic injection and industry grant from BASF (20%), and the Texas Forest Service (41%). Of this total, 88% was devoted to professional salaries, fringe benefits, and seasonal wages, and the remainder (12%) to equipment, operating expenses, and indirect costs. Overall, WGFPMC account expenditures exceeded available funds by $1,743. Due to the federal and corporate grants ($79,942), we currently have a surplus of $41,505 in these accounts at the end of CY 2005. As a result, membership dues will remain at $8,000 per full member and $2,500 per associate member in CY 2006.

Emergency funds totaling $24,000 (rediscovered WGFPMC funds from FY2000 and 2001) were being held in a separate account awaiting a decision on how to spend them.

Table 44. WGFPMC Expenditures by Source of Funding - CY 2005

	Source			Total	% of Total
	WGFPMC	TFS	Fed./Ind. Grants *		
A. Salaries and Wages					
Principal Investigator (Grosman) (100%)	$ 14,747 (26%)	$ 41,929 (74%)	$ 0	$ 56,676	
Research Specialist (Helvey) (100%)	4,732 (20%)	0	18,931 (80%)	23,663	
Staff Forester (Upton) (75%)	12,002 (30%)	16,831 (45%)	0	28,833	
SPB Specialist (Murphrey) (9%)	3,422 (9%)	0	0	3,422	
2.5 Seasonal Technicians (4 mos. ea.)	16,924	0	2,332	19,256	
Total Salaries and Wages	$ 51,827	$ 58,760	$ 21,262	$ 131,850	
B. Fringe Benefits / TFS Matching	$ 11,436	$ 16,592	$ 4,273	$ 32,301	
	63,263	75,352	25,536	164,151	88%
C. Operating Expenses					
Supplies	$ 2,279	$ 0	$ 3,680	$ 5,959	
Vehicle Use and Maintainance	1,837	0	5,659	7,497	
Travel	3,121	0	1,171	4,291	
Telecommunications (15% of PCS)	547	0	0	547	
Utilities (15% of PCS)	0	1,165	0	1,165	
Other Services	1,959	0	200	2,159	
(rentals, publications, postage, etc.)					
Total Operating Expenses	$ 9,744	$ 1,165	$ 10,710	$ 21,619	12%
Indirect Costs (26%)			1,805	1,805	
Grand Total	$ 73,007	$ 76,517	$ 38,051	$ 187,575	
% of Total	39%	41%	20%	100%	100%

* Grant funds remaining from 2004; grant awarded to TFS from the Southern Pine beetle Initiative to evaluate systemic insecticide injection treatment of trees for protection from southern pine beetle (Jan 1 - Dec 31, 2005); and grant donations from BASF for evaluation of fipronil.

	WGFPMC	TFS	Fed./Ind. Grants *
Funding Available from January 1 - December 31, 2005	$ 71,264		$ 79,942

Table 45. WGFPMC Proposed Budget by Source of Funding - CY 2005

	Source			
	WGFPMC	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 &	$ 10,887	$ 18,939	$ 29,826	
8% of Wages)	58,992	98,011	157,003	88%
C. Operating Expenses				
Supplies	$ 2,748	$ 2,500	$ 5,248	
Vehicle Use and Maintainance	5,324	1,510	6,834	
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	2,200	2,000	4,200	
(rentals, publications, postage, etc.)				
Total Operating Expenses	$ 12,272	$ 9,610	$ 21,882	12%
Grand Total	$ 71,264 ***	$ 107,621	$ 178,885	
% 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 $904 for WGTIP seed analysis = $71,264.

Table 46. WGFPMC Proposed Budget by Source of Project - CY 2005

	Activity					
	Administration	Tip Moth Studies		Systemic	LCA and Weevil	
	Site Visits/Service	(Impact & HR)	(Systemic Trt)	Injection Studies	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	$ 2,504	$ 2,070	$ 2,070	$ 2,820	$ 1,320	$ 10,784
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	$ 41,587	$ 32,176	$ 36,838	$ 48,704	$ 19,579	$ 178,885