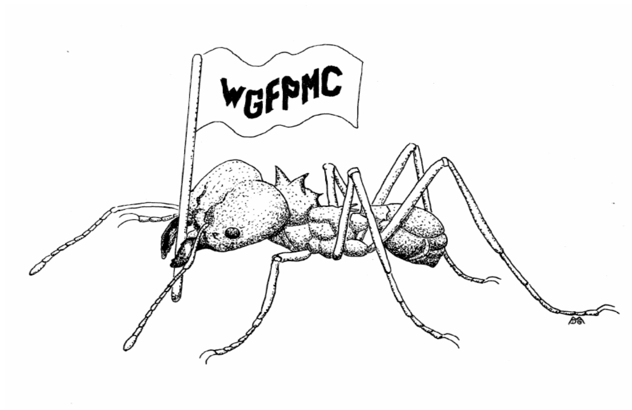
Western Gulf Forest Pest Management Cooperative



Report on
Research Accomplishments in 2004

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Executive Summary

The Western Gulf Forest Pest Management Cooperative (WGFPMC) made significant strides in 2004. 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 2003. These projects contained twelve 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 2005 Project Proposals.

Membership in the WGFPMC did not change in 2004. **Thank you for your continued support!**

Seasonal technicians, Jamie Burns, Valena Bryan, Brian Pope, Billy Whitworth and Dustin Hollowell 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 Libor Myslevic, a 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 104 phone/e-mail requests were addressed relating to the following topics: leaf-cutting ants/Volcano®, pine tip moth, reproduction weevils, bark beetles (southern pine beetle, *Ips* and black turpentine beetle), cone and seed insects (coneworms and seed bugs), pitch canker and shoot dieback, spiders, and cypress looper.

Given that Volcano® leafcutter ant bait is expected to be phased out in 5 - 8 years, trials were conducted in 2001 to evaluate the effectiveness of another citrus pulp bait containing the active ingredient fipronil (Blitz®, produced by Aventis). As a result of these trials, a proposal was submitted to the Environmental Protection Agency (EPA) to register this formulation in the U.S. under the new product name "BES 100." We still await final EPA approval. In the mean time, a small study was completed in 2004 to evaluate the effectiveness of a "new" product called Grant's Total Ant Killer Bait. It was found to have the same formulation and efficacy as the old Amdro® leaf-cutting ant bait. Only 25% of the colonies were killed after a single application of the Grant's bait

Rainfall (78+ inches) in 2004 was more than 30 inches above normal (46+ inches) in Lufkin! Most areas in the Western Gulf Region also received above average rainfall. Northern east Texas was one of the few areas that was dry, particularly early in the year. Several other areas had a relatively short period of drought in August and September before the rains came back in earnest in the fall. The high moisture levels during the fall months perhaps set the stage for an outbreak of pitch canker and shoot dieback in several loblolly and slash pine stands in Texas and Louisiana. Disease damage has been observed to be light to moderate in 4 – 6 year old loblolly stands and heavy in one 18-year old stand.

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 again were low in the spring but rebounded markedly in several locations by mid-summer. Due, in part, to the presence of a very small cone crop in several Western Gulf seed orchards, coneworm and seed bug pressure was very high. At one site, nearly 2/3 of the potential seed crop was lost due to these insects. On the positive side, no infestations of the southern pine beetle were reported in Texas, Louisiana, Arkansas or Oklahoma in 2004. However, 50 – 60 southern pine beetle infestations were reported to have developed on state and national forests in Mississippi.

Progress continues on the evaluation and development of systemic insecticides and injection systems. For the sixth year in a row, loblolly seed orchard trees injected a single time in 1999 with emamectin benzoate alone or combined with thiamethoxam had significantly reduced levels of coneworm damage. A manuscript tentatively entitled "Systemic insecticide injections for control of cone and seed insects in loblolly pine seed orchards – 6-year results" is in preparation. A second study, initiated in 2003, was continued to determine the duration of different applications of Denim® (emamectin benzoate) and two formulations of fipronil using three different injection systems. Cone and seed insect control in the second year was markedly improved compared to the first year.

Two new injection trials were initiated in 2004 to evaluate the potential of systemic insecticide injections for protection of acorn crops in hardwood seed orchards from acorn weevil and high-valued pine trees from pine bark beetles. None of the insecticide products tested in the hardwood seed orchard proved to be effective in reducing losses due to acorn weevils. In contrast, emamectin benzoate and fipronil were found to be highly effective in preventing the colonization and mortality of stressed loblolly pines by *Ips* engraver beetles. A manuscript entitled "Efficacy of systemic insecticides for protection of single trees against southern pine engraver beetles (Coleoptera: Scolytidae)" also is in preparation. As result of the finding in the bark beetle trial, a secondary trial was initiated in the fall of 2004 to evaluate the potential of emamectin benzoate and fipronil in preventing the colonization of wood from injected trees by termites.

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 2004. Forty-one impact plots on 25 sites are now established in the Western Gulf Region. An additional 12 hazard-rating plots were established in 2003, bringing the total to 73. The analysis of impact data and development of a hazard-rating model is ongoing. Mr. Andy Burrow, Temple-Inland, has take over the development of the model. A final report will be provided to members in the spring 2005.

Systemic insecticide trials revealed that 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 second growing season. Three fipronil technique and rate refinement trials were established on 14 sites across the South. All trials again showed that fipronil applied by root soaks and dips and in plant holes provides excellent protection during the first 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 second year after planting compared to untreated areas. A pilot test conducted in 2003 showed that imidacloprid plus fertilizer spikes, pushed into the soil near newly planted seedlings, significantly reduced tip moth damage until the middle of the second growing season and improved growth compared to check trees. A related trial 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.

LEAF-CUTTING ANT

Grant's Bait Trial - East Texas

Highlights:

- The production and sale of Volcano® Leafcutter Ant Bait has been discontinued pending the purchase of the remaining supply of technical sulfluramid by Red River Specialties from DuPont.
- A registration package was submitted to EPA in 2002 to register the Blitz® formulation in the U.S. under the new product name "BES 100." EPA has yet to approve the registration.
- A 'new' ant bait, Grant's Kills Ants® Total Ant Killer Bait, was registered in TX and LA in late 2003. A small trial was initiated in December 2003 to evaluate its efficacy against the Texas leaf-cutting ant. The bait was effective only 25% of time in halting ant activity after 16 weeks.

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. Grant Laboratories, CA, has recently acquired the rights to the 'old' Amdro leaf-cutting ant bait. They are now marketing this same bait under the name 'Grant's Kills Ants® Total Ant Killer Bait'. This bait was approved for registration in TX in November 2003.

Objective: Reevaluate the efficacy of the hydramethylnon/corn grit bait formulation (Grant's Kills Ants® Total Ant Killer Bait) in reducing activity in Texas leaf-cutting ant colonies.

Study Sites: Active colonies (13) were located in east Texas on lands owned by Texas Forest Service, Temple-Inland and private landowners.

Insecticide:

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

Grant's Kills Ants® Total Ant Killer 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).

<u>Bait</u> - Loose bait spread evenly over entire CNA at ¾ lb per colony in December 2003 and February 2004.

<u>Check</u> - untreated colonies

Application Dates:

Early Winter 2003: Treatments applied to 3 colonies in December.

Late Winter 2004: Treatments applied to 5 colonies in February.

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

Results:

Efficacy Trial: - Colonies treated in December 2003 were not rechecked until 8 weeks post-treatment treatment (Table 1). The activity of treated colonies in early February and April 2004 was somewhat lower than that of untreated colonies, but none became inactive even after 16 weeks post-treatment.

Treatments made in February 2004 were generally more effective with 3 of 5 colonies being inactive after 8 weeks post-treatment. However, one of these 3 colonies recovered after 16 weeks. Overall, the mean level activity for the 3 surviving treated and untreated colonies was very similar after 16 weeks.

Acknowledgements: Thanks go to I.N Brown, TFS, Temple-Inland and several private landowners who provided access to ant colonies. We appreciate the donation of ant bait made by Grant Laboratories, CA for the trial.

Table 1. Efficacy of Grant's Total Ant Killer Bait (hydromethylnon) applied over central nest area to control the Texas leaf-cutting ant (*Atta texana*) in East Texas (Dec. 2003 and Feb. 2004).

Treatment	Period Colonies Treated	No. of Colonies Treated	Mean Nest Area (m^2)	Mean # Mounds @ Trt.	Mean % initial activity [a] (% inactive colonies): 2 wk		8 wk		16 wk	
Grant's Total Ant Killer Bait® spread over CNA @ 340g/ colony	12/15	3	46	95	----	----	69.7	(0)	65.2	(0)
	2/20 - 2/27	5	31	87	36.2	(60)	92.2	(60)	34.1	(40)
		8	37	90	36.2	(60)	85.3	(38)	51.9	(25)
Check (no treatment)	12/15	2	49	102	----	----	80.3	(0)	98.6	(0)
	2/20 - 2/27	3	24	90	139.0	(0)	160.5	(0)	46.8	(0)
		5	34	95	139.0	(0)	128.4	(0)	67.5	(0)
	Total	13								
	Mean		36	92						

CNA = Central Nest Area

Summary and Registration Status of Leaf-cutting Ant Control Options

Based on our previous experience with Amdro® in the mid-1990s, if the Grant's bait was to be effective against leaf-cutting ants, we should have seen very little or no activity 8 weeks after treatment. However, all colonies in December were very active after 8 weeks. The bait did show some efficacy during the February trials with at least 2 of the 5 colonies going completely inactive after 8 weeks.

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°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.

Note: In January 2005, it was announced that Ambrands was making available a new product, Amdro® Ant Block Home Perimeter Ant Bait. I was informed by the company that this is not same formulation as the old Amdro® and new Grant's bait. It apparently contains more sugars that should make it more attractive to leaf-cutting ants. Ambrands has agreed to provide a case of bait for testing. We'll soon find out if their claim is true.

The future availability of Volcano® is 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. However, DuPont has yet to sell the technical material to Red River Specialties. No one seems to know why DuPont is dragging its feet on the sale. As a result of the delay, shipments of bait from Mexico have been discontinued indefinitely.

In early 2002, Bayer CropScience (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 is to be restricted to licensed applicators. After nearly three years, EPA has yet to approve the registration of BES-100. In June 2004, Don Grosman was informed by Mr. Adrian Krygsman, (Bayer registration manager for BES-100) that EPA had completed their internal review of the registration package. The review, forwarded to Don Grosman, requested clarification on several points and recommended changes to the dose chart. All suggested changes were approved and the review was sent back to EPA. Mr. Krygsman had expected that EPA would give final approval for the registration of BES-100 within one to three months. However, in January 2005 we were informed that the registration package was being held up by an environmental fate review in EPA. Bayer was informed that they have two options. One was to pay a fee to obtain final approval, although it still may be held up in review. The other option was to request a Special Local Need (24c) registration in Texas and Louisiana. Bayer is currently contacting the Department of Agriculture of these states to determine if a 24c is possible. Another potential problem is where the bait will be manufactured. The original Blitz bait is manufactured in Brazil in a plant apparently now owned by BASF. Agreements between Bayer and BASF may be in place that will allow Bayer to sell the future BES-100 in the United States. Unfortunately, Bayer is uncertain if this will be possible. The WGFPMC will continue to work with Bayer towards the registration of this product.

In the mean time, landowners have no safe <u>and</u> effective means of controlling leaf-cutting ants. Methyl bromide is still registered for use against leaf-cutting ants. Although effective, it is highly toxic, very expensive and the applicator equipment is difficult, if not impossible, to find. The Grants' bait and new Amdro® 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

Duration Study - Magnolia Springs, TX

Highlights:

- Single and double Systemic Tree Injection Tube (STIT) injections of treatments containing emamectin benzoate continued to reduce coneworm damage by 76 - 83% in 2004 – 6 years after initial injection.
- STIT injection treatments containing emamectin benzoate or thiamethoxam did not significantly reduce seed bug damage or improve filled seed yield in 2003 – 72 months post treatment. Control of seed bugs will require yearly injections.

Objectives: 1) Continue evaluations on the residual activity of emamectin benzoate and emamectin benzoate/thiamethoxam mixture, applied by the STIT injector in 1999 and 2000 for control of coneworms and seed bugs in loblolly pine seed orchards.

Study Site: 20 acre “082” orchard (drought-hardy loblolly pine) removed from production in 1995 -- Texas Forest Service Magnolia Springs Seed Orchard, Jasper Co., TX.

Insecticides:

Emamectin benzoate (Arise SL®) -- avermectin derivative

Thiamethoxam (Novartis 293) -- experimental insecticide formulation with similar activity compared to imidacloprid.

Design: Randomized complete block with clones as blocks. 10 treatments X 10 clones reduced to 5 treatments X 10 clones (= 50 ramets) used for study in 2004.

Application Methods:

STIT Injection – In 1999 and 2000, a 3/8 in diameter hole, 11 cm (4.5 in) deep was drilled parallel to the ground; number of holes was equal to the volume of insecticide solution to be applied divided by 50 ml (the capacity of each injector); holes were placed at a height of 1 m. -- the prefilled STIT injector (Helson et al. 2001) was hammered into the drill hole, and pressurized to 50 psi. Most treatment solutions drained within 15 minutes. The volume of insecticide solution applied was based on the diameter of each treatment tree as follows:

Tree Diameter	Treatments 1 and 2	Treatments 3 and 4
<15 cm	20 ml	40 ml combined
16 - 20 cm	20 - 40 ml	40 - 80 ml
21 - 25 cm	40 - 60 ml	80 - 120 ml
26 - 30 cm	60 - 80 ml	120 - 160 ml
>30 cm	+20 ml/5 cm dia. increment	+40 ml/5 cm dia. increment

Treatments:

1) 4% emamectin benzoate (Arise SL®) by STIT injector (applied April 1999) (N = 10)
2) 4% emamectin benzoate (Arise SL®) by STIT injector (applied April 1999 & April 2000) (N = 10)
3) 1:1 mixture of 4% emamectin benzoate (Arise SL®) and 5% thiamethoxam by STIT injector (applied April 1999) (N = 10)
4) 1:1 mixture of 4% emamectin benzoate (Arise SL®) and 5% thiamethoxam by STIT injector (applied April 1999 & April 2000) (N = 10)
5) Check (untreated) (N = 10)

Data Collection:

***Dioryctria* Attacks** -- All cones that could be reached by bucket truck were picked in early October; 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; seed lots were radiographed (X-ray); seeds were categorized as full seed, empty, seed bug-damaged, 2nd year abort, seedworm-damaged, and other damage.

Conelet and Cone Survival: Data was not collected in 2004.

Results: The orchard block containing the treatment trees had not been sprayed since 1995 and the cone crop on most study trees was small, suggesting that pressure from coneworms and seed bugs would be high. This was confirmed for coneworms by over 43% damage on check cones in 2004; the highest levels observed during the 6 years of this study (Table 2). Fairly high numbers of seed bugs also were observed in trees while evaluating cone survival and collecting cones in the fall. Seed x-ray analysis is on-going, so actual seed bug damage levels are not known at this time.

<u>Treatment Effect on Coneworm Damage</u>: In 1999 and 2000, treatments containing emamectin benzoate (alone or combined with thiamethoxam) significantly reduced early and late coneworm damage compared to the check (Table 2). Overall reductions for both emamectin benzoate alone and emamectin benzoate plus thiamethoxam treatments were >96% compared to the check. Overall reductions declined somewhat in 2001 (range 84% to 91%) and further in 2002 (range 45 to 58%) (Fig. 1). However, the treatment effects improved in 2003; reduction in coneworm damage ranged from 63% to 74%. Protection actually improved further in 2004 with reductions of coneworm damage ranging from 76% to 83%. The addition of thiamethoxam did not improve or reduce the performance of emamectin benzoate against coneworm. Results for two-injection treatments containing emamectin benzoate did not differ significantly from single-injection treatments. Therefore, a single injection of emamectin benzoate is sufficient to protect trees against coneworm for six full years. Only the single and double dose of emamectin benzoate alone saw significantly higher proportions of healthy cones compared to the check, but this treatment did not differ from the two combination injection treatments. Overall, the six-year average for coneworm damage reduction ranges from 74% to 80% (Fig. 1).

<u>Treatment Effect on Seed Bug and Overall Damage:</u> The x-ray analyses of the 2004 seed lots are on-going. A study update will be provided to members once the analyses are completed. However, for now, it may suffice to say that we do not anticipate that any of the treatments

reduced seed bug damage in 2004. None of treatments have significantly reduced damage since 2001 (Table 3, Fig. 2). Treatment effect on overall (coneworm + seed bug) damage in 2004 has yet to be determined. Table 4 and Figure 3 show the results from 1999 – 2003.

Acknowledgements: We appreciate the assistance provided by I.N Brown, TFS Magnolia Springs Seed Orchard Manager, and Don Travis and for the use of the bucket truck. Thanks also go to Tom Byram for allowing us to continue the project even though the orchard block needed to be rogued.

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Helson, B.V., D.B. Lyons, K.V. Wanner, and T.A. Scarr. 2001. Control of conifer defoliators with neem-based systemic bioinsecticides using a novel injection device. Can. Ent. 133: 729-744.

Table 2. Mean percentages (± SE) of cones killed early and late by coneworms, other-damaged cones, and healthy cones on loblolly pine protected with systemic injections of emamectin benzoate (EB) or emamectin benzoate + thiamethoxam (EB + Thia.), Magnolia Springs Seed Orchard, Magnolia Springs, Jasper Co., TX, 1999 - 2004.

				Mean Coneworm Damage (%)				
Year	Treatment	Application Technique, Treatment Date(s)	N	Early (small dead)	Late (large dead and infested)	Total	Mean Other Damage (%) *	Mean Healthy (%)
1999	EB	STIT - Apr., '99	20	1.0 ± 0.3 **a**†	0.3 ± 0.1 **a**	1.3 ± 0.4 **a**	41.3 ± 4.4 **a**	57.4 ± 4.5 **b**
	EB + Thia.	STIT - Apr., '99	20	3.3 ± 0.6 **b**	0.9 ± 0.2 **a**	4.2 ± 0.8 **b**	42.5 ± 3.2 **a**	53.3 ± 3.2 **b**
	Check		10	12.0 ± 1.7 **d**	9.4 ± 2.8 **c**	21.4 ± 3.8 **d**	41.1 ± 2.7 **a**	37.6 ± 3.8 **a**
2000	EB	STIT - Apr., '99	10	0.1 ± 0.1 **a**	0.5 ± 0.3 **a**	0.6 ± 0.3 **a**	47.0 ± 7.7 **a**	52.4 ± 7.8 **a**
	EB	STIT - Apr., '99 & '00	10	0.4 ± 0.3 **a**	0.1 ± 0.1 **a**	0.5 ± 0.3 **a**	60.1 ± 5.9 **a**	39.4 ± 5.9 **a**
	EB + Thia.	STIT - Apr., '99	10	0.2 ± 0.1 **a**	0.5 ± 0.4 **a**	0.7 ± 0.5 **a**	51.6 ± 6.1 **a**	47.8 ± 6.2 **a**
	EB + Thia.	STIT - Apr., '99 & '00	10	0.5 ± 0.3 **a**	0.4 ± 0.2 **a**	0.8 ± 0.3 **a**	55.1 ± 7.2 **a**	44.6 ± 7.3 **a**
	Check		10	4.0 ± 0.9 **b**	17.1 ± 4.2 **b**	21.1 ± 4.3 **b**	51.3 ± 3.6 **a**	27.6 ± 5.0 **a**
2001	EB	STIT - Apr., '99	6	3.3 ± 1.0 **a**	1.8 ± 0.9 **a**	5.0 ± 1.3 **a**	27.1 ± 8.4 **a**	67.8 ± 9.4 **b**
	EB	STIT - Apr., '99 & '00	6	4.3 ± 1.0 **a**	1.1 ± 0.4 **a**	5.4 ± 1.1 **a**	30.7 ± 8.2 **a**	63.9 ± 9.0 **b**
	EB + Thia.	STIT - Apr., '99	6	3.1 ± 1.3 **a**	1.3 ± 0.4 **a**	4.4 ± 1.4 **a**	28.8 ± 7.6 **a**	66.7 ± 8.6 **b**
	EB + Thia.	STIT - Apr., '99 & '00	5	2.8 ± 2.0 **a**	0.3 ± 0.2 **a**	3.1 ± 2.1 **a**	28.3 ± 5.2 **a**	71.4 ± 5.4 **b**
	Check		6	14.9 ± 2.2 **b**	19.2 ± 3.6 **b**	34.2 ± 3.3 **b**	17.3 ± 3.6 **a**	48.5 ± 5.1 **a**
2002	EB	STIT - Apr., '99	10	6.8 ± 1.6 **a**	8.6 ± 1.2 **ab**	15.4 ± 2.5 **a**	10.7 ± 4.3 **a**	74.0 ± 6.2 **ab**
	EB	STIT - Apr., '99 & '00	10	7.4 ± 2.5 **a**	7.1 ± 1.8 **a**	14.5 ± 3.6 **a**	7.8 ± 3.4 **a**	77.7 ± 5.9 **b**
	EB + Thia.	STIT - Apr., '99	9	6.3 ± 1.1 **a**	11.3 ± 2.1 **ab**	17.6 ± 2.6 **a**	12.9 ± 4.9 **a**	69.5 ± 7.1 **ab**
	EB + Thia.	STIT - Apr., '99 & '00	9	5.3 ± 0.7 **a**	8.1 ± 1.4 **ab**	13.5 ± 1.6 **a**	12.5 ± 3.2 **a**	74.0 ± 3.9 **ab**
	Check		10	20.0 ± 3.6 **b**	12.2 ± 1.9 **b**	32.2 ± 4.4 **b**	8.6 ± 2.7 **a**	59.2 ± 4.0 **a**
2003	EB	STIT - Apr., '99	10	5.2 ± 0.9 **a**	1.8 ± 0.6 **a**	7.0 ± 1.0 **a**	13.7 ± 4.6 **a**	79.3 ± 4.9 **ab**
	EB	STIT - Apr., '99 & '00	10	7.0 ± 2.7 **a**	1.5 ± 0.5 **a**	8.5 ± 2.7 **a**	14.0 ± 3.7 **a**	77.4 ± 5.2 **ab**
	EB + Thia.	STIT - Apr., '99	9	6.0 ± 3.0 **a**	4.1 ± 1.6 **a**	10.1 ± 3.0 **a**	14.1 ± 5.3 **a**	75.8 ± 7.6 **ab**
	EB + Thia.	STIT - Apr., '99 & '00	10	6.1 ± 2.2 **a**	1.5 ± 0.7 **a**	7.5 ± 2.7 **a**	11.8 ± 3.5 **a**	80.6 ± 5.4 **b**
	Check		10	16.3 ± 2.2 **b**	10.9 ± 3.4 **b**	27.2 ± 3.6 **b**	7.9 ± 1.9 **a**	64.9 ± 4.5 **a**
2004	EB	STIT - Apr., '99	10	6.1 ± 1.7 **a**	1.4 ± 0.6 **ab**	7.5 ± 2.1 **a**	31.5 ± 5.2 **ab**	61.0 ± 6.8 **b**
	EB	STIT - Apr., '99 & '00	10	8.5 ± 2.5 **a**	1.8 ± 0.5 **ab**	10.2 ± 2.8 **a**	33.1 ± 3.9 **ab**	56.7 ± 3.8 **b**
	EB + Thia.	STIT - Apr., '99	9	9.7 ± 2.6 **a**	0.6 ± 0.3 **a**	10.3 ± 2.6 **a**	37.6 ± 4.9 **b**	52.1 ± 6.2 **ab**
	EB + Thia.	STIT - Apr., '99 & '00	10	7.1 ± 3.1 **a**	0.5 ± 0.3 **a**	7.6 ± 3.1 **a**	39.1 ± 7.3 **b**	53.3 ± 7.6 **ab**
	Check		9	38.7 ± 7.3 **b**	4.7 ± 1.6 **b**	43.4 ± 7.6 **b**	20.8 ± 3.0 **a**	35.7 ± 7.3 **a**

* 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.

Table 3. Seed bug damage, seed extracted, and seed quality (Mean + SE) from second-year cones of loblolly pine protected with systemic injections of emamectin benzoate (EB) or emamectin benzoate + thiamethoxam (EB + Thia.), Magnolia Springs Seed Orchard, Jasper Co., TX, 1999 - 2003.

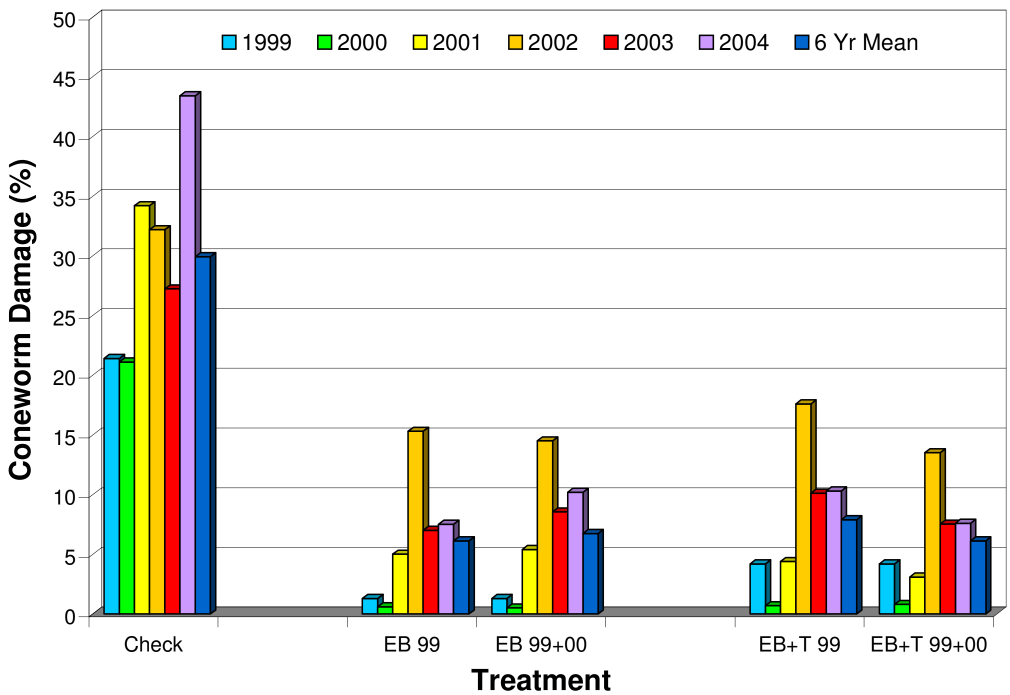
Year	Treatment	Application Technique, Treatment Date(s)	N	Mean Seed Bug Damage (%) Early (2nd Yr Abort)	Mean Seed Bug Damage (%) Late	Mean Seed Bug Damage (%) Total	Mean No. Seeds per Cone	Mean No. Filled Seed per Cone	Mean No. Empty Seed per Cone
1999	EB	STIT - Apr., '99	20	0.7 + 0.2 **b***	34.4 + 3.7 **c**	35.1 + 3.8 **c**	66.4 + 7.0 **a**	32.1 + 6.5 **ab**	13.3 + 2.4 **a**
	EB + Thia.	STIT - Apr., '99	20	0.4 + 0.1 **ab**	24.6 + 3.9 **b**	25.0 + 3.9 **b**	83.1 + 6.9 **a**	48.4 + 6.2 **c**	16.1 + 1.8 **a**
	Check		10	1.7 + 0.3 **c**	51.3 + 5.3 **d**	53.0 + 5.5 **d**	60.2 + 6.9 **a**	18.6 + 5.8 **a**	10.5 + 1.6 **a**
2000	EB	STIT - Apr., '99	10	0.5 + 0.3 **a**	15.6 + 2.8 **b**	16.1 + 3.0 **b**	81.3 + 11.5 **a**	59.1 + 9.6 **ab**	7.6 + 1.1 **a**
	EB	STIT - Apr., '99 & '00	10	0.6 + 0.2 **ab**	14.4 + 2.0 **b**	15.1 + 2.1 **b**	89.0 + 9.1 **a**	62.6 + 7.5 **abc**	10.2 + 1.6 **a**
	EB + Thia.	STIT - Apr., '99	10	0.4 + 0.1 **a**	17.2 + 2.8 **bc**	17.6 + 2.9 **bc**	97.6 + 7.2 **a**	66.1 + 6.0 **bcd**	12.2 + 2.3 **a**
	EB + Thia.	STIT - Apr., '99 & '00	10	0.7 + 0.3 **ab**	6.9 + 1.4 **a**	7.6 + 1.5 **a**	103.8 + 6.9 **a**	86.8 + 7.4 **d**	8.7 + 1.1 **a**
	Check		10	1.3 + 0.5 **b**	23.0 + 3.2 **c**	24.3 + 3.5 **c**	75.8 + 10.3 **a**	48.3 + 6.9 **a**	8.8 + 2.3 **a**
2001	EB	STIT - Apr., '99	6	0.7 + 0.3 **a**	39.1 + 8.3 **a**	39.8 + 8.2 **a**	76.1 + 17.5 **a**	44.0 + 15.8 **a**	5.9 + 2.0 **a**
	EB	STIT - Apr., '99 & '00	6	1.0 + 0.4 **a**	36.2 + 2.3 **a**	37.2 + 2.6 **a**	94.7 + 13.9 **a**	50.2 + 8.6 **a**	8.7 + 1.7 **a**
	EB + Thia.	STIT - Apr., '99	6	0.3 + 0.1 **a**	32.9 + 2.5 **a**	33.2 + 2.7 **a**	87.2 + 13.2 **a**	50.1 + 8.3 **a**	7.4 + 3.1 **a**
	EB + Thia.	STIT - Apr., '99 & '00	5	0.7 + 0.2 **a**	20.1 + 2.9 **a**	20.8 + 2.9 **a**	103.0 + 11.4 **a**	75.2 + 10.4 **a**	6.1 + 1.4 **a**
	Check		6	0.5 + 0.2 **a**	32.5 + 5.1 **a**	33.0 + 5.0 **a**	84.5 + 9.6 **a**	51.5 + 8.4 **a**	5.3 + 1.7 **a**
2002	EB	STIT - Apr., '99	10	6.2 + 4.3 **b**	28.3 + 3.7 **a**	34.4 + 5.0 **a**	65.3 + 9.2 **a**	42.4 + 9.1 **a**	3.0 + 0.6 **a**
	EB	STIT - Apr., '99 & '00	10	2.3 + 1.1 **ab**	28.6 + 6.5 **a**	30.9 + 6.3 **a**	82.1 + 8.8 **a**	57.1 + 8.3 **a**	3.0 + 0.4 **a**
	EB + Thia.	STIT - Apr., '99	9	1.6 + 0.8 **ab**	34.0 + 7.0 **a**	35.6 + 7.6 **a**	76.9 + 9.1 **a**	49.4 + 9.3 **a**	4.2 + 0.7 **a**
	EB + Thia.	STIT - Apr., '99 & '00	9	0.6 + 0.1 **a**	25.2 + 2.6 **a**	25.8 + 2.7 **a**	84.9 + 3.8 **a**	59.1 + 4.4 **a**	3.3 + 0.5 **a**
	Check		10	0.5 + 0.1 **a**	31.2 + 1.7 **a**	31.6 + 1.7 **a**	83.4 + 6.2 **a**	53.1 + 4.8 **a**	3.0 + 0.5 **a**
2003	EB	STIT - Apr., '99	10	11.7 + 5.2 **a**	12.7 + 1.8 **a**	24.4 + 4.6 **a**	112.8 + 11.5 **a**	80.1 + 10.3 **a**	3.9 + 0.8 **a**
	EB	STIT - Apr., '99 & '00	10	8.5 + 1.8 **a**	16.9 + 2.3 **a**	25.4 + 2.7 **a**	113.9 + 7.0 **a**	79.6 + 6.8 **a**	4.2 + 0.8 **a**
	EB + Thia.	STIT - Apr., '99	9	5.6 + 1.2 **a**	18.9 + 2.7 **a**	24.6 + 3.0 **a**	106.3 + 6.1 **a**	73.3 + 5.1 **a**	5.6 + 1.5 **a**
	EB + Thia.	STIT - Apr., '99 & '00	10	9.1 + 1.2 **a**	13.5 + 1.8 **a**	22.6 + 1.8 **a**	114.2 + 7.3 **a**	82.0 + 5.1 **a**	4.6 + 0.5 **a**
	Check		10	8.7 + 2.0 **a**	14.2 + 2.0 **a**	22.9 + 2.6 **a**	118.9 + 8.8 **a**	86.9 + 7.5 **a**	3.8 + 0.8 **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.

Table 4. Mean % (+ SE) cone and seed losses from insects (coneworms and seed bugs) and reductions in damage from second-year cones of loblolly pine protected with systemic injections of emamectin benzoate (EB) or emamectin benzoate + thiamethoxam (EB + Thia.), Magnolia Springs Seed Orchard, Jasper Co., TX, 1999 - 2003.

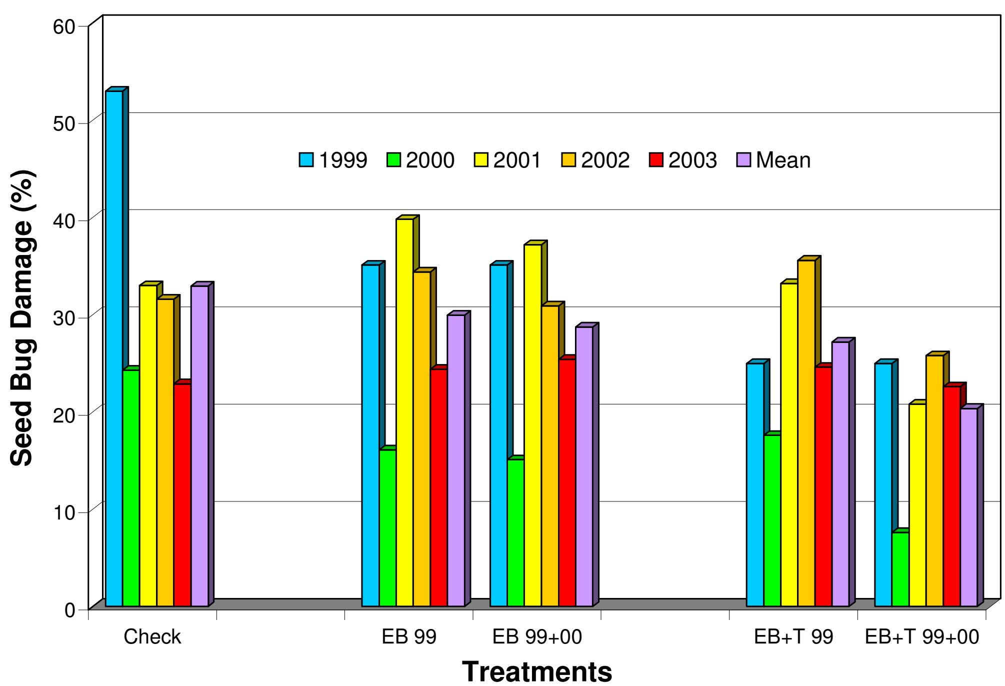
Treatment	Application Technique, Treatment Date(s)	1999 N	1999 Mean Combined Losses (%)	1999 Mean Reduction (%)	2000 N	2000 Mean Combined Losses (%)	2000 Mean Reduction (%)	2001 N	2001 Mean Combined Losses (%)	2001 Mean Reduction (%)	2002 N	2002 Mean Combined Losses (%)	2002 Mean Reduction (%)	2003 N	2003 Mean Combined Losses (%)	2003 Mean Reduction (%)
EB	STIT - Apr., '99	20	20.1 + 2.4 **a***	51.0												
EB	STIT - Apr., '99	10			10	9.2 + 2.4 **ab**	67.5	6	32.7 + 7.0 **b**	36.3	10	39.8 + 4.3 **ab**	21.7	10	26.9 + 4.3 **a**	36.5
EB	STIT - Apr., '99 & '00	10			10	6.0 + 1.2 **a**	79.0	6	29.4 + 2.8 **b**	42.7	10	39.1 + 5.6 **ab**	23.0	10	27.6 + 3.3 **a**	34.8
EB + Thia.	STIT - Apr., '99	20	17.4 + 2.2 **a**	57.7												
EB + Thia.	STIT - Apr., '99	10			10	8.0 + 0.8 **ab**	71.9	6	27.4 + 3.3 **ab**	46.6	9	38.9 + 3.8 **ab**	23.4	9	28.3 + 3.0 **a**	33.2
EB + Thia.	STIT - Apr., '99 & '00	10			10	4.1 + 0.7 **a**	85.7	5	17.7 + 2.8 **a**	65.5	9	32.7 + 2.1 **a**	35.6	10	25.7 + 2.8 **a**	39.2
Check		10	41.1 + 3.6 **b**		10	28.4 + 3.0 **e**		6	51.3 + 3.4 **c**		10	50.8 + 3.8 **b**		10	42.3 + 3.2 **b**	

* 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.



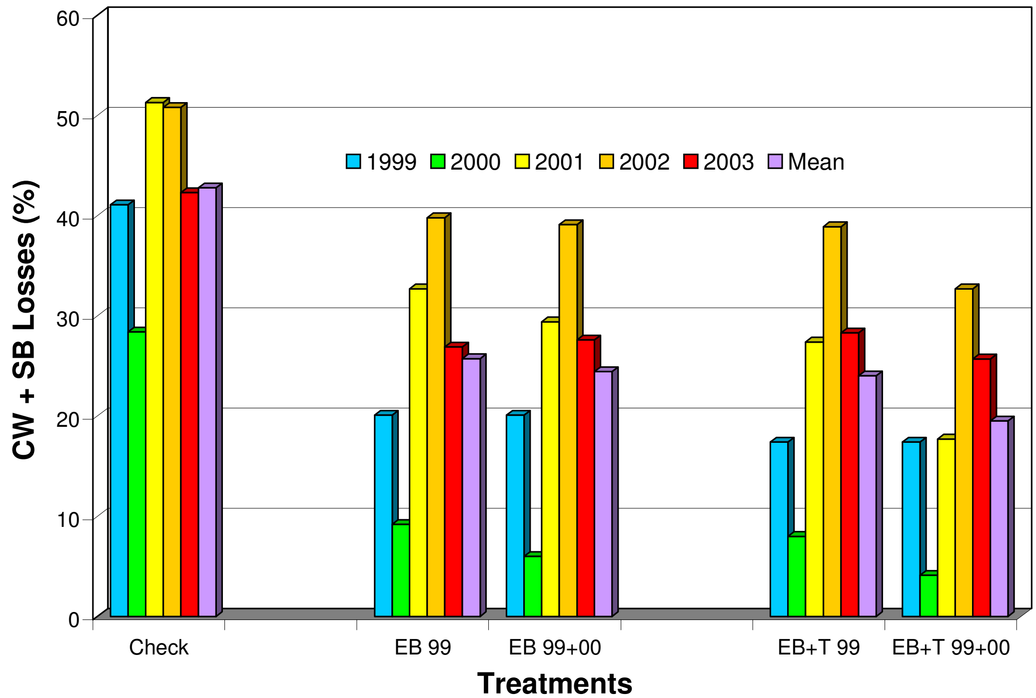
* The treatments indicate the product injected (EB = emamectin benzoate; EB + T = emamectin benzoate + thiamethoxam) and the timing of injections (99 = 1999 only; 99+00 = 1999 and 2000).

Figure 1. Percent of loblolly pine cones damaged by coneworms (*Dioryctria* spp.) during the Duration Study from 1999 to 2004, Magnolia Springs Seed Orchard, Jasper Co., TX.



* The treatments indicate the product injected (EB = emamectin benzoate; EB + T = emamectin benzoate + thiamethoxam) and the timing of injections (99 = 1999 only; 99+00 = 1999 and 2000).

Figure 2. Percent of loblolly pine seeds damaged by seed bugs (*Tetyra* sp. and *Leptoglossus* sp.) during the Duration Study from 1999 to 2003, Magnolia Springs Seed Orchard, Jasper Co., TX.



* The treatments indicate the product injected (EB = emamectin benzoate; EB + T = emamectin benzoate + thiamethoxam) and the timing of injections (99 = 1999 only; 99+00 = 1999 and 2000).

Figure 3. Percent combined losses from coneworms (*Dioryctria* spp.) and seed bugs (*Tetyra* sp. and *Leptoglossus* sp.) during the Duration Study from 1999 to 2003, Magnolia Springs Seed Orchard, Jasper Co., TX.

SYSTEMIC INSECTICIDE INJECTION TRIALS

Denim® and Fipronil Study – Magnolia Springs, TX

Highlights:

- Coneworms and seed bugs caused 44% and 67% losses to cones and seed, respectively, on untreated trees; the highest levels in the past 7 years.
- Denim® (16 ml, all injection methods) improved conelet survival by 48% and cone survival by 23% in the second year after injection (2004). However, fipronil (10 ml, Termidor® & EC) only improved conelet survival by 26%.
- Single injections of Denim® (16 and 8 ml rates) reduced coneworm damage by 99% and 97%, respectively, and seed bug damage by 12% and 14%, respectively. Fipronil (EC) reduced coneworm and seed bug damage by 80% and 14%, respectively.
- Overall insect damage (coneworm + seed bug) was reduced to the greatest extent (38% and 36%) by Denim® injected at rates of 8 ml and 16 ml, respectively.

Objectives: 1) Continue evaluating the efficacy of systemic injections of Denim® (emamectin benzoate) and fipronil in reducing seed crop losses in loblolly pine seed orchards and 2) determine the duration of treatment efficacy.

Study Site: 20 acre orchard block containing 12 year-old drought-hardy loblolly pine -- Texas Forest Service Magnolia Springs Seed Orchard, Jasper Co., TX.

Insecticides:

Emamectin benzoate (Denim®) -- avermectin derivative

Fipronil (Termidor® and experimental EC formulations) -- a pheny pyrazole insecticide that has shown systemic activity against other Lepidoptera (tip moth)

Design: Randomized complete block with clones as blocks. 8 treatments X 6-8 clones = 62 ramets used for study.

Application Methods:

STIT – In early April 2003, four holes, 3/8 in diameter and 8 cm (3 in) deep, were drilled about 1 m high at cardinal points on the tree bole. The pre-determined volume of insecticide was divided among four injectors. The prefilled injector was hammered into the drill hole and pressurized to 70 psi. Most treatment solutions drained within 30 minutes.

Arborjet™: Throughout April, at least four holes, 3/8 in diameter and 8 cm (3 in) deep, were drilled about 1 m high at cardinal points on the tree bole. Arborplugs were installed in each hole. The Arborjet™ system was used to inject a predetermined amount of product into each hole. Due to drought conditions, usually one or more plugs failed (leaked) on each treatment tree. Either additional injection points were installed on a treatment tree until the full amount was injected into each tree or injections were delayed until early in the morning on later dates.

Sidewinder™: Throughout April, at least four holes, 7/16 in diameter and 8 cm (3 in) deep, were drilled about 1 m high at cardinal points on the tree bole. The Sidewinder™ drill was installed in the hole and a predetermined amount of product was pumped into the tree. Due to drought conditions, injections often failed (leaks). Either new injection points were installed until the full amount was injected into each tree or injections were delayed until early in the morning on later dates.

Treatments:

1) 16 ml of 1.92% emamectin benzoate (Denim®) per inch tree diameter at breast height (DBH) by STIT injector (N = 8)
2) 8 ml of 2% emamectin benzoate (Denim®) per inch tree DBH by STIT injector (N = 8)
3) 16 ml of 2% emamectin benzoate (Denim®) per inch tree DBH by Arborjet™ injector (N = 8)
4) 16 ml of 2% emamectin benzoate (Denim®) per inch tree DBH by Sidewinder™ injector (N = 8)
5) 10 ml of 4% fipronil (experimental EC) per inch tree DBH by Arborjet™ or Sidewinder™ injectors (N = 8)
6) 4 ml of 4% fipronil (Termidor®) per inch tree DBH by Arborjet™ or Sidewinder™ injectors (N = 6)
7) Asana® XL (foliar standard) applied by hydraulic sprayer to foliage 5 times per year at 9.6 oz/100 gal at 5-week intervals beginning in April. (N = 8)
8) Check (untreated) (N = 8)

Data Collection:

Conelet and Cone Survival – Six to ten branches were tagged per sample tree (minimum of 50 conelets and 50 cones) in April 2004; 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 early October; 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 orchard block containing the treatment trees has not been sprayed since establishment and most cone crops were small in 2004 - suggesting that pressure from coneworms and seed bugs would be high. This was confirmed for coneworms by 44% damage on check cones in 2004 (Table 6). This contrasts with the 31% damage on the same trees in 2003. Relatively high numbers of seed bugs, leaffooted and shieldbacked pine seed bugs, were observed in the trees in 2004. This was reflected by the 67% damage to seed in check trees (Table 7).

<u>*Treatment Effect on Conelet and Cone Survival*</u>: Cones and conelets on tagged branches were examined in April and September. Nearly all injection and foliar treatments significantly improved survival of conelets and cones compared to check trees; only the Termidor® (fipronil)

treatment did not differ from the check (Table 5, Figs. 4 & 5). None of the Denim® 16 ml and Fipronil EC treatments differed significantly from each other in conelet or cone survival. Overall survival improved markedly in 2004 compared to 2003 with gains in conelet and cone survival ranging from 47% to 57% and from 128% to 155%, respectively (Table 5).

Treatment Effect on Coneworm Damage: All emamectin benzoate and the fipronil EC injection treatments significantly reduced early and late coneworm damage compared to the check (Table 6, Fig. 6). Both the early- and late-season damage observed for these treatments in 2004 were markedly lower than observed in 2003. Overall, the Denim® treatment (16 ml) applied by the Arborjet injector provided the greatest reduction in total coneworm damage (99.6%) compared to the check (Fig. 6). The other Denim® treatments (16 ml STIT, 16 ml Sidewinder™ and 8 ml STIT) and fipronil EC were a little less effective, reducing damage by 99%, 97%, 97% and 80%, respectively. Two of three high rate Denim® treatments (Arborjet™ & Sidewinder™) and the lower rate (8 ml) Denim® treatment each had significantly higher proportions of healthy cones compared to the check.

Treatment Effect on Seed Bug and Seedworm Damage: In 2004, seed bug damage levels (67%) in check cones were the highest observed in at least 7 years (Table 7). The generally higher level of damage early in the growing season compared to earlier in the year again indicates that the leaffooted pine seed bug had a greater impact on seed production at this orchard than did the shieldbacked pine seed bug. None of the injection treatments significantly reduced total seed bug damage (Fig. 7); only the Asana XL foliar treatment showed some efficacy against this insect. However, the foliar treatment plus two injection treatments, Denim 16 ml Sidewinder and fipronil EC, increased the number of full seeds per cone compared to the check.

Seedworm damage in the past had been so low (<1%), even in seed from check trees, that it was not included in data analyses. However, 2004 was different. Mean damage to seed caused by seedworm ranged from 3 to 8% for all treatments (Table 7). Damage to seed on one particular clone (SDH59) was exceptionally heavy for several ramets (mean 13%) (Fig. 8). Unfortunately, the SDH59 ramet assigned to be a check had died. Thus, all treatment means were higher than the check.

Treatment Effect on Overall Insect Damage: An estimate of the combined losses due to the two primary insect pest groups, coneworms and seed bugs, was calculated as in the Duration study by adding the proportion of coneworm-damaged cones to the proportion of all seed in healthy cones damaged by seed-bug. In this study, it is conservatively estimated that in 2004 coneworms and seed bugs in combination reduced the potential seed crops of check trees by 64% (Table 8). The Denim® treatments (16 ml and 8 ml) were most effective in reducing overall insect damage, 38% and 36%, respectively (Fig. 9).

Acknowledgements: We appreciate the assistance provide by I.N Brown, TFS Magnolia Springs Seed Orchard Manager, and Don Travis and for the use of the bucket truck. We appreciate chemical donations and injection equipment loans made by Arborjet, Inc, BASF, and Syngenta.

Table 5. Mean percentages (± SE) of surviving conelets and cones on branches of loblolly pine protected with systemic injection of Denim® (emamectin benzoate) or fipronil or foliar treatments of Asana® XL, Magnolia Springs Seed Orchard, Magnolia Springs, Jasper Co., TX, 2003 - 2004.

Year	Treatment	Application Technique, Treatment Date(s)	N	Mean Survival (%) Conelets	Mean Survival (%) Cones
2003	Denim 16 ml	STIT - Apr., '03	8	89.1 ± 4.0 **cd**†	82.8 ± 4.9 **cd**
	Denim 16 ml	Arborjet (AJ) - Apr., '03	8	96.0 ± 0.9 **d**	89.1 ± 4.2 **d**
	Denim 16 ml	Sidewinder (SW) - Apr., '03	8	94.2 ± 3.1 **d**	81.9 ± 5.4 **bcd**
	Denim 8 ml	STIT - Apr., '03	8	88.1 ± 5.1 **cd**	85.8 ± 1.5 **cd**
	Fipronil EC 10 ml	AJ & SW - Apr., '03	8	84.9 ± 3.6 **bc**	65.3 ± 5.0 **a**
	Fipronil T 10 ml	AJ & SW - Apr., '03	6	71.7 ± 7.2 **ab**	63.6 ± 11.2 **a**
	Asana XL	Hydraulic Foliar 5X in '03	8	82.0 ± 3.3 **bc**	72.0 ± 4.9 **abc**
	Check		8	63.0 ± 3.8 **a**	68.9 ± 4.7 **ab**
2004	Denim 16 ml	STIT - Apr., '03	7	78.1 ± 4.9 **bc**	84.9 ± 4.9 **d**
	Denim 16 ml	Arborjet (AJ) - Apr., '03	7	83.5 ± 4.0 **cd**	78.1 ± 6.1 **cd**
	Denim 16 ml	Sidewinder (SW) - Apr., '03	8	81.9 ± 7.8 **cd**	87.3 ± 4.8 **d**
	Denim 8 ml	STIT - Apr., '03	7	63.6 ± 10.0 **ab**	82.8 ± 7.4 **d**
	Fipronil EC 10 ml	AJ & SW - Apr., '03	8	83.7 ± 4.2 **cd**	78.9 ± 5.5 **cd**
	Fipronil T 10 ml	AJ & SW - Apr., '03	4	63.6 ± 9.7 **ab**	52.7 ± 17.1 **ab**
	Asana XL	Hydraulic Foliar 5X in '03	7	91.9 ± 3.0 **d**	63.5 ± 6.1 **bc**
	Check		6	53.2 ± 9.3 **a**	34.3 ± 8.8 **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.

Table 6. Mean percentages (± SE) of cones killed early and late by coneworms, other-damaged cones, and healthy cones on loblolly pine protected with systemic injections of Denim® (emamectin benzoate) or fipronil or foliar treatments of Asana® XL, Magnolia Springs Seed Orchard, Magnolia Springs, Jasper Co., TX, 2003 - 2004.

				Mean Coneworm Damage (%)				
Year	Treatment	Application Technique, Treatment Date(s)	N	Early (small dead)	Late (large dead and infested)	Total	Mean Other Damage (%) *	Mean Healthy (%)
2003	Denim 16 ml	STIT - Apr., '03	8	8.1 ± 2.2 **a†**	0.5 ± 0.2 **a**	8.6 ± 2.2 **a**	5.1 ± 1.2 **a**	86.3 ± 2.8 **b**
	Denim 16 ml	Arborjet (AJ) - Apr., '03	8	10.4 ± 4.3 **a**	3.5 ± 2.6 **ab**	13.9 ± 4.7 **a**	17.0 ± 4.8 **b**	69.1 ± 4.9 **ab**
	Denim 16 ml	Sidewinder (SW) - Apr., '03	8	10.3 ± 5.4 **a**	2.4 ± 2.0 **a**	12.7 ± 5.6 **a**	10.2 ± 2.5 **ab**	77.1 ± 7.4 **b**
	Denim 8 ml	STIT - Apr., '03	8	7.2 ± 1.9 **a**	3.9 ± 3.4 **ab**	11.0 ± 3.9 **a**	15.1 ± 4.2 **b**	73.9 ± 6.8 **ab**
	Fipronil EC 10 ml	AJ & SW - Apr., '03	8	16.5 ± 3.5 **ab**	3.0 ± 0.9 **ab**	19.5 ± 4.2 **ab**	14.0 ± 3.0 **b**	66.5 ± 6.8 **a**
	Fipronil T 10 ml	AJ & SW - Apr., '03	6	26.3 ± 11.2 **b**	6.3 ± 1.8 **bc**	32.7 ± 12.2 **b**	8.9 ± 2.2 **ab**	58.5 ± 11.9 **a**
	Asana XL	Hydraulic Foliar 5X in '03	8	16.6 ± 4.1 **b**	8.8 ± 2.4 **c**	25.4 ± 5.3 **b**	11.1 ± 1.9 **b**	63.5 ± 6.0 **a**
	Check		8	19.4 ± 4.9 **b**	11.2 ± 2.0 **c**	30.6 ± 4.6 **b**	13.6 ± 2.8 **b**	55.8 ± 6.4 **a**
2004	Denim 16 ml	STIT - Apr., '03	7	0.1 ± 0.1 **a†**	0.5 ± 0.2 **a**	0.5 ± 0.2 **a**	37.6 ± 9.4 **a**	61.8 ± 9.5 **ab**
	Denim 16 ml	Arborjet (AJ) - Apr., '03	7	0.0 ± 0.0 **a**	0.1 ± 0.1 **a**	0.2 ± 0.1 **a**	36.2 ± 6.4 **a**	63.9 ± 6.4 **b**
	Denim 16 ml	Sidewinder (SW) - Apr., '03	8	1.0 ± 1.0 **a**	0.3 ± 0.3 **a**	1.3 ± 1.0 **a**	33.7 ± 8.0 **a**	64.9 ± 7.8 **b**
	Denim 8 ml	STIT - Apr., '03	7	0.8 ± 0.4 **a**	0.7 ± 0.6 **ab**	1.5 ± 0.6 **ab**	33.8 ± 10.8 **a**	64.8 ± 10.9 **b**
	Fipronil EC 10 ml	AJ & SW - Apr., '03	8	8.1 ± 3.5 **b**	0.6 ± 0.4 **a**	8.7 ± 3.6 **bc**	35.6 ± 5.7 **a**	55.8 ± 7.0 **ab**
	Fipronil T 10 ml	AJ & SW - Apr., '03	4	26.3 ± 14.1 **cd**	4.3 ± 2.6 **bc**	30.5 ± 13.4 **de**	27.4 ± 10.6 **a**	42.1 ± 18.0 **ab**
	Asana XL	Hydraulic Foliar 5X in '03	6	12.2 ± 5.1 **bc**	9.4 ± 3.9 **c**	21.6 ± 8.8 **cd**	26.4 ± 7.8 **a**	52.0 ± 14.9 **ab**
	Check		6	41.0 ± 9.6 **d**	3.4 ± 1.4 **bc**	44.3 ± 9.6 **e**	23.3 ± 8.7 **a**	32.4 ± 12.7 **a**

* 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.

Table 7. Seed bug damage, seed extracted, and seed quality (Mean + SE) from second-year cones of loblolly pine protected with systemic injections of emamectin benzoate (Denim®) or fipronil or foliar treatments of Asana® XL, Magnolia Springs Seed Orchard, Magnolia Springs, Jasper Co., TX, 2003 - 2004.

				Mean Seed Bug Damage (%)			Mean	Mean No.	Mean No.
		Application Technique,		Early			Seedworm	Seeds	Filled Seed
Year	Treatment	Treatment Date(s)	N	(2nd Yr Abort)	Late	Total	Damage (%)	per Cone	per Cone
2003	Denim 16 ml	STIT - Apr., '03	8	1.1 + 0.2 **ab**†	16.9 + 3.9 **a**	18.0 + 3.8 **a**	NA	122.1 + 10.4 **a**	93.3 + 10.1 **a**
	Denim 16 ml	Arborjet (AJ) - Apr., '03	8	1.1 + 0.3 **ab**	12.1 + 3.1 **a**	13.2 + 3.0 **a**	NA	108.8 + 5.7 **a**	89.1 + 6.5 **a**
	Denim 16 ml	Sidewinder (SW) - Apr., '03	8	0.7 + 0.2 **a**	15.8 + 3.9 **a**	16.5 + 3.9 **a**	NA	109.0 + 5.7 **a**	85.9 + 7.7 **a**
	Denim 8 ml	STIT - Apr., '03	8	0.7 + 0.3 **a**	14.2 + 2.9 **a**	14.9 + 3.0 **a**	NA	107.5 + 10.5 **a**	86.3 + 10.0 **a**
	Fipronil EC 10 ml	AJ & SW - Apr., '03	8	4.9 + 1.5 **c**	15.5 + 2.9 **a**	20.3 + 3.7 **a**	NA	100.8 + 6.4 **a**	77.2 + 7.5 **a**
	Fipronil T 10 ml	AJ & SW - Apr., '03	6	9.2 + 4.9 **c**	12.5 + 2.6 **a**	21.7 + 5.1 **a**	NA	99.3 + 15.8 **a**	75.9 + 14.8 **a**
	Asana XL	Hydraulic Foliar 5X in '03	8	0.9 + 0.3 **a**	14.3 + 3.9 **a**	15.2 + 3.9 **a**	NA	109.5 + 10.9 **a**	91.4 + 12.3 **a**
	Check		8	4.3 + 1.4 **bc**	16.9 + 4.4 **a**	21.2 + 4.0 **a**	NA	99.6 + 9.6 **a**	76.4 + 9.8 **a**
2004	Denim 16 ml	STIT - Apr., '03	8	31.8 + 8.6 **ab**	25.1 + 5.6 **bc**	56.9 + 6.9 **b**	3.8 + 0.6 **a**	93.1 + 9.5 **ab**	34.5 + 10.1 **ab**
	Denim 16 ml	Arborjet (AJ) - Apr., '03	8	42.4 + 11.5 **bc**	18.9 + 3.9 **ab**	61.3 + 8.3 **b**	4.8 + 1.7 **a**	93.1 + 9.8 **ab**	30.4 + 10.6 **ab**
	Denim 16 ml	Sidewinder (SW) - Apr., '03	8	31.4 + 6.9 **ab**	25.7 + 4.5 **bc**	57.1 + 5.0 **b**	8.2 + 2.9 **a**	105.0 + 11.0 **b**	32.8 + 8.6 **b**
	Denim 8 ml	STIT - Apr., '03	8	36.6 + 6.6 **bc**	20.9 + 2.2 **abc**	57.5 + 6.5 **b**	7.4 + 4.1 **a**	97.0 + 14.3 **ab**	27.1 + 5.3 **ab**
	Fipronil EC 10 ml	AJ & SW - Apr., '03	8	32.0 + 6.5 **ab**	25.7 + 4.3 **bc**	57.7 + 4.8 **b**	4.7 + 1.0 **a**	92.8 + 8.1 **ab**	30.4 + 6.4 **b**
	Fipronil T 10 ml	AJ & SW - Apr., '03	4	27.3 + 11.2 **ab**	27.7 + 4.1 **c**	55.0 + 11.2 **ab**	5.6 + 1.9 **a**	80.8 + 9.5 **ab**	31.6 + 12.4 **ab**
	Asana XL	Hydraulic Foliar 5X in '03	7	21.0 + 6.9 **a**	20.4 + 4.6 **abc**	41.4 + 6.4 **a**	4.6 + 1.9 **a**	85.5 + 15.6 **a**	46.4 + 14.4 **b**
	Check		6	50.4 + 13.6 **c**	16.3 + 5.0 **a**	66.7 + 11.4 **b**	3.0 + 1.7 **a**	75.6 + 6.9 **a**	18.3 + 6.3 **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.
NA = Not Available

Table 8. Mean % ($\pm$ SE) cone and seed losses from insects (coneworms and seed bugs) and reductions in damage from second-year cones of loblolly pine protected with systemic injection of Denim® (emamectin benzoate), or fipronil, or foliar treatments of Asana® XL, Magnolia Springs Seed Orchard, Magnolia Springs, Jasper Co., TX, 2003 - 2004.

		2003			2004		
Treatment	Application Technique & Rate & Treatment Date	N	Mean Combined Losses (%)	Mean Reduction (%)	N	Mean Combined Losses (%)	Mean Reduction (%)
Denim 16 ml	STIT - Apr., '03	8	23.7 ± 4.7 **a**†	42.5	8	36.9 ± 7.6 **a**	42.5
Denim 16 ml	Arborjet (AJ) - Apr., '03	8	22.6 ± 5.8 **a**	45.0	8	42.9 ± 7.6 **ab**	33.0
Denim 16 ml	Sidewinder (SW) - Apr., '03	8	23.9 ± 6.2 **a**	41.8	8	39.9 ± 6.7 **ab**	37.8
Denim 8 ml	STIT - Apr., '03	8	21.8 ± 4.1 **a**	47.0	8	41.1 ± 8.0 **ab**	35.9
Fipronil EC 10 ml	AJ & SW - Apr., '03	8	31.5 ± 5.2 **ab**	23.5	8	41.1 ± 5.2 **ab**	35.8
Fipronil T 10 ml	AJ & SW - Apr., '03	6	44.0 ± 10.9 **b**	-7.1	4	53.4 ± 10.9 **bc**	16.7
Asana XL	Hydraulic Foliar 5X in '03	8	34.4 ± 6.1 **ab**	16.5	7	46.3 ± 5.7 **ab**	27.8
Check		8	41.1 ± 4.3 **b**		6	64.1 ± 7.5 **c**	
Denim 16 ml **	STIT, AJ & SW - Apr., '03	24	23.4 ± 3.1 **a**	43.1	24	39.9 ± 4.1 **a**	37.8
Denim 8 ml	STIT - Apr., '03	8	21.8 ± 4.1 **a**	47.0	8	41.1 ± 8.0 **a**	35.9
Fipronil 10 ml **	AJ & SW - Apr., '03	14	36.9 ± 5.5 **b**	10.4	12	45.2 ± 4.9 **a**	29.5
Asana XL	Hydraulic Foliar 5X in '03	8	34.4 ± 6.1 **ab**	16.5	7	46.3 ± 5.7 **a**	27.8
Check		8	41.1 ± 4.3 **b**		6	64.1 ± 7.5 **b**	

† 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.

** Comparison after three Denim 16 ml and two fipronil treatments were combined.

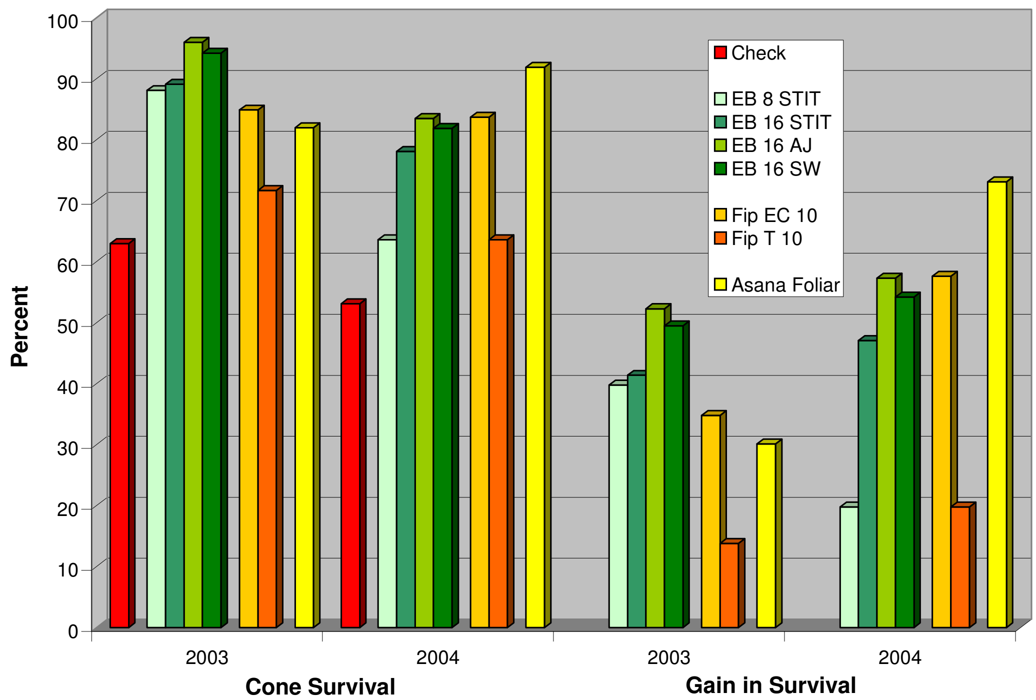


Figure 4. Percent survival and gain in survival of loblolly pine conelets protected with injections of Denim® (emamectin benzoate) or fipronil or foliar treatments with Asana® XL, Magnolia Springs Seed Orchard, Jasper Co., TX, 2003 - 2004.

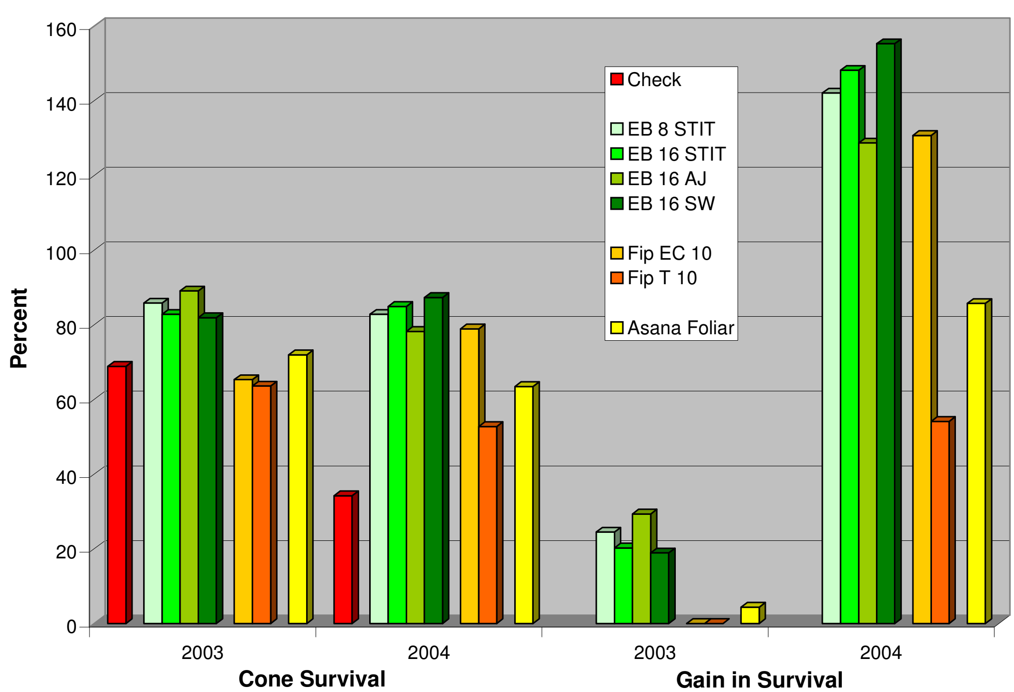


Figure 5. Percent survival and gain in survival of loblolly pine cones protected with injections of Denim® (emamectin benzoate) or fipronil or foliar treatments with Asana® XL, Magnolia Springs Seed Orchard, Jasper Co., TX, 2003 - 2004.

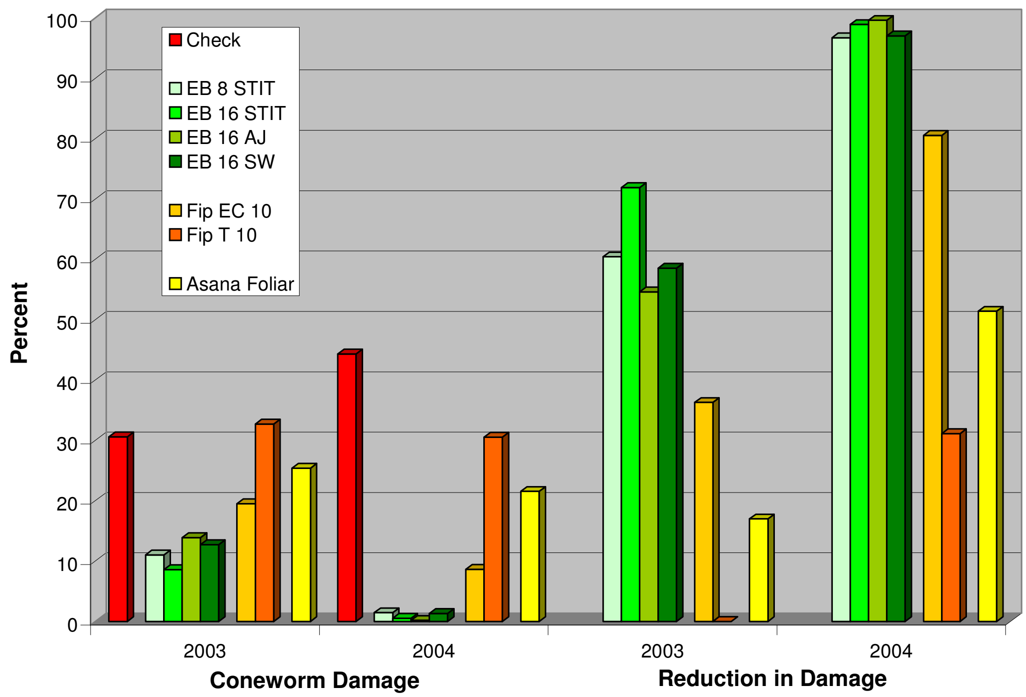


Figure 6. Percent coneworm (*Dyrictria* spp.) damage and reduction in damage on second-year loblolly pine cones protected with injections of Denim® (emamectin benzoate) or fipronil or foliar treatments with Asana® XL, Magnolia Springs Seed Orchard, Jasper Co., TX, 2003 - 2004.

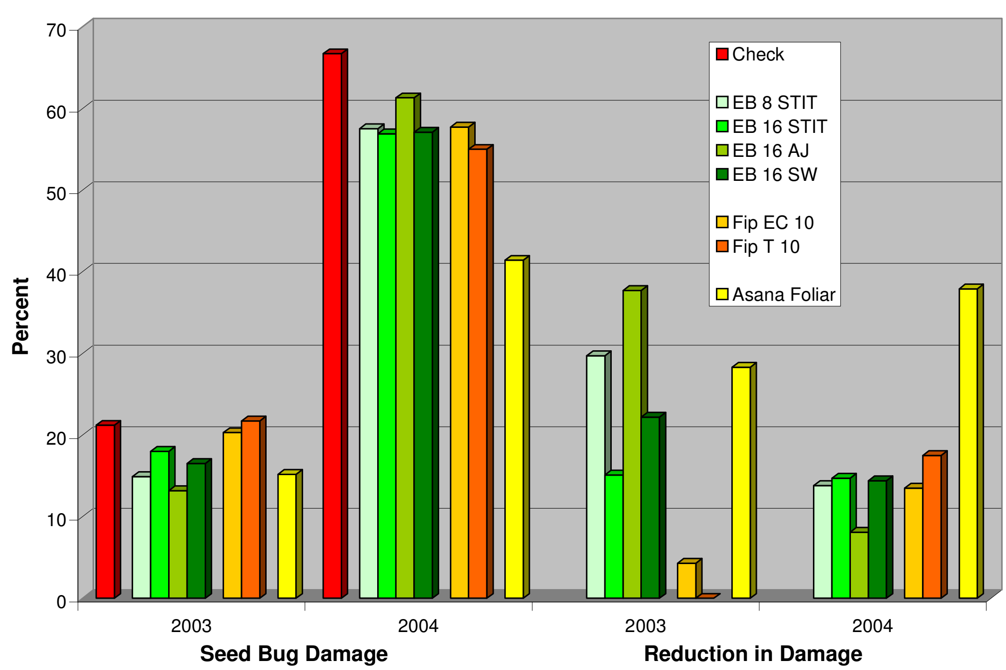


Figure 7. Percent seed bug (*Tetyra* sp. and *Leptoglossus* sp.) damage and reduction in damage on loblolly pine seed protected with injections of Denim® (emamectin benzoate) or fipronil or foliar treatments with Asana® XL, Magnolia Springs Seed Orchard, Jasper Co., TX, 2003 - 2004.

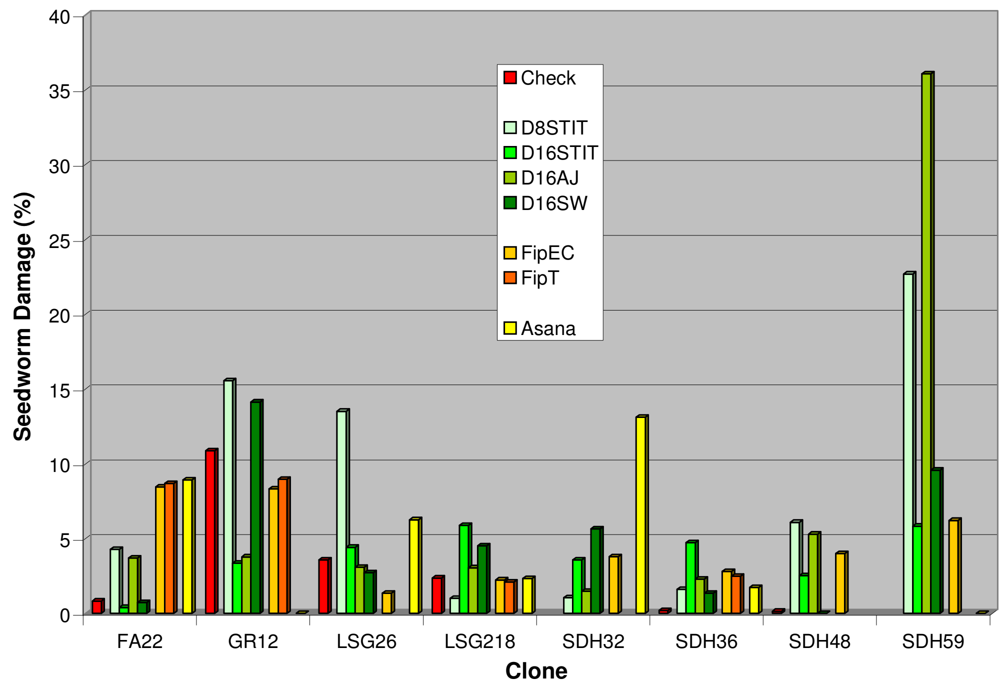


Figure 8. Percent seedworm (*Tetyra* sp. and *Leptoglossus* sp.) damage on pine seed among treatments and loblolly pine clones protected with injections of Denim® (emamectin benzoate) or fipronil or foliar treatments with Asana® XL, Magnolia Springs Seed Orchard, Jasper Co., TX, 2004.

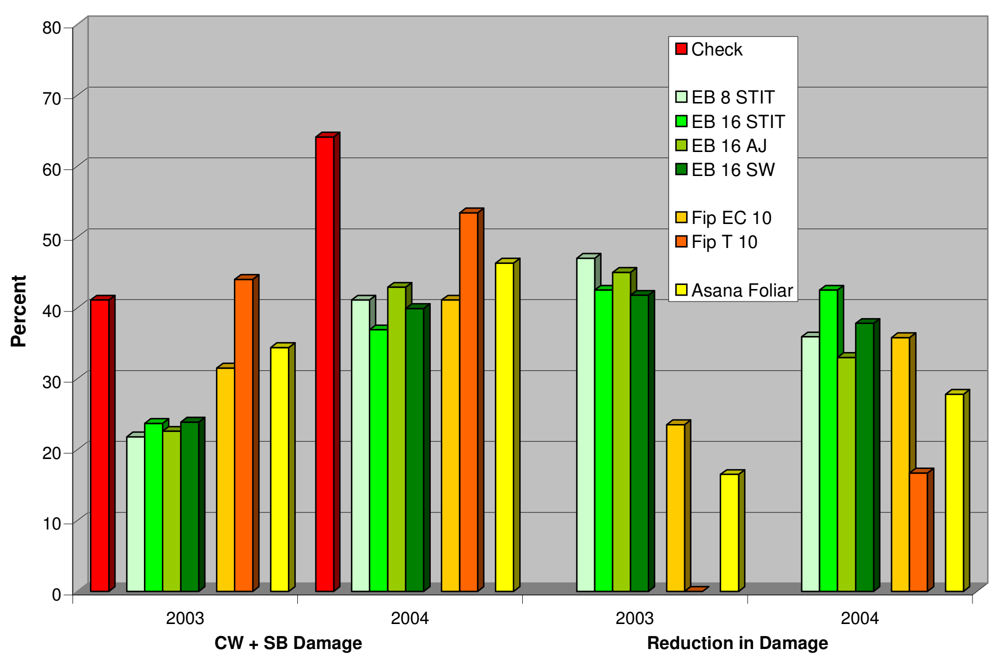


Figure 9. Percent combined losses from coneworms (*Dyrictria* spp.) and seed bugs (*Tetyra* sp. and *Leptoglossus* sp.) and reduction in damage on loblolly pine cones and seed protected with injections of Denim® (emamectin benzoate) or fipronil or foliar treatments with Asana® XL, Magnolia Springs Seed Orchard, Jasper Co., TX, 2003 - 2004.

SYSTEMIC INSECTICIDE INJECTION TRIALS

Protection of Live Oak Acorn Crops from Acorn Weevil

Highlights:

- Acorn weevils damaged 33% of the 2004 live oak acorn crop on untreated trees.
- Neither Denim® nor imidacloprid were effective in significantly reducing weevil-caused damage on injected trees compared to untreated checks.

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

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

Insecticides:

Emamectin benzoate (Denim®) -- avermectin derivative
Imidacloprid -- a highly systemic neonicotinoid insecticide with known activity against Coleoptera

Design: Randomized complete block with clones as blocks. 4 treatments X 5-7 clones = 26 ramets used for study.

Application Methods:

In late May 2004, 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:

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)
8) Check (untreated) (N = 7)

Data Collection:

Starting in early September, the study trees were checked weekly for acorn ripeness. When acorns began to drop (September 17), all acorns that had dropped within a 6 foot radius of each tree trunk were collected every 3 to 4 days. Acorns were collected until mid-December when acorn drop ceased. After each collection all acorns were dried for 24 hrs, counted and stored temporarily in refrigerators or coolers.

Random samples of 200 acorns were evaluated for each tree. Acorns were initially divided into three categories: 1) Acorns with weevil oviposition sites and larvae emergence holes, 2) acorns with weevil oviposition site(s) only, and 3) clean healthy acorns. Acorns with oviposition sites only were further evaluated by splitting each acorn in half at the oviposition site. 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: The study trees averaged 26 cm in diameter. All treatments were quickly injected into study trees using Arborjet's Tree IV system – often in less than 5 minutes. Unfortunately, in August, the bark was found to be splitting on several smaller-diameter, fast-growing trees that had been injected with Denim®. 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.

The acorns began to drop from most trees in mid- to late-September. It was found that nearly all acorns collected from the ground had one or more marks that indicated that weevils had oviposited into the acorn. In contrast, most acorns that were still held in the trees were without oviposition marks. Thus, acorns collected initially in September were biased for weevil damage. To obtain an accurate measure of weevil damage levels on untreated trees as well as determine efficacy of the treatments, acorn collections were made every 3-4 days throughout the acorn drop period.

All collected acorns were air-dried in trays for 24 hrs, counted and stored in plastic bags with paper towels (to absorb excess moisture) in refrigerators or coolers. Unfortunately, fungi that began growing on the acorns in the bags damaged many acorns. To prevent further fungal damage, all acorns were spread out in trays to dry. Then, the weevil larvae began to emerge. Imagine if you will, returning to work after a weekend, walking into a room where 75 trays are laid out and finding thousands of weevil larvae crawling all over the floor (Figs. 10 & 11). Three weeks later a 200 acorn sample was taken and evaluated for weevil damage.

Figure 10. Drying acorns in TFS library.

Figure 11. Emerged acorn weevil larvae.

The orchard block containing the treatment trees has not been sprayed since establishment - suggesting that pressure from weevils would be moderate to high. This was confirmed by 31% damage on check acorns in 2004 (Table 9).

Treatment Effect on Weevil Damage: None of the injection treatments significantly reduced weevil damage compared to the check (Table 9). Although damage was reduced, the amount of early season damage was fairly high (>7%) for all treatments. Overall, the Denim® treatment (16 ml) applied by the STIT injector provided the greatest reduction in total weevil damage (73%) compared to the check (Fig. 12). The other Denim® treatments (8 ml STIT, 16 ml Sidewinder™ and 16 ml Arborjet™) were a little less effective; reducing damage by 64%, 59% and 55%, respectively. Two of three high rate Denim® treatments (STIT & Sidewinder™) had significantly higher proportions of healthy cones compared to the check.

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. and Syngenta.

Table 9: Acorn weevil damage on live oak acorns following trunk injection of trees with emamectin benzoate or imidacloprid in May 2004, Hudson, Angalina Co., Texas.

Treatment	N	Mean (+ SE) No. of Acorns/Tree	Mean (+ SE) Percent of Acorns: Weeviled	Mean (+ SE) Percent of Acorns: Healthy
Emamectin (2:1:1 EB:meth:water)	5	3551 ± 910 **a** †	18.5 + 7.9 **a**	81.5 ± 7.9 **a**
Emamectin (1:1 EB:meth.)	7	4102 ± 1802 **a**	33.9 + 7.8 **a**	66.1 ± 7.8 **a**
Imidacloprid (1:3 Ima-jet:ADDjet)	7	6440 ± 2116 **a**	21.6 + 3.3 **a**	78.4 ± 3.3 **a**
Check (untreated)	7	5330 ± 1868 **a**	36.1 + 10.3 **a**	63.9 ± 10.3 **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

Single Tree Protection from Southern Pine Bark Beetle Study – Wells, TX

Highlights:

- We evaluated the efficacy of the systemic insecticides dinotefuran, emamectin benzoate, fipronil, and imidacloprid for preventing attacks and brood production of *Ips* engraver beetles (Coleoptera: Scolytidae) and wood borers (Coleoptera: Cerambycidae) on standing, stressed trees and bolt sections of loblolly pine (*Pinus taeda*) in East Texas.
- Emamectin benzoate was highly effective in preventing engraver beetles and associated wood borers from successfully colonizing both stressed trees and pine bolt sections.
- Fipronil was moderately effective in reducing insect colonization of bolts one month after injection and nearly as effective as emamectin benzoate at three and five months after injection. Fipronil also was highly effective in preventing bark beetle-caused mortality of stressed trees.
- Imidacloprid and dinotefuran were ineffective in preventing bark beetle and wood borer colonization of bolts or standing, stressed trees.
- The injected formulation of emamectin benzoate was found to cause long vertical lesions in the sapwood / phloem interface at each injection point.

Objectives: 1) Evaluate the efficacy of systemic injections of emamectin benzoate, imidacloprid, dinotefuran and fipronil in reducing success of pine bark beetles attacks on loblolly pine; 2) evaluate the treatments applied using Arborjet's Tree IV™ pressurized injection system; and 3) determine the duration of treatment efficacy.

Study Sites: Two 20-year-old, recently thinned loblolly pine plantations were selected on land owned by Temple-Inland Forest Products about 3 miles south of Wells, Texas. Trees in one plantation were injected for use in a bolt study (Trial 1). Trees in ½ acre section of the second plantation were injected as part of a single-tree protection study (Trial 2). A staging area also was set up in the second plantation where bolts from the first plantation were exposed to bark beetles and wood borers.

Population Monitoring:

A clear panel of acetate (10 cm wide by 25 cm long) was attached to the center of each bolt after deployment of bolts or 2 m high on standing trees after deployment of pheromone baits to monitor arrival of bark beetles. The top surface of each panel was coated entirely with Stikem Special® trapping compound (Michel and Pelton, Emeryville, CA). The traps were left in place for two weeks.

Treatments:

1) Emamectin benzoate (Denim®, 1.92% ai, Syngenta) – Denim® was mixed 1:1 with methanol and applied at 18.6 ml solution per inch of tree diameter at breast height (DBH) (= 0.2 g active per inch DBH).
2) Imidacloprid (IMA-jet, 5% ai, Arborjet, Inc.) – IMA-jet was mixed 1:3 with ADD-jet and applied at 16 ml solution per inch of tree DBH (= 0.2 g active per inch DBH).

3) Fipronil (Regent 2.5EC, 28.2% ai, BASF) – Regent was mixed 1:2.8:7.5 with methanol and water and applied at 8 ml solution per inch of tree DBH (= 0.2 g active per inch DBH).
4) Dinotefuran (10% ai) – Dinotefuran was mixed 1:3 with water and applied at 8 ml solution per inch of tree DBH (= 0.2 g active per inch DBH).
6) Check (untreated)

* Arborjet, Inc. provided the imidacloprid and dinotefuran formulations, BASF provided the fipronil formulation, and Syngenta provided the emamectin benzoate formulation

Treatment Methods and Evaluation:

Two 20-year-old, recently-thinned loblolly pine plantations were selected on land owned by Temple-Inland Forest Products Corporation about 20 km northwest of Lufkin (Angelina County), Texas. Fifteen trees in one plantation were injected with one of four systemic insecticides for use in a bolt (log section) study (Trial 1). Six trees per insecticide were injected in a 0.2 ha section of the second plantation as part of a single-tree protection study (Trial 2). A staging area also was set up in the second plantation where bolts from the first plantation were exposed to bark beetles and wood borers.

Trial 1: Seventy-five loblolly pine trees, 15 – 20 cm diameter at breast height (DBH), were selected in March 2004. Each treatment consisted of a single insecticide formulation injected into four cardinal points about 0.3 m above the ground on each tree in April (16^{th} – 23^{rd}) using the new Arborjet Tree IV™ microinfusion system (Arborjet, Inc. Woburn, MA).

After 1 (May 24), 3 (July 19) and 5 (September 2) months post-injection, 5 trees of each treatment were felled and two 1.5 m-long bolts were removed from the 3 m and 8 m heights of the bole. The bolts were transported to a nearby 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 + lanerione combination, ipsenol or cis-verbenol; Phero Tech, Inc., Delta, BC, Canada) were attached separately to three 1 m stakes evenly spaced in the study area. Racemic ipsdienol and cis-verbenol were used with the second and third series of bolts deployed in July and September, respectively. The packets were removed after 2 weeks when signs of bark beetle attacks (boring dust) were observed on most test bolts.

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

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, a section of lower bole (~60-80 cm) containing the injection points was taken from each injected tree. The bark was later removed around the injection points 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.

Trial 2: Thirty loblolly pines, 15 – 20 cm DBH, were selected in the second plantation in March 2004 to provide 6 replicates per treatment. Each treatment was injected into four cardinal points of target trees about 0.3 m above the ground in April (16^{th} – 23^{rd}) using the Arborjet Tree IV™ system. At 5 weeks post-injection (May 28), frills were cut with a hatchet into the sapwood between the injection points near the base of the tree. A cellulose sponge was inserted into each cut and loaded with 10 ml of a 4:1 mix of sodium N-methyldithiocarbamate (MS) (Woodfume®; Osmose, Inc., Buffalo, NY) plus dimethyl sulfoxide (DMSO) (Aldrich Chemical) (Roton 1987, Strom et al. 2004). This treatment reduces resin flow to near zero in 1-2 weeks. The intent was to stress the trees and make them susceptible to bark beetle attack without directly killing them. Pheromone packets containing racemic ipsdienol + lanerione, ipsenol or cis-verbenol were attached (June 7) atop 3 m stakes evenly spaced in between and around the study trees to encourage attack by the three species of *Ips*. However, the initial results of the bolt trial suggested that encouraging attacks of *Ips calligraphus* (the largest and most common species) alone would allow for easier and more accurate measurements of beetle attack success. Thus, pheromone baits containing only ipsdienol and cis-verbenol (pheromones of *I. calligraphus*) were deployed on all stakes on June 17^{th}. The baits were changed every 4 weeks throughout the study.

A clear panel of acetate (10 cm X 25 cm) coated with Stickem Special® was attached 2 m above ground on standing trees after deployment of pheromone baits to monitor arrival of bark beetles. After two weeks, the traps were removed and all bark beetles were identified and counted.

Three weeks after pheromone deployment (June 28), each tree was evaluated by marking a 30 cm section of bole at a height of 3 m. All visible *Ips* attacks and cerambycid egg niches were counted within the marked area. The number of trees with fading crowns also was recorded. Thereafter, the trees were evaluated weekly for crown fading. When crown fading did occur, the symptomatic trees were felled and two bolts taken and evaluated for attack success and gallery length as described in Trial 1. All remaining trees were felled on August 9, 66 days after initial pheromone deployment when no additional trees had died for 3 weeks. Treatment efficacy was determined by comparing tree survival, beetle attacks and egg gallery length on treated and untreated bolts. Data were transformed and statistically analyzed as described for Trial 1.

Results:

Trial 1: 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 lesions of various length and widths at nearly all injection points. Trees injected with dinotefuran or fipronil had lesions that extended only a short distance from the injection points (Table 10, Fig. 12). Imidacloprid-induced lesions were nearly twice as long as the former treatments in the first series of bolts, but did not differ from them in the second bolt series. Lesions resulting from the emamectin benzoate treatment were far longer than the other treatments for both bolt series (Fig. 13 & 14). In both series of bolts, the true length of these lesions could not be determined because almost all lesions extended beyond the ends of the bolts.

Signs of beetle attack (boring dust) were 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. There was concern that if cerambycid larvae were allowed to develop for an extended period, their feeding activity would obscure or obliterate the *Ips* galleries. Thus, each series of bolts were retrieved 3 weeks after deployment and stored temporarily in a TFS seedling cooler (~45^{o}F) to slow cerambycid development until the bolts could be evaluated.

<u>*Ips* Attack Success</u> – The number of *Ips* engraver beetles landing on individual bolts varied considerably but did not differ among the treatments for either height or series (Table 11). In contrast, the total number of attacks (nuptial chambers constructed) by male beetles often differed among the treatments. The number of attacks was not necessarily reflective of the success of the attack. As expected, in May, untreated bolts were heavily attacked (Fig. 15). Whereas, in July, significantly fewer attacks were found on check bolts compared to most of the

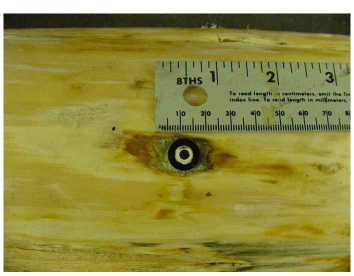


Figure 12. Lesion surrounding injection point on dinotefuran-treated bolt

Figure 13. Lesion surrounding injection point on emamectin benzoate-treated bolt (May).

Figure 14. Lesion surrounding injection point on emamectin benzoate-treated bolt (July).

Table 10: Mean length and width of lesions surrounding injection points one and three months after injections of four systemic insecticides into loblolly pine in 2004. Wells, Texas.

		1 Month Post-injection		3 Months Post-injection	
Treatment	n	Length (cm)	Width (cm)	Length (cm)	Width (cm)
Dinotepheran (Dino)	20	3.6 **a** *	1.6 **a**	5.5 **a**	1.5 **ab**
Emamectin Benzoate (EB)	20	47.3+ **c**	2.3 **b**	63.5+ **b**	1.8 **b**
Fipronil (Fip)	20	4.1 **a**	1.5 **a**	4.1 **a**	1.4 **ab**
Imidacloprid (Imid)	20	7.3 **b**	1.7 **a**	6.1 **a**	1.3 **a**

+ Leasion usually extended well past the end the bolt.

* 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: Attraction to and attack success and gallery construction of *Ips* engravers beetles on loblolly pine bolts cut one, three and five months after trunk injection with four systemic insecticides in 2004, Wells, Texas.

Evaluation Period	Bolt Height	Trt *	Mean # of *Ips* Caught / Trap	Mean # of Nuptial Chambers Without Egg Galleries		Mean # of Nuptial Chambers With Egg Galleries		Mean Total # of Nuptial Chambers
				No.	Total	No.	Total	
1 Month Post-Injection (May)	3 m	Dinotefuran	4.8 **a**	0.6 **a** *	3.9	14.8 **b**	96.1	15.4 **a**
		Emamectin	3.8 **a**	14.6 **c**	78.5	4.0 **a**	21.5	18.6 **a**
		Fipronil	4.0 **a**	10.2 **c**	48.6	10.8 **b**	51.4	21.0 **a**
		Imidacloprid	5.6 **a**	2.0 **b**	11.0	16.2 **b**	89.0	18.2 **a**
		Check	6.8 **a**	0.0 **a**	0.0	16.0 **b**	100.0	16.0 **a**
	8 m	Dinotefuran	2.8 **a**	1.2 **ab**	9.8	11.0 **b**	90.2	12.2 **a**
		Emamectin	4.8 **a**	9.0 **c**	69.2	4.0 **a**	30.8	13.0 **ab**
		Fipronil	3.6 **a**	2.6 **b**	10.1	23.2 **b**	89.9	25.8 **bc**
		Imidacloprid	3.8 **a**	3.0 **bc**	19.0	12.8 **b**	81.0	15.8 **abc**
		Check	5.0 **a**	0.2 **a**	0.7	27.2 **b**	99.3	27.4 **c**
3 Months Post-Injection (July)	3 m	Dinotefuran	5.4 **a**	1.0 **a**	17.9	4.6 **c**	82.1	5.6 **a**
		Emamectin	1.8 **a**	11.0 **b**	100.0	0.0 **a**	0.0	11.0 **ab**
		Fipronil	4.8 **a**	9.8 **b**	77.8	2.8 **b**	22.2	12.6 **b**
		Imidacloprid	2.6 **a**	4.2 **a**	38.9	6.6 **c**	61.1	10.8 **ab**
		Check	2.4 **a**	0.8 **a**	13.3	5.2 **c**	86.7	6.0 **a**
	8 m	Dinotefuran	2.2 **a**	1.4 **ab**	13.2	9.2 **c**	86.8	10.6 **bc**
		Emamectin	3.4 **a**	8.4 **c**	100.0	0.0 **a**	0.0	8.4 **b**
		Fipronil	4.6 **a**	19.2 **c**	91.4	1.8 **b**	8.6	21.0 **c**
		Imidacloprid	2.0 **a**	3.8 **b**	40.4	5.6 **bc**	59.6	9.4 **b**
		Check	2.8 **a**	0.0 **a**	0.0	3.8 **b**	100.0	3.8 **a**
5 Months Post-Injection (Sept.)	3 m	Dinotefuran	2.6 **a**	0.0 **a**	0.0	4.2 **b**	100.0	4.2 **ab**
		Emamectin	1.2 **a**	3.8 **b**	100.0	0.0 **a**	0.0	3.8 **a**
		Fipronil	1.2 **a**	7.4 **c**	92.5	0.6 **a**	7.5	8.0 **b**
		Imidacloprid	1.6 **a**	0.2 **a**	4.3	4.4 **b**	95.7	4.6 **ab**
		Check	1.6 **a**	0.0 **a**	0.0	5.2 **b**	100.0	5.2 **ab**
	8 m	Dinotefuran	0.6 **a**	0.2 **a**	3.8	5.0 **b**	96.2	5.2 **a**
		Emamectin	0.4 **a**	4.4 **b**	100.0	0.0 **a**	0.0	4.4 **a**
		Fipronil	0.8 **a**	5.4 **b**	81.8	1.2 **a**	18.2	6.6 **a**
		Imidacloprid	1.5 **ab**	2.2 **b**	30.6	5.0 **b**	69.4	7.2 **a**
		Check	2.2 **b**	0.0 **a**	0.0	7.8 **b**	100.0	7.8 **a**

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

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 sharp contrast, on emamectin benzoate-treated bolts evaluated in May, most attacks were unsuccessful at the 3 m (79%) and 8 m (69%) heights (Fig. 16) and all (100%) attacks were unsuccessful at both heights in July (Fig. 20) and September. It appeared that nearly all attacks were aborted or the beetles died as soon as they penetrated into the phloem region.

There were a few successful *Ips* attacks on one tree out of five in May, but these attacks were far fewer in number compared to check trees and were restricted to narrow strips on the bolt (Fig. 17). Similarly, in May, a number of trees treated with fipronil (Fig. 18) and imidacloprid (Fig. 19) showed patches or strips of reduced attack success. But, the uncolonized strips were usually narrower. This indicates that fipronil and imidacloprid had not dispersed laterally around the trees to the same extent as emamectin benzoate.

Figure 15. Untreated bolt from 3 m. Black marks = nuptial chambers; red lines = egg galleries; green marks = egg galleries with brood.

Figure 16. Emamectin benzoate bolt from 3 m. Black marks surrounded by blue circle = unsuccessful attacks

Figure 17. Emamectin benzoate-treated bolt with clear and colonized strips.

Fig 18. Fipronil-treated bolt with clear and colonized strips.

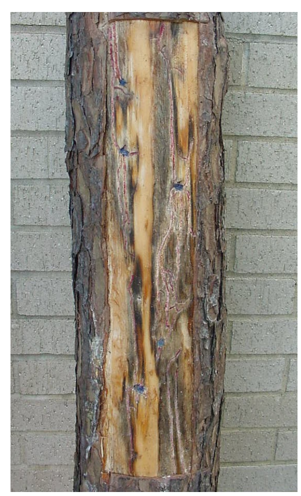


Fig 19. Imidacloprid-treated bolt with clear and colonized strips.

Nearly half (49%) of the attacks on fipronil-treated trees were unsuccessful (no egg galleries) on bolts taken from 3 m. This treatment did not reduce attack success at the 8 m height. Both treatments, fipronil in particular, were more effective by July in preventing successful attacks on 3 m (78%) and 8 m (91%) bolts. The clear, uncolonized area extended nearly all the way around the fipronil-treated tree bole, while the clean areas were still narrow or nonexistent on imidacloprid bolts (Fig. 20).

In May, emamectin benzoate sharply reduced the total number (81% and 96%) and length (94% and 99%) of egg galleries at 3 m and 8 m, respectively, compared to check trees (Table 12). No other treatment reduced the total number of galleries. However, when the number and length of galleries with brood were compared to galleries without brood, all injection treatments reduced the proportion of galleries with brood and their lengths relative to the checks. Fipronil was second only to emamectin benzoate in reducing the number and length of egg galleries with brood. In July and September, emamectin benzoate completely prevented the construction of egg galleries in all bolts. Fipronil was nearly equal in its efficacy in the second and third series. Although a few egg galleries were constructed, almost none had developing brood. Imidacloprid and dinotefuran did reduce the proportion of galleries with brood and their lengths relative to the checks but the proportions were all greater than 50% of the totals.

Figure 20. July bolt treatment groups, from left to right, imidacloprid, emamectin benzoate, fipronil, dinotefuran and check.

<u>Cerambycid Larval Feeding</u> – In May, cerambycid larvae were found to have fed upon 30% and 34% of the phloem area on untreated bolts taken from 3 m and 8 m, respectively, during the 3 weeks period between tree felling and bolt evaluation (Table 13). In contrast, very little larval feeding or development was found on emamectin benzoate-treated bolts. Overall, this treatment reduced feeding damage by 93% and 100% on bolts from 3 m and 8 m, respectively. Fipronil reduced feeding by 82% on bolts at 3 m, but only by 55% at 8 m. On the other hand, imidacloprid reduced feeding by 98% on bolts at 8 m, but only by 61% at 3 m. Dinotefuran had no apparent effect at 3 m, but reduced feeding by 60% at 8 m. Cerambycid larvae fed upon 23 - 25% and 9 - 14% of the phloem area on untreated bolts taken in July and September, respectively (Table 13). In contrast, both series of bolts exhibited no larval feeding or development on emamectin benzoate-treated bolts from 3 m and only 2% of the fipronil bolt was fed upon from the same height. No colonization occurred at 8 m for either treatment. Imidacloprid and dinotefuran did not significantly reduce the area fed upon by borer larvae compared to the check 3 and 5 months after injection.

Table 12: Mean number and length of Ips engravers beetles egg galleries in loblolly pine bolts cut one, three and five months after trunk injection with four systemic insecticides in 2004, Wells, TX.

			Number of Egg Galleries					Length of Egg Galleries				
			Without Brood		With Brood			Without Brood		With Brood		
Evaluation Period	Bolt Ht	Trt *	No.	% Total	No.	% Total	Total Galleries	cm	% Total	cm	% Total	Total Length
1 Month Post-Injection (May)	3 m	Dinotefuran	33.2 **b** *	61.5	20.8 **c**	38.5	54.0 **b**	146.0 **b**	44.3	183.4 **c**	55.7	329.4 **bc**
		Emamectin	10.0 **a**	80.6	2.4 **a**	19.4	12.4 **a**	15.5 **a**	50.5	15.2 **a**	49.5	30.7 **a**
		Fipronil	23.6 **b**	70.2	10.0 **b**	29.8	33.6 **b**	64.4 **b**	47.7	70.6 **b**	52.3	135.0 **b**
		Imidacloprid	35.2 **b**	54.0	30.0 **c**	46.0	65.2 **b**	159.0 **b**	36.0	283.2 **c**	64.0	442.2 **c**
		Check	29.0 **b**	44.1	36.8 **c**	55.9	65.8 **b**	114.8 **b**	23.8	368.4 **c**	76.2	483.2 **c**
	8 m	Dinotefuran	29.2 **b**	68.9	13.2 **b**	31.1	42.4 **b**	128.0 **b**	55.4	103.2 **b**	44.6	231.2 **b**
		Emamectin	4.0 **a**	95.2	0.2 **a**	4.8	4.2 **a**	12.3 **a**	91.1	1.2 **a**	8.9	13.5 **a**
		Fipronil	46.2 **b**	63.3	26.8 **c**	36.7	73.0 **b**	149.6 **b**	45.0	183.2 **b**	55.0	332.8 **b**
		Imidacloprid	29.6 **b**	60.4	19.4 **bc**	39.6	49.0 **b**	118.8 **b**	37.6	197.0 **b**	62.4	315.8 **b**
		Check	30.0 **b**	31.7	64.6 **d**	68.3	94.6 **b**	104.4 **b**	17.7	483.8 **c**	82.3	588.2 **b**
3 Months Post-Injection (May)	3 m	Dinotefuran	3.4 **ab**	20.0	13.6 **b**	80.0	17.0 **c**	12.4 **ab**	7.6	150.4 **b**	92.4	162.8 **c**
		Emamectin	0.0 **a**		0.0 **a**		0.0 **a**	0.0 **a**		0.0 **a**		0.0 **a**
		Fipronil	5.6 **b**	100.0	0.0 **a**	0.0	5.6 **b**	19.4 **b**	100.0	0.0 **a**	0.0	19.4 **b**
		Imidacloprid	6.4 **b**	31.1	14.2 **b**	68.9	20.6 **c**	36.0 **b**	19.2	151.4 **b**	80.8	187.4 **c**
		Check	2.2 **ab**	12.9	14.8 **b**	87.1	17.0 **c**	14.4 **b**	9.2	142.0 **b**	90.8	156.4 **c**
	8 m	Dinotefuran	10.4 **c**	37.7	17.2 **c**	62.3	27.6 **c**	59.8 **c**	28.2	152.2 **bc**	71.8	212.0 **c**
		Emamectin	0.0 **a**		0.0 **a**		0.0 **a**	0.0 **a**		0.0 **a**		0.0 **a**
		Fipronil	2.8 **bc**	93.3	0.2 **a**	6.7	3.0 **b**	8.2 **b**	89.1	1.0 **a**	10.9	9.2 **b**
		Imidacloprid	8.2 **c**	47.1	9.2 **b**	52.9	17.4 **c**	42.6 **bc**	32.8	87.4 **b**	67.2	130.0 **c**
		Check	1.0 **ab**	7.7	12.0 **bc**	92.3	13.0 **c**	2.4 **ab**	1.5	153.6 **c**	98.5	156.0 **c**
5 Months Post-Injection (Sept.)	3 m	Dinotefuran	2.6 **bc**	21.7	9.4 **b**	78.3	12.0 **c**	12.8 **c**	11.2	101.6 **b**	88.8	114.4 **c**
		Emamectin	0.0 **a**		0.0 **a**		0.0 **a**	0.0 **a**		0.0 **a**		0.0 **a**
		Fipronil	0.6 **ab**	60.0	0.4 **a**	40.0	1.0 **b**	2.4 **ab**	41.4	3.4 **a**	58.6	5.8 **b**
		Imidacloprid	1.4 **abc**	10.6	11.8 **b**	89.4	13.2 **c**	9.2 **bc**	5.6	154.2 **b**	94.4	163.4 **c**
		Check	2.8 **c**	17.7	13.0 **b**	82.3	15.8 **c**	9.8 **c**	6.1	150.6 **b**	93.9	160.4 **c**
	8 m	Dinotefuran	7.8 **d**	39.4	12.0 **b**	60.6	19.8 **c**	57.8 **c**	31.3	126.8 **b**	68.7	184.6 **c**
		Emamectin	0.0 **a**		0.0 **a**		0.0 **a**	0.0 **a**		0.0 **a**		0.0 **a**
		Fipronil	0.8 **ab**	40.0	1.2 **a**	60.0	2.0 **b**	2.2 **a**	14.5	13.0 **a**	85.5	15.2 **b**
		Imidacloprid	3.4 **c**	18.9	14.6 **b**	81.1	18.0 **c**	19.6 **b**	11.9	144.8 **b**	88.1	164.4 **c**
		Check	2.4 **bc**	11.9	17.8 **b**	88.1	20.2 **c**	10.8 **b**	4.6	223.4 **b**	95.4	234.2 **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 13: Cerambycid larval feeding in loblolly pine bolts cut one, three and five months after trunk injection with four systemic insecticides in 2004. Wells, Texas.

		Percent Phloem Area Consumed by Larvae		
Bolt Ht	Trt *	1 Month Post Injection (May)	3 Months Post Injection (July)	5 Months Post Injection (Sept.)
3 m	Dinotefuran	28.3 **c** *	33.1 **c**	16.9 **c**
	Emamectin	2.2 **a**	0.0 **a**	0.0 **a**
	Fipronil	5.4 **ab**	1.5 **a**	1.7 **ab**
	Imidacloprid	11.8 **bc**	14.0 **b**	5.9 **bc**
	Check	29.9 **c**	23.0 **bc**	9.3 **c**
8 m	Dinotefuran	13.6 **b**	33.9 **b**	3.6 **b**
	Emamectin	0.0 **a**	0.0 **a**	0.0 **a**
	Fipronil	15.4 **b**	0.0 **a**	0.0 **a**
	Imidacloprid	0.6 **a**	8.3 **b**	4.5 **b**
	Check	34.1 **c**	24.5 **b**	14.2 **b**

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

Trial 2: Although the study area had adequate rainfall to maintain general tree health, the Vapam/DMSO treatment had the desired effect of stressing the trees. Resin weeping down the bark surface was the most visible sign of stress and this occurred on nearly 40% of study trees ($F = 0.4487$; $df = 4, 25$; $P = 0.7723$). The treatments did not differ in proportion of trees with this stress symptom. Five of the six check trees showed signs of bark beetle attack (pitch tubes and boring dust) 2 weeks after the Vapam /DMSO treatment was administered. All study trees were evaluated about 4 weeks after the Vapam/DMSO treatment (= 24 days after initial pheromone deployment).

All checks and imidacloprid-treated trees were heavily attacked by *Ips* and most had two or more cerambycid egg niches at 3 m (Table 14). In contrast, emamectin benzoate- and fipronil-treated trees had significantly fewer *Ips* attacks at the same height. Of the few *Ips* attacks that were found on these trees, nearly all appeared to have been unsuccessful based on the fact that the pitch tubes at the entrance holes were dry and brittle. There were no differences among the

Table 14: Attraction and attacks by *Ips* engravers beetles and cerambycids to standing loblolly pine after trunk injection with four systemic insecticides in 2004. Wells, Texas.

Treatment	Mean # of *Ips* Caught / Trap	Mean # of Attacks / 0.3 m Bole Section at 3 m After 24 Days	
		Ips	Cerambycid
Dinotefuran	8.7 **b** *	6.2 **b**	4.5 **a**
Emamectin	1.2 **a**	0.5 **a**	0.8 **a**
Fipronil	5.2 **ab**	1.3 **a**	1.3 **a**
Imidacloprid	8.5 **b**	12.7 **c**	4.7 **a**
Check	6.5 **b**	14.7 **c**	4.3 **a**

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

treatments in the proportion of trees with early signs of fading crowns (yellowing needles) (Fig. 21, Table 15). None of the emamectin benzoate- and fipronil-treated trees had fading crowns; whereas, half (3 of 6) of the imidacloprid-treated trees were fading. Two check trees and one dinotefuran-treated tree also exhibited fading crowns.

Figure 21. Fading crown indicating tree mortality.

The study was discontinued after 66 days when no additional trees had faded in 20 days (Table 15). In the end, all (100%) of the imidacloprid-treated and 5 of 6 (83%) of each of the check and dinotefuran-treated trees had died due to bark beetle attack. In contrast, all emamectin benzoate- and fipronil-treated trees survived. Evaluation of cut bolts showed that all trees had been attacked, but the emamectin benzoate-treated bolts had significantly fewer attacks at both heights than the check (Table 16). All attacks that did occur were completely unsuccessful.

Table 15: Visible signs of mortality of standing loblolly pine after trunk injection with four systemic insecticides in 2004; Wells, Texas.

	Percentage of trees with fading crowns after:					
Treatment	24 days	32 days	39 days	46 days	52 days	66 days
Dinotefuran	16.7 **ab**	66.7 **b**	83.3 **b**	83.3 **b**	83.3 **b**	83.3 **b**
Emamectin	0.0 **a**	0.0 **a**	0.0 **a**	0.0 **a**	0.0 **a**	0.0 **a**
Fipronil	0.0 **a**	0.0 **a**	0.0 **a**	0.0 **a**	0.0 **a**	0.0 **a**
Imidacloprid	50.0 **b**	83.3 **b**	83.3 **b**	83.3 **b**	100.0 **b**	100.0 **b**
Check	33.3 **ab**	66.7 **b**	83.3 **b**	83.3 **b**	83.3 **b**	83.3 **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 16: Effects of four systemic insecticides on attack success and gallery construction of *Ips* engraver beetles on loblolly pine bolts cut after tree mortality or the end of the trial in 2004; Wells, Texas.

		Mean # of nuptial chambers without egg galleries		Mean # of Nuptial Chambers With Egg Galleries		
Bolt height	Treatment	No.	% of total	No.	% of total	Mean total # of nuptial chambers
3 m	Dinotefuran	6.8 **b** *	38.7	10.8 **b**	61.3	17.7 **c**
	Emamectin	3.0 **ab**	100.0	0.0 **a**	0.0	3.0 **a**
	Fipronil	5.0 **b**	81.1	1.2 **a**	18.9	6.2 **ab**
	Imidacloprid	0.2 **a**	2.0	8.0 **b**	98.0	8.2 **bc**
	Check	3.2 **ab**	32.8	6.5 **b**	67.2	9.7 **bc**
8 m	Dinotefuran	0.3 **a**	8.0	3.8 **bc**	92.0	4.2 **ab**
	Emamectin	1.3 **ab**	100.0	0.0 **a**	0.0	1.3 **a**
	Fipronil	1.5 **ab**	33.3	3.0 **ab**	66.7	4.5 **ab**
	Imidacloprid	2.7 **b**	21.3	9.8 **c**	78.7	12.5 **b**
	Check	0.8 **ab**	12.2	6.0 **bc**	87.8	6.8 **b**

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

One fipronil tree was partially colonized and may have ultimately succumbed to attack if the trial had been allowed to continue for a few more weeks. Even if this tree had eventually died, this would have left 83% of the treatment trees still alive and indicates that fipronil is a good protection option. Both emamectin benzoate- and fipronil-treated bolts had significantly fewer and shorter *Ips* egg galleries with and without brood and less area fed upon by cerambycid larvae compared to all other treatments (Table 17).

Conclusions: All chemical formulations were quickly injected into the study trees for both trials using the Arborjet Tree IV system. However, evaluation of the phloem and xylem surrounding the injection points revealed that the emamectin benzoate solution caused the development of long vertical lesions. The occurrence of these lesions indicates that at least one component of the injected formulation is detrimental to plant tissue. Since methanol was used as a solvent in both the emamectin benzoate and fipronil formulations, it is unlikely that this component caused the lesions. Denim® (emamectin benzoate) was developed for spray applications and contains 3 inert ingredients (mineral oil, butylated hydroxytolulene and an organic solvent) that allow the active ingredient to spread and adhere to the foliar surface. A recent subtractive bioassay conducted by Arborjet, Inc with white pine suggests that the cause of the excessively long lesions on emamectin benzoate-treated trees was due to organic solvent component in the Denim® formulation (Joe Doccola, Arborjet Inc., personal communication). Further tests are needed to develop an emamectin benzoate formulation that is effective against target insects, yet non-toxic to the trees upon injection into cambial and xylem tissue.

In both trials, 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.

Fipronil 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.

Imidacloprid and dinotefuran, both neonicotinoids, do not appear to have any marked effect against bark beetles. Imidacloprid effectively reduced the amount of cerambycid larval feeding one month post-injection, but it was only marginally effective after three months in both the bolt and standing tree trials and did not differ from the check after five months. These findings

Table 17: Effects of four systemic insecticides on gallery construction of *Ips* engravers beetles and cerambycid larval development in loblolly pine bolts cut after tree mortality or at the end of the trial in 2004; Wells, Texas.

		Mean # of Number of Egg Galleries					Mean Length of Egg Galleries					
		Without Brood		With Brood			Without Brood		With Brood			Cerambycid
Bolt Ht	Trt *	No.	% of Total	No.	% of Total	Total Number	cm	% of Total	cm	% of Total	Total Length	Feeding Area
3 m	Dinotefuran	18.3 **b** *	61.1	11.7 **b**	38.9	30.0 **b**	71.2 **b**	45.2	86.3 **b**	54.8	157.5 **b**	9.8 **b**
	Emamectin	0.0 **a**		0.0 **a**		0.0 **a**	0.0 **a**		0.0 **a**		0.0 **a**	0.0 **a**
	Fipronil	1.0 **a**	85.7	0.2 **a**	14.3	1.2 **a**	3.5 **a**	58.3	2.5 **a**	41.7	6.0 **a**	0.0 **a**
	Imidacloprid	27.2 **b**	71.2	11.0 **b**	28.8	38.2 **b**	179.8 **c**	59.6	121.7 **b**	40.4	301.5 **b**	5.7 **b**
	Check	17.2 **b**	59.5	11.7 **b**	40.5	28.8 **b**	108.3 **bc**	48.0	117.2 **b**	52.0	225.5 **b**	3.6 **b**
8 m	Dinotefuran	11.3 **bc**	42.2	15.5 **b**	57.8	26.8 **b**	83.7 **b**	36.4	146.5 **b**	63.6	230.2 **b**	11.7 **c**
	Emamectin	0.0 **a**		0.0 **a**		0.0 **a**	0.0 **a**		0.0 **a**		0.0 **a**	0.0 **a**
	Fipronil	7.2 **ab**	93.5	0.5 **a**	6.5	7.7 **a**	20.2 **a**	89.0	2.5 **b**	11.0	22.7 **a**	0.0 **a**
	Imidacloprid	19.0 **c**	57.3	14.2 **b**	42.7	33.2 **b**	102.0 **b**	46.9	115.5 **b**	53.1	217.5 **b**	0.5 **ab**
	Check	18.5 **c**	40.5	27.2 **b**	59.5	45.7 **b**	91.0 **b**	30.8	204.0 **c**	69.2	295.0 **b**	6.2 **bc**

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

support the reported activity by imidacloprid against Asian long horned beetle, another cerambycid (Joe Doccola, Arborjet, Inc., personal communication), but also suggest that emamectin benzoate and fipronil may provide better, longer term tree protection against this exotic pest species.

Because southern pine beetle (SPB) populations were extremely low in east Texas in 2004, *Ips* engraver beetles were used as an alternative organism for this study. However, it is necessary to conduct addition trials to confirm the effectiveness of emamectin benzoate and fipronil against SPB. Additional trials also are needed to confirm activity of these two chemicals against other destructive bark beetle species including the mountain pine beetle, *D. ponderosae* Hopkins, western pine beetle, *D. brevicomis* LeConte, spruce beetle, *D. rufipennis* (Kirby), Douglas-fir beetle, *D. pseudotsugae* Hopkins, pine engraver, *I. pini* (Say), piñyon ips, *I. confusus* (LeConte), California five-spined ips, *Ips paraconfusus* Lanier and Arizona five-spined ips, *I. lecontei* Swaine.

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 has been found to prevent successful attack by *Ips* engravers. If a lower dose were to be injected in trees at the leading edge of an active 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 thinned stands for the project. We appreciate the chemical donations and injection equipment loans made by Arborjet, Inc, BASF, and Syngenta and field assistance of Libor Myslevic.

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SYSTEMIC INSECTICIDE INJECTION TRIALS

Protection of Pine Wood Against Termites

Highlights:

- The trial was initiated in November 2004 and is on-going.

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

Justification: It is well know that subterranean termites (*Coptotermes*, *Heterotermes* and *Reticulitermes* spp.) will quickly locate and begin colonization of downed timber. However, we noticed that residual logs from trees that had been injected with emamectin benzoate or fipronil as part of the bark beetle injection trial (2004), felled in May and June, and laying on the ground still had not been colonized by termites or other wood boring insects by October 2004. In contrast, logs from most untreated study trees were being colonized by termites and wood boring insects within the 3 to 5 months they had been on the ground.

Fipronil is already registered as a termiticide under the brandname, 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 1m height of the bole of each tree and tagged. From each bolt, two 2.5 cm thick cookies were cut and tagged (60 cookies total). The wood surfaces of each cookie were sanded smooth.

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

In May and November 2005 (6 and 12 months after deployment), the cookies will be evaluated for termite damage. Ratings will be made at the location of the most extensive damage as follows:

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

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

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.

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®). Dr. Gary DeBarr, USFS retired, had tested the possibility of injecting systemic insecticides as a means to reduce cone and seed insect losses, but with mixed results. He believed that 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.

Emamectin Benzoate - Over the past six years, emamectin benzoate (Arise SL®), injected as part of the initial Seed Orchard Duration trial, has 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 Arise SL® formulation is also reported to be highly effective (providing 3+ years of protection) in Japan against the pinewood nematode, *Bursaphelenchus xylophilus*, and its cerambycid vector, *Monochamus alternatus* (Dr. David Cox, Syngenta Crop Protection, personal communication). The maximum duration of this chemical's residual activity against cone and seed insects has yet to be determined. However, the small seed orchard market and the flammability of the product carrier has discouraged Syngenta from pursuing registration of the Arise® (emamectin benzoate) formulation in this country.

Syngenta recently registered emamectin benzoate (Proclaim®, Denim®) with EPA in the United States. A preliminary trial conducted in 2002 indicated that the Denim® formulation could be injected into loblolly pine using the STIT injector. The Denim®/Fipronil Trial was initiated in 2003 in part to test the efficacy of the Denim® formulation for control of cone and seed insects. This is the third study conducted by the WGFPMC to demonstrate that emamectin benzoate is effective in protecting 1st-and 2nd-year loblolly cones against coneworms.

Seven years of 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 has been reluctant to support an injection use registration regardless of the fact that Denim is already registered in the U.S.

Since 2002, an attempt is being made to expand the forestry market of emamectin benzoate through trials with other tree and pest species. For example, emamectin benzoate injected into several species of hardwoods was nearly as effective as imidacloprid in causing mortality to larvae of the Asian longhorned beetle (Therese Poland, USFS, personal communication). In another trial, emamectin benzoate was injected into two white pine trees near Blackburg, VA in early August 2002. Twigs, taken from these injected trees two weeks later, were presented to male and female pales weevils, *Hylobius pales*, in petri dishes. Feeding activity was considerably reduced compared to untreated twigs and 100% mortality of both weevil sexes occurred within two weeks after exposure to treated twigs (Jeff Fidgeon, Virginia Tech, unpublished data).

Emamectin benzoate also was found in field trials to be highly effective against forest tent caterpillar in Kentucky (Dr. Daniel Potter, University of Kentucky, personal communication). Most recently in 2004, injected emamectin benzoate (Denim®) was tested for efficacy against acorn weevils and southern pine engraver beetles. Although emamectin benzoate was found to be ineffective against the acorn weevil (see Acorn Weevil Report). it 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. However, the Denim® formulation has several negative characteristics that limit its potential use as an injectable formulation. Denim® (undiluted) is a much more viscous (27 centipose) compared to the Arise® (5 centipose) formulation. High viscosity, combined with drought conditions, caused injection times in 2003 to be considerably longer (20-40 minutes per tree for Denim® versus 5-10 minutes per tree for Arise®). If injection of seed orchard and ornamental trees is ever to become cost effective, it is essential that injection times be reduced to 10-15 minutes per tree. In addition, an organic solvent component of Denim® was found in 2004 to cause stem necrosis (long vertical lesions) in loblolly pine (see Bark Beetle Study) and live oak (Acorn Weevil Trial). In light of these limitations, Syngenta has recently reached an agreement with Arborjet, Inc. to develop a new injectable formulation of emamectin benzoate. Arborjet has already identified the organic solvent component in Denim® that caused the stem necrosis and is in the process of selecting an alternative solvent that can be mixed with technical emamectin benzoate to create a non-toxic, low viscosity formulation for injection use (Joe Doccola, Arborjet™, personal communication).

Three WGFPMC proposals have been developed for 2005 to evaluate the new 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). In addition, we plan to continue evaluating the potential of emamectin benzoate for protection of wood against termites. Arborjet also has plans to arrange the testing of 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 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 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), two formulations (Termidor® and an experimental EC) of fipronil were injected into trees as part of the Denim®/fipronil trial in 2003. As with the Denim®, initial movement and efficacy of fipronil was apparently limited by drought conditions. However, both formulations of fipronil, particularly the EC, showed much improved performance in reducing overall coneworm damage in 2004 compared to 2003. In 2004, the EC formulation also was found to be highly effective in preventing the colonization and mortality of stressed loblolly pine by southern pine bark beetles (see Bark Beetle Report). Although this formulation has not been found to cause stem necrosis in injected trees, BASF has elected to develop a new and "improved" formulation of fipronil for injection use. It should be available for comparison with the new formulation of emamectin benzoate in the three new WGFPMC trials mentioned above. In addition, further evaluation of the effects (duration) of fipronil on coneworm- and seed bug-damage on trees injected in 2003 is warranted for 2005.

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 bug 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 need 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. However, 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.

Dinotephuran - Dinotephuran (Valent) is a "3rd generation" neonicotinoid insecticide with primary activity against sucking insects as well as Coleoptera (beetles). On the spur of the moment last spring (2004), we decided to include dinotephuran as part of the bark beetle trial. It was applied at the same rate (0.2g/DBH") as the other treatments (emamectin benzoate, fipronil and imidacloprid). Dinotephuran did not appear to be effective against either bark beetles or woodborers. However, Arborjet later found that injections of dinotephuran at 0.4g/DBH" was as effective as imidacloprid against emerald ash borer. One advantage dinotephuran 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 dinotephuran 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.

PINE TIP MOTH TRIALS

Impact Study – Western Gulf Region

Highlights:

- Six new impact plots were established in 2004, bringing the total to 40 plots established since 2001.
- Analyses of 2004 data alone or combined with 2001 - 2003 data are ongoing.

Objectives: 1) Determine the impact of Nantucket pine tip moth infestation on height and diameter growth and form of loblolly pine in the Western Gulf Region and 2) identify a treatment threshold for pine tip moth infestation.

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 2003 and monitored until late November 2004 (Fig. 22). Lures were changed at 4 - 6 week intervals, depending on mean temperatures.

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

Design: 24 sites X 1-2 plots X 2 treatments X 50 trees = 4,000 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. 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 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: Five new impact plots were established in 2004; bringing the total number of plots established since 2001 to 40 (Fig. 23). Andy Burrow, Temple-Inland, has agreed to assist in the analysis of impact data and look at the relationship between tip moth damage and tree growth as well as evaluate how site parameters may influence this relationship. Analysis of 2004 data alone or combined with past year's data is ongoing. A final report will be provided to WGFPMC members later this spring.

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, 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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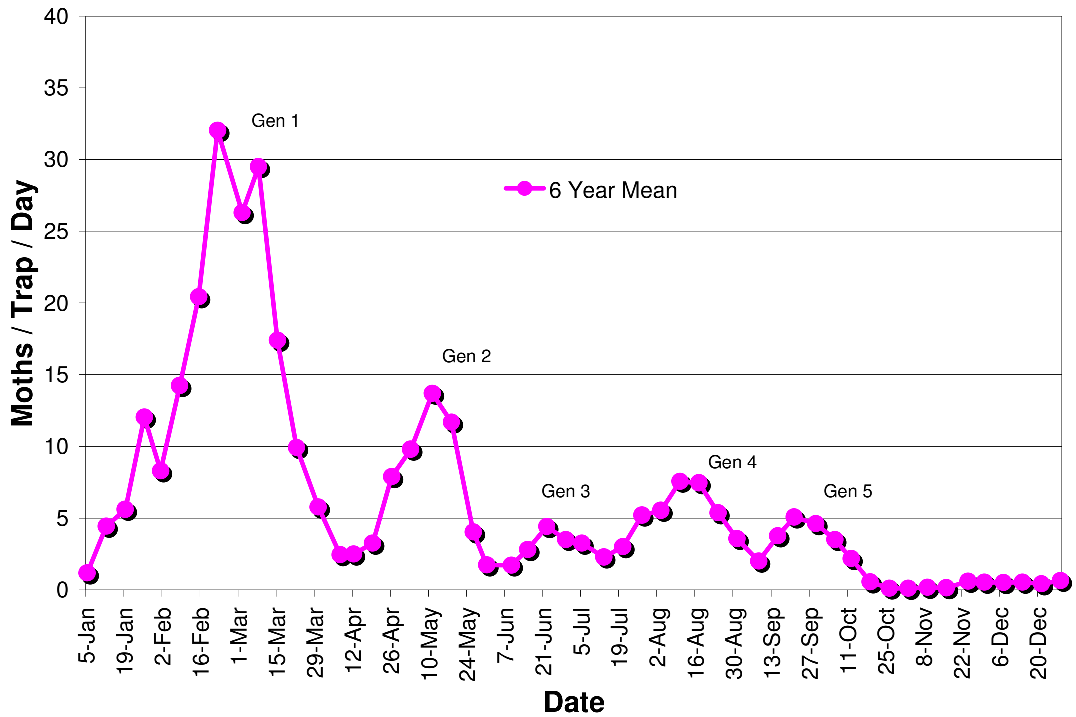

Figure 22. Mean number of pine tip moth adults captured per trap per day in the Lufkin, TX area (1999 – 2004).

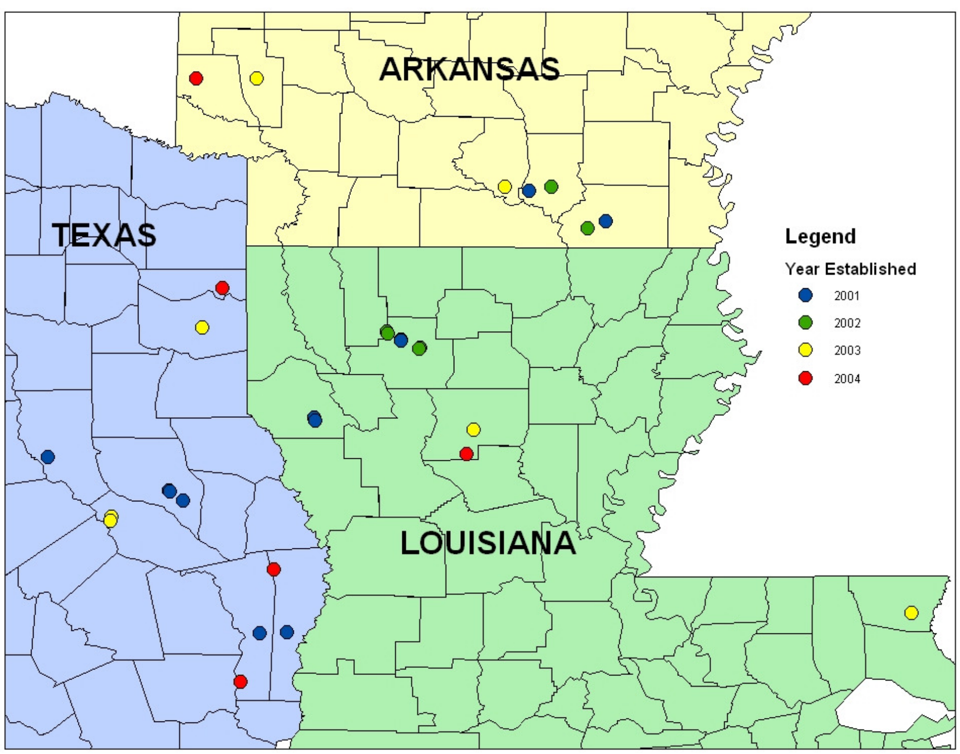

Figure 23. Distribution of 40 one- to four-year old impact sites in the Western Gulf Region –2004.

PINE TIP MOTH TRIALS

Hazard Rating Study – Western Gulf Region

Highlights:

- Data on site characteristics were collected from 32 plots (10 - first-year and 21 - second-year) in the Western Gulf Region in 2004. In total, 72 hazard-rating plots have been established since 2001.
- Andy Burrow has made progress in the development of a hazard-rating model.

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 32 Western Gulf plots (10 - first-year and 21 - second-year) in 2003 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 – 1^{st}, 2^{nd}, 3^{rd}, 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 2^{nd} 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.

Results: Mr. Andy Burrow, Temple Inland, volunteered early last year to help us 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 (three years' worth) was consolidated and sent to Mr. Burrows by the end of March 2004. Don Grosman and Andy had several meetings during the summer and fall to discuss the development of the model. Considerable progress has been made, but the development of the model is still ongoing. A final report should be available to WGFPMC members later this spring.

Figure 24 shows the distribution of all 72 hazard-rating sites established in the Western Gulf Region from 2001 to 2004.

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, 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.

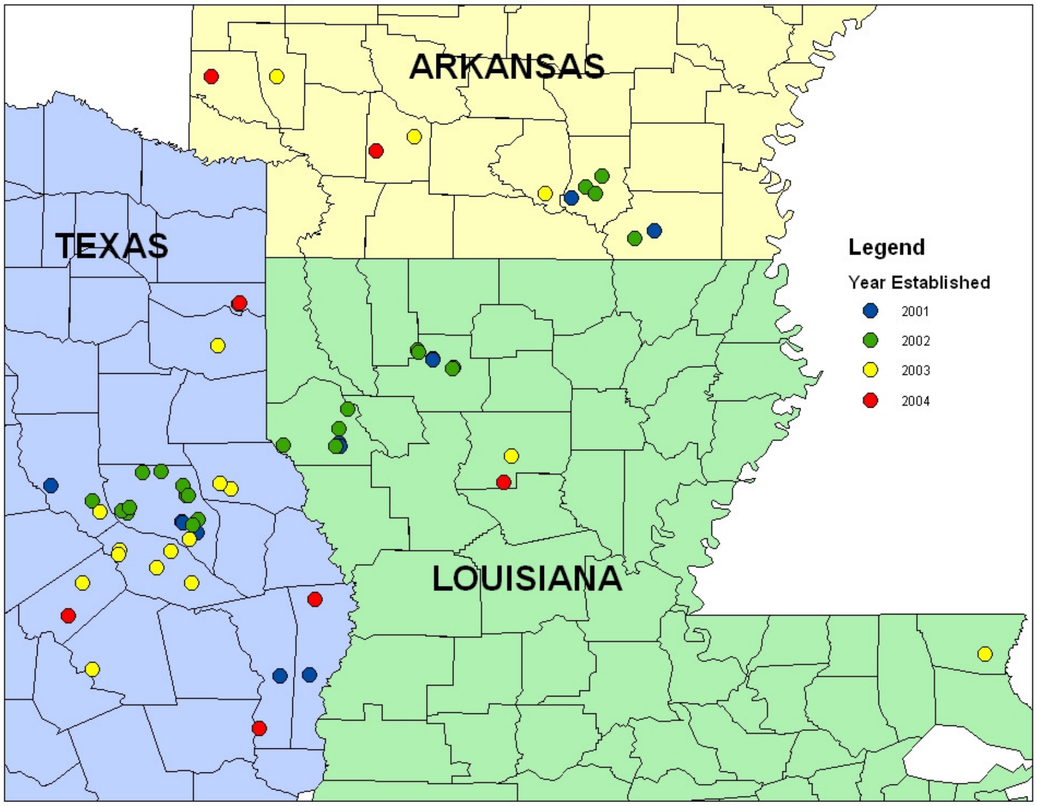

Figure 24. Distribution of 72 hazard-rating plots established 2001 -2004 in the Western Gulf Region.

PINE TIP MOTH TRIALS

Seedling Treatment Study – Rusk Co., TX

Highlights:

- Fipronil-treated seedlings continue to show stable gains in height, diameter and volume growth compared to check trees. In contrast, the gains made by seedlings treated with Mimic®, imidacloprid or thiamethoxam have declined in the third year after planting.

Objectives: 1) Continue evaluating the efficacy of several systemic insecticides (emamectin benzoate, imidacloprid, thiamethoxam 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 (Fig. 25). Two plots, containing 350 trees (5 rows X 70 trees), were 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. Plot 3: 1 site X 10 treatments X 50 trees = 500 monitored trees.

Treatments:

Plot 1 & 2: Chemical Effect:

1) Emamectin benzoate (Proclaim®) solution (0.12%) root soak
2) Fipronil (Termidor® SC) solution (0.157%) root soak
3) Imidacloprid (technical) solution (0.53%) root soak
4) Thiamethoxam (25 WP) solution (0.17%) root soak
5) Tebufenozide (Mimic®, 0.8 oz/gal) foliar spray (5X) prior to each generation in 2002 and 2003
6) Check (untreated)

Treatment Evaluation in 2004: Tip moth damage was not evaluated in 2004, 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 2004.

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 18). 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 19 & 20).

In 2003, damage levels on check trees averaged nearly 50% lower than 2002 levels (Table 18). Activity of all root-soak treatments also declined compared to the previous year. However, fipronil 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 19 & 20). 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 19). However, only fipronil and Mimic®-treated trees continued to be both significantly taller in height and larger in volume than check trees. The fipronil treatment has maintained a stable volume growth rate relative to the check trees over the past two years (Fig. 26). In contrast, the growth rate of Mimic®-, imidacloprid- and thiamethoxam-treated trees declined in 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 (Table 20).

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 18. Effect of systemic chemical treatments on pine tip moth infestation of loblolly pine shoots (top whorl) after each generation during the first 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	Mean Pct. Red. (All 5
Treatment §	N	Gen 1		Gen 2		Gen 3		Gen 4		Gen 5		Yr. 1	Gen)
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	Mean Pct. Red. (All 5	Mean Pct. Red. (2 Yr
Treatment §	N	Gen 1		Gen 2		Gen 3		Gen 4		Gen 5		Yr. 1	Gen)	Avg)
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 19. 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 - 2004.

		Mean Tree Measurements (Pct. Gain Compared to Check)					
		Height (cm)			Diameter (cm)		
Treatment §	N	2002	2003	2004	2002	2003	2004
Emamectin	100	47.1 **a** * (-9)	145.1 **a** (-3)	285.7 **a** (-3)	0.69 **a** (-8)	2.61 **a** (-4)	3.51 **a** (-4)
Fipronil	100	56.3 **cd** (9)	157.3 **b** (5)	314.3 **cd** (7)	0.82 **ab** (9)	3.00 **c** (10)	4.04 **b** (11)
Imidacloprid	100	55.2 **bc** (7)	156.7 **b** (4)	310.6 **cd** (6)	0.85 **bc** (12)	3.07 **cd** (12)	4.01 **b** (10)
Thiamethoxam	100	55.1 **bc** (7)	157.6 **b** (5)	306.3 **bc** (4)	0.84 **bc** (11)	2.95 **bc** (8)	3.95 **b** (9)
Mimic® (foliar)	100	59.9 **d** (16)	173.6 **c** (15)	323.7 **d** (10)	0.91 **c** (20)	3.25 **d** (19)	4.30 **c** (18)
Check	100	51.7 **b**	150.3 **ab**	294.2 **ab**	0.75 **a**	2.73 **ab**	3.64 **a**

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

Table 20. Effect of systemic chemical treatments on loblolly pine volume growth and form on Plots 1 & 2, Evans Tract, Fairchild State Forest, Cherokee Co., TX, 2002 - 2004.

Treatment §	N	Volume (cm^3) (Pct. Gain Compared to Check) 2002		2003		2004		% Trees Forked 2003	2004
Emamectin	100	27.3 **a** *	(-27)	1083.3 **a**	(-17)	4071.9 **a**	(-12)	16.8 **b**	4.2 **ab**
Fipronil	100	47.6 **b**	(27)	1678.2 **c**	(28)	5932.7 **c**	(28)	1.0 **a**	6.2 **ab**
Imidacloprid	100	47.6 **bc**	(27)	1687.7 **c**	(29)	5504.3 **bc**	(19)	16.3 **b**	5.1 **ab**
Thiamethoxam	100	47.4 **b**	(26)	1551.6 **bc**	(18)	5372.9 **bc**	(16)	19.2 **b**	6.1 **ab**
Mimic® (foliar)	100	60.6 **c**	(61)	2189.9 **d**	(67)	6993.2 **d**	(51)	4.0 **a**	1.0 **a**
Check	100	37.5 **ab**		1312.4 **ab**		4630.8 **ab**		18.4 **b**	7.1 **b**

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

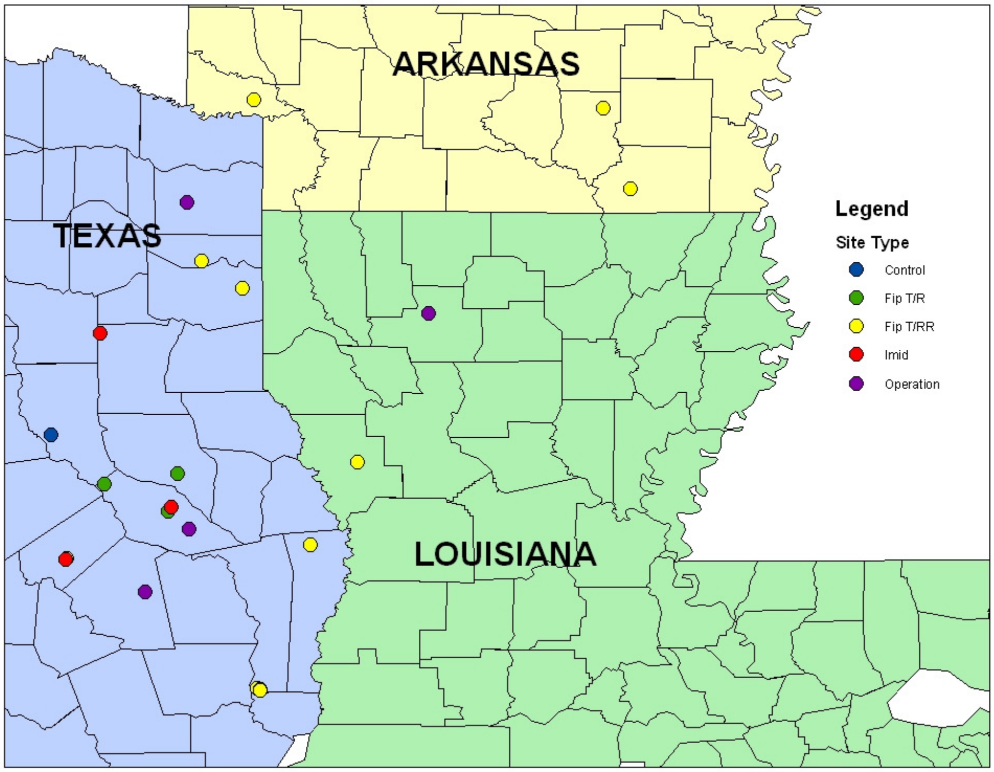

Figure 25. Distribution of tip moth control plots established in 2002 -2004 in the Western Gulf Region.

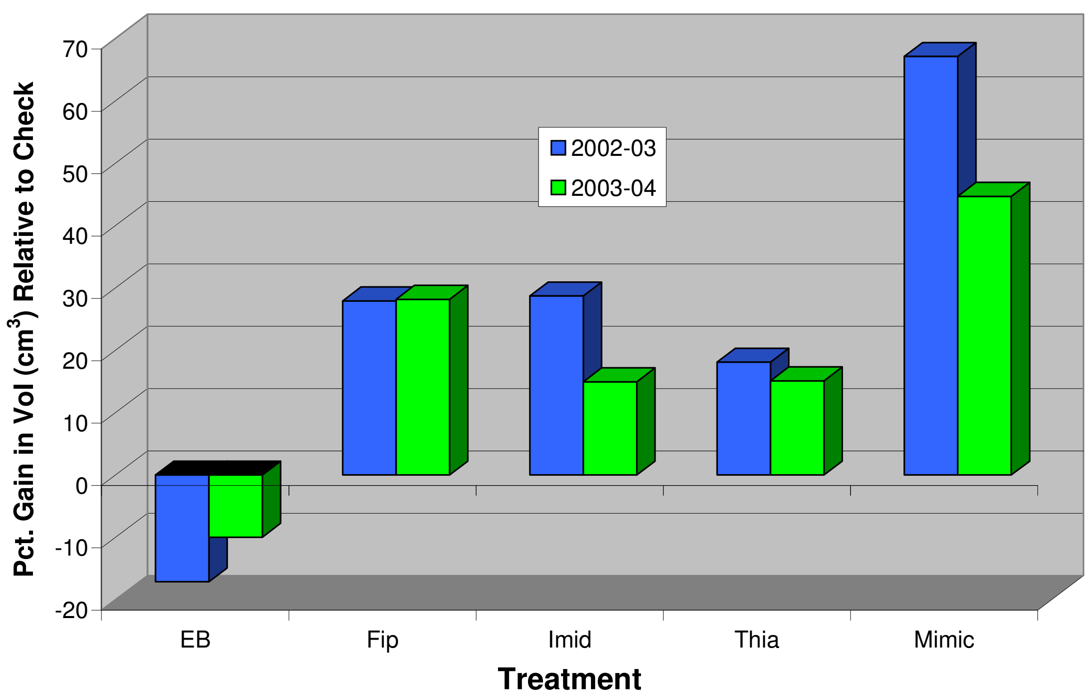

Figure 26. Percent gain in volume (cm^3) growth of loblolly pine treated with systemic or foliar insecticides relative to untreated trees, Fairchild State Forest, 2002 -2004.

PINE TIP MOTH TRIALS

Fipronil Technique and Rate Study – Western Gulf and East Coast

Highlights:

- The plant hole (Termidor®) treatment still provided excellent protection against tip moth in the second-growing season, reducing damage by 93% in TX and 91% in NC compared to untreated check trees. The root dip with Terrasorb™ treatment provided moderate protection, reducing tip moth damage in TX by 39% and in NC by 30%.
- Second-year trees that had been treated by root soak (0.3% Regent®) consistently had the greatest improvement in height, diameter and volume parameters compared to check trees.
- Seedlings soaked with Regent® consistently had less tip moth damage than seedlings soaked with Termidor® at the same rate (0.3%). There were no significant differences in height and diameter growth between these treatments, but volume index was significantly greater for Regent®-treated trees.
- Increasing the dose rate from 0.0003% to 0.3% significantly improved protection provided by fipronil (Termidor®) root soaks on NC sites, but not in TX. The effect of dosage rate on tree growth was inconsistent.
- Seedlings treated with the highest fipronil concentration (6.5% in plant holes) experienced significantly lower seedling survival on two TX sites compared to check trees, but no such effect was observed on any of the other sites. In contrast, seedlings treated with moderate fipronil rates had significantly higher survival.

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 (all in Angelina Co., see Fig. 25); 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) 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 2003/2004 and 2004/2005.

Results:

Survival: In 2003, treatment concentration affected seedling survival on two sites in TX. Seedlings treated with fipronil (6.5%) in the plant hole on the TX1 and TX3 sites generally did not show phytotoxic symptoms, but were apparently negatively affected by the treatment. These seedlings had significantly lower survival compared to the checks (Table 21). In contrast, seedling survival did not differ among treatments on the remaining sites (Tables 22 & 23). In 2004, some additional seedling mortality occurred for most treatments and sites, but not enough to be of concern.

Tip Moth Infestation: In 2003, no tip moth damage was recorded on NC sites after the first generation due to an unscheduled permethrin application for weevil control (Table 23). On the remaining sites, tip moth damage levels on check trees after the first generation were variable, with means ranged from a low of 4 –8% in TX, 43 – 44% in GA, and 51% in VA (Tables 21, 22 & 23). Whereas damage levels steadily increased in each subsequent generation on TX sites, they tended to peak early in the year (first or second generation) on the East Coast sites. A very similar pattern emerged on TX and NC sites in 2004.

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 (Tables 21 & 22). 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.

In 2003, all higher rate ($\geq$ 0.3%) dip, soak and plant hole treatments generally performed well in reducing tip moth damage during the first generation (Tables 21, 22 & 23). 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 4). 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 21 & 23). 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 with root dip with Terrasorb™ reduced tip moth damage in TX and NC by 39% and 30%, respectively, compared to check trees (Table 4). Both high rate (0.3%) root soak treatments (Termidor® and Regent®) showed moderate activity in NC, but neither treatment had any effect in TX.

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 (Tables 24, 25 & 26). 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 (Tables 24, 25 & 26). 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.

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 21. Effect of fipronil application technique and rate on pine tip moth infestation of loblolly pine shoots (top whorl)and tree survival on three sites in east Texas, 2003 - 2004.

			Mean Percent Top Whorl Shoots Infested by Tip Moth (Pct. Reduction Compared to Check)																		Mean Percent
Year	Treatment §	N	Gen 1			Gen 2			Gen 3			Gen 4			Gen 5			Overall Mean			Tree Survival
2003	T Fip Furrow 1	150	4.5	**15**		8.2	**11**		10.2	**33**	*	25.8	**10**		26.2	**23**	*	15.0	**19**	*	98 *
	T Fip Furrow 1+1	150	1.7	**69**	*	10.3	**-12**		15.4	**-2**		26.8	**7**		33.3	**2**		17.6	**5**		96 *
	T Fip + TerraSorb Dip	150	2.3	**57**	*	2.0	**79**	*	1.2	**92**	*	5.0	**83**	*	6.2	**82**	*	3.3	**82**	*	99 *
	T Fip Soak 0.003%	150	2.5	**54**	*	6.2	**33**	*	11.9	**21**		25.5	**11**		36.3	**-7**		16.7	**10**		92
	T Fip Soak 0.03%	150	3.3	**39**		5.6	**39**	*	8.5	**43**	*	21.0	**27**		28.2	**17**		13.1	**29**	*	94
	T Fip Soak 0.3%	150	2.2	**60**	*	1.5	**84**	*	2.6	**82**	*	9.2	**68**	*	19.8	**42**	*	7.1	**62**	*	97 *
	R Fip Soak 0.3%	150	1.9	**64**	*	0.3	**97**	*	1.4	**90**	*	8.3	**71**	*	12.8	**62**	*	5.0	**73**	*	98 *
	T Fip Plant Hole 6.5%	150	2.9	**46**		0.9	**90**	*	0.2	**99**	*	0.4	**98**	*	0.2	**99**	*	0.6	**97**	*	76 *
	Check	300	5.4			9.2			15.1			28.7			34.1			18.5			90
2004	T Fip Furrow 1	150	3.0	**42**		7.8	**-46**		7.0	**44**	*	30.6	**-19**		27.8	**13**		15.2	**5**		93 *
	T Fip Furrow 1+1	150	4.6	**12**		10.8	**-102**	*	6.7	**46**	*	20.5	**20**		34.0	**-6**		15.4	**4**		94 *
	T Fip + TerraSorb Dip	150	2.5	**52**	*	1.0	**80**	*	1.9	**85**	*	15.3	**41**	*	28.3	**11**		9.8	**39**	*	98 *
	T Fip Soak 0.003%	150	6.6	**-25**		2.0	**63**	*	3.8	**69**	*	27.9	**-8**		34.9	**-9**		14.9	**7**		90
	T Fip Soak 0.03%	150	4.7	**11**		11.7	**-118**	*	5.1	**59**	*	29.9	**-16**		30.7	**4**		16.1	**0**		91
	T Fip Soak 0.3%	150	2.7	**48**		5.9	**-10**		15.8	**-27**		27.5	**-7**		27.0	**16**		15.8	**2**		93 *
	R Fip Soak 0.3%	150	4.4	**16**		9.7	**-81**	*	15.7	**-26**		37.6	**-46**	*	36.3	**-13**		20.3	**-26**	*	96 *
	T Fip Plant Hole 6.5%	150	0.4	**92**	*	0.0	**100**	*	0.1	**99**	*	3.3	**87**	*	2.6	**92**	*	1.2	**93**	*	73 *
	Check	300	5.3			5.3			12.4			25.7			32.0			16.1			90

§ 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% or better compared to check.

Table 22. Effect of fipronil application technique and rate on pine tip moth infestation of loblolly pine shoots (top whorl) and tree survival after 4 generations on two sites in Georgia - 2003 & 2004.

			Mean Percent Top Whorl Shoots Infested by Tip Moth (Pct. Reduction Compared to Check)															Mean Percent
Year	Treatment §	N	Gen 1			Gen 2			Gen 3			Gen 4			Overall Mean			Tree Survival
2003	T Fip Furrow 1	100	47.5	**-9**		45.4	**25**	*	49.7	**3**		32.3	**1**		43.7	**7**		97
	T Fip Furrow 1+1	100	38.3	**12**		51.0	**15**	*	52.2	**-2**		35.0	**-7**		44.1	**6**		99
	T Fip + TerraSorb Dip	100	20.3	**54**	*	1.1	**98**	*	2.9	**94**	*	2.9	**91**	*	6.8	**85**	*	99
	T Fip Soak 0.003%	100	47.4	**-8**		34.6	**43**	*	40.3	**21**	*	36.3	**-11**		39.6	**15**	*	99
	T Fip Soak 0.03%	100	35.9	**18**	*	10.6	**82**	*	14.0	**73**	*	15.2	**53**	*	18.9	**60**	*	99
	T Fip Soak 0.3%	100	24.5	**44**	*	5.2	**91**	*	2.1	**96**	*	2.0	**94**	*	8.5	**82**	*	95
	R Fip Soak 0.3%	100	30.2	**31**	*	2.0	**97**	*	6.9	**86**	*	3.8	**88**	*	10.8	**77**	*	97
	T Fip Plant Hole 6.5%	100	30.8	**30**	*	0.9	**99**	*	0.8	**98**	*	0.0	**100**	*	8.1	**83**	*	98
	Check	100	43.7			60.2			50.9			32.7			46.9			97
2004	T Fip Furrow 1	100																
	T Fip Furrow 1+1	100																
	T Fip + TerraSorb Dip	100																
	T Fip Soak 0.003%	100																
	T Fip Soak 0.03%	100																
	T Fip Soak 0.3%	100																
	R Fip Soak 0.3%	100																
	T Fip Plant Hole 6.5%	100																
	Check	100																

§ 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.

Table 23. Effect of fipronil application technique and rate on pine tip moth infestation of loblolly pine shoots (top whorl) and tree survival after each of 3 generations on two sites in North Carolina - 2003 & 2004.

			Mean Percent Top Whorl Shoots Infested by Tip Moth (Pct. Reduction Compared to Check)												Mean Percent
Year	Treatment §	N	Gen 1			Gen 2			Gen 3			Overall Mean			Tree Survival
2003	T Fip Furrow 1	---	---	---		---	---		---	---		---	---		---
	T Fip Furrow 1+1	---	---	---		---	---		---	---		---	---		---
	T Fip + TerraSorb Dip	150	NA			2.4	**94**	*	2.3	**94**	*	2.3	**94**	*	96
	T Fip Soak 0.003%	150	NA			38.8	**3**		43.2	**-6**		40.6	**-2**		97
	T Fip Soak 0.03%	150	NA			8.1	**80**	*	21.4	**48**	*	14.7	**63**	*	93
	T Fip Soak 0.3%	150	NA			0.6	**98**	*	4.8	**88**	*	2.7	**93**	*	94
	R Fip Soak 0.3%	150	NA			3.8	**91**	*	3.7	**91**	*	6.9	**83**	*	96
	T Fip Plant Hole 6.5%	150	NA			0.9	**98**	*	0.0	**100**	*	0.4	**99**	*	91
	Check	150	NA			40.0			40.8			39.8			96
2004	T Fip Furrow 1	---	---	---		---	---		---	---		---	---		---
	T Fip Furrow 1+1	---	---	---		---	---		---	---		---	---		---
	T Fip + TerraSorb Dip	150	35.6	**32**	*	19.8	**40**	*	29.1	**14**	*	28.1	**30**	*	94
	T Fip Soak 0.003%	150	54.2	**-3**		30.7	**7**		27.9	**17**		37.9	**5**		93
	T Fip Soak 0.03%	150	52.0	**1**		32.3	**3**		31.1	**8**		38.6	**4**	*	86
	T Fip Soak 0.3%	150	38.6	**27**	*	24.9	**25**	*	22.3	**34**	*	28.7	**28**	*	92
	R Fip Soak 0.3%	150	43.8	**17**		21.3	**36**	*	30.0	**11**		32.2	**20**	*	90
	T Fip Plant Hole 6.5%	150	5.9	**89**	*	2.4	**93**	*	3.1	**91**	*	3.8	**91**	*	90
	Check	150	52.6			33.2			33.8			40.1			95

§ 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.

Table 24. Effect of fipronil application technique and rate on loblolly pine height growth after two years on eight sites in Virginia, North Carolina, Georgia and Texas - 2003 & 2004.

		Mean Height (cm) of 1st Year Loblolly Pine (Pct. Gain Compared to Check)																				
		3 Generation Sites						4 Generation Sites					5 Generation Sites									
Year	Treatment §	VA	NC1	NC2	NC Mean			GA1	GA2	Mean			TX1	TX2	TX3	Mean				Overall Mean		
2003	T Fip Furrow 1	---	---	---	---			49.8	42.9	46.4	**7**		49.5	55.2	59.5	54.8	**8**	*		51.5	**5**	*
	T Fip Furrow 1+1	---	---	---	---			44.2	44.9	44.6	**3**		46.1	50.2	55.9	50.8	**0**			48.2	**-1**	
	T Fip + TerraSorb Dip	54.1	55.1	53.5	54.3	**27**	*	71.3	66.1	68.7	**58**	*	56.3	57.6	67.9	60.5	**19**	*		60.6	**28**	*
	T Fip Soak 0.003%	49.9	53.5	37.8	45.9	**7**		49.0	51.6	50.3	**16**	*	45.1	53.2	58.3	52.0	**2**			49.7	**5**	*
	T Fip Soak 0.03%	58.1	50.9	51.6	51.2	**20**	*	60.6	53.1	56.9	**31**	*	43.4	57.6	61.2	54.2	**7**	*		54.5	**15**	*
	T Fip Soak 0.3%	57.9	50.8	55.6	53.1	**24**	*	65.3	54.2	59.6	**37**	*	48.0	60.5	46.6	51.8	**2**			54.6	**15**	*
	R Fip Soak 0.3%	53.1	67.0	58.5	62.6	**46**	*	62.0	58.2	60.1	**38**	*	51.6	52.2	70.6	57.9	**14**	*		59.5	**25**	*
	T Fip Plant Hole 6.5%	57.3	59.5	56.1	57.9	**35**	*	62.0	58.8	60.4	**39**	*	48.2	49.9	66.5	54.5	**7**	*		57.4	**21**	*
	Check	44.3	50.7	34.1	42.8			45.2	41.7	43.4			49.3	51.0	52.1	50.8			A	47.4		
																			B	48.8		
2004	T Fip Furrow 1	---	---	---	---			NA	NA	NA			134.9	160.8	167.9	155.3	**8**			NA		
	T Fip Furrow 1+1	---	---	---	---			NA	NA	NA			123.0	146.3	164.4	144.6	**0**			NA		
	T Fip + TerraSorb Dip	NA	166.5	121.9	144.2	**5**		NA	NA	NA			163.9	161.4	179.5	168.1	**16**	*		NA		
	T Fip Soak 0.003%	NA	164.1	107.9	135.7	**-1**		NA	NA	NA			122.6	157.2	169.0	149.2	**3**			NA		
	T Fip Soak 0.03%	NA	152.1	133.6	143.1	**5**		NA	NA	NA			101.8	164.7	167.4	146.2	**1**			NA		
	T Fip Soak 0.3%	NA	157.3	136.8	147.9	**8**		NA	NA	NA			132.3	167.1	141.5	147.3	**2**			NA		
	R Fip Soak 0.3%	NA	196.4	147.0	172.8	**26**	*	NA	NA	NA			134.0	158.5	180.6	157.7	**9**	*		NA		
	T Fip Plant Hole 6.5%	NA	192.4	167.5	180.5	**32**	*	NA	NA	NA			125.3	137.9	180.6	147.7	**2**			NA		
	Check	NA	167.6	102.4	136.7			NA	NA	NA			129.4	152.3	151.2	144.4			A	NA		
																			B	NA		

§ 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

Table 25. Effect of fipronil application technique and rate on loblolly pine diameter growth after two years on eight sites in Virginia, North Carolina, Georgia and Texas - 2003 & 2004.

		Mean Diameter (cm) of 1st Year Loblolly Pine (Pct. Gain Compared to Check)												
		3 Generation Sites				4 Generation Sites			5 Generation Sites					
Year	Treatment §	VA	NC1	NC2	NC Mean	GA1	GA2	Mean	TX1	TX2	TX3	Mean		Overall Mean
2003	T Fip Furrow 1	---	---	---	---	0.87	0.75	0.81 **3**	1.06	1.41	1.31	1.26 **15** *		1.08 **7** *
	T Fip Furrow 1+1	---	---	---	---	0.78	0.78	0.78 **-1**	0.99	1.18	1.27	1.15 **5**		1.00 **-1**
	T Fip + TerraSorb Dip	1.00	1.27	1.35	1.31 **21** *	1.21	1.06	1.13 **44** *	1.17	1.32	1.40	1.29 **18** *		1.23 **21** *
	T Fip Soak 0.003%	1.03	1.24	1.02	1.14 **5**	0.86	0.93	0.90 **14** *	0.96	1.29	1.25	1.16 **6**		1.07 **5**
	T Fip Soak 0.03%	1.11	1.16	1.44	1.29 **19** *	1.07	0.91	0.99 **26** *	0.81	1.30	1.23	1.12 **2**		1.12 **10** *
	T Fip Soak 0.3%	1.09	1.21	1.53	1.36 **26** *	1.12	0.92	1.02 **29** *	1.05	1.41	0.92	1.13 **3**		1.15 **13** *
	R Fip Soak 0.3%	0.99	1.54	1.58	1.40 **30** *	1.09	0.93	1.01 **29** *	1.04	1.15	1.60	1.26 **15** *		1.25 **23** *
	T Fip Plant Hole 6.5%	1.01	1.37	1.59	1.47 **36** *	0.97	0.92	0.95 **20** *	0.86	1.03	1.35	1.08 **-1**		1.14 **12** *
	Check	0.90	1.17	0.97	1.08	0.85	0.73	0.79	1.06	1.14	1.08	1.09	A	1.02
													B	1.01
2004	T Fip Furrow 1	---	---	---	---	NA	NA	NA	3.15	4.09	4.11	3.81 **13** *		NA
	T Fip Furrow 1+1	---	---	---	---	NA	NA	NA	3.01	3.56	4.00	3.52 **5**		NA
	T Fip + TerraSorb Dip	NA	3.10	2.70	2.90 **15** *	NA	NA	NA	3.70	3.82	4.29	3.93 **17** *		NA
	T Fip Soak 0.003%	NA	2.91	2.16	2.53 **0**	NA	NA	NA	2.71	3.74	3.90	3.43 **2**		NA
	T Fip Soak 0.03%	NA	2.80	2.95	2.88 **14**	NA	NA	NA	2.33	4.02	3.93	3.47 **3**		NA
	T Fip Soak 0.3%	NA	2.67	3.05	2.85 **13**	NA	NA	NA	3.12	4.05	3.35	3.51 **4**		NA
	R Fip Soak 0.3%	NA	3.64	3.56	3.60 **43** *	NA	NA	NA	3.10	3.68	4.23	3.67 **9** *		NA
	T Fip Plant Hole 6.5%	NA	3.34	3.44	3.39 **34** *	NA	NA	NA	2.55	3.10	4.11	3.26 **-3**		NA
	Check	NA	2.89	2.12	2.53	NA	NA	NA	3.01	3.63	3.45	3.37	A	NA
													B	NA

§ 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

Table 26. Effect of fipronil application technique and rate on loblolly pine volume (Ht X Dia^2) growth after two years on eight sites in Virginia, North Carolina, Georgia and Texas - 2003 & 2004.

		Mean Volume (cm^3) of 1st Year Loblolly Pine (Pct. Gain Compared to Check)																				
		3 Generation Sites						4 Generation Sites					5 Generation Sites									
Year	Treatment §	VA	NC1	NC2	Mean			GA1	GA2	Mean			TX1	TX2	TX3	Mean				Overall Mean		
2003	T Fip Furrow 1	---	---	---	---			42.0	28.2	35.3	**6**		67.8	128.9	154.3	117.6	**39**	*		84.9	**19**	
	T Fip Furrow 1+1	---	---	---	---			33.9	30.3	32.1	**-4**		56.3	84.1	126.2	88.8	**5**			65.7	**-8**	
	T Fip + TerraSorb Dip	59.2	116.7	166.9	141.8	**98**	*	119.1	81.9	100.3	**201**	*	88.8	112.4	188.5	129.1	**52**	*		119.6	**72**	*
	T Fip Soak 0.003%	56.5	106.0	52.0	79.8	**11**		43.3	53.6	48.5	**46**	*	46.4	97.1	117.4	85.9	**1**			71.7	**3**	
	T Fip Soak 0.03%	75.9	89.7	145.2	115.1	**61**		76.3	56.0	66.2	**99**	*	37.9	115.7	126.6	93.9	**11**			90.3	**30**	*
	T Fip Soak 0.3%	75.9	106.4	228.3	162.8	**127**	*	93.0	55.7	73.7	**121**	*	60.9	134.4	54.4	83.9	**-1**			100.9	**45**	*
	R Fip Soak 0.3%	59.5	216.4	199.7	165.9	**132**	*	83.7	59.0	71.2	**114**	*	68.4	83.8	275.9	140.0	**65**	*		133.7	**93**	*
	T Fip Plant Hole 6.5%	65.5	140.5	226.1	180.9	**153**	*	67.7	55.8	61.9	**86**	*	55.2	68.7	218.3	110.7	**31**			112.1	**62**	*
	Check	39.8	91.1	49.3	71.6			39.7	26.8	33.3			72.6	79.1	104.2	84.8			A	69.4		
																			B	71.2		
2004	T Fip Furrow 1	---	---	---	---			NA	NA	NA			1610	2958	3517	2735	**32**	*		NA		
	T Fip Furrow 1+1	---	---	---	---			NA	NA	NA			1493	2108	3260	2283	**10**			NA		
	T Fip + TerraSorb Dip	NA	2190	1466	1828	**35**		NA	NA	NA			2643	2591	4082	3095	**50**	*		NA		
	T Fip Soak 0.003%	NA	1788	798	1287	**-5**		NA	NA	NA			1150	2356	2871	2112	**2**			NA		
	T Fip Soak 0.03%	NA	1503	1595	1548	**14**		NA	NA	NA			795	2981	3219	2388	**15**			NA		
	T Fip Soak 0.3%	NA	1704	2112	1890	**39**	*	NA	NA	NA			1535	2942	2106	2205	**7**			NA		
	R Fip Soak 0.3%	NA	3406	2383	2917	**115**	*	NA	NA	NA			1634	2382	4169	2721	**31**	*		NA		
	T Fip Plant Hole 6.5%	NA	2612	2662	2636	**94**	*	NA	NA	NA			1114	1553	4653	2395	**16**	*		NA		
	Check	NA	1780	887	1357			NA	NA	NA			1525	2275	2404	2070			A	NA		
																			B	NA		

§ 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

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 after the first generation. Overall damaged was reduced by 83 – 97% compared to check trees. All plant hole treatments significantly improved height and volume growth and most improved diameter growth.
- Higher rate (1% and 3%) root soak treatments applied to all types of seedlings (bare root, containerized and rooted cuttings) significantly reduced tip moth damage throughout the whole growing season. Overall damaged was reduced by 85 – 99% 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 after the first generation. Overall damaged was reduced by 90 – 95% compared to check trees. However, based on data from two sites, none of the treatments significantly improved height , diameter or volume growth 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 Fig. 25). 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. Plots 1 & 2: 2 sites X 9 treatments X 50 trees = 450 monitored trees. Plot 3: 1 site X 11 treatments X 50 trees = 550 monitored trees.

Treatments:

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

1) In-furrow (2X - 0.026%, 0.62 ml Regent®/liter of water)
2) In-furrow (4X - 0.051%, 1.24 ml Regent®/liter)
3) In-furrow (4X - 0.051%, 1.24 ml Regent®/liter + methanol)
4) In-furrow (8X - 0.102%, 2.48 ml Regent®/liter)
5) In-furrow (2X - 0.0256%, 0.62 ml Regent®/liter) + Plant hole, 30 ml (0.267%, 6.8 ml/liter)
6) In-furrow (4X - 0.0512%, 1.24 ml Regent®/liter) + Plant hole, 30 ml (0.267%, 6.8 ml/liter)
7) In-furrow (4X - 0.0512%, 1.24 ml Regent®/liter + methanol) + Plant hole, 30 ml (0.267%, 6.8 ml/liter + methanol)
8) In-furrow (8X - 0.1%, 2.48 ml Regent®/liter) + Plant hole, 30 ml (0.267%, 6.8 ml/liter)
9) Plant hole only - 30 ml (0.267%, 6.8 ml Regent®/liter) applied to plant hole
10) Foliar application (5X) of pine seedlings with Mimic® 2LV (0.6 ml / liter of water)
11) Check (lift and plant)

<u>Extra Treatment for TFS Site</u>

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)

<u>Trial 2: Root soak of containerized and bare root seedlings</u>

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

<u>Extra Treatments for TFS Site</u>

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**:** 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 27). 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 increase in fipronil concentration 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 28).

Trial 2: Root Soak of Bare Root and Containerized Seedlings**:** 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 29). 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. On another site, fipronil treatments of rooted cuttings provide 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 30).

Trial 3: Root Coating Evaluation**:** 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 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).

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Table 27. Effect of fipronil application technique and rate (Trial 1) on pine tip moth infestation of loblolly pine shoots (top whorl) and tree survival after each of 5 generations on four sites in in the Western Gulf Region - 2004.

		Mean Percent Top Whorl Shoots Infested by Tip Moth (Pct. Reduction Compared to Check)																		Mean % Tree Survival @		
Treatment §	N	Gen 1			Gen 2			Gen 3			Gen 4			Gen 5			Overall Mean			Gen 4		
Furrow 2x R	200	1.0	**75**	*	3.0	**55**	*	17.6	**12**		28.9	**19**	*	24.9	**-5**		15.1	**17**	*	85	**-4**	
Furrow 4x R	200	1.6	**59**	*	7.6	**-13**		16.5	**18**		29.8	**16**		25.9	**-9**		16.2	**10**		82	**1**	
Furrow 4x R + meth	200	1.0	**74**	*	3.3	**51**	*	17.2	**15**		30.3	**15**	*	33.5	**-41**	*	17.5	**3**		84	**-2**	
Furrow 8x R	200	3.4	**12**		8.1	**-21**		16.8	**16**		29.6	**17**	*	21.7	**8**		16.3	**10**		80	**2**	
Furrow 2x R + PH	200	3.4	**13**		1.2	**82**	*	3.2	**84**	*	3.6	**90**	*	4.2	**82**	*	3.1	**83**	*	91	**-11**	*
Furrow 4x R + PH	200	2.5	**37**		0.4	**94**	*	0.0	**100**	*	0.5	**98**	*	0.6	**97**	*	0.8	**96**	*	77	**6**	
Furrow 4x R + meth + PH	200	2.3	**42**		0.2	**97**	*	0.0	**100**	*	0.1	**100**	*	0.0	**100**	*	0.5	**97**	*	87	**-5**	
Furrow 8x R + PH	200	1.6	**58**		0.7	**90**	*	0.0	**100**	*	0.4	**99**	*	0.0	**100**	*	0.6	**97**	*	84	**-2**	
Plant Hole only	200	2.7	**29**		0.0	**100**	*	0.2	**99**	*	0.3	**99**	*	0.0	**100**	*	0.6	**97**	*	79	**4**	
Mimic spray	200	1.7	**55**		0.3	**96**	*	1.0	**95**	*	0.3	**99**	*	0.8	**97**	*	0.9	**95**	*	82	**0**	
Check	200	3.9			6.7			20.1			35.5			23.7			18.1			82		
Furrow 4x R + RD + PH	50	1.0	**86**		2.4	**86**	*	0.0	**100**	*	0.0	**100**	*	0.0	**100**	*	0.4	**99**	*	76	**3**	
Check (TFS)	50	7.3			17.2			37.6			54.4			47.5			33.5			78		

§ R = Regent, PH = Plant Hole, RD = Root Dip   = treatment reduced damage by >75% compared to check.

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

Table 28. Effect of fipronil application technique and rate (Trial 1) on loblolly pine growth parameters and tree survival after the first year on four sites in the Western Gulf Region - 2004.

Treatment §	N	Mean End or Season Loblolly Pine Seeding Growth Measurements (Pct. Gain Compared to Check) Height (cm)			Diameter (cm)			Volume (cm^3)			Mean % Tree Survival		
Furrow 2x R	200	39.6	**6**	*	0.62	**7**		20.3	**14.1**		85	**-4**	
Furrow 4x R	200	40.5	**9**	*	0.65	**11**	*	20.6	**16.1**		82	**1**	
Furrow 4x R + meth	200	40.4	**8**	*	0.63	**9**		22.6	**27**		84	**-2**	
Furrow 8x R	200	39.7	**7**	*	0.62	**7**		20.0	**12.4**		80	**2**	
Furrow 2x R + PH	200	41.8	**12**	*	0.66	**13**	*	25.9	**45.4**	*	91	**-11**	*
Furrow 4x R + PH	200	45.3	**22**	*	0.71	**22**	*	33.4	**87.8**	*	77	**6**	
Furrow 4x R + meth + PH	200	42.2	**13**	*	0.65	**12**	*	24.4	**37.3**	*	87	**-5**	
Furrow 8x R + PH	200	42.5	**14**	*	0.63	**8**		24.1	**35.6**	*	84	**-2**	
Plant Hole only	200	42.9	**15**	*	0.64	**10**	*	25.5	**43.1**	*	79	**4**	
Mimic spray	200	38.3	**3**		0.58	**0**		16.4	**-7.9**		82	**0**	
Check	200	37.3			0.58			17.8			82		
Furrow 4x R + RD + PH	50	43.3	**21**	*	0.74	**22**	*	29.7	**33.2**	*	76	**3**	
Check (TFS)	50	35.8			0.61			22.3			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 29. 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)																	
Treatment §	N	Gen 1 (5)			Gen 2 (5)			Gen 3 (4)			Gen 4 (2)			Gen 5 (5)			Overall Mean		
0.3% R BR RS	250	3.3	**60**	*	2.7	**72**	*	3.2	**79**	*	10.4	**72**	*	5.4	**76**	*	3.8	**79**	*
0.3% R + meth BR RS	250	3.0	**64**	*	3.0	**69**	*	5.1	**67**	*	17.4	**53**	*	5.2	**77**	*	5.0	**72**	*
1.0% R BR RS	300	4.8	**43**	*	2.0	**80**	*	1.4	**91**	*	7.5	**79**	*	2.9	**87**	*	2.7	**85**	*
3.0% R BR RS	250	3.6	**57**	*	0.4	**96**	*	0.5	**97**	*	2.5	**93**	*	1.5	**93**	*	1.4	**92**	*
BR Mimic or Pounce Spray	250	7.3	**12**		6.8	**30**	*	5.3	**65**	*	15.3	**58**	*	10.1	**55**	*	8.9	**50**	*
Check Bare Root	250	8.3			9.7			15.3			36.6			22.5			17.8		
1.0% Icon BR RS	50	1.3	**81**	*	0.0	**100**	*	0.0	**100**	*	2.2	**95**	*	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		
0.3% R Cont. RS	200	0.9	**68**		1.3	**82**	*	1.8	**78**	*	2.3	**94**	*	2.5	**88**	*	1.5	**89**	*
0.3% R + meth Cont. RS	200	1.7	**40**		1.0	**87**	*	7.9	**4**		15.6	**63**	*	4.7	**76**	*	5.0	**63**	*
1.0% R Cont. RS	200	0.3	**90**	*	0.3	**97**	*	0.2	**98**	*	3.5	**92**	*	0.3	**98**	*	0.6	**96**	*
3.0% R Cont. RS	200	0.0	**100**	*	0.0	**100**	*	0.0	**100**	*	0.4	**99**	*	0.3	**99**	*	0.1	**99**	*
Check Containerized	200	2.9			7.3			8.3			41.8			20.2			13.4		
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	**100**	*	2.5	**86**	*
Check (TI)	50	11.8			4.2			24.9			30.6			15.83			17.5		

§ 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 30. Effect of fipronil application technique and rate (Trial 2) on loblolly pine seedling growth parameters and tree survival one season after planting on five sites in east Texas and North Carolina - 2004.

Treatment §	N	Mean End of Season Loblolly Pine Seedling Growth Measurements (Pct. Gain Compared to Check) Height (cm)			Diameter (cm)			Volume (cm^3)			Mean % Tree Survival		
0.3% R BR RS	250	58.6	**7**	*	0.94	**4**		69.2	**15**		92	**-6**	
0.3% R + meth BR RS	250	51.2	**-7**	*	0.78	**-14**	*	42.8	**-29**	*	76	**12**	*
1.0% R BR RS	300	59.8	**9**	*	0.96	**6**		76.1	**27**	*	91	**-5**	
3.0% R BR RS	250	56.0	**2**		0.94	**5**		67.7	**13**		82	**6**	
BR Mimic or Pounce Spray	250	54.6	**0**		0.90	**1**		68.4	**14**		91	**-4**	
Check Bare Root	250	54.8			0.90			60.0			87		
1.0% Icon BR RS	50	52.0	**0**		1.02	**-4**		92.0	**-9**		64	**3**	
2.0% Icon BR RS	50	40.4	**-22**	*	0.72	**-32**	*	34.3	**-66**	*	56	**15**	
Check Bare Root	50	52.0			1.07			101.3			66		
0.3% R Cont. RS	200	47.9	**11**	*	0.88	**15**	*	59.2	**80**	*	95	**-1**	
0.3% R + meth Cont. RS	200	46.5	**8**		0.87	**14**	*	55.1	**68**	*	90	**5**	*
1.0% R Cont. RS	200	48.4	**13**	*	0.86	**13**	*	52.3	**59**	*	95	**-1**	
3.0% R Cont. RS	200	48.6	**13**	*	0.89	**16**	*	60.0	**82**	*	93	**2**	
Check Containerized	200	43.0			0.76			32.9			95		
0.3% R Cut. RS	50	NA			NA			NA			100	**0**	
0.3% R + meth Cut. RS	50	NA			NA			NA			100	**0**	
1.0% R Cut. RS	50	NA			NA			NA			98	**2**	
3.0% R Cut. RS	50	NA			NA			NA			98	**2**	
Check Cuttings	50	NA			NA			NA			100		

§ 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.
NA = Data not available

Table 31. 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.

Treatment §	N	Mean Percent Top Whorl Shoots Infested by Tip Moth (Pct. Reduction Compared to Check) Gen 1 (4 sites)			Gen 2 (4 sites)			Gen 3 (3 sites)			Gen 4 (2 sites)			Gen 5 (3 sites)			Overall Mean (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 32. Effect of fipronil application technique and rate (Trial 3) on loblolly pine growth parameters and tree survival one season after planting on three sites in the Western Gulf Region and East Coast -

Treatment §	N	Mean End of Season Loblolly Pine Seeding Growth Measurements (Pct. Gain Compared to Check)									Mean % Tree Survival		
		Height (cm)			Diameter (cm)			Volume (cm^3)					
1.0% R & TS RD	200	59.9	**-1**		0.89	**-13**	*	75.0	**-9**		84	**13**	*
1.0% R + meth & TS RD	200	52.4	**-14**	*	0.80	**-22**	*	43.4	**-47**	*	39	**59**	*
3.0% R & TS RD	200	51.6	**-15**	*	0.73	**-28**	*	38.6	**-53**	*	79	**17**	*
TS RD & Mimic Spray	200	62.9	**4**		1.08	**5**		93.2	**13**		97	**-1**	
TS RD Check	200	60.7			1.02			82.3			96		
1.0% R & DW RD	200	63.3	**6**		0.99	**5**		85.1	**21**		95	**-1**	
3.0% R & DW RD	200	61.0	**2**		0.93	**-1**		75.3	**7**		83	**12**	*
DW RD Check	200	59.9			0.94			70.6			95		
1.0% R & Clay RD	200	58.8	**7**		0.91	**4**		63.5	**14**		93	**3**	
3.0% R & Clay RD	200	56.6	**3**		0.87	**0**		61.4	**10**		93	**3**	
Clay RD Check	200	54.9			0.87			55.6			96		

§ 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.

NA = Data Not Available

PINE TIP MOTH TRIALS

Fipronil Operational Planting Study – TX and LA

Highlights:

- Fipronil-treated seedlings in both treatment areas consistently had lower tip moth damage levels (shoot and terminal) compared to check areas throughout the second growing season. Overall, fipronil reduced damage by 11% - 44%.
- Fipronil-treated seedlings continued to show improved growth as measured by average height, diameter and volume index in both treated areas.

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 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 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 untreated half contained treated seedlings. Ten 10-tree plots were evenly spaced within each of the half tract (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) 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 diameter and height (at 6") in late November 2004.

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 33).

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 33).

Aphid Infestation and Weevil Damage: In addition to tip moth damage, pine seedlings also were evaluated for the occurrence of other insects or their damage. Aphid infestation and regeneration weevil-caused damage were most prevalent in 2003 and were found to be impacted by the fipronil treatments (see 2003 Annual Report). Very little other insect occurrence or damage was observed in 2004, so data were not included in the analysis.

Tree Growth: In 2003, seedlings treated with fipronil were significantly taller than check trees, with gains ranging from 5 – 16% (Table 34). 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 34).

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.

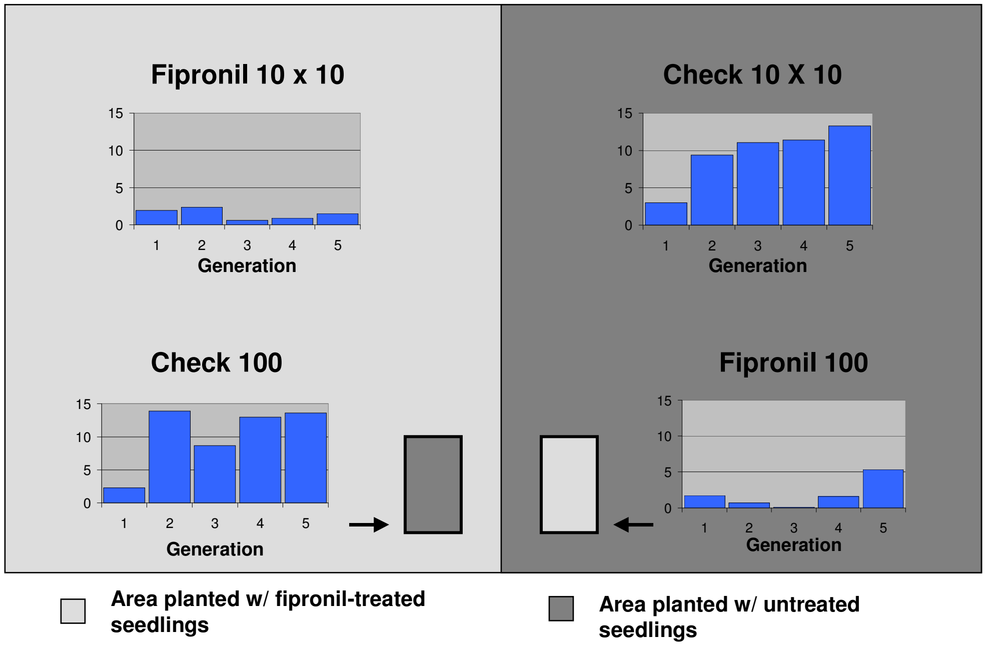

Figure 27. Mean percent of pine shoots (top whorl) infested by pine tip moth during each of 5 generations on four operational planting sites in East Texas (3) and Louisiana (1) – 2003.

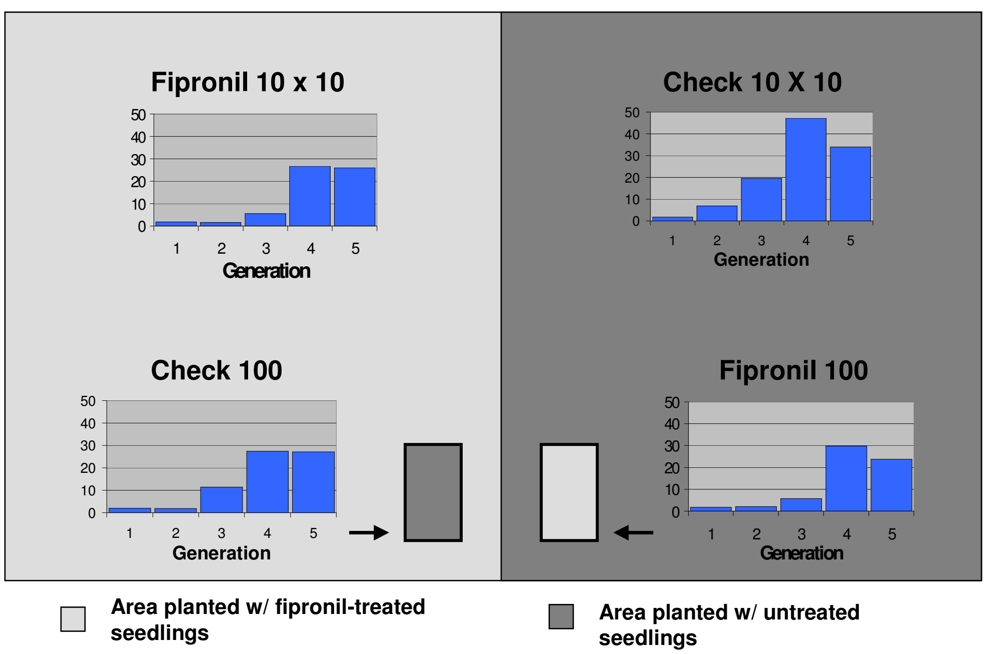

Figure 28. Mean percent of pine shoots (top whorl) infested by pine tip moth during each of 5 generations on four operational planting sites in East Texas (3) and Louisiana (1) – 2004.

Table 33. 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 - 2004.

Year	Treatment	N	Mean Percent Top Whorl Shoots Infested by Tip Moth					Overall Mean	Pct Red.
			Gen 1	Gen 2	Gen 3	Gen 4	Gen 5		
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**	

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

Table 34. Effect of operational planting of fipronil-treated seedlings on loblolly pine growth and survival after two seasons on four sites in east Texas or Louisiana, 2003 - 2004.

			Mean End of Season Tree Measurements (Pct. Gain Compared to Similar Check)		
Year	Treatment	N	Height (cm)	Diameter (cm)	Volume (cm^3)
2003	Fipronil 10 X 10	400	49.1 **b** * (5)	0.86 **a** (1)	57.5 **bc** (13)
	Check 10 X 10	399	46.7 **a**	0.85 **a**	50.7 **ab**
	Fipronil 100	405	52.3 **c** (16)	0.94 **b** (16)	64.7 **c** (46)
	Check 100	419	45.1 **a**	0.81 **a**	44.4 **a**
2004	Fipronil 10 X 10	400	142.0 **bc** (5)	2.88 **c** (7)	1516.6 **b** (20)
	Check 10 X 10	399	135.8 **b**	2.69 **b**	1261.4 **a**
	Fipronil 100	405	147.5 **c** (22)	3.15 **d** (30)	1818.8 **c** (85)
	Check 100	419	120.8 **a**	2.43 **a**	983.1 **a**

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

PINE TIP MOTH TRIALS

Imidacloprid (Spike & Tablet) Studies

Highlights:

- Imidacloprid plus fertilizer spikes continued to significantly reduce tip moth damage in the second year after planting. Both imidacloprid and disulfoton treatments also continued to show improvements in all tree growth parameters compared to check trees.
- All imidacloprid tablet treatments, with and without fertilizer, provided good to excellent protection against tip moth through most of the year; reducing damage levels by 39 – 84%. However, none of the tablet treatments improved height or diameter growth. There was no apparent rate effect on treatment efficacy or seedling 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. In 2004, two second-year plantations were selected at Groveton and Overton, Texas (see Fig. 25). 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). **Note:** Scott Cameron, International Paper Co., also established study plots on the East Coast in 2004.

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 2004 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.

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

Research Approach:

In both 2003 and 2004, 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.

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 (November) following planting. Data was analyzed by GLM and the Tukey's Compromise test using Statview or SAS statistical programs.

Results:

<u>Insecticide/fertilizer spikes</u>

In 2003, fertilizer spikes containing imidacloprid or disulfoton were effective in significantly reducing tip moth damage for three and two generations, respectively (Table 35). 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 36). 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 35). Seedling 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.

Imidacloprid Tablets

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 37). In contrast, nearly all treatments containing imidacloprid or fertilizer alone or combined provide 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 38). Only seedlings receiving a 5% imidacloprid + fertilizer tablet had significantly greater volume index compared to check trees.

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.

Table 35. 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 - 2004.

			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		

***** 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 36. Effect of imidacloprid + fertilizer or disolfoton + fertilizer plant spikes on loblolly pine growth on one site in east Texas, 2003 - 2004.

			End of Season Tree Parameters (Pct. Gain over Check)									Mean Percent
Year	Treatment	N	Height (cm)			Diameter (cm)			Volume (cm^3)			Tree Survival
2003	Imidacloprid + Fert.	50	58.8	**18**	*	1.21	**14**	*	101.4	**41**	*	98 *
	Disulfoton + Fert.	50	54.5	**9**	*	1.21	**15**	*	95.4	**32**	*	96 *
	Check	100	49.8			1.06			72.1			90
2004	Imidacloprid + Fert.	50	160.5	**24**	*	3.56	**18**	*	2222.6	**46**	*	94
	Disulfoton + Fert.	50	151.6	**17**	*	3.59	**19**	*	2314.5	**52**	*	94
	Check	100	129.4			3.01			1524.9			87

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

Table 37. 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.

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		
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		

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

Table 38. 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.

Treatment	N	Mean End of Season Tree Measurements (**Pct. Gain Compared to Check**)									Mean % Tree Survival	
		Height (cm)			Diameter (cm)			Volume (cm^3)				
5% Imid.	100	48.8	**-4**		0.75	**-19**	*	49.9	**-27**		70	**-1**
10% Imid.	100	48.3	**-5**		0.80	**-14**		60.6	**-12**		61	**12**
15% Imid.	100	43.8	**-14**	*	0.68	**-26**	*	31.9	**-54**	*	55	**20**
20% Imid.	100	50.0	**-2**		0.89	**-4.2**		89.1	**29.5**		64	**7**
5% Imid. + Fert.	100	54.8	**8**		1.03	**11.1**		104.6	**52.1**	*	70	**-1**
10% Imid. + Fert.	100	45.0	**-11**		0.72	**-23**	*	40.7	**-41**		60	**13**
15% Imid. + Fert.	100	39.4	**-22**	*	0.60	**-35**	*	34.2	**-50**		58	**16**
20% Imid. + Fert.	100	50.5	**-1**		0.88	**-5.1**		81.7	**18.8**		67	**3**
Fert. only	100	42.9	**-16**	*	0.75	**-19**	*	43.3	**-37**		58	**16**
Mimic spray	100	47.8	**-6**		0.85	**-8.5**		58.7	**-15**		72	**-4**
Check	100	50.9			0.93			68.8			69	

* 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 7 years (1998 – 2004), 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 infestations? During the past four years we have established 40 impact plots and 72 hazard-rating plots in the Western Gulf Region and accumulated a large pool of data from which to address these two questions. Regression analyses are ongoing 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, has nearly completed a prototype hazard-rating model to assess the relationship between different site characteristics and tip moth infestation levels. These models will need 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 2005 and beyond. However, given the volume of work that still needs to be conducted on current impact, hazard-rating and control sites, it is suggested that we discontinue establishment of new impact and hazard-rating sites for the time being. An updated report will be provided to WGFPMC members later this spring.

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

The Termidor® formulation of fipronil was initially used as part of the Seedling Treatment Trial (2002). Although the results were good, the following Technique and Rate Trial (2003) showed that Regent®-treated seedlings consistently 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 Icon® formulation also was found to be highly effective against tip moth on one site in 2004. Additional evaluations may be warranted for this product.

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

So far, we have devised three general ways of treating bare root seedlings after lifting: root soak, root dip or plant hole treatment. All three treatment techniques were evaluated in 2003 and 2004 and all proved to be effective in reducing tip moth damage at least through the first year. Only the root dip and plant hole treatments significantly reduced damage into the second year. The 2004 data indicates protection is generally improved with increased fipronil concentrations. There has been considerable concern expressed by BASF and some of forest industry members about the potential for excessive chemical exposure when treating or handling treated bare root seedlings. In addition, the time and effort required to treat seedlings, particularly using the root soak technique, may be prohibitive. Given these concerns and limitations, we decided not to conduct any additional trials to evaluate root soak and root dip treatments of bare root seedlings.

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 holes 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 been contacted and informed of our situation. He indicated he would be interested in working with us if the WGFPMC elects to continue development of the plant hole technique.

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 gift ($50,000) to support the WGFPMC research projects. Dr. Harry Quicke has agreed to attend the Executive Committee meeting in February to discuss the results of recent trials and prospects for future product registration.

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 Cropscience 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 Cropscience 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 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. 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 2005. 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 2005 (Nate Royalty, Bayer, personal communication).

2004 Expenditures vs. Budget

Expenditures to operate the WGFPMC for CY 2004 totaled $150,114 (Table 39). This was $6,606 less than the projected $156,720 budget (Table 40 and 41) due to the lower than expected operating expenses. Sources of funding to cover expenses were derived from membership dues (36%), the FSPIAP federal grants for systemic injection and industry grants for leaf-cutting ant trials (18%), and the Texas Forest Service (45%). Of this total, 89% was devoted to professional salaries, fringe benefits, and seasonal wages, and the remainder (11%) to equipment, operating expenses, and indirect costs. Due to the federal and corporate grants ($35,016), we currently have a surplus of $11,860 in the WGFPMC account and $6,339 in the federal grant accounts (total = $18,199 at the end of CY 2004). As a result, membership dues will remain at $8,000 per full member and $2,500 per associate member in CY 2005.

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

Table 39. WGFPMC Expenditures by Source of Funding - CY 2004

	Source				% of
	WGFPMC	TFS	Fed./Ind. Grants *	Total	Total
A. Salaries and Wages					
Principal Investigator (Grosman) (100%)	$ 14,699 (26%)	$ 42,869 (74%)	$ 0	$ 57,568	
Staff Forester (Upton) (75%)	12,283 (31%)	16,831 (44%)	0	29,114	
SPB Specialist (Smith) (10%)	3,452 (9%)	0	0	3,452	
4 Seasonal Technician (4 mos. ea.)	11,076		11,638	22,713	
Total Saleries and Wages	$ 41,510	$ 59,700	$ 11,638	$ 112,847	
B. Fringe Benefits / TFS Matching	$ 8,778	$ 7,436	$ 981	$ 17,195	
	50,288	67,136	12,618	130,042	89%
C. Operating Expenses					
Supplies	$ 1,137	$ 0	$ 3,009	$ 4,146	
Vehicle Use and Maintainance	662	0	5,763	6,424	
Travel	1,050	0	383	1,433	
Telecommunications (15% of PCS)	303	0	0	303	
Utilities (15% of PCS)	0	1,165	0	1,165	
Other Services (rentals, publications, postage, etc.)	1,105	0	1,878	2,983	
Total Operating Expenses	$ 4,257	$ 1,165	$ 11,033	$ 16,456	11%
Indirect Costs (10.5%)			3,616	3,616	
Grand Total	$ 54,545	$ 68,301	$ 27,268	$ 150,114	
% of Total	36%	45%	18%	100%	100%

* Grant funds remaining from 2004; grant awarded to TFS from the Forest Service Pesticide Impact Assessment Program to evaluate systemic insecticide treatment of seedlings for control of pine tip moth (Jan 1 - Dec 31, 2004); and grant donations from BASF for evaluation of fipronil and Griffin L.L.C. and Dow AgroScience for evaluation of leafcutting ant baits.

	WGFPMC	TFS	Fed./Ind. Grants
Funding Available as of January 1, 2004	$ 62,582	$ 65,141	$ 31,761

Table 40. WGFPMC Proposed Budget by Source of Funding - CY 2004

	Source				Total	% of Total
	WGFPMC		TFS and Others*			
A. Salaries and Wages						
Principal Investigator (Grosman) (100%)	$ 16,779	(30%)	$ 39,152	(70%)	$ 55,931	
Staff Forester (Upton) (75%)	11,962	(32%)	16,073	(43%)	28,035	
SPB Specialist (Smith) (10%)	3,478	(10%)	0		3,478	
3 Seasonal Technician (4 mo. ea)	7,290		14,580		21,870	
Total Salaries and Wages	$ 39,509		$ 69,805		$ 109,314	
B. Fringe Benefits (30% of Salaries)	$ 9,666		$ 16,568		$ 26,233	
	49,175		86,373		135,547	86%
C. Operating Expenses						
Supplies	$ 4,500		$ 1,000		$ 5,500	
Vehicle Use and Maintainance	3,724		1,000		4,724	
Travel	4,239		750		4,989	
Telecommunications (15% of PCS)	450		0		450	
Utilities (15% of PCS)	0		1,300		1,300	
Other Services (rentals, publications, postage, etc.)	3,200		1,000		4,200	
Total Operating Expenses	$ 16,113		$ 5,050		$ 21,163	14%
Grand Total	$ 65,288 **		$ 91,423		$ 156,710	
% of Total	42%		58%		100%	100%

* includes any new members or federal grants.

** member dues at $8,000/yr for seven members; $2,500/yr for one member, $5,438 CY03 surplus,and $1,350 for WGTIP seed analysis. = $65,288

Table 41. WGFPMC Proposed Budget by Source of Project - CY 2004

	Activity				
	Administration	Tip Moth Studies		Systemic	
	Site Visits/Service	(Impact & HR)	(Systemic Trt)	Injection Studies	Total
A. Salaries and Wages					
Entomologist III (100%)	$ 22,372 (40%)	$ 11,186 (20%)	$ 11,186 (20%)	$ 11,186 (20%)	$ 55,930
Staff Forester (75%)	0	9,345 (25%)	9,345 (25%)	9,345 (25%)	28,035
SPB Specialist (10%)	0	1,739 (5%)	0	1,739 (5%)	3,478
3 Seasonal Technicians (4 mos. ea.)	0	7,436 (34%)	7,217 (33%)	7,217 (33%)	21,870
B. Fringe Benefits (30% of Salaries)	$ 6,712	$ 6,681	$ 6,159	$ 6,681	$ 26,233
C. Operating Expenses					
Travel and Vehicle Use	$ 4,750	$ 2,340	$ 1,740	$ 894	$ 9,724
Supplies & Postage	2,700	1,600	1,200	1,200	6,700
Other Operating Expenses	1,660	1,030	1,030	1,030	4,750
Grand Total	$ 38,194	$ 41,357	$ 37,877	$ 39,292	$ 156,720