Table 1. Control of emerald ash borer in Troy, Michigan, with insecticide treatments in 2004 and 2005.

2004 treatment	Larvae/m² Oct. 2004	2005 treatment	% dieback June 2005	Larvae/m² Oct. 2005	% dieback June 2006
IMA-jet injection	0.0*	None	24.3*	15.2	48.0
Onyx 13 oz, twice	3.1*	Onyx 8 oz, twice	30.0*	39.9	48.1
IMA-jet injection	1.2*	None	21.1*	24.3	59.4
Onyx 32 oz, once	1.9*	Onyx 16 oz, once	38.9	22.0	65.8
ACECAP implant	2.8*	ACECAP implant	27.5*	37.4	81.0
BotaniGard, twice	4.7	BotaniGard, twice	35.6	75.7	86.0
Untreated control	10.1	None	50.3	65.4	93.1

* Indicates treatment mean is different from control mean at P = 0.05

EFFECTS OF TRUCK INJECTION ON EMERALD ASH BORER DENSITY AND ASH SURVIVAL: A FOUR-YEAR STUDY

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ABSTRACT

When emerald ash borer (EAB), *Agrilus planipennis* Fairmaire, was first discovered in the U.S., development of effective control methods was identified as a critical short-term research priority. We initiated studies to determine the efficacy of available insecticide products for controlling EAB larvae and adults. We developed bioassay methods to evaluate mortality of adult beetles feeding on leaves from our study trees. We also developed methods to quantify density of emerged beetles and feeding larvae. These measures yield results within one growing season, provide a means to compare treatments, and are indicative of potential product efficacy. Ultimately, a treatment is only effective, however, if it prolongs the life and preserves the aesthetic value of treated trees for a significant period of time (i.e., several years). In this study, we evaluated the survival of white and green ash treated annually for four years with trunk injections of imadacloprid products or with bidrin.

SETTING AND TREATMENTS

Our studies began in 2003, with nearly uninfested street trees in two Ann Arbor, Michigan, neighborhoods. The Forsythe neighborhood included both white ash (*F. americana*) and green ash (*F. pennsylvanica*); mean DBH was 30 and 38 cm, respectively. Ash trees in Forsythe were not abundant and were generally widely spaced; we estimated that there was ca. 1000 m^2 ash phloem per km^2. We selected 18 green ash and 18 white ash in 2003 and randomly assigned them to one of two imidacloprid treatments or to be left as untreated controls. Trees were trunk-injected in mid-May of each year from 2003 to 2006. Trees were treated with either Imicide (10% solution, one 3-ml Mauget capsule per 5 cm DBH) or Pointer (12% solution in 2003 and 5% solution in 2004-2006; 1 ml per 10.2 cm basal circum injected with a Wedgle injector) (n = 6 of each species per treatment).

In the Dartmoor neighborhood, green ash trees were abundant and larger than in the Forsythe neighborhood. We estimated that there was ca. 33,000 m^2 phloem per km^2 in this neighborhood and mean DBH was 42 cm Treatments were assigned randomly to one of four treatments or left as untreated controls (n = 6 green ash per treatment). Treatments evaluated included trunk injections of Imicide applied with Mauget capsules (rate as above), Pointer applied with a Wedgle, or bidrin (dicrotophos) applied with Mauget capsules (82% Inject-A-Cide B formulation; one 2 ml Mauget capsule per 5 cm DBH). We tested two timings for bidrin trees: 'Early' bidrin trees were treated in mid-June to target adult EAB, while 'Late' bidrin trees were treated in mid-July to target young larvae. Imidacloprid treatments were applied in mid-May of each year.

SAMPLING

We evaluated EAB density every fall from 2003 to 2006 by counting cumulative D-shaped exit holes left by emerging adult EAB and woodpecker attacks on the trunk and in the canopy of each tree. Woodpecker attacks were included because woodpeckers prey primarily on overwintering prepupae that have completed feeding and would have a high probability of emerging as adults in spring. We sampled EAB density on at least five stem or limb sections distributed from 1.5 m aboveground on the trunk to the top-most 8 cm-diameter limbs. Canopy condition was evaluated as percent dieback in July or August of each year. Our intention was to track survival and monitor EAB density and canopy for all trees in each treatment. However, in winter of 2006, the city of Ann Arbor required the removal of conspicuously damaged trees; thus, our final mortality tally includes trees that either died or exceeded 40 percent dieback in the fall of 2005.

EAB DENSITY

For green ash at Forsythe (Figure 1), EAB density in trees injected with either Pointer (via the Wedgle) or Imicide (via Mauget capsules) was significantly lower than in untreated control trees in 2004 and 2005. By 2006, all of the untreated control trees, and all but one of the trees injected with Pointer had been removed by the city due to advanced canopy decline. In 2006, larva density in the four remaining trees treated with Imicide had stabilized at a level that was less than 20 percent of the maximum density in untreated control trees.

In the white ash at Forsythe (Figure 2), larva density was generally lower in the Imicide/Mauget trees than in controls or Pointer/Wedgle trees in 2006, even though treatments did not significantly differ in any year.

At the Dartmoor site, EAB density in trees treated with insecticides did not differ from that of control trees in any year. However, when all treated trees were considered together, EAB density was less than half that in untreated control trees in 2005 (Figure 3).

CANOPY DIEBACK AND SURVIVAL

For green ash at Forsythe, mean canopy dieback remained below 25% through 2006 for the trees injected with Imicide/Mauget and 80% of those trees that survived to summer 2006. Dieback for trees injected with Pointer/Wedgle was lower than for untreated control trees through 2005. By 2006, however, all Pointer-treated and control trees had less than 40 percent dieback Table 1).

For the white ash at Forsythe, canopy dieback in trees injected with Imicide/Mauget did not differ significantly from Control trees, but 60 percent of the Imicide/Mauget trees were alive in 2006 compared to 33 percent survival of control trees. None of the Pointer-treated trees survived to 2006.

In the Dartmoor site, none of the trees injected with Pointer/Wedgle or the untreated controls survived to 2006. For all trees injected with Imicide/Mauget or Bidrin/Mauget, mean canopy dieback in 2006 was slightly less than 50 percent. Rate of tree survival was 50 percent for Imicide/Mauget, 33% for the Early injection of Bidrin/Mauget and 50 percent for the Late injection of Bidrin/Mauget.

SUMMARY

Our results, spanning four years, represent the longest evaluation of the efficacy of trunk injections for EAB control and illustrate how rapidly the density of EAB can build. The trunk injection treatments did reduce EAB density relative to untreated controls in the green ash at Forsythe and Dartmoor.

In terms of long-term tree survival and condition, however, our results are somewhat disappointing. None of the trees injected with the Pointer/Wedgle at the Forsythe or Dartmoor sites survived to 2006.

The green ash trees injected with Imicide/Mauget at Forsythe exhibited relatively low dieback, and 80 percent of these trees survived to 2006. Average dieback for the other trees injected with Imicide/Mauget, Bidrin/Mauget–Early or Bidrin/Mauget-Late ranged from 45 to 50 percent in 2006, and 33 to 50 percent of those trees survived to 2006.

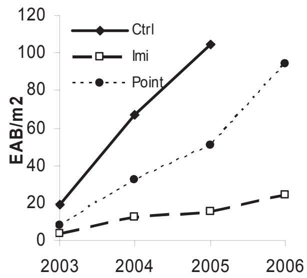

Figure 1. Emerald ash borer density (cumulative number of exit holes and woodpecker attacks per m^2) in green ash trees injected with Imicide/Mauget (Imi) or Pointer/Wedgle (Point) or untreated controls (Ctrl) Forsythe site, 2003-2006.

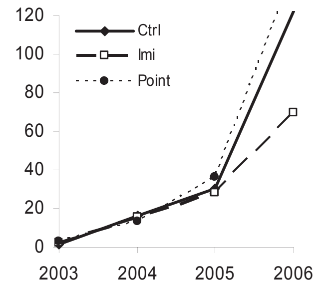

Figure 2. Emerald ash borer density (cumulative number of exit holes and woodpecker attacks per m^2) in white ash trees injected with Imicide/Mauget (Imi) or Pointer/Wedgle (Point) or untreated controls (Ctrl) Forsythe site, 2003-2006.

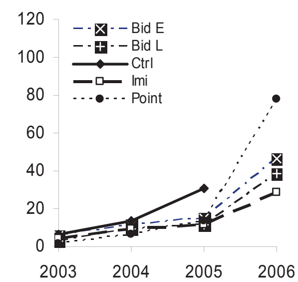

Figure 3. Emerald ash borer density (cumulative number of exit holes and woodpecker attacks per m2), in white ash trees injected with Bidrin Early (Bid E), Bidrin Late (Bid L), Imicide/Mauget (Imi) or Pointer/Wedgle (Point), or untreated controls (Ctrl), Dartmoor site, 2003-2006.

Table 1. Percent canopy dieback and survival (defined as percent of trees with less than 40 percent dieback) for green or white ash trees treated with bidrin/Mauget-Early (Bid E), bidrin/Mauget-Late (Bid L), Imicide/Mauget (Imi/Mauget) or Pointer/Wedgle (Pointer), or left as untreated controls at the Forsythe and Dartmoor neighborhoods in Ann Arbor, Michigan.

		Mean % dieback		**% Survival**	
Dataset	**Treatment**	**2005**	**2006**	**2005**	**2006**
Forsythe-green ash	Control	82	--	0	0
	Imi/Mauget	22	14	83	80
	Pointer/Wedgle	44	86	43	0
Forsythe-white ash	Control	9	52	100	33
	Imi/Mauget	19	50	86	60
	Pointer/Wedgle	18	80	100	0
Dartmoor-green ash	Control	51	--	17	0
	Imi/Mauget	14	45	83	50
	Pointer/Wedgle	25	82	50	0
	Bidrin/Mauget Early	28	49	67	33
	Bidrin/Mauget Late	20	45	100	50