The Battle Plan:
Defining a Strategy to Manage the Emerald Ash Borer in Kentucky

by Ignazio Graziosi, Bill Davidson and Lynne Rieske-Kinney

Kentucky virgin forests were described by early explorers as *"Giant forests of oak and tulip, beech and ash, … grow so close that their leafy branches spread a canopy through which the rays of the sun could scarcely penetrate, producing twilight effects even at high noon."* (from: Robert Collins's "A History of Daniel Boone National Forest). Now, after benefiting in innumerable ways, we may be on the edge of losing one of those very trees.

A Native Tree and a Beetle From China

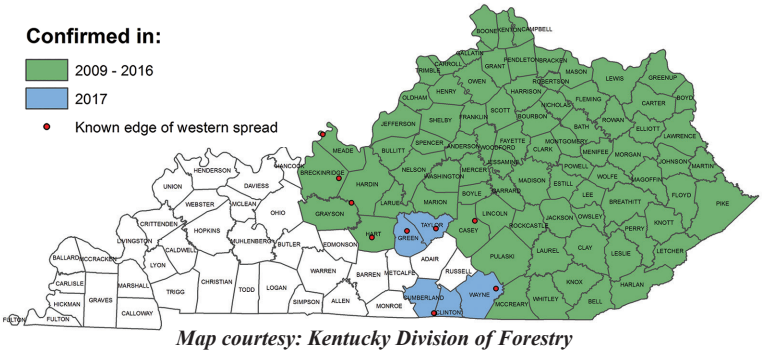
The emerald ash borer (*Agrilus planipennis*), commonly called EAB, has killed some 38 million ash trees since its discovery in Michigan in 2002. Native to China, the ½ inch long metallic green beetle attacks all American species of ash (*Fraxinus sp.*) and the native white fringe tree (*Chionanthus virginicus*), and can infest trees of all ages in cities, parks and forests. Larvae feed under the bark disrupting the phloem and causing extensive canopy dieback. Attacked trees die rapidly. Clear signs of EAB presence are serpentine larval galleries visible under the bark, and D-shaped holes that adult beetles chew through the bark when they emerge in late spring and summer (Figure 1).

Figure 1. Signs of EAB include extensive canopy mortality, larval galleries visible under the bark, and D-shaped holes where adult beetles chew through the bark.

Invading Kentucky

The borer has invaded most states east of the Mississippi River, and the Canadian provinces of Quebec and Ontario. It has been detected as far west as Colorado and Texas. Movement of firewood and timber facilitates its spread. EAB has been reported in Kentucky since 2009, and currently over 2/3 of the counties are reportedly infested. Urban trees were the first to be impacted, but natural forests are now equally affected. With the exception of blue ash, which shows some resistance, our ash trees in North America are highly susceptible to EAB, and the beetle is not constrained by natural enemies like predators and parasitoids. Without any factors to keep EAB numbers in check and limit their spread, ash trees will no longer be a significant component of Kentucky forests (Figure 2). Insecticides can be effective, but EAB kills ash trees so quickly, and populations move so rapidly, that developing a long-term, broad range management strategy has been difficult.

Predicted change in Ash Resources	Year	2010	2020
	# of stems/acre	38.9	.36



Map courtesy: Kentucky Division of Forestry

Figure 2. Without factors to keep EAB in check, ash trees will no longer be a significant component of Kentucky forests. Source: Kentucky Division of Forestry, June 17, 2017 (map), Levin-Nielsen and Rieske 2014 (prediction).

The Tools

Systemic insecticides are effective but they kill both EAB and their natural enemies. Trees treated chemically are defended for 1-3 years and some can recover from the EAB infestation. But applications are costly, time consuming, often require specialized gear and certified applicators, and are not without risk to non-target organisms including pollinators and honeybees. The approach is well suited for cities and ornamental trees, but is clearly impractical for extensive use in forests. In contrast, biological control has the potential for sustainable, long-term regulation of EAB on a regional scale, perhaps saving trees over large areas. Biological control involves the intentional release of natural enemies into infested areas to help regulate pest populations. Two species of parasitoid wasps targeting EAB larvae (*Tetrastichus planipennisi* and *Spathius agrili*), and one egg parasitoid (*Oobius agrili)* were discovered in the forests of China as effective population regulators for the beetle and approved for release in the US in 2007. But establishment of natural enemies requires time, appropriate conditions, and some luck; EAB kills trees so quickly that populations move to new areas, making establishment of natural enemies challenging.

The Strategy

Our aim is to slow ash decline and EAB development by ap-

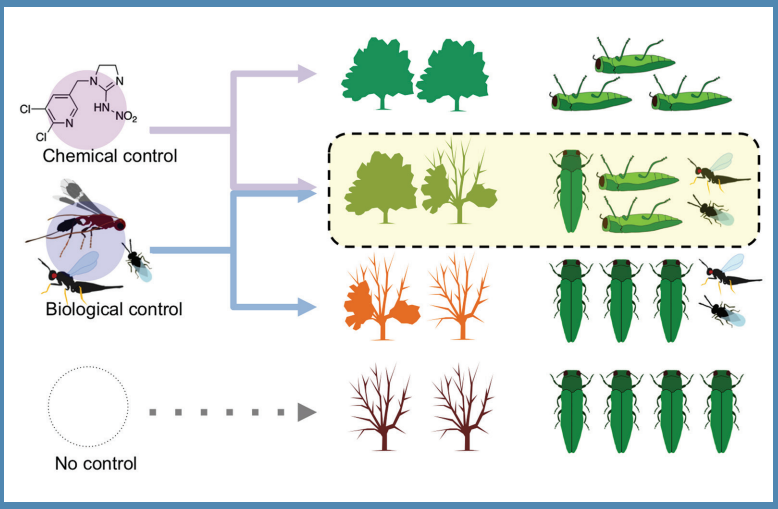


Figure 3. We are slowing ash decline and beetle development using low-dose systemic insecticides while simultaneously releasing parasitoids, thereby creating a longer window of opportunity for biological control to establish.

plying a low-dose of systemic insecticide while simultaneously mass-releasing parasitoids. This is creating a longer window of opportunity for parasitoids to establish and provide long-term regulation of EAB populations (Figure 3). We used imidacloprid soil drench applications applied at lethal rates and also applied at sub-lethal rates (full and 1/2 label rate) with weekly releases of parasitoids in forests with varying levels of EAB damage. During the period 2013-15 more than 180,000 parasitoids were released. We measured EAB infestation levels, parasitoid establishment, and changes in the community of insects inhabiting the forest.

Beetle Response to Management

Emerald ash borer infestation numbers were lower in trees that received imidacloprid, either full or half strength, relative to trees in plots that did not receive imidacloprid (Figure 4, top). Adults and larvae of the parasitoid *T. planipennisi* were recovered in high numbers from plots where releases took place, even when insecticide was applied (Figure 4, bottom), suggesting that imidacloprid does not impede successful establishment of biological control agents. Chemical applications did not negatively impact the main groups of resident wasps and bees, as we consistently found similar numbers in imidacloprid-treated and untreated plots.

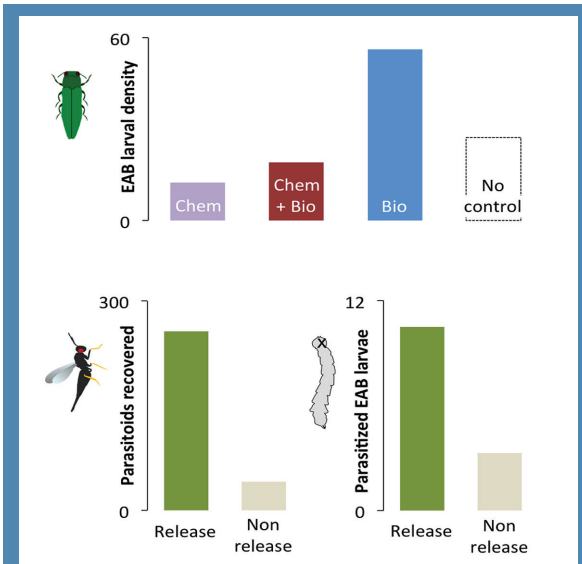


Figure 4. Emerald ash borer infestation levels are lower even with a sub-lethal imidacloprid dose; this does not prevent establishment of introduced natural enemies.

How are Forest Insect Inhabitants Responding to Declining Ash?

We have high hopes that some of our native insects can act as natural enemies of the emerald ash borer and help to contain the invasion. We've recovered 11 native species of parasitoids, including *Atanycolus hicoriae* and *Phasgonophora sulcata*, two wasps that appear to

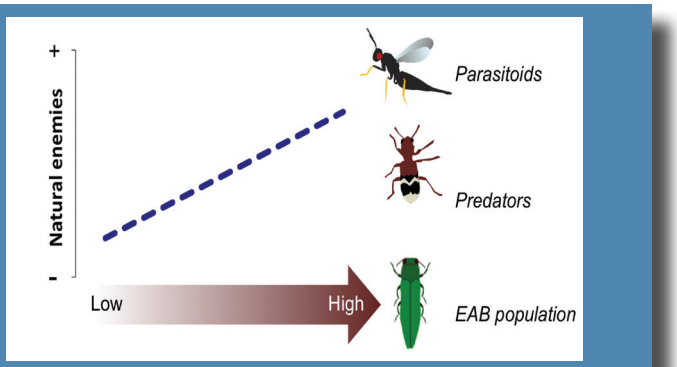


Figure 5. As EAB populations increase, the number of introduced and native natural enemies also increases, providing hope for mitigating future EAB outbreaks.

increase in abundance in EAB-infested forests, and the parasitic beetle *Catogenus rufus*. As EAB outbreaks progress and ash trees decline, the numbers of introduced or native natural enemies increase; we're hoping this will create population regulators to keep EAB in check in newly invaded areas or when our ash forests regenerate Figure 5).

Additional Perspectives

We continue our approach of blending chemical and biological control for EAB management. We are closely evaluating native natural enemies to evaluate their role in regulating EAB populations, with the hope of facilitating their effects. Understanding all components in the system is key to developing a sustainable integrated management approach to reduce the effects of the emerald ash borer invasion in Kentucky.

To learn more:

EAB spread in Kentucky: University of Kentucky EAB information page http://pest.ca.uky.edu/EXT/EAB/welcomeeab.html

Results of the project: Davidson and Rieske "Establishment of classical biological control targeting emerald ash borer is facilitated by use of insecticides, with little effect on native arthropod communities" Biological Control, 2016.

Natural enemies in Kentucky: Davidson and Rieske "Native Parasitoid Response to Emerald Ash Borer (Coleoptera: Buprestidae) and Ash Decline in Recently Invaded Forests of the Central United States" Annals of the Entomological Society of America, 2015

EAB Management – Definitions

Biological control: To regulate pest populations (in this case, EAB) with the use of natural enemies

Population regulation: To keep EAB numbers below a damage threshold

Parasitoids: Often small wasps that locate the pest (EAB) and insert their eggs into them. Parasitoid larvae feed and grow, thus killing the EAB

Predators: Often other insects or birds (especially woodpeckers), hunt the pest (EAB) for food

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