

SLAM: A Multi-Agency Pilot Project to SLOW Ash Mortality Caused by Emerald Ash Borer in Outlier Sites

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Since its discovery in southeast Michigan in 2002 (Haack et al. 2002), the emerald ash borer (EAB, Fig. 1), *Agrius planipennis* Fairmaire (Coleoptera: Buprestidae), has continued to spread and kill ash (*Fraxinus*) trees at an alarming rate. As of February 2010, EAB has killed tens of millions of ash trees in Michigan, at least 12 additional U.S. states, and the Canadian provinces of Ontario and Quebec (Fig. 2, EAB Info 2010). Early efforts to eradicate isolated infestations were expensive and generally unsuccessful. While federal quarantine regulations minimize long-range artificial movement of ash, they do little to reduce natural dispersal of EAB, population build up, and the resulting local progression of ash mortality. When new infestations of EAB are found, local residents, municipal foresters and resource managers are left to cope with EAB on their own.

Researchers have made considerable progress in developing survey tools and management tactics for EAB (Poland and McCullough 2006, Poland 2007). These tools are now being put to use in a pilot study in Michigan's Upper Peninsula. The



Figure 1. EAB adult feeding on ash. Photo by Deborah Miller, USDA Forest Service.

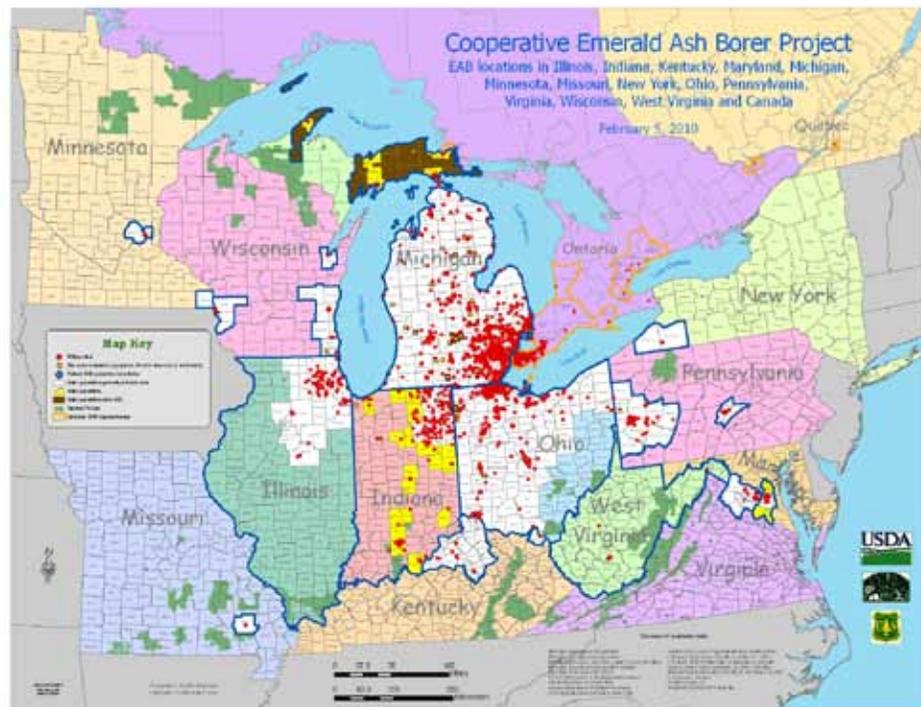


Figure 2. EAB North American distribution as of 5 February 2010 (EAB Info 2010)

project is designed to develop, implement and evaluate an integrated strategy to delay the onset and progression of ash mortality in outlier sites that are relatively isolated from major EAB infestations. The integrated approach to SLOW Ash Mortality, or SLAM as it is called, was developed and is being tested cooperatively by scientists and partners from Michigan State University, the USDA Forest Service, Michigan Technological University (MTU), the Michigan Departments of Agriculture (MDA) and Natural Resources and Environment (MDNRE), and the USDA Animal and Plant Health Inspection Service (APHIS).

The SLAM approach does not aim to eradicate isolated infestations. Rather, the goal of SLAM is to reduce EAB population growth, which in turn, slows the progression of widespread ash mortality within and beyond the project area. Slowing the rate of ash mortality provides time for resource managers, municipalities and property owners to be proactive, instead of simply reacting to overwhelming numbers of dead and often hazardous trees. For example, forest managers can use the time to set up timber sales and develop regeneration plans for sites dominated by ash. Municipal foresters can develop long-term plans to treat or replace vulnerable ash trees in the landscape with alternate species. The SLAM program

incorporates 1) surveys to determine EAB distribution and density, 2) inventories or surveys to assess ash abundance and distribution, 3) activities to suppress EAB populations, 4) regulatory measures, and 5) public information and outreach campaigns.

The SLAM Pilot Study Sites

The multi-agency pilot study to evaluate the SLAM approach focuses on sites near Moran and St. Ignace in Mackinac County, just north of the Mackinac Bridge in Michigan's Upper Peninsula (Fig. 3). These two distinct, isolated infestations of EAB were detected in 2007 when a girdled ash tree, used to survey for EAB, was debarked and found to be infested with EAB larvae. Surveys in the fall of 2007 identified 13 infested trees near Moran. The infestation appeared to be relatively recent. Only one tree had EAB exit holes and tree ring analysis suggested the infestation was probably less than 4-6 years old. A single infested tree was also found in Straits State Park near St. Ignace in fall 2007.

SLAM is likely to be most successful in isolated EAB outlier sites that are geographically distinct from well-established EAB infestations. The probability of success will also be greater if the EAB infestation is relatively recent and ash mortality is minimal or concentrated in a small area.

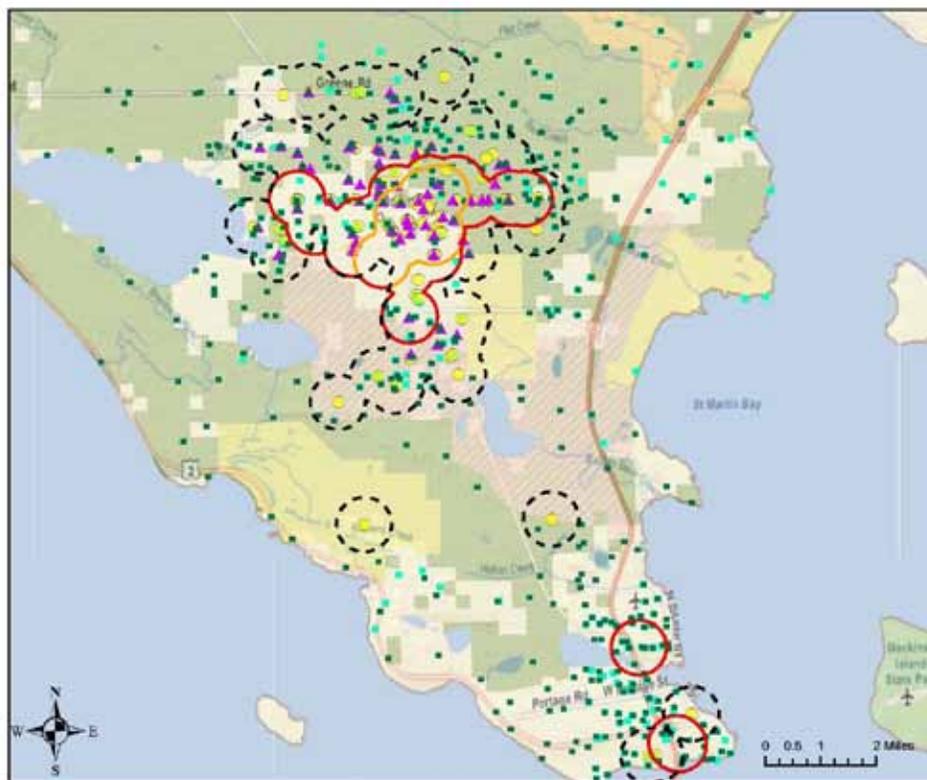


Figure 3. EAB infestation at the Moran sites (northern clusters) and St. Ignace sites (southern clusters) in Mackinac County, MI. Boundary lines at 0.5 miles from the last infested trees are indicated for 2007 (yellow), 2008 (red), and 2009 (black dashed). Map produced by Amos Ziegler and Gabriel Carballo, Michigan State University, using ash inventory and EAB detection survey data gathered by the EAB SLAM multi-agency team.

Thus, both the Moran and St. Ignace sites were considered good candidates for testing the SLAM management approach. In 2008 and 2009, additional surveys with girdled trees and traps were conducted and in 2009 suppression treatments were initiated.

Implementing the SLAM Program

1. Surveys of EAB distribution and density. After the discovery of the two outlier infestations near Moran and St. Ignace in 2007, initial delimiting surveys were conducted. These consisted of relatively rapid assessments of the situation using visual surveys and destructive sampling of suspect trees.

In 2008, an extensive systematic grid-based survey was conducted to more accurately determine the extent of the infestation as well as to determine EAB spatial distribution and density. Surveys were conducted using girdled trap trees (ash trees with a band of bark and phloem removed around the circumference of the tree) and artificial sticky traps. Girdled ash trees, especially open-grown trees, are significantly more attractive to EAB than healthy ash trees and can be

used for survey and detection (McCullough et al. 2009a, 2009b). When girdled trees are debarked in fall, survey crews can record the number of EAB larvae on each tree and their life stages. This enables researchers to estimate EAB density in the project area and the locations where adult EAB are likely to be abundant the following year.

Artificial traps have been developed incorporating attractive visual and olfactory cues. Odors from the leaves of stressed ash trees (Rodriguez-Saona et al. 2006), ash leaf volatiles (deGroot et al. 2008, Grant et al. 2010) and volatiles from ash bark (Crook et al. 2008) elicit antennal responses and are attractive to EAB. The beetles are also attracted to certain colors including purple (Francese et al. 2005) and a bright shade of light green (Crook et al. 2009) as well as to large visual silhouettes that mimic open-grown trees (McCullough et al. 2008). Artificial traps used in the SLAM pilot study consisted of purple prism panels coated with Pestick to capture beetles. Traps were hung in the canopy of ash trees and baited with Manuka oil or an 80:20 mixture of Manuka and Phoebe oil. These natural oils contain

several attractive volatiles found in ash bark. Although not as effective as girdled trees, artificial sticky traps are less costly and do not require trees to be destroyed. Girdled trees are more suitable to accurately delimit a known infested area and obtain data on EAB development rate and population density, but traps can be used when ash trees are not available for girdling.

The 2008 EAB survey was based on systematic grids of girdled trees. Artificial traps were used when an ash tree was not available for girdling. In the core area, (i.e., within a 1.5 mile radius from the outermost infested trees identified in the initial 2007 delimitation survey) 1 trap tree was located in each 40 ac grid cell (16 grid cells per square mile). APHIS officials also required that a trap be placed in each 40 ac grid cell; therefore, when possible, 40 ac grid cells contained both a trap tree and an artificial trap. In the next 1.5 mile band surrounding the core area (the area bounded by the 1.5 to 3 mile radii from the last known positive tree), 1 trap tree or trap was located in each 160 acre grid cell (4 grid cells per square mile). Finally 1 trap tree or trap was installed per square mile in the area bounded by the 3 to 6 mile radii from the last known positive tree.

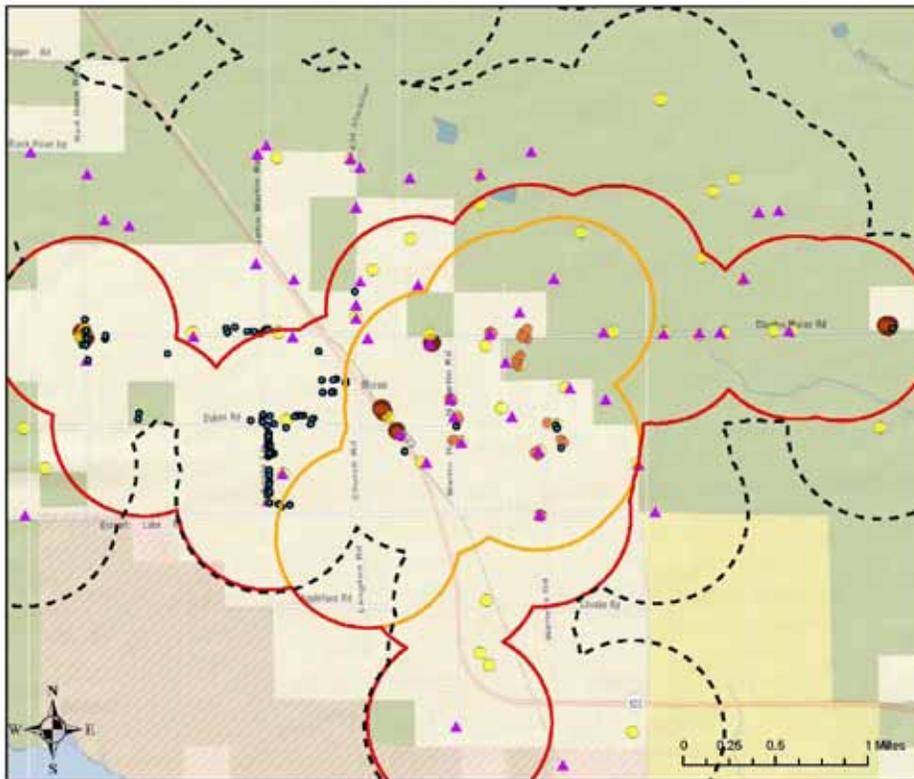
At the Moran site, 24 infested trees were found in 2008, harboring an average of 7.8 EAB larvae per m² of bark surface area, which represents a very low density of EAB. In addition, 4 satellite infestations were found, more than 800 m away from what appeared to be the core infestation. Adult EAB were captured on 10 of the purple traps, but at least 8 of the positive traps were hung in girdled trees. The infestation in Straits Park and St. Ignace was smaller; eight girdled trees had larvae and one infested tree was found just north of the city of St. Ignace. Although the 2008 survey results indicated that the EAB infestations were relatively small and no trees had any visual symptoms of EAB injury, it was clear the EAB populations were building and beginning to disperse and that management activities were warranted.

Surveys to assess EAB distribution were repeated in 2009. As in 2008, trees were girdled in early to mid-June and cut and debarked in September and October. Suppression treatments were implemented in 2009 (see below) along with continuing surveys following the same systematic grid-based survey protocols. The locations of positive traps and trap trees and 0.5 mile boundaries beyond the last infested tree for each year are presented in Figure 3.

2. Ash Density and Distribution. A reasonably accurate assessment of ash abundance,

EAB Infestation and Treatments in Moran, MI

November 5, 2009

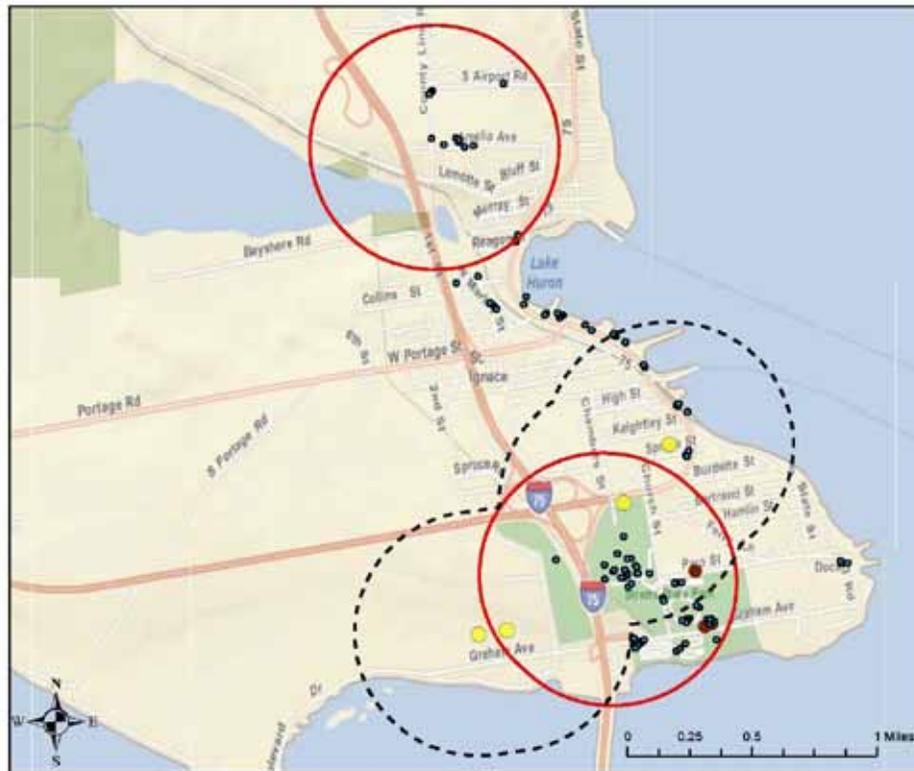


distribution and size is important for planning suppression treatments and evaluating the efficacy of management activities. Knowledge of the local ash resource is necessary to identify trees to be used for trap trees, sink trees, insecticide treatments, or for harvest and utilization. Estimates of the density and distribution of the existing EAB population, combined with systematically collected ash data can be used by researchers and managers to model and evaluate EAB population buildup and spread, the progression of ash mortality, and the impact of management activities.

For the SLAM pilot study, fairly detailed ash inventory data are being collected in order to accurately evaluate the project. Intensive ash surveys are expensive. In an operational program, of course, intensive inventory, analysis, and evaluation won't be necessary and less expensive systematic surveys can be used to provide the information necessary to implement treatments. In 2009, an intensive effort to systematically inventory ash trees from ground surveys was launched. Ash data were also obtained from US Forest Service FIA (Forest Inventory and Analysis) data and stand maps, St. Ignace street tree inventories, and surveys of ash within the city limits and Straits State Park, as well as data from EAB detection trees.

EAB Infestation and Treatments in St Ignace, MI

November 5, 2009



3. Suppression of EAB Populations.

A number of viable treatment options are available to reduce EAB population densities and minimize population build up. Suppression treatments include a) removal of infested trees, b) insecticide treatments, c) clusters of 3-4 girdled trees, and d) ash utilization or selected ash removal to reduce brood material. Biological control with native or introduced natural enemies may also become part of SLAM programs in some areas. Some or all of these activities can be combined and integrated in the SLAM approach. Implementation of tactics is site-specific and depends on the local distribution and abundance of ash trees, the existing EAB population levels, and a variety of other local situations that can affect which activities are preferred or not available because of particular constraints. At the SLAM pilot study sites, a combination of tree removal, insecticide treatment, sink trees, and ash utilization has been implemented (Fig. 4, details described below).

A. Removal of infested trees. Removal of trees known to be infested with EAB can help to reduce the EAB population within SLAM sites if the infested trees are destroyed before EAB adults emerge. EAB

Figure 4. Maps of emerald ash borer SLAM pilot study sites in (a) Moran (upper) and (b) St. Ignace (lower), indicating the locations of traps (purple triangles) and detection trees (yellow circles) that were removed, trees treated with insecticide (blue circles), and clusters of girdled sink trees (orange and brown circles). Maps produced by Amos Ziegler and Gabriel Carballo, Michigan State University, using ash inventory and EAB detection survey data gathered by the EAB SLAM multi-agency team.

infested trees can produce approximately 90-100 adults per square meter (8-10 EAB per square ft) of bark surface area. A single 20 inch (50 cm) diameter ash tree, therefore, has the potential to produce about 3600-4000 beetles before it succumbs (McCullough and Siegert 2007). At the SLAM sites, all detection trees and trees found to be infested were cut and destroyed during the fall of 2007, 2008 and 2009 (Fig. 4a, 4b, where yellow circles represent detection trees with larvae that were removed and destroyed, uninfested detection trees were also removed and destroyed but are not displayed on the maps).

B. Insecticide treatments: Several insecticide products have been tested for control of EAB, including cover sprays, soil applications, bark-penetrating trunk sprays, and stem injection with systemic insecticides. Of all the products tested, trunk injection with TREE-äge™ (emamectin benzoate) appears to offer the highest level of control. Studies have found excellent control for at least 2 years after a single injection (Herms et al. 2009, McCullough et al. 2010). Larval densities in treated trees were reduced by more than 99% compared to untreated trees and mortality of adult EAB that were fed leaves from treated trees was 100% (McCullough et al. 2010). Systemic injection with imidacloprid can also provide control but study results have been variable and it must be applied annually (Herms et al. 2009, McCullough et al. 2010). Basal trunk sprays with dinotefuran provide levels of control similar to imidacloprid (McCullough et al. 2010). Soil applications of imidacloprid products have provided variable levels of control and effectiveness has been especially inconsistent on large trees (Herms et al. 2009, McCullough et al. 2010).

At the SLAM sites, trees were injected in 2009 with TREE-äge™ (Fig. 4a, 4b, where small blue circles represent trees injected with insecticides). The goal was to create a buffer zone roughly 400 to 800 m around the outermost infested trees in the core area, to intercept and kill EAB that disperse out of the core. Selection of trees for treatment, however, had to be based on tree availability, land ownership, and accessibility. Currently, insecticide treatments are not permitted on U.S. National Forest land that falls within the SLAM project area.

C. Sinks of girdled trees. In addition to functioning as detection tools, girdled trees can concurrently serve as “sinks” for the next generation of EAB. If girdled trees are removed and destroyed before the next generation of adult EAB emerge, a large component of future EAB adults can be eliminated. Clusters of girdled trees provide an even more powerful attraction source than individual girdled trees and can influence dispersing EAB adults and the spatial distribution of the population (Siegert et al. 2010). In an ongoing study, EAB adults were strongly attracted to 10-acre plots with clusters of girdled trees while few EAB larvae were on trees in adjacent 10 acre plots that were untreated. Establishing clusters of sink trees inside the core of an outbreak rather than on the outer edges may help retain beetles within the core and reduce the likelihood of EAB adults dispersing to distant trees.

At the SLAM sites, clusters of 3-4 girdled trees were established in the core areas at Moran, St. Ignace, and in the vicinity of the satellite populations, along with the individual girdled trees used for the grid-based EAB detection surveys. All clusters of girdled trees were inside the known boundaries of the core and were cut, debarked and destroyed during fall of the same year (Fig. 4a, 4b, where orange and brown circles represent clusters of girdled trees where larvae were or were not found, respectively. All clusters were within the core outlined by the red boundary).

D. Ash Utilization. Harvesting ash trees for timber or firewood reduces the ash phloem that EAB larvae need for development.

Large ash trees, which typically make up < 10% of the ash trees at any given site, can potentially produce hundreds to thousands of EAB adults. Small ash trees, on the other hand, are usually abundant but collectively account for relatively few of the EAB produced in a site. Removing a few large trees can sometimes eliminate much of the available food for EAB larvae. Unfortunately, reducing ash phloem by itself is unlikely to slow EAB spread. Spread rates could potentially increase because beetles are forced to fly further to locate a suitable host tree. An integrated approach that focuses on insecticide treatments combined with girdling and sink trees will be more effective at slowing EAB population growth than simply reducing ash phloem (Mercader et al. 2010a, 2010b).

A phloem reduction project was completed at the Moran project site on the Hiawatha National Forest in March 2008. In an area of 550 acres, 445 large ash trees (30 cm dbh or larger) were felled along with an additional 100 smaller ash trees. Trees were dropped onto the ground and cut into smaller sections (< 1 m lengths) and left in the woods. Although the trees were probably not infested, the logs were bucked to enhance desiccation and reduce survival of any EAB larvae that may have been present in the trees. In addition, guidelines were developed to encourage harvesting of ash trees in any timber sale on the National Forest lands. Consulting foresters worked with private property owners in the Moran area to set up timber sales, which included harvesting of merchantable ash trees. Efforts were also directed to encourage landowners to use ash on their property for firewood.

E. Biological Control. To date, woodpeckers remain the most important natural enemy of EAB larvae. Predation rates of up to 90% have been recorded at some sites. Unfortunately, woodpecker predation is not consistent; at some sites few or no EAB larvae are killed by woodpeckers. Attracting woodpeckers into a local area and enhancing predation of EAB larvae could help reduce EAB densities, and can also help locate very lightly infested trees. Potential options for increasing woodpecker predation include providing suet during the summer when the birds are raising their offspring. Retaining woodpeckers in selected sites throughout the year could enhance predation on EAB during the winter and spring.

Much effort has been directed toward development of biological control for EAB. Three parasitoids native to China have been extensively studied in quarantine or containment laboratories in the United States and were granted approval for release in 2007 (Bauer et al. 2008). Rearing and production of the parasitoids is difficult, expensive, and labor intensive. The implementation of other treatments (removal of infested trees, insecticide treatments, removal of girdled trees, and ash utilization and phloem reduction) at the SLAM sites may make it more difficult for released natural enemies to locate EAB hosts and become established. Therefore, there are no immediate plans to release the Chinese parasitoids at the Moran and St. Ignace SLAM sites. However, natural enemy releases at these sites could be considered in the future if EAB populations build up and spread to the point that establishment is likely. There are plans to release two of the three Chinese parasitoids at different isolated infestations in the Upper Peninsula that were more recently discovered in Houghton, Delta and Schoolcraft Counties.

4. Regulatory Measures. Quarantines that regulate the transport of ash logs, firewood, nursery trees and related commodities that could harbor EAB are a basic management tactic imposed in all locations where EAB has been found. This is no different in the SLAM project area. It is imperative that EAB life stages are not transported from the SLAM sites to un-infested areas. Some of the SLAM project activities generate ash logs and firewood that may

contain EAB life stages, but the material is destroyed or used within the existing quarantine regulations.

5. Public Outreach and Education.

Success of the SLAM pilot project requires support from local residents and landowners. Eliciting this support requires residents and landowners to be fully informed about the goals, methods, and results of the project. There have been several public meetings, newspaper articles, extension bulletins and information displays in Moran and St. Ignace since 2007. Residents and landowners are kept apprised of the progress and plans associated with the SLAM project and all activities in their area.

Evaluating the SLAM Pilot Study

A simulation model has been developed that predicts how EAB populations will grow and spread based on ash abundance and distribution at a particular site (Mercader et al. 2010a, 2010b). It can be used to predict how EAB populations and ash mortality are likely to advance over time if no action is taken. The model can also estimate effects of activities such as insecticide treatment, girdled trees or phloem reduction on EAB spread and ash mortality at a specific site.

At the SLAM sites, detailed EAB and ash distribution data are being gathered through intensive surveys. These data will be used to model how EAB populations build up and spread in the absence of any management. The model results can then be compared to what is actually observed at the SLAM sites to evaluate the success of suppression tactics. Costs and benefits of the SLAM approach will also be quantified. Recent estimates indicate that the economic costs likely to be incurred by U.S. municipalities with ash landscape trees in a 25-state area predicted to be infested by EAB in the next decade, will exceed \$10 billion by 2020 (Kovacs et al. 2010). If the SLAM approach can slow EAB and associated ash mortality in the U.S., people and ecosystems would benefit substantially by the postponement of having to deal with EAB.

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