SLAM

A Strategy to SL.ow A.sh M.ortality
In Emerald Ash Borer Outlier Sites

February 2009

For more information contact: Steve Katovich, US Forest Service, 1992 Folwell Avenue, St. Paul, MN 55108 skatovich@fs.fed.us

INTRODUCTION AND BACKGROUND

Emerald ash borer (*Agrilus planipennis* Fairmaire) populations are expanding naturally and through artificial transport of infested ash material. Additional populations of emerald ash borer (EAB) will undoubtedly continue to be discovered. When a localized outlier site is found, there are currently few options to manage EAB or mitigate damage. Eradication has been attempted, but such efforts are expensive, generally unpopular with affected landowners, and have a poor record of success. Regulations imposed to limit ash transport from infested areas should reduce some artificial dispersal of EAB. Regulatory efforts alone, however, do little to alter the increase and spread of EAB populations and the subsequent onset and progression of ash mortality.

Research has shown that the rate at which ash tree mortality advances is related to EAB density. As outlier populations build and coalesce, the area encompassing dead, dying and declining ash trees increases dramatically. A do-nothing or a regulation-only approach means that EAB populations will build and advance largely unchecked, literally killing tens of millions of ash trees in forests, rural and urban areas in a relatively short amount of time. Continued expansion of EAB appears to threaten the long-term viability of at least 15 ash species native to the U.S.

When EAB was first identified in North America in 2002, little information about this beetle was available from its native range. Over the past few years, scientists have learned much about the biology of this invasive pest. Technology and methods for EAB survey and control have progressed considerably. Continued research may yield more options for EAB management and increase the effectiveness of existing technology. Slowing the movement of EAB and the advance of ash mortality buys time for research and technology development. It also buys time for many communities and forest managers to manipulate their existing ash resource so that the eventual impact from EAB is not as overwhelming.

This document summarizes an integrated, multi-year strategy designed to suppress EAB population growth and delay the onset and progression of widespread ash mortality in isolated outlier sites. Major components of a SLAM approach can incorporate any combination of tactics to reduce the rate at which EAB populations build and expand. Such components could include:

(1) systemic insecticides to control EAB adults and/or larvae;
(2) attracting or concentrating EAB on girdled trees that are subsequently removed and
(3) harvesting or removing ash trees from selected areas to reduce the amount of phloem (food) available for EAB development.

It is important to note that the tactics integrated into a SLAM approach must be site-specific. The particular tactics employed at an outlier site should account for the distribution and abundance of ash trees and the EAB population in that site, but must also reflect local conditions. A timber harvest, for example, might be an appropriate tactic in a forested setting but would not be useful in a residential area.

We must also recognize that our knowledge of EAB and our ability to manage an EAB infestation are still evolving. As new information or new control options become available, they can be incorporated into a SLAM strategy. But implementation of a multi-year program based on the SLAM principles and practices outlined in this document, should provide a practical, feasible method to slow the progression of ash mortality across the landscape.

GOALS AND OBJECTIVES OF A SLAM PROJECT

- Reduce the rate at which EAB populations grow and spread
- Slow the onset and progression of widespread ash mortality in an EAB outlier site.

SELECTING AN APPROPRIATE SITE

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 (e.g. ≤ 5 years) and ash mortality is minimal and/or concentrated. We do not yet know, however, how old or how large an infestation must be before a SLAM effort becomes ineffective.

One reason why SLAM is likely to work best in relatively recent or low density sites involves girdled trees and their ability to attract adult EAB. Research has shown that girdled trees are highly attractive to adult beetles in locations where EAB populations are relatively low. In sites where most of the ash trees are relatively healthy, a girdled tree can act as a beacon to EAB beetles, including the females, who prefer to lay eggs on stressed trees. In sites where most ash trees are stressed, however, the signals emitted by girdled trees are not as distinctive. When EAB densities are high, many trees will be heavily stressed and declining, reducing the effectiveness of girdled trees. Thus, areas where EAB has been established for several years and many ash trees are already declining may be less amenable to a SLAM strategy than a relatively recent outlier.

Though older infestations may not be ideal locations to implement a SLAM practices, they still may benefit from many of the suggested suppression tactics. Focused insecticide treatment programs, timely removal of infested trees, efforts to utilize ash and reduce phloem, and girdling then removing "sink" trees should reduce EAB numbers under a variety of EAB population pressures. Any reduction in EAB density and population growth should slow the rate at which tree mortality advances.

COMPONENTS OF A SLAM PROJECT

I. Surveys - delineating EAB density and distribution

As mentioned above, a SLAM strategy is more likely to be successful when implemented at an EAB outlier site that is relatively localized and where the overall EAB density is relatively low. Once a population is found, surveys will be needed to identify the extent of an infestation and the density of the EAB population. Accurate information about the spatial distribution of infested trees is useful in focusing suppression activities. Over time, information on EAB spread and changes in population densities will be needed. SLAM efforts must be viewed from a long-term perspective, in that management efforts may occur in an area for a number of years. Some level of annual surveying will be required to monitor spread, adjust tactics and assess project success.

A. Initial delimiting survey: Initial delimiting surveys are often completed relatively quickly, within a few weeks to several months of a new detection. The intent is to give a rapid assessment of the existing EAB situation. Delimitation surveys are commonly set up in a grid pattern and may initially rely upon visual observations to locate symptomatic trees. Further surveys include some level of destructive sampling (cutting and peeling ash trees) to confirm the presence or absence of EAB.

B. Trapping grids: Following an initial delimiting survey, a grid-based trapping protocol should be implemented over the project area. The intent of this grid-based survey is to determine the spatial distribution of the infestation. The trapping density is based on practical considerations and the need to establish a grid that is dense enough to detect very low densities of EAB with a reasonably high level of confidence.

Considerations:

- Girdled trees will generally be favored over purple panel traps and lures for two reasons. First, girdled trees potentially serve two purposes: They can be used for EAB detection and delimitation if debarked, and as "sink" trees when they are removed, debarked or otherwise destroyed.

- Secondly, the detection threshold associated with girdled trees is substantially lower than the detection threshold associated with the panel traps. In areas where suitable ash trees are not present or available for girdling, purple panel traps baited with Manuka/Phoebe oil lures can be used.

- Dates for girdling trap trees or setting traps and debarking trees or retrieving traps should be based on accumulated degree days for the local area. Many land grant universities report degree day accumulations on a weekly basis during the growing season.

- If trees are girdled and remain standing for more than one year, they will in effect, be a source of beetles. Adult EAB lay more eggs on girdled trees, larval survival is higher and most beetles will develop in a single year on very stressed girdled trees. Therefore, do NOT leave girdled trees on the site. Girdled trees should be felled and debarked or destroyed in the fall, winter or early spring following their establishment, to ensure larvae die before completing development.

- Debarking girdled (or non-girdled) trees in fall or winter should cause larvae to die because of desiccation and/or exposure to cold. If an entire tree is not debarked, pieces with intact bark should be bucked up into small sections to enhance desiccation. Debarking and bucking will need to be finished by late winter or early spring. In some areas, trap trees may be more accessible in the winter when the ground is frozen.

- When trap trees are debarked, some very important data can be collected that may assist in evaluating the local EAB population status and the likelihood of success or failure of certain management practices.

- Trapping grids will need to be adjusted annually, based on results from previous surveys.

II. The local ash resource - determining ash density and distribution

A reasonably accurate assessment of ash abundance, distribution and tree size will be useful for planning suppression and evaluation activities. Efficient placement of insecticide treatment areas, sink trees, phloem reduction projects, etc. require knowledge of the local ash resource.

Assessing the ash resource in an area is vital because it provides information about the amount and distribution of ash phloem, the EAB food source. Reliable ash inventory data can be used in models to estimate the amount of ash phloem present on the landscape and based upon that; beetle production over time. Estimates of the density and distribution of the existing EAB population, combined with information about the ash resource, will allow researchers and managers to model EAB population buildup, spread and the progression of ash mortality. Models can be used to evaluate the effects of potential management actions such as insecticide treatments or sink trees. The models can also be used to predict what would happen in the absence of any proactive management. Results can then be compared to what is actually observed to determine whether suppression tactics have been successful.

A web-based model to estimate ash phloem can be accessed at http://www.ashmodel.org/.

A. Collect and summarize ash inventory data that may already exist. A number of sources may provide ash inventories or related data for the project area. This includes Forest Service, Forest Inventory and Analysis (FIA) data, local community inventories of street trees and parks, and National Forest System stand exam data. Aerial photographs may identify corridors of ash likely to enhance EAB spread.

Considerations:
- FIA data is generally reliable on a county-wide basis. It is often unreliable for smaller project areas.

B. **Collect and summarize new ash inventory data**. Intensive inventories of the local ash resource can be very useful. A variety of methods for obtaining inventory data should be considered.

Considerations:
- Variable radius (prism) plots are relatively efficient and typically provide accurate basal area estimates, especially for pole-sized and larger trees.

- Survey crews conducting trap tree surveys or setting panel traps can often efficiently collect useful ash inventory data.

- Conducting aerial surveys in spring or fall may help to identify concentrations of ash and scattered ash in swamps or open areas. Aerial surveys may include sketch map data, aerial photography or some type of remotely sensed data.

- SLAM activities within urban areas would also benefit by reliable ash inventory data. Determining the distribution, size and abundance of urban ash trees can help refine EAB survey protocols and identify priorities and costs associated with insecticide treatment or tree removal.

III. Suppression of EAB populations

Actions can be taken to reduce existing EAB populations and to minimize future population growth and expansion. Direct actions against EAB populations include controlling EAB life stages by destroying infested trees or using insecticides. Indirect actions include harvesting ash trees and reducing the amount of ash phloem available for larval feeding.

Direct reduction of EAB populations

A. Removal of trees known to be infested: Prompt removal of trees known to be infested, prior to adult beetle emergence, should be a priority in SLAM project areas.

Considerations:
- Infested trees will need to be removed or treated to ensure that developing EAB progeny are not allowed to emerge. This can entail chipping, grinding, complete bark removal, burning or other methods.

- Trees that have been dead for more than one year may no longer have EAB within them. Removal of these trees will not result in any reduction in the number of EAB.

B. Sinks –girdled trees: Girdled ash trees are more attractive to adult EAB than healthy ash trees. Female beetles preferentially oviposit on girdled trees unless there are other stressed trees nearby. If girdled trees are removed prior to beetle emergence, a large component of future adults can be eliminated. Girdled trees deployed in a systematic survey grid (see Section I) can concurrently serve as "sinks" for the subsequent generation of EAB.

Considerations:

- Deploying sink trees in a grid pattern can provide valuable survey information.

- As EAB densities build in an area, the effectiveness of girdled trees to function as traps or sinks appears to diminish. While the EAB density at which this will occur is currently unknown, pilot projects and related projects already in progress will help to define this threshold.

C. Sinks - clusters of girdled trees: In addition to the systematic grid of girdled trees, clusters of 3-6 girdled trees can be installed within the project area. Results from preliminary studies in northern lower MI showed that clusters of girdled trees effectively functioned as sinks in areas with low-density EAB populations.

Considerations:

- A cluster of 3-6 freshly girdled ash trees should generate a substantial plume of volatile compounds that are attractive to adult beetles. Female EAB should lay a substantial component of their eggs on these trees. Destroying these trees in fall or winter should eliminate a substantial proportion of the larvae produced locally.

- Placement of girdled tree clusters can be determined using maps and on-site visits to assess factors such as ash density, distribution and habitat heterogeneity.

Selecting the best trees for sinks or insecticide trees: All of our native ash (*Fraxinus* spp.) will attract EAB adults. However, if different species are present select by priority, from most to least preferred: (1) green ash, (2) black ash, (3) white ash and (4) blue ash. EAB adults prefer trees that get plenty of sun. Therefore, the best trees would be (1) open-grown trees (most preferred); followed by (2) hedgerow tree (2-3 sides mostly open); and (3) edge trees along the edge of a woodlot. Least preferred would be shaded trees in closed canopy woodlots, where the canopy and trunk are not exposed to sun (suppressed or overtopped trees).

In addition, easy access is important for accessing sink trees for debarking or removal, and for insecticide application.

Comment [m1]: The idea that EAB prefer large trees is NOT supported by data. I know Andrew thinks it is, but that's largely a function of capturing more adults on sticky bands on larger trees than on smaller trees and not standardizing the area. THere are various other data sets (not just our data) that show no relationship between tree diam and EAB colonization. Furthermore, larger trees are way more difficult to fell, debark, etc. than smaller trees.

D. Insecticide treatments: Insecticide options are available for controlling EAB adults and in some cases, EAB larvae. Insecticides can certainly be used to protect valuable landscape ash trees. Insecticide treatment can also function to reduce EAB population density.

Considerations:

- Treating ash trees for EAB control can be costly and results vary depending upon factors such as the health of the tree, the extent of previous EAB injury, the insecticide product and application method selected and the local EAB population pressure.
- Most ash trees have been treated with systemic neo-nicotinoid insecticides such as products containing imidacloprid or dinotefuron. These insecticides have been effective in many but not all settings. The products must be re-applied annually.
- Recent research has shown that the insecticide emamectin benzoate provided nearly 100% control of EAB for at least 2 years after a single trunk injection. Because trees do not need to be treated annually, economic and practical considerations may favor use of this insecticide product.
- One option for using insecticides in a SLAM project area could be to create a "buffer" of treated trees to limit survival of dispersing EAB adults or their offspring.
- Lethal trap trees may be another option for consideration. Treating girdled trees (see letters B and C above) with insecticides 2-3 weeks before girdling could create "lethal trap trees" that kill EAB attracted to the trees.

<u>*Indirect reduction of EAB populations*</u>

E. Phloem reduction: Reducing ash phloem means that fewer EAB larvae can complete development and emerge as adults from a specific area. Phloem reduction can be accomplished many ways and does not necessarily mean that all of the ash trees need to be removed. Data from several sites have shown that only a small proportion of ash trees are large (e.g. > 10 inches DBH), while most ash trees are < 4-5 inches in diameter. Large ash trees can potentially produce hundreds of EAB adults but small ash trees produce relatively few, even when the small trees are abundant. Removing a few large trees can sometimes eliminate much of the available food for EAB larvae. Landowners may even recognize some economic benefits by targeted harvests of large ash trees for lumber or firewood. Phloem reduction models are available for land managers that can be used to compare and contrast different management approaches.

Questions have arisen about whether cutting or removing ash trees can actually increase the rate of spread of EAB. We believe that this can occur to some extent but only if all ash trees are removed from a given area. If some ash trees are still available to "absorb" dispersing beetles, the rate of spread is unlikely to change substantially. Moreover, because fewer beetles are produced within the area, fewer beetles will be available to disperse either naturally or artificially. This issue can be addressed by considering an integrated approach that combines phloem reduction (e.g. removing selected trees) with girdling or insecticide treatment of remaining trees.

1. Cut and leave. In this scenario, selected ash trees are cut and left on site. Cut and leave projects may be most appropriate for areas where access is limited, where site disturbance is a concern (e.g. wet sites likely to be impacted by heavy equipment), or when trees are not merchantable. Bucking the trees into smaller logs after felling will enhance desiccation, perhaps reducing survival of young EAB larvae on those trees.

Considerations:

- Cutting infested trees is unlikely to prevent older, late stage EAB larvae already present from completing development and emerging as adults. However, cut logs and branches would not be colonized by subsequent generations of EAB.
- Cut-and-leave projects may prove most useful on the outer edges of SLAM project areas, where trees are unlikely to be infested or have a very low density of developing larvae.
- Managers do not need to be overly concerned about stump sprouts following cutting. It will take a considerable amount of time before the sprouts grow large enough to provide more than a minimal amount of phloem.
- If trees are expected to be cut and left on site, they should not be girdled.

2. Commercial timber sales. Harvesting merchantable ash trees can benefit landowners while simultaneously reducing the potential production of EAB in an area.

Considerations:

- Timber sales can generate funds for private or public landowners.
- SLAM project areas will be regulated (under quarantine). Log transport will need to be coordinated with regulatory officials.
- Providing assistance to landowners by coordinating sales or with tree marking, sale layout, contracts, site restoration and related activities could increase interest in harvesting and the effectiveness of timber sales.

3. Noncommercial tree removal may be appropriate in some areas where ash trees need to be removed for safety or aesthetic reasons. This might occur along roads or trails, or in park or landscape situations.

Ash trees are often common along road or trail right-of-ways. In addition to removing phloem, right-of-way cutting may also eliminate "corridors" that appear to enhance EAB dispersal and spread.

Considerations:

- Trees growing along transportation corridors, (i.e. road corridors) may need to be removed after cutting to avoid hazards created by logs in the right-of-way or conflicts with private property.

- If trees can be girdled before they are removed, they reduce the current EAB density as well as the future EAB density.

4. Emamectin benzoate insecticide. Treating trees with emamectin benzoate insecticide effectively reduces the amount of phloem available for EAB production in a given year. An advantage of using insecticides, instead of simply cutting or removing trees, is that the density of adult beetles will also likely be reduced by the insecticide. In addition, these trees can affect the EAB population for multiple years (assuming trees are treated at 2-3 year intervals).

Considerations:

- Not all insecticide products are highly effective at controlling EAB larvae.

- Insecticides will need to be reapplied at 2-3 year intervals to prevent EAB larval development.

IV. Regulatory Component to SLAM

Quarantines that restrict the transport of ash logs, firewood, nursery trees and related commodities is a basic management tactic imposed in all locations where EAB has been found in the U.S. This will be no different in a SLAM project area. It is imperative that EAB life stages are not transported from within a SLAM project area to un-infested areas.

Considerations:

- SLAM activities could generate ash logs or firewood products, possibly containing EAB life stages. Utilization of ash products should be encouraged but only within the context of existing quarantines. Regulatory compliance will need to be addressed as SLAM projects are developed.

V. Public Outreach – Communication and Education

The SLAM project represents a fundamentally new strategy for managing EAB outlier sites. The success of a project will require support from residents and landowners in the vicinity of the area. Eliciting this support will require residents and landowners to be fully informed about the goals, methods and results of the project. Therefore, public outreach should be identified as an important component of a successful SLAM project.

Considerations:

- Outreach activities should serve to complement regulatory activities designed to prevent artificial transport of infested ash material.

- Various agencies and entities involved in SLAM activities will need to cooperate to ensure that information is accurate and consistent.

VI. Biological Control

Using parasitoids or other natural enemies to reduce EAB density in a local area is consistent with the underlying objectives of SLAM and could likely be integrated with other activities. Likewise, slowing ash mortality complements biological control efforts.

A. Asian parasitoids. Classical biological control, which involves introducing a non-native natural enemy, may eventually be a part of a SLAM effort. Three Asian parasitoid wasps that attack EAB eggs or larvae have been released in selected EAB infestations since 2007. Researchers are learning more about how to rear and release these Asian parasitoids each year.

B. Native parasitoid(s). Scientists are also studying native parasitoids that could be used for augmentative biological control in SLAM sites. One species, *Atanycolus hicoriae*, appears to have potential for sites where EAB densities are generally low and may be useful in SLAM sites.

C. Woodpecker predation. 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 other sites, few or no EAB larvae are killed by woodpeckers. Attracting woodpeckers into a local area and enhancing predation of EAB larvae could help to reduce EAB density. Potential options for increasing EAB predation could include providing suet to retain woodpeckers in selected sites throughout the year.

VII. Urban Component to SLAM

The presence of a high human population density, numerous homes, high value landscape trees and a variety of other factors combine to make urban areas much different from rural areas when considering EAB management tactics. However, the basic principles of SLAM still exist, reduce or maintain EAB populations at lower levels and reduce the amount of available food for EAB (ash phloem).

Considerations:

- Because of the higher economic and aesthetic values that are likely with landscape trees and the lack of trees suitable for girdling, insecticide treatment may be a primary focus in urban areas.

- Tree removal costs can be high in urban areas. Dead ash trees generally deteriorate rapidly and many will become hazardous especially along streets and in yards.

- A coordinated approach to EAB management in urban areas will require a strong commitment to outreach and education.

Communities within a SLAM project area should be provided with advice and assistance in developing a response plan for EAB

VIII. Evaluation of the Slam Approach

Methods to evaluate the SLAM approach will draw on results from previous and on-going EAB research. For example, dendrochronological studies at several outlier sites have shown that EAB must be present at a site for at least 3-4 years before densities build high enough to cause trees to die. Further, results from the dendrochronological reconstruction of ash mortality in southeast Michigan showed that ash mortality progressed at a rate of roughly 4 miles per year during its expansion phase from 1998-2002. This information can be used as a comparison to EAB caused tree mortality extent and levels at SLAM sites.

A simulation model has been developed that predicts how EAB populations will grow and spread based on ash abundance and distribution at a site. Scientists are continuing to refine the model, but it can be used to predict how EAB populations and ash mortality advance if no action. 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.

Costs and benefits of a SLAM approach need to be quantified at pilot sites, to identify effective and efficient strategies. Efforts to conduct an economic evaluation are underway at SLAM pilot sites.