SLAM

Steps in Implementing a Strategy to **SL**.ow **A**.sh **M**.ortality

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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 efforts attempted in the first few years after EAB was discovered were expensive and generally had a poor record of success. Regulations imposed to limit transport of ash nursery trees, logs, firewood and related items from infested areas should reduce 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.

The rate at which ash tree mortality advances is related to EAB density. Therefore, an over-riding theme within the SLAM approach is to reduce EAB numbers and the growth of EAB populations. This can occur by destroying EAB life stages before adults can disperse and reproduce, concentrating and eliminating adult beetles and their progeny, and reduce the amount of food (ash phloem) available for the development of large numbers of EAB offspring. 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 unchecked. Under that scenario, extensive local tree mortality is likely to occur much sooner than under a SLAM management scenario

Applying a SLAM approach will not eradicate EAB, nor will it eliminate tree mortality. The goal of this management strategy is to slow the local invasion process and allow land managers time to be proactive rather than simply reacting to overwhelming numbers of dead, often hazardous trees. When EAB was first identified in North America in 2002, little information about this beetle was available. Tools available for EAB survey and control have progressed considerably. Continued research and methods development will yield more options for EAB management and increase the effectiveness of existing technologies. Slowing the movement of EAB and the advance of ash mortality buys time for research and technology development.

This document outlines an integrated strategy designed to suppress EAB population growth and delay the onset and progression of widespread ash mortality in isolated outlier sites. Suggested components include surveys to define EAB distribution and density in the area, inventories or surveys to assess ash abundance and distribution, EAB suppression activities, regulatory measures, and a public information and outreach effort. Each component does play an important role in the overall strategy but activities to suppress local EAB populations are vital. Surveys and inventories along with regulatory and outreach activities, if not combined with some type of active suppression, will have little impact on EAB populations and ash tree mortality.

Under SLAM, suppression activities are combined and integrated. Such activities may include:

(1) systemic insecticides to kill EAB adults and larvae;
(2) prompt removal of infested ash trees before EAB adults can emerge;
(3) attracting or concentrating EAB in girdled trees that are subsequently destroyed before the next generation of adults can emerge;
(4) harvesting and utilizing ash trees which reduces the amount of phloem (food) available for EAB development.

Utilizing some or all of these activities along with the other suggested components should slow the rate at which local EAB populations grow and slow the local buildup of dead and dying ash trees.

It is important to note that the tactics integrated into a SLAM project must be site-specific. Managers should account for the local distribution and abundance of ash trees, the existing EAB population levels, and a variety of other local situations that could alter what activities are stressed or not available because of local constraints. A timber harvest, for example, might be an appropriate tactic in a forested setting but would probably not be practical in a residential area.

GOALS AND OBJECTIVES OF A SLAM PROJECT

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

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 these areas most of the local ash trees will be relatively healthy and 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 heavily infested and stressed, however, the signals emitted by girdled trees are not as distinctive. Thus, the effectiveness of girdled trees will decline in areas where EAB densities are high. In sites where EAB has been established for several years and many ash trees are already declining or dying, a SLAM strategy may be less successful than in a site with a relatively recent infestation.

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

Urban vs. Rural approaches 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 are still applicable to urban areas. Activities that reduce or maintain EAB populations at lower levels, concentrate and kill EAB, and reduce the amount of available food for EAB (ash phloem) will be appropriate in urban areas, as well as in rural areas.

Considerations:

- Because of the higher economic and aesthetic values associated with landscape trees and the lack of trees suitable for girdling, insecticide treatments will likely 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.

COMPONENTS OF A SLAM PROJECT

I. EAB survey - delineating EAB density and distribution

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 the infestation and estimate the density of the EAB population. Accurate information about the spatial distribution of infested trees is useful in focusing treatment activities. Over time, information on EAB spread and changes in population densities will be useful.

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. However, visual surveys have significant limitations when surveying for low-level EAB infestations. More reliable delimiting surveys are likely to include some level of destructive sampling (cutting and peeling ash trees) to confirm the presence or absence of EAB galleries or life stages in trees that are likely showing no visual external symptoms of infestation.

B. Systematic EAB survey: Following an initial delimiting survey, a grid-based survey protocol should be implemented over the project area. The intent of this grid-based survey is to more accurately determine the spatial distribution of an infestation. Trapping density is often based on practical considerations and costs balanced with 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 panel traps for several reasons. First, when girdled trees are debarked, they provide useful information about EAB density and larval development. Second, girdled trees serve as "sink" trees when they are debarked or otherwise destroyed. Debarking will kill the larvae in the girdled tree, reducing the number of adult beetles that will emerge and reproduce the following summer.

- Third, 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, the panel traps 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 breeding 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 standing 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 will 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, useful 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. Larval developmental stage (evidence of a 1- or 2-year life cycle) and the number of larvae can be recorded. EAB density (e.g. number of larvae per square meter) and potential beetle production can be estimated for trees of various diameters. *(See McCullough and Siegert, 2007, Journal of Economic Entomology, vol. 100(5), pages 1557-1586)*

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

> For a copy of, "Using girdled trap trees effectively for emerald ash borer detection, delimitation and survey" go to *http://www.na.fs.fed.us/fhp/eab/survey/eab_handout.pdf*

II. Ash inventory - determining ash density and distribution

A reasonably accurate assessment of ash abundance, distribution and size will be useful for planning suppression treatments and evaluation activities. Identifying trees for insecticide treatments, use as sink trees, or for utilization requires knowledge of the local ash resource.

Assessing the ash resource in an area 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 beetle production over time. Estimates of the density and distribution of the existing EAB population, combined with systematically collected ash data 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 management. Results can then be compared to what is actually observed to evaluate the success of suppression tactics.

It should be noted that every ash tree in an area does not need to be counted. Intensive ash tree surveys can become expensive. Systematic ash surveys must be balanced against costs of EAB suppression activities.

A. Collect and summarize ash inventory data that may already exist. A number of sources may already have ash inventories or related data for the project area. This includes local community tree inventories of street or park trees, Forest Service - Forest Inventory and Analysis (FIA) data, and stand data from state or national forests. Aerial photographs or other remote sensing products may be very useful in identifying concentrations of ash or corridors of ash that could potentially 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**. 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 trees that are pole-sized or larger.

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

- 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 form of remotely sensed data.

- SLAM activities within urban areas would also benefit by reliable ash data from street tree inventories and related sources. 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 – treatment tactics for reducing local EAB populations

Actions can be taken to reduce existing EAB populations and 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 or removing ash trees and reducing the amount of ash phloem available for larval feeding.

> Recent research findings support a greater emphasis on the use of insecticide treated trees for EAB suppression. In addition, prompt removal of infested trees before adult beetles emerge is important, especially in locations where EAB has recently been discovered and densities are likely to be low. Removing a few key infested trees, especially if they are large and heavily infested, could remove a locally significant number of EAB adults.

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

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, debarking, burning or other methods.

- Trees that have been dead for more than one year are unlikely to harbor EAB. Removal of these trees will not result in any reduction in the number of EAB.

> EAB infested trees can produce ca. 90-100 adult EAB per square meter (8-10 EAB per square ft) of bark surface area. A single 20 inch diameter ash tree has the potential to produce approximately 3600-4000 beetles before it succumbs.

B. Insecticide treatments: Insecticide options are available for controlling EAB adults, and in some cases, larvae. Insecticides can certainly be used to protect individual, high value landscape ash trees. Within a SLAM strategy, insecticide treatments are used to create trees that are lethal to EAB. Many of the insecticides now available will create leaf tissue toxic to adult beetles that visit treated ash trees and feed on the leaves. Adult EAB must feed on ash leaves for at least two weeks before females begin to lay eggs, providing a window of opportunity for control. Further, emamectin benzoate (EB), a relatively new insecticide product, kills developing EAB larvae. Therefore, females that do not encounter toxic leaves but lay eggs on EB treated trees will still fail to produce offspring. This insecticide-induced mortality of EAB adults and larvae can have a significant impact on EAB population growth in localized sites.

Considerations:

- The insecticide emamectin benzoate (sold as TREE-Age) has provided nearly 100% control of EAB for at least 2 years after a single trunk injection in research studies. Because trees do not need to be treated annually, economic and practical considerations favor use of this insecticide product. This product is new, however, and full EPA registration is still underway. Several states have special 24(c) registrations that permit use of this product for EAB control in ash trees.

- Many ash trees have been treated with systemic neonicotinoid insecticide products containing imidacloprid or dinotefuron. These insecticides have been effective in many but not all settings. The products must be re-applied annually.

- 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. In a 2009 study, treating girdled trees with emamectin benzoate 3 weeks before girdling effectively created "lethal trap trees" that attracted EAB but prevented larvae from developing on the trees (see further discussion at the bottom of page 8).

For a copy of, "Insecticide options for protecting ash trees from emerald ash borer" go to *http://www.emeraldashborer.info/files/Multistate_EAB_Insecticide_Fact_Sheet.pdf.*

Selecting the best trees for insecticide or sink trees: All of our native ash (*Fraxinus* spp.) will attract EAB adults. However, if different ash 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 also 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 mostly shaded (suppressed or overtopped trees).

In addition, easy access may be important for sink trees that must be girdled, debarked, removed or even treated with insecticide.

C. Sinks – girdled trees: Girdled ash trees are consistently more attractive to adult EAB than healthy ash trees. Female beetles preferentially oviposit (lay eggs) on girdled trees unless there are other stressed trees nearby. If girdled trees are removed before the next generation of adult EAB can emerge, a large component of future adults can be eliminated. Girdled trees deployed in a systematic survey grid (see Compnent 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.
- Girdled sink trees are often referred to as "trap-trees", a technique with a long history of use in forest pest management.

D. Sinks - clusters of girdled trees: Clusters of girdled trees may be useful in creating a more powerful attraction for dispersing EAB adults than isolated single girdled trees. Results from field studies showed that clusters of girdled trees effectively functioned as attractive sinks and strongly influenced EAB dispersal in areas with low-density EAB populations.

Considerations:

- A cluster of 3-4 freshly girdled ash trees will generate a 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 significant 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.
- Managers should consider site access when creating sinks because girdled trees will need to be cut and either removed or debarked to eliminate the chance of EAB adult emergence. If tree cutting is not a viable option, then creating lethal trap trees should be considered (see below).

There is evidence to suggest that at very low EAB population levels, the location of sink trees can influence how beetles disperse. Sink trees will pull some beetles towards them as EAB adults respond to the presence of artificially damaged trees. Placing clusters of sink trees inside the core of an outbreak versus outside the outer edges could pull dispersing beetles away from the edges and potentially reduce spread rates.

In 2009 field studies, **lethal trap trees** were created by injecting trees with emamectin benzoate in late May, then girdling the trees 3 weeks later. The lethal trap trees will produce few, if any, adult EAB the following summer.

Lethal trap trees may be most useful where access is limited and tree removal or tree cutting and peeling would be difficult to accomplish. In this scenario, lethal trap trees (treated, then girdled) could remain standing, assuming they posed no hazard to people or property.

Indirect reduction of EAB populations

E. Ash utilization or selected ash removal: Harvesting ash trees for timber or firewood reduces the ash phloem that EAB larvae need for development. 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 in most areas, only a small proportion of ash trees are large (e.g. > 10 inches DBH), while most ash trees are relatively small (< 4 inches DBH). Large ash trees can potentially produce hundreds to thousands 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 recognize some economic benefits by targeted harvests of large ash trees for lumber or firewood. However, in some situations, it will not be possible to economically utilize all cut ash material. That should not deter managers from considering this approach.

Reducing ash phloem by itself is unlikely to slow spread. In some cases local EAB spread rates may increase because beetles are forced to fly further to locate a suitable host tree. An integrated approach that combines phloem reduction (e.g. removing selected trees) with insecticide treatments or girdling and sinks will be more effective than simply reducing ash phloem. The presence of sink trees may serve to retain many beetles in an any area and reduce the numbers of beetles likely to disperse long distances.

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, reducing survival of young EAB larvae.

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.

- Managers do not need to be overly concerned about stump sprouts following cutting. Sprouts may eventually grow large enough to provide some phloem but they are unlikely to contribute to EAB populations in the short term.

- If trees are expected to be 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, railroad, 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 physically removed after cutting to avoid hazards created by logs and branches in the right-of-way or conflicts with private property owners.

- If trees can be girdled before they are removed, they may serve as valuable sink trees.

F. Encouraging natural enemies of EAB: 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 to reduce EAB densities, it can also help in locating very lightly infested trees. Potential options for increasing woodpecker predation could include providing suet to retain woodpeckers in selected sites throughout the year.

Classical biological control, which involves introducing a non-native natural enemy, may eventually be a part of SLAM efforts in some sites. Three Asian parasitoid wasps that attack EAB eggs or larvae have been released in selected EAB infestations since 2007. Scientists are also studying native parasitoids that could be used for augmentative biological control in SLAM sites. One native species, the newly described *Atanycolus cappaerti*, may have potential for releases in some outlier sites.

IV. Regulatory Efforts – minimizing the risk of EAB spread

Quarantines that restrict the transport of ash logs, firewood, nursery trees and related commodities are a basic management tactic imposed in all locations where EAB has been found. 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 strategy represents a fundamentally new approach for managing EAB outlier sites. The success of a project will require support from residents and landowners in the vicinity of the infestation. Eliciting this support will require residents and landowners to be fully informed about the goals, methods and results of the project. Therefore, public outreach and education should be identified as a key component of any SLAM project.

Considerations:

- Project goals should be realistic and clearly identified. SLAM is not an eradication strategy and EAB will likely kill the vast majority of local ash trees over time. SLAM is proposed as a method of buying time for local residents and property managers to reduce local ash inventories and to diversify forest and urban tree resources. This will reduce the vulnerability of the area to an overwhelming ash mortality event.

- Carefully developed outreach information can be helpful in supplementing insecticide programs, survey efforts and regulatory activities.

- 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 must cooperate to ensure that information is accurate and consistent.

VI. Evaluation – judging success or failure

Methods to evaluate the SLAM approach will draw on results from previous and on-going EAB research and from several pilot projects that are the focus of intensive monitoring. We have a number of locations where EAB has arrived and expanded without any effort to suppress EAB populations or reduce damage. Comparisons between SLAM sites and those locations will be a part of the SLAM evaluation effort.

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 is attempted. 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 will need to be quantified at pilot sites, to identify effective and efficient strategies.

Considerations:

- Evaluating success and failure is dependent upon reasonable goals and objectives. SLAM projects are not eradication projects; tree mortality and beetle expansion should be expected. Evaluation should focus on the rate at which ash mortality expands and progresses.