Emerald Ash Borer Management Recommendations for the City of Poughkeepsie

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Introduction

The emerald ash borer (EAB), *Agrilus planipennis* (Fig. 1) is an invasive beetle that arrived in the United States in wooden packing material shipped from Asia (Bauer and Duan 2017). The beetle targets ash trees, (*Fraxinus sp.)*, a native North American species often planted in urban areas as a street tree (USDA 2014). EAB was first encountered in the United States in 2002 in Detroit, Michigan and Windsor, Ontario (Poland and McCullough 2006), and was discovered in New York State in Cattaraugus County during the summer of 2009 (Whitmore 2011). Non-native, invasive organisms are often more likely to become established in cities due to the high commercial traffic in these areas (Poland and McCullough 2006). The beetle has traversed the country due to the movement of firewood, nursery trees, and other infested wood (Cappaert et al. 2005). As of 2014, Dutchess County is in the Quarantine Zone for New York State (NYS DEC 2014, see Fig. 2a), meaning that ash wood cannot be moved into or out of the area. The Mid-Hudson area in general is considered a "core" of EAB infestation (McDonnell 2013; see Fig. 2b). In response to the growing the growing threat of EAB in Dutchess County, the Vassar Farm and Ecological Preserve (VFEP) developed and implemented an EAB management plan in mid-2015. As of this year, EAB is firmly established among the City of Poughkeepsie's ash population.

Fig. 1: The emerald ash borer
(Source: David Cappaert, Michigan State University, Bugwood.org)

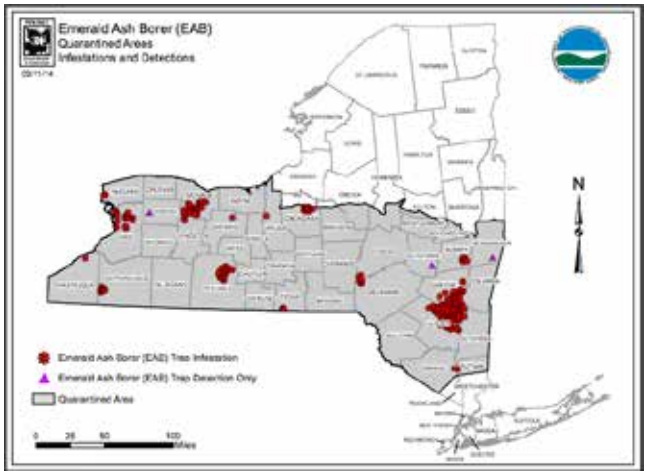

Fig. 2a: Quarantine Areas, Infestations, and Detections
(Source: NYS DEC)

Ash Trees in the City of Poughkeepsie

Street trees are a vital resource for cities. Through evapotranspiration and absorption into roots and soils, street trees absorb substantial amounts of rainfall and are thus beneficial in terms of stormwater management. Street trees also capture CO_2 and other airborne pollutants released with automobile emissions, improving air quality. Moreover, street trees help cool urban heat islands by shading pavement and other surfaces. Many city trees provide important habitat for urban species, and groups of street trees can serve as wildlife corridors, especially for birds (Mullaney et al. 2014). Street trees also help improve aesthetics, increase property values, and strengthen communities (Burden 2006). In 1978, the City of Poughkeepsie Shade Tree Commission was established to oversee the planting and care of the City's trees (City of Poughkeepsie 2017). For the past 38 years, the City has retained its status as a Tree City USA, recognized for its excellence in urban forestry planning and management (Arbor Day Foundation 2017). Street trees are therefore particularly meaningful to the City of Poughkeepsie.

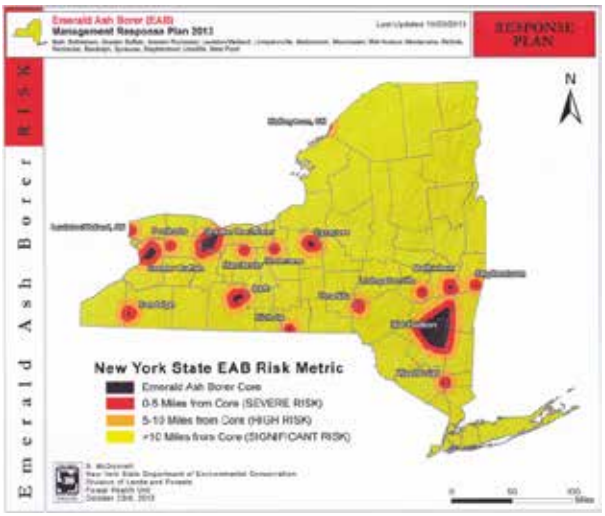

Fig. 2b: EAB Infestation Cores, NYS
(Source: S. McDonnell, NYS DEC)

Poughkeepsie's street trees are diverse, with 84 species comprising a population of 6,987 individuals (Urban Forestry, LLC 2006). Of those street trees, 405 (5.8%) are either white or green ash trees. Green ash (*Fraxinus pennsylvanica*) is much more common in the City than white ash (*Fraxinus americana*). Ash is an excellent street tree, as it tolerates a relatively wide range of soil pHs (Cornell University 2017), which tend to fluctuate in urban environments. Ash is identified by its compound leaves, opposite branching pattern, and diamond-shaped bark (The Tree Doctor 2017).

Fig. 3: EAB adult (above) and larva (below)
(Source: David Cappaert, Michigan State University, Bugwood.org)

EAB Biology

Life Cycle

The adult emerald ash borer measures 10-20mm in length and 4mm wide (Cornell Cooperative Extension 2012). Adult borers lay their eggs in the crevices of the ash's diamond-shaped bark at least 1.4 m above the ground in a newly infested tree (Kovacs et al. 2010). Larvae hatch about two weeks after eggs are laid (Poland

et al. 2006). Larvae are white, with several bell-shaped segments comprising a body up to 38 mm in length (see Fig. 2; Cornell Cooperative Extension 2012). Upon hatching, the larvae proceed to tunnel into the vascular system of the tree, excavating telltale S-shaped galleries (Fig. 3) in their wake (de Groot et al 2006). Larval activity effectively girdles the tree over time, inhibiting the transport of water and nutrients (Sadof et al 2017). Larvae mature within the tree and bore their way out as adults in the spring through distinct D-shaped holes (Fig. 4; de Groot et al 2006). Adult beetles then feed on ash leaves prior to mating and dispersal (Poland et al. 2006). Borers are most active on warm, cloudless, windless days (USDA–APHIS 2008).

Fig. 4: S-shaped gallery, City of Poughkeepsie

Fig. 5: D-shaped exit holes and vertical bark splitting, City of Poughkeepsie

Population Dynamics

Burr and McCullough (2014) describe the spread of EAB as a “wave”. During an EAB infestation insect density starts out low then steadily increases. As ash trees decline, the beetle population grows exponentially until the ash population is entirely infested. After all or most of the ash trees die the beetle moves on to another healthy population.

Effects on Ash Trees

EAB infestation usually commences towards the top of the tree and progresses downwards over time (Cappaert 2005); therefore symptoms in the initial stage of infestation are not easily seen. Thus, by the time D-shaped holes and/or S-shaped galleries are visible at eye-level, the infestation is likely already too well-established in the tree for treatment to be viable. Other symptoms of ash tree stress are epicormic branching, vertical bark splitting, blonding due to woodpecker activity, and crown dieback (de Groot et al 2006).

Natural Predators

EAB has several natural predators in its native ranges of China and the Russian Far East (Bauer and Duan 2017; Haack et al. 2015), though ash trees in those regions appear to be resistant to EAB (Rebek et al. 2008). However, parasitic wasps and other natural predators of EAB are not native to the U.S., and ash trees here have no defenses against the invasive

beetle. Woodpeckers are an important native species that feed on EAB (Cappaert 2005), but their predation is not enough to sufficiently curb the spread of infestation (Lindell et al. 2008). Parasitoid wasps have been imported and released in forest stands of ash with moderate rates of success at EAB population control. For instance, Duan and colleagues (2017) observed a 36-85% larval parasitism rate by *Ooibus agrili* among ash saplings. However, parasitism rates declined with increasing tree size. Rates of success varied among parasitoid species as well (Duan et al. 2017). See *EAB Treatment and Tree Management* section for further information regarding parasitoid wasp release.

Fig. 6a: Ash tree displaying symptoms of EAB infestation (crown dieback, epicormic branching), City of Poughkeepsie

Fig. 6b: Ash tree killed by EAB infestation, City of Poughkeepsie

Ash Tree Assessment

In late 2015, the City of Poughkeepsie Shade Tree Commission met with the VFEP to discuss the potential implementation of an EAB management plan similar to that of the VFEP in the City of Poughkeepsie. EAB presence was confirmed on the VFEP in March of 2017. Distinct signs of EAB infestation, such as extensive dieback and blonding, were also observed among scattered street trees in the City by residents and passersby. In response to the clear threat to Poughkeepsie's ash trees, the Environmental Cooperative at the Vassar Barns conducted a survey of the City's street ash trees to assess the extent of the infestation within city limits. This survey informed the recommendations listed in this document.

Working with data from a 2006 street tree inventory, tree points were plotted on a map (Fig. 7) in ArcGIS using address geocoding. Ash tree points were then extracted from the larger data set and plotted on a separate map. Using the ArcGIS Collector app, tree points were ground-truthed in the field for location accuracy. Tree condition was also updated in the database using the Collector app. The following symptoms were noted as signs of tree stress, potentially indicating EAB presence (see Fig. 6a): epicormic branching (shoots sprouting from base of tree trunk), crown dieback, vertical bark splitting, and blonding and woodpecker activity.

D-shaped exit holes and S-shaped galleries underneath bark were considered definitive signs of EAB activity. Trees that only displayed stress symptoms (i.e., not D-shaped holes or S-

shaped galleries) were deemed “symptomatic” and are indicated on the map by yellow tree points. Trees that displayed either D-shaped holes or S-shaped galleries (and/or any of the above stress symptoms) were deemed infested with EAB and are denoted on the map by red tree points. “Asymptomatic” trees are defined as trees exhibiting neither stress symptoms nor signs of EAB; in other words, apparently healthy. These trees are displayed on the map as green tree points. Trees originally included in the 2006 report but which had since been removed were not included on the map.

Results

The results of our survey indicate that EAB is well-established among the street ash tree population in the City of Poughkeepsie. 8.4% of City ash trees are definitively infested with EAB, while over half (58.8%) of City ash display symptoms of stress to varying degrees, potentially due to EAB infestation. Regardless of whether these stress symptoms are due to EAB or not, trees in stressed conditions are much more vulnerable to infestation than non-stressed trees, putting the majority of the City’s ash trees at high risk. Only about one third of Poughkeepsie city trees appear to be asymptomatic for EAB infestation at the moment. Infested trees are scattered throughout the city, which means that EAB infestation cannot be contained to one particular core location and will likely spread to all or most ash trees in the City within the next year or two.

EAB Treatment and Tree Management

Biocontrol

While biocontrol efforts have been implemented with some success in forest stands of ash, parasitoid wasp release is not suitable for urban environments such as the City of Poughkeepsie. The release method for many species of parasitoid wasps involves attaching a plastic container to ash tree trunks (USDA–APHIS 2016), and these containers are at risk of being disturbed in urban areas with high traffic. Additionally, parasitoid wasp dispersal is limited, in some cases less than 1 km (Duan et al 2011), posing a major obstacle for dispersal in cities where ash trees are irregularly scattered over a large area.

Pesticide Treatment

The suitability of pesticide treatment varies depending on the extent and severity of infestation. In uninfested localities within 10-15 miles of a known EAB infestation, insecticide treatment of ash trees may be an effective and worthwhile investment (Herms et al. 2014). Insecticide treatment may also be effective in the early stages of EAB infestation, as ash trees can withstand and recover from minor EAB damage (Poland et al. 2006). Various cost analyses have shown that early insecticide treatment of ash trees is often less expensive than the removal and replacement of infested trees (Sadof et al. 2017; Herms et al. 2014). However, EAB is often difficult to detect in ash populations until it is too late to treat. For example, trees with greater than 50% crown dieback are already too heavily damaged to respond to insecticide treatment (Spears et al. 2014). Insecticide treatment is a multi-year procedure that may be detrimental to non-target organisms depending on the active ingredient applied. Listed below in Table 1 are the most commonly applied EAB insecticides and their potential side effects.

Table 1: EAB Insecticide Options

Insecticide Active Ingredient	**Application Method**	**Benefits**	**Drawbacks**
Imidacloprid	Trunk injection, trunk spray, soil drench	Designated by EPA as reduced-risk*, low toxicity to mammals*, breaks down rapidly in water in the presence of sunlight, not highly toxic to woodpeckers*	Harmful/fatal to honey bees at certain concentrations*, does not break down readily in water without sunlight (can persist in groundwater)*, provides only 1 year of EAB control**
Dinotefuran	Trunk spray, soil drench	Designated by EPA as reduced-risk*, breaks down rapidly in water in the presence of sunlight*, not highly toxic to woodpeckers*	Does not break down readily in water without sunlight (can persist in groundwater)*, provides only 1 year of EAB control**
Emamectin benzoate (TREE-äge)	Trunk injection (annual)	Designated by EPA as reduced-risk*, not highly toxic to woodpeckers*, provides higher/longer lasting protection against EAB**, found to be the most effective EAB insecticide treatment**	Can be harmful to non-target aquatic and terrestrial organisms (highly toxic to pollinators at certain concentrations) ⁂
Azadirachtin (TreeAzin)	Trunk injection	Botanically derived✲ , protection against EAB for 1-2 years*, not found toxic to bees, breaks down rapidly in water∗	Not toxic to EAB adults (but increases larval mortality, which limits adult emergence)*

*Hahn, J., Herms, D.A., McCullough, D.G. 2011. Frequently Asked Questions Regarding Potential Side Effects of Systemic Insecticides Used to Control Emerald Ash Borer. North Central IPM Center Bulletin. 2nd edition. 16 pp.
**Poland, T., McCullough, D., Ciaramitaro, T., Cappaert, D., Anulewicz, A. 2016. Evaluation of Systemic Insecticides to Control Emerald Ash Borer. USDA Forest Service Northern Research Station; [accessed 2017 Aug]. https://www.nrs.fs.fed.us/disturbance/invasive_species/eab/control_management/systemic_insecticides/
⁂ Durkin, P.R. Emamectin benzoate: Human Health and Ecological Risk Assessment, Final Report. 2010. USDA Forest Service, Southern Region; [accessed 2017 Aug]. https://www.fs.fed.us/foresthealth/pesticide/pdfs/052-23-03b_Emamectin-benzoate.pdf
✲ Cranshaw, W. 2014. Control Options for Emerald Ash Borer in Colorado. Colorado State University Extension; [accessed 2017 Aug]. http://bspm.agsci.colostate.edu/files/2014/02/EAB-control-options-February-11.pdf
∗ Pesticide Information Profile: Azadirachtin. 1995. Extension Toxicology Network; [accessed 2017 Aug]. http://pmep.cce.cornell.edu/profiles/extoxnet/24d-captan/azadirachtin-ext.html

Because EAB symptoms are already highly visible throughout the City of Poughkeepsie, attempting to "save" the City's ash by treating all or most of them with insecticides is not a viable option. Instead, we recommend that a few (5 or 6) choice ash trees be treated, while the City's remaining ash are removed and replaced in a phased process. Each ash tree provides specific benefits based on its size, health, and location, and these factors should all be taken into account when choosing ash trees to treat. Ash trees chosen for treatment should be young but mature, seed-bearing, and healthy. Smaller ashes are also more likely to respond to systemic insecticide than ash trees with larger DBH measurements. Treatment is a multi-year process and can only be administered by certified professionals. Healthy ash trees that contribute significantly to the landscape aesthetics of public areas such as schools and churches, and which do not grow in close proximity to power lines or other utilities, are good candidates for insecticide treatment. The cost of insecticide treatment varies with the size of the tree, the number of trees being treated, and the type of insecticide used.

Phased Removal and Replacement

The majority of remaining ash trees should ultimately be removed and replaced in phases. Tree removal is a costly, time consuming, and labor-intensive process that requires thorough communication between City municipality workers and tree specialists. However, removal is the safest and most realistic EAB treatment option for the City of Poughkeepsie considering the extent of EAB damage - dead and/or dying trees have the potential to fall and damage homes and cars or injure passersby if not removed promptly. Trees that are clearly EAB-infested (red points) should be removed first and replaced with appropriate species (see below for list of recommended street tree species). Trees with the most severe symptoms of stress should be addressed next by close monitoring on a monthly basis for definite signs of EAB infestation. These should be removed and replaced in subsequent years following the first round of removal of the most severely EAB-damaged trees. All other street ash trees should continue to be monitored and removed and replaced as necessary based on the severity of damage, which is likely to worsen in the next few years.

In terms of replacement species, maximum urban forest diversity should be a goal in order to prevent future damage from other species-specific pests. Cornell Cooperative Extension describes a "10-20-30 Rule", wherein they recommend that an urban forest should not consist of more than 10% of one species, 20% of one genus, and 30% of one family (Hargrave et al. 2010). Other criteria to be considered are tree height, canopy shape, growth rate, and whether a tree produces fruit (Cornell Cooperative Extension 2011). The following species have been selected from a list of recommendations by George Profous, Senior Forester with the New York State Department of Environmental Conservation, for street ash tree replacement. These trees are generally tolerant of changes in soil pH, moisture, and salt levels, and most are relatively small (<30 ft. in height). Information on each species was taken from Cornell University's Woody Plants Database (2017). Options include:

- American smoketree - *Cotinus obovatus*
- Hackberry - *Celtis occidentalis*
- European Hornbeam - *Carpinus betulus* ('Fastigata' cultivar)
- American Hornbeam - *Carpinus caroliniana*
- Eastern Redbud - *Cercis canadensis*
- Black Locust - *Robinia pseudoacacia* ('Globe' cultivar)
- Common Honeylocust - *Gleditsia triacanthos* ('Imperial' cultivar)
- Japanese Tree Lilac - *Syringa reticulata* ('Summer Snow', 'Ivory Silk' cultivars)
- Hybrid Elm - *Ulmus 'Frontier'* (resistant to Elm Yellows, Dutch Elm Disease, and Elm Leaf Beetle)

Tree removal is a highly visible procedure and may confuse or concern residents who have ash trees on their blocks. For this reason, it is imperative that City of Poughkeepsie residents be informed of tree removal prior to its occurrence, through email, paper mailing, and/or other forms of announcement. Besides public, street ash trees, the City of Poughkeepsie is also home to many ash trees on private land. The treatment and removal of these private trees is outside of the City's jurisdiction and is solely the responsibility of homeowners. However, informational pamphlets and other materials, as well as public educational outreach events, can increase awareness of EAB among City residents and help inform decisions about treating privately owned ash trees.

After ash trees are cut down, ash wood can be used for lumber, firewood, or wood chip for landscaping (Coon 2007). However, EAB-infested lumber cannot be moved out of quarantine areas (see Fig. 2a).

EAB presence is widespread across the entire city of Poughkeepsie. It is too late to save most of the City's street ash trees with pesticide treatment, and the issue of removal and replacement must still be addressed promptly. Street trees are extremely ecologically, financially, and aesthetically valuable resources for urban areas, and the loss of the City's ash trees will be particularly detrimental. City municipal workers and residents alike should approach the EAB issue through active dialogues and careful monitoring of city ash trees. While treatment, removal, and replacement decisions are ultimately those for the City of Poughkeepsie municipality to make, this document serves as a recommendation for future actions concerning EAB infestation.

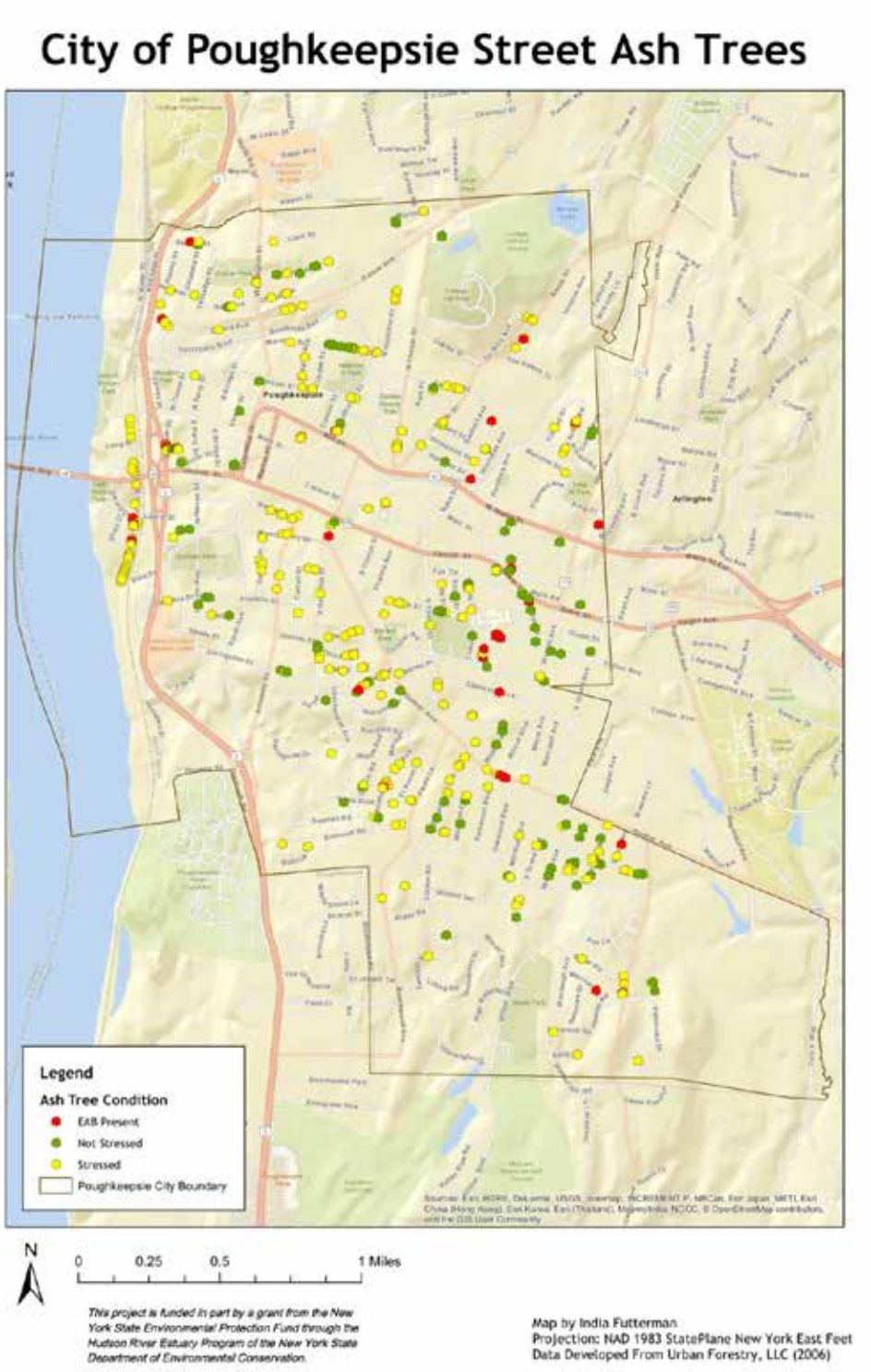

Fig. 7: City of Poughkeepsie Ash Tree Survey Map

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