Host Tree Information
MacFarlane and Meyer (2005) summarized ash distribution literature in relation to emerald ash borer distribution and found that ash trees are an important minor component in forest types of many different types. They determined that some white ash cultivars may be resistant to emerald ash borer. Upland, maturing second growth forests have less vigorous ash trees, while younger, open forests have more vigorous trees (MacFarlane and Meyer, 2005) that may be able to better withstand emerald ash borer attacks.

In no-choice tests to determine favored host trees, emerald ash borer males lived for 17-21 days on ash (Fraxinus nigra, F. pennsylvanica, F. uhdei, and F. velutina) (Haack et al. 2004). Mean longevity was 20 days when fed privet (Ligustrum) and 13 days feeding on swamp privet (Forestiera). On elms (Ulmus parvifolia and U. pumila) and other possible hosts (hackberry - Celtis, butternut – Juglans cinerea, black walnut – J. nigra, Forsythia, and lilac - Syringa), males lived for 6-8 days. In a 48 hour no-choice test, some feeding was observed on forsythia, fringe tree (Chionanthus), lilac, privet, and swamp privet, while almost no feeding was observed on elm, hackberry, hickory (Carya) and walnut (Haack et al. 2004).

McCullough et al. (2004) observed differences in female oviposition on alternate hosts. Half as many eggs were found to be laid on elm, walnut, hickory and hackberry, while number of eggs observed laid on privet was intermediate between the other trees and on ash. Larval galleries were observed on all species except hickory and gallery density was greatest for ash and privet, while low in elm, walnut and hackberry. Although galleries were observed on alternate hosts, the authors suggest that the observation of small and malformed galleries indicate unlikely development on these hosts, except for privet, which from this information and the adult feeding from above, may indicate it as a suitable alternate host. In the field, logs of green ash, walnut and elm were tied together and hung from heavily infested trees. First stage galleries were prevalent on the ash logs and only 1 gallery was observed on walnut. No galleries were found on the elm logs (McCullough et al. 2004).

Distribution and Dispersal
Currently, 15,000 square miles are infested with emerald ash borer in Michigan and Ohio (http://www.aphis.usda.gov/ppq/ep/eab, accessed December 2005). Just recently (January 2006), a quarantine was imposed in Hamilton and Marion Counties in Indiana, due to an estimated 7 year old emerald ash borer infestation found there in street trees (Campbell, pers. comm., 2006).

Smith (2005) has gathered preliminary genetic data on the relatedness of emerald ash borer populations found in the U.S. to populations from China, Japan and Korea, which
will assist in the search for more biological control agents and enable researchers to better understand invasion dynamics.

In Michigan, a single introduction of emerald ash borer through firewood in an area far from the main infestation, gave researchers the opportunity to study dispersal of emerald ash borer (McCullough et al. undated #1). Within 100 m of the point of origin, 70% of emerald ash borer galleries were detected. Galleries were found in decreasing number as the distance increased from this point, however, one gallery was noted in a tree 750 m from the point of origin. As distance increased from the point of origin, the mid- and upper-canopies were more likely to have galleries than the trunk or lower canopy (McCullough et al. undated #1).

Haack and Petrice (undated, #1) exposed emerald ash borer infested logs to increased temperatures in the lab to speed up emerald ash borer development and then placed logs at two Michigan sites in early summer (before wild emerald ash borer would emerge) to study dispersal. Ash trap logs (logs banded with sticky material and positioned vertically) were set at distances up to 3000 m from the infested logs. Only two emerald ash borers were recovered from an estimated 3000, one at 250 m and the other at 1500 m (Haack and Petrice, undated, #1).

**Biology and Identification**

Emerald ash borers have been described as having one generation per year. However, researchers have determined that some emerald ash borers remain larvae and develop for two and maybe even three years. Fifty percent of larvae may have this two year development, typically in emerald ash borer infesting healthy trees (Smitley and McCullough, 2005).

While emerald ash borer is a non-native beetle, many beetles in the same genus, *Agrilus*, are native to North America. A screening distinguishing emerald ash borer from natives notes that emerald ash borer has no patches of pubescence, a copper/green pronotum, elytra and abdominal sternites emerald green, and abdominal tergites purplish-copper in color (Zablotny, undated).

**Monitoring**

The method currently used to detect emerald ash borer by the Michigan Department of Agriculture (MDA) is to girdle a mature ash tree, making it more attractive to emerald ash borer and coating it with a sticky band to trap the beetles (Oliver et al. 2005a). This trapping method is unpopular with landowners and the tree can not be used for trapping again (Oliver et al. 2005a). So, research for the best method to detect emerald ash borer is important.

Research evaluating traps for detecting emerald ash borer have determined that color plays a role in attraction. Significantly more beetles were caught on purple glue-coated corrugated plastic panels hung from trees at a height of 1.8 m² than any other color (Francese et al. 2005a). Using large purple glue-coated corrugated plastic panel traps (15 cm X 90 cm), researchers determined that traps should be placed at the forest edge and...
not in the woods were the low light levels may affect trap attractiveness (Oliver et al. 2005b).

Small, girdled ash trees were also tested for attractiveness since they can be moved to different locations easily. Triangular, purple corrugated plastic sticky traps were placed on the girdled trees to collect beetles. Although the type of damage was not significantly different, more emerald ash borers were found on green ash trees (‘urbanite’) that were girdled or had their trunk scraped (Oliver et al. 2005a).

Testing many different types of traps, Francese et al. (2005b) discovered that the MDA Program trap collected significantly more emerald ash borers. The Pherotech’s purple version elm bark beetle trap collected the second highest number of emerald ash borers. The other traps tested were the Lindgren funnel, IPM Tech Intercept Panel, and a purple wallpapers trap. The authors note that the MDA Program trap was the only trap in association with damaged ash trees. The elm bark beetle trap was also associated with ash trees (undamaged). The elm bark beetle trap and the others tested are based on visual attraction, which may be affected by low light levels in the wooded testing area (Francese et al. 2005b).

**Control Information**

**U.S. and Canadian Management Plans**

In January 2004 an ash free zone (AFZ) from Lake Erie to Lake St. Clair was completed at the leading edge of the emerald ash borer infestation into Canada. Over 100,000 trees were removed and the AFZ measured 30 x 10 km. Unfortunately, emerald ash borers were found past the AFZ and these trees are currently being removed (Marchant, 2004).

In the US, a similar strategy was used during 2003-04. In 2003 a fire break zone and in 2004 AFZs or reduced ash zones (RAZ) were employed to prevent further spread of emerald ash borer (Bell, pers. comm., 2006). Unfortunately, movement of host material, firewood and logs caused infestations outside the main area of infestation past the AFZ/RAZs (Bell, pers. comm., 2006).

In 2005, the control strategy focused on surveying for the edge of the main infestation in Michigan and containing the current infestation to prevent further spread into: 1) Indiana and Ohio through southern Michigan, 2) into Canada through Michigan’s border in St Clair County, and 3) the upper Michigan peninsula through the Mackinac Bridge (McPartlan et al. undated). These “gateways” are 50 mile wide bands (6 miles in the case of the border between Michigan and Canada) where intense surveying occurs. Outside of the gateways and within the gateway themselves aggressive control is implemented, which is the removal of all trees within a ½ mile radius of infested trees. Dependent on funding and proximity to the gateways, control of emerald ash borer infestations detected in other areas may include tree removal and/or herbicide use (McPartlan et al. undated). This strategy is expected to continue in 2006 (Bell, pers. comm., 2006).

Regulatory action to prevent the human-assisted spread of emerald ash borer has increased and outreach programs are educating the general public on control activities.
and will prevent human-assisted spread of emerald ash borer. In 2006, APHIS will conduct a national survey for the presence of emerald ash borer (McPartlan et al. undated).

Citing the difficulty of detecting and effectively eradicating Emerald ash borer, further eradication efforts in Indiana have been halted (Ellen Jacquart, pers. comm. 2006).

**Predators and Parasitoids**

Beetles and woodpeckers have been observed feeding on emerald ash borers in Michigan. Parasitoids that attack *Agrilus* spp. are present in areas with emerald ash borer, however, parasitism is too low (<1%) to reduce emerald ash borer numbers that would prevent ash tree mortality (Gould et al. 2005). Entomopathogenic fungi infect 2% of emerald ash borer immatures (Gould et al. 2005).

Classical biological control research, the introduction of predators and parasitoids from the pest’s native area for its control, was begun in 2002 and potential parasitoids for introduction have been found in China (Gould et al. 2005). There, emerald ash borer is typically not a pest because of ash tree resistance and natural enemies that keep populations low. By looking at the average number of parasitoid species naturally supported by emerald ash borer in the U.S. and Eurasia, the potential of finding additional parasitoids in China is low (Gould et al. 2005).

**Spathius sp. (Hymenoptera: Braconidae)**

Currently, this wasp has successfully been reared in the laboratory and host range testing is occurring in quarantine in the U.S. Adult wasps paralyze emerald ash borer larvae and lay 1-20 eggs on the outside of a larva (Gould et al. 2005). The eggs hatch and the wasp larvae use the paralyzed emerald ash borer larvae as a food source. The wasp larvae become adults during the spring and at the time emerald ash borer larvae are present in the preferred stage (3rd and 4th instar). In China, *Spathius* sp. parasitism rates were 90%. This wasp has 4 generations per year.

**Oobius sp. (Hymenoptera: Encyrtidae)**

Currently, this egg parasitoid is being reared in quarantine in the U.S. for future host range testing (Gould et al. 2005). The adults are parthenogenic, meaning they reproduce without male fertilization (Gould et al. 2005).

**Tetrastichus sp. (Hymenoptera: Eulophidae)**

Currently, rearing methods are being developed in quarantine in the U.S. This wasp has 4 generations per year and parasitism rates in China were 50% at one site (Gould et al. 2005).

**Sclerodermus sp. (Hymenoptera: Bethylidae)**

The current status of this insect as a potential biological control agent is unknown. Female wasps deposit 15-20 eggs. Parasitism rates are low and females are typically wingless (70%) so dispersal abilities may be limited. Additionally, some *Sclerodermus* can sting people, making the release of this wasp unlikely (Gould et al. 2005).
**Insecticides**

Research in this area is more pertinent for preventing infestation of ash trees in urban areas than in natural areas. Several insecticides and application methods are currently being tested by Smitley *et al.* (2005). Insecticides include an entomopathogenic fungus – *Beauveria bassiana*, bifenthrin, acephate, orthene and imidacloprid, applied as foliar and trunk sprays, soil drenches, or trunk injections. Preliminary results were positive and for all treatments, especially the imidacloprid and acephate injections and bifenthrin trunk sprays (Smitley *et al.* 2005).

Currently, microbial control of emerald ash borer using registered insecticides containing a bacterium, *Bacillus thuringiensis (Bt)*, is not as promising. In the laboratory, feeding on *Bt* sprayed leaves caused adult mortality only at concentrations in excess of the label rate (Bauer *et al.* 2004). Other isolates and toxins are being tested (Bauer *et al.* 2004).

**Survival in firewood and through chipping**

Movement of emerald ash borer from infested to uninfested areas can occur naturally through flight but also with human assistance in infested firewood or chipped trees. Most immature stages of emerald ash borer are present in trees throughout the year (Haack and Petrice, undated, #2). Survival was observed in logs cut from July to October and stored in the shade or in the sun. However, survival was lower in logs stored in the sun than in the shade and cut in July-August than September-October (Haack and Petrice, undated, #2). Infested trees chipped to 4” chips were found to contain live emerald ash borer larvae, while 1” chips did not. Chips larger than 1” should be incinerated (McCullough *et al.* undated, #2).

**References**


Bell, Philip. 2006. EAB Program Director, USDA/APHIS, personal communication.


1) http://www.aphis.usda.gov/ppq/ep/eab/