Do Chinese Ashes Offer Hope in Combating Emerald Ash Borer?©

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THE PROBLEM

The emerald ash borer (EAB), *Agrilus planipennis*, was found in Detroit, Michigan, in July 2002. It established there and developed into a highly invasive pest within the urban landscape of Detroit. The adult beetles feed on ash foliage but cause little damage. Their larvae feed on the inner bark of ash trees, disrupting the tree's ability to transport water and nutrients. As a result, healthy trees typically die or are reduced to a suckering coppice within a few years after the initial infestation.

Emerald ash borer probably arrived in North America in solid wood packing material from freight shipped from its native Asia. While the country of origin and year of arrival have not been determined, based on initial data, it is hypothesized that EAB may have been introduced from the Tianjin City area, a large municipal zone southeast of Beijing, China. The core of infestation (southeastern Michigan and the adjacent area of Ontario, Canada) now extends over thousands of square miles, and outlying infestations have been found in 14 states throughout the central and eastern United States and southeastern Canada (Fig. 1).

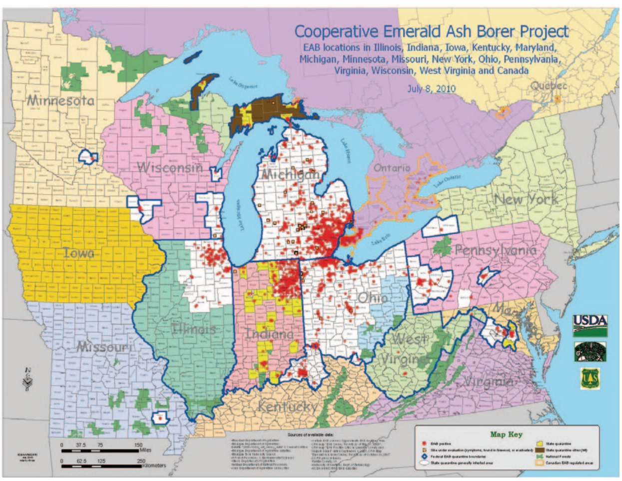

Figure 1. Current emerald ash borer infestation zone, as of 10 Sept. 2010.

To date, it is estimated that over 40 million ash trees have been killed by this pest and there are an estimated 8 billion ash trees currently growing in the U.S. It appears that no North American ash species is resistant to this pest, although researchers have found a few individual trees in heavily invested EAB zones that remain alive with minimal infestation. These trees are being propagated to determine if they possess some level of genetic-related resistance.

This insect's impact has cost municipalities, property owners, nursery operators, and the forest products industry tens of millions of dollars. Each year as the infestation spreads, losses continue to build. Because ash are relatively easy to grow and are tolerant of typical urban conditions, they are commonly planted. Ash accounts for 5%–20% of all street trees in many Midwestern and Canadian cities. For example, 14.4% of the leaf cover in Chicago is made up of the city's 600,000 ash trees (Nowak et al., 2010). Green ash (*Fraxinus pennsylvanica*) is an especially useful tree for urban planting because of their general tolerance to salt, drought, compaction, and pH. However, the popularity of cultivars in the urban landscape has resulted in near monocultures that increase both the risk and the impact of EAB damage. The loss of ash trees has and will continue to affect nursery production and tree sales.

THE POTENTIAL VALUE OF CHINESE ASHES

In China, EAB is usually a secondary or periodic pest on the few species that have been studied, infesting only stressed trees and not necessarily resulting in tree mortality. There are several Chinese ash species where no information regarding EAB resistance is established. Most outbreaks in China have been associated with urban and restoration plantings involving North American species. Both green ash and velvet ash (*F. velutina*) have been extensively planted in many northern Chinese cities.

There are 22 *Fraxinus* species listed in the Flora of China (Flora of China, 1996). Some of these species are tropical, and not suitable for regions of the U.S. currently under siege by EAB, but are of potential utility for expanding the range of ash adaptation or for responding to EAB, should the pest adapt to tropical or subtropical areas in the New World.

The identification of various Chinese ash species is difficult because no modern monograph exists. In two documented instances, seed collected by the Chinese Academy of Sciences was incorrectly identified as Chinese ash, *F. chinensis*. Not until after researchers used this material in in-depth research studies did the true identification become apparent — the plants were determined to be green ash. Similar mistakes have also been documented with seed lots imported from China by reputable U.S.A. seed companies.

For future work it is important to gain access to true-to-type plants of known wild origin. Tree species that share a long co-evolutionary history with insects and pathogens are likely to have developed mechanisms of resistance that allow them to coexist. When insects and pathogens are introduced to different parts of the world, high levels of susceptibility can be observed, presumably in part due to the lack of co-evolutionary history between the insect (or pathogen) and host. In such cases, use of non-native tree species as a source of resistance for introgression into native susceptible tree species can be quite helpful. Examples of successfully developing interspecific hybrids include hybrid hemlocks (*Tsuga chinensis* × *T. caroliniana*) with resistance to hemlock wooly adelgid and hybrid chestnut trees (*Castanea mollisima* × *C. dentata*) resistant to the chestnut blight (Koch et al., 2010). If first generation hybrids show good resistance to the insect (or pathogen), then a back-cross breeding program may be initiated to produce seedlings containing the introgressed resistance and the characteristics of the native parent species. This is the approach being used by The American Chestnut Foundation, and would be the model approach used to produce EAB-resistant North American ash species (Hebard, 2005).

In 2008, I had the opportunity to participate in a collecting expedition to Shaanxi Province, China, along with other staff members from institutions who are members of the North America — China Plant Exploration Consortium (NACPEC). For the first time since I had participated in five previous NACPEC-sponsored expeditions, this trip was focused on primarily collecting ash germplasm. Typically there had been too many other *more exciting* species and there was no cause to focus on ash.

Shaanxi Province is located in north-central China. This expedition involved collecting in the north side of the botanically rich Qin Ling mountain range. We collected several thousand seeds of five *Fraxinus* species including Pax's ash (*F. paxiana*), island ash (*F. insularis*), Manchurian ash (*F. mandshurica*), Chinese ash (*F. chinensis*), and Chinese flowering ash (*F. stylosa*) — several of these species are poorly represented in the U.S. For example, Pax's ash and island ash are being grown at only two or three botanical institutions. We made several collections of these species, along with Chinese ash, Manchurian ash, and Chinese flowering ash. Of these, Manchurian ash is probably the best known, as it is a large growing tree with an established landscape value. There is one cultivated selection of Manchurian ash, 'Mancana', and two selections which are hybrids of Manchurian ash and the North American black ash (*F. nigra*). All of these originated at the Morden Research Station, Morden, Manitoba. Of the other species, island ash and Chinese flowering ash are medium-sized trees that may have urban use potential if they prove adaptable. Pax's ash is a shrubby species that possesses extremely large flower clusters, although its landscape potential is unknown.

NEW GERMPLASM SUPPORTING RESEARCH

Efforts to control EAB are occurring via three avenues; research, eradication, and quarantine. Research is being done to develop better ways to detect new infestations, to control *A. planipennis* beetles and larvae, to test *Fraxinus* species for resistance or susceptibility to EAB, and to develop new plants resistant to EAB for landscape and forestry use.

Currently, plants from seed collected in the 2008 expedition are being used by leading researchers, including researchers at The Morton Arboretum to study EAB resistance. The plants are being used in on-going, broad-ranging studies of EAB host range and preference. Chinese, North American, and European ash species are being evaluated in leaf-feeding and longevity trials.

There is evidence of resistance to EAB in some Chinese *Fraxinus*. One study that investigated the EAB infestation history of established ash plantings in China reported that some Manchurian ash trees showed signs of past EAB infestation (old exit holes and calloused larval galleries), but were still alive and no longer showed signs of infestation. This evidence of infestation without mortality shows a certain degree of resistance or tolerance in Manchurian ash compared to North American species. Also, EAB has been shown to exist in Manchurian ash forests in China without reaching outbreak levels. This also would be consistent with the presence of resistance or tolerance genes in Asian ash, which may be a product of the coevolution of Asian ash with EAB (Cappaert et al., 2005).

Another leading researcher, Jennifer Koch from the USDA Forest Service, North Research Station, is using these seedlings to perform genetic sequencing to help understand the taxonomic relationship of the Chinese ash species to other species. The genomics of several of these species have not been previously documented. This information is important to understand the potential for new hybrids, and potentially resistant plants, to be created. Once a range of resistant genotypes is identified, they can go a long way toward preserving the horticultural market for ash in the urban landscape. Identifying appropriate genetic material to create new North American-Asian ash hybrids that combine resistance genes from the Asian species with useful characteristics from the North American species is an important way of maintaining our ability to use ash in the landscape by creating resistance to this EAB without the use of expensive and ineffective pesticides. Additionally, Asian ash may prove to be a useful introduced species if hybrids are not successful. Many of the Asian ash species I observed in China were growing in highly favorable growing conditions. They may not possess the urban tolerance to be considered broadly adaptable on their own. Clonal production of these plants should be relatively easy. *Fraxinus* express a high degree of graft compatibility with different species successfully grafted onto one another. Typically, nearly all cultivated ash selections are grafted onto green ash due to its vigor and environmental tolerance. Whether an EAB-resistant Asian species can be successfully grown for the long-term on an adaptable, yet EAB-susceptible rootstock, like green ash, is an area for future testing.

IN CONCLUSION

It is still too early to understand the full impact EAB has had on North American ashes, but the prospects appear ominous. Considering the resistance demonstrated by Manchurian ash it is highly likely that resistance is held by other Asian ash species as well. Asian ashes are critically important to determine the full range of EAB response and to assess the adaptation of Asian ash species to American conditions and their appropriateness for urban landscapes and U.S. forestry uses.

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