How did the Emerald Ash Borer (*Agrilus planipennis*) infest Michigan and what are some possible techniques to control its spread?

Introduction

The Emerald Ash Borer, *Agrilus planipennis*, Fairmare (Coleoptera: buprestidae) is an invasive beetle that feeds and reproduces primarily in ash trees (Haack and Petrice 2004). Surveys conducted in 2004 in southeastern Michigan suggest that roughly 15 million ash trees in both forested and urban areas are dead or infested with *A. planipennis*, including green ash (*F. pennsylvanica*), white ash (*F. Americana*), and black ash (*F. nigra*). Blue ash (*F. quadrangulata*) appears to be less preferred by *A. planipennis* but will be attacked if other nearby ash species have been exhausted (Poland and McCullough 2006). When white and green ash stands grow together, green ash is consistently attacked sooner than white ash it has been observed that densities of *A. planipennis* do not increase on white ash until green ash has started to decline significantly (Cappaert et al. 2005). The most widely distributed ash species in the United States, green ash is often the dominant overstory species on heavy, wet soils, along river corridors, and has been a popular choice for urban plantings (Cappaert et al. 2005, Poland and McCullough 2006). Because of the ecological and social importance of green ash and its high mortality from *A. planipennis* this paper will focus primary on the effects of *A. Planipennis* on green ash, however all ash species can be affected and are declining from the *A. planipennis*.

Discovery of EAB

A. planipennis was discovered in southeastern Michigan in 2002, although most researchers agree it was introduced at least 10 years prior to its discovery (Cappaert et al. 2005). The infestation was discovered June 25, 2002 when five entomologists representing various organizations visited Detroit, MI to investigate reports of declining ash population (Cappaert, et al. 2005). The group collected iridescent green beetles, which were later identified as *Agrilus planipennius*, a phloem-feeding species that had not previously been collected outside of its native range in Asia (Cappaert et. al, 2005). Later evidence suggested that *A. planipennis* was initially introduced to urban Detroit, MI where it was able to become established and develop into an invasive pest (Poland and McCullough 2006). *A. planipennis* is native to China, Japan, Korea, Mongolia, Far East Russia, and Taiwan (Bauer et. al, 2003). While historically imported nursery stock has been the most common source of nonindigenous forest insects, most researchers agree that infested solid wood packing materials or dunnage was the source for this invasion (Poland and Mcullough, et al., 2006).

Ash trees are the most common fast growing woodland tree, however, one theory states that it is not through woodlots that *A. planipennis* became established and began widespread infestation of Michigan. The theory states that when *A. planipennis* first arrived in Detroit it began attacking urban trees, which are frequently planted in unfavorable sites and are exposed to stress from pollution, soil compaction and damage (Poland and McCullough 2006). These stressful conditions could have made urban trees more susceptible to attack and increased the likelihood that *A. planipennis* would successfully establish itself and increase in population (Poland and McCullough 2006). Furthermore large residential and business developments in urban areas are often composed of a single shade tree species, making it easer for an invasive pest to dominate the stand (Poland and McCullough 2006). It is not known if these factors played a direct role in the establishment of *A. planipennis*.

The ten-year time lag between the likely introduction of *A. planipennis* and its discovery in 2002 is not an uncommon occurrence with a nonindigenous invasive pest (Shigesada and Kawasaki 1997)). A lag phase of a number of years my occur before weather conditions, abundance of hosts, or other variables are right for an exponential increase in population by the invasive (Shigesada and Kawasaki 1997). Detection of the *A. planipennis* infestation was made more difficult because trees with low-to-moderate *A. planipennis* densities show few external symptoms (Cappaert et al. 2005). Trees with the most common symptoms such as epicormic shoots, canopy dieback, and bark cracks over larval galleries typically are already heavily infested (Cappaert et al., 2002).

On July 16, 2002 the Michigan Department of Agriculture imposed a state quarantine regulating the movement of nursery ash trees, logs, and other ash related products from infested counties (Cappaert et al. 2005). However, later work tracing back nursery stock found that young ash trees from nurseries in the infested area of southeastern Michigan were already planted in many uninfested areas of Michigan and Ohio (Cappaert, et al., 2002) This evidence suggests that many outlier populations of *A. planipennis* were established years before its discovery and the quarantine regulations (Cappaert et al. 2005). It is clear that movement of infested firewood, nursery stock, logs, and related material helped to spread the initial infestation and while current regulations prevent the movement of all non-coniferous firewood from the infested area, without further public education this will continue to be a vector of spread (Cappaert et al. 2005). Another concern is the potential of *A. planipennis* to spread itself by flight, and while research is currently on-going in this area, preliminary data shows that half of tested individuals traveled less then 50m under laboratory conditions; however, some covered over 5,000m (Bauer et al., 2003). Preliminary field tests indicate the average female travels only .5km (Cappaert et al. 2005).

Fig. 3. Borders of current *A. planipennis* quarantine (14 Feb. 2005). Source: USDA APHIS.

Graphic showing quarantine areas as of February 2005. Taken from (Cappaert et al. 2005).

Detection and Control

With 15 million ash trees already infested or dead much research is being done on how to control the spread of *A. planipennis* (Cappaert et al. 2005). Development of an effective means for detection of low-density *A. planipennis* infestations is an important regulatory step. Initially visual assessments were used to detect newly infested sites, but it was determined these were inadequate especially for low-density detection (Cappaert et al. 2005). Based on observations that *A. planipennis* prefers to attack already infested or stressed trees, regulatory agencies now use girdled trap trees to detect new infestations and gauge the population density of already infested stands (Cappaert et al. 2005). While this is a significant improvement over visual surveys, it is still a labor intensive and imprecise technique (Cappaert et al. 2005). There is much interest in developing effective lures and less destructive traps to streamline this process and improve accuracy (Cappaert et al. 2005).

Ecological Economic and Social impacts

Rough estimates indicate that there are nearly 850 million ash trees in many ecosystems that are threatened by *A. Planipennis* (Poland and McCullough 2006). The projected economic loss in wood value alone would exceed $1.7 billion, not including jobs loss and loss to secondary industries (Poland and McCullough 2006). Ash wood is used for tool handles, baseball bats, furniture, cabinets, crating, cardboard, and paper, all of these industries would be harmed by a collapse in ash populations (Poland and McCullough 2006).

As discussed in the introduction the specific ecological impacts from ash mortality are not known. White ash grows primarily in mixed-species stands and is an important component in at least 26 cover types (Cappaert 2005). Black ash grows in bogs and swamps and in northern areas is sometimes the only tree growing in swamps. Effects of widespread black ash mortality on these ecosystems are hard to predict (Cappaert 2005). Finally, as discussed in the introduction, green ash is a very abundant tree in both forested and urban areas, and its loss would be significant. These are only a few of the species that would be effected, there are at least 16 endemic ash species in the United states (Cappaert 2005).

Conclusion

Effective containment of *A. planipennis* will require much additional research, a combined regulatory effort including cooperation from the public in and around affected areas (Cappaert et al. 2005). Currently, regulatory officials are focused on protecting 'gateways' to minimize the spread of *A. planipennis* to new areas. Scientists are working to create more effective lures and traps to aid in detection of any spread or increase in population density

(Cappaert et al. 2005). It is hoped that on going research into biological control with indigenous enemies or control with microbial pathogens may prove effective for suppressing established populations. The ecological and social impacts of damage to an ecosystem that is both a 1.7 billion dollar industry and that provides food and shelter to many key species are likely to be high (Poland and McCullough 2006). However, is hope that with further research we can mitigate the impacts and began restoration.

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