Forest Carbon and Climate Program
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Increasing Urban Forest Resilience to the Emerald Ash Borer and Climate Change

A Case Study in Detroit, Michigan

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Executive Summary

The invasive Emerald Ash Borer (EAB) decimated the urban tree canopy in Detroit, Michigan starting in the mid-1990s (Cappert et al. 2005). As a result of planting efforts in the aftermath of Dutch Elm Disease, much of the city's canopy was dominated by ash trees, creating ideal conditions for an ash-specific invasive pest outbreak.

Increasing the resilience of urban forests and their ability to resist threats is essential, as climate-driven impacts are projected to become more severe (Rutledge et al. 2024). The U.S. Forest Service (USDA FS), American Forests (AF), and the Greening of Detroit are spearheading research and initiatives in the City of Detroit to combat the effects of the EAB by producing and planting EAB-resistant ash trees (Pike et al 2020). In addition, the Tree Equity Score tool, developed by American Forests, is being used to prioritize planting efforts in neighborhoods and communities of greatest need to maximize benefits and expand equitable access to urban trees.

Combatting the negative impacts of the EAB in Detroit will increase the ability of the urban canopy to resist future climate change stressors and invasive pests and pathogens. Increasing canopy diversity and concentrating planting efforts on underserved areas are two key strategies to ensure long-term benefits of urban forests to local communities.

The Emerald Ash Borer: A Pest Devastates Detroit's Tree Canopy

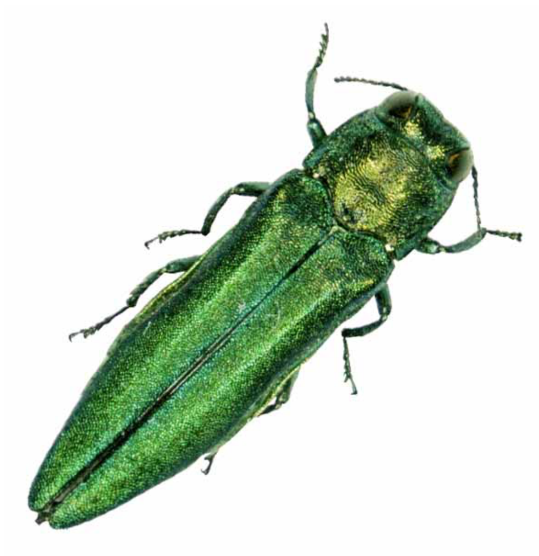

Figure 1: The Emerald Ash Borer. Source: Arbor Day Foundation, n.d.

The Emerald Ash Borer (EAB) is a beetle that burrows into ash trees (*Fraxinus* spp), causing defoliation and canopy dieback which can lead to mortality in ash species that lack resistance mechanisms (Center for Invasive Species Research, 2023). Although it was formally identified in Detroit in 2002, ash tree decline was first observed in the city in 1998, indicating that the EAB likely arrived from China as early as the mid-1990s (Herms & McCollough 2014). Due to the high proportion of ash trees in Detroit, urban canopies were decimated by the insect, declining from 31% in 2005 to 22.5% in 2008, largely due to mass mortality of ash trees driven by the EAB infestation (American Forests 2012). By 2009, Detroit had seen a 99% decrease in total ash trees (Herms et al. 2009). It's estimated that by 2003, a six-county region surrounding Detroit had lost between five and seven million ash trees (Cappert et al. 2003).

This mass dieback event had severe impacts on the ecosystem services provided by Detroit's trees, reducing benefits such as cooling and flood mitigation.

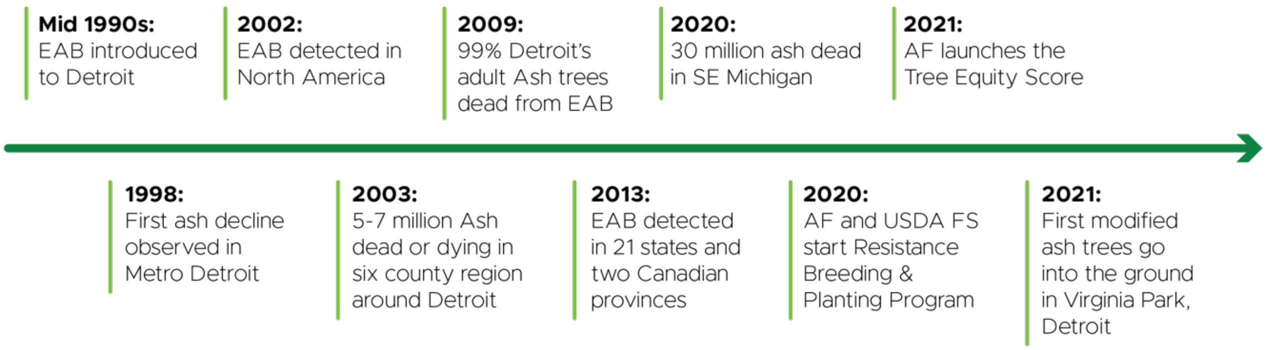

Figure 2: Timeline of EAB in Detroit. Compiled based on resources 5, 8, 11, 17.

Why Was Detroit Vulnerable to the EAB? A Cautionary Tale

The EAB is native to Asia, where ash species more resistant to EAB and less likely to die from infestations (Rebek et al. 2008) than the white (*Fraxinus americana)*, black (*F. nigra)*, and green ash (*F. pennsylvanica*) species. These three species - native to North America - were abundant in Michigan when the beetle arrived in the mid-1990s. The EAB was likely introduced to Detroit via ash wood shipping pallets or crating imported from China (Herms & McCullough 2014).

The city's legacy of ash abundance started in the aftermath of another massive tree die-off. Before ash dominated Detroit's tree canopy, elms were common in the area. But, from 1950-1980 the Dutch Elm Disease (DED) – a pathogen transmitted by bark beetles and root grafts (Rebek & Olson 2017) – was able to easily spread through the city's urban canopy, wiping out more than 500,000 elm trees (American Forests 2012).

After the spread of DED, ash trees were planted to help rebuild Detroit's urban tree canopy. The dominance of this species created ideal conditions for the EAB to become established and proliferate. Employing strategies such as planting diverse tree species and developing and planting trees with resistance to pests and pathogens can help increase the resilience of urban forests. These strategies can enhance the sustainability of urban forests and protect the benefits they provide to local communities and environments.

Detroit's Urban Forest: Overview & Benefits

Figure 3: Benefits provided by urban forests. Source: Cities4Forests (n.d.)

Urban forests provide many benefits to the people, animals, and plants that live near them. Forests provide clean air and water, mitigate flooding, reduce heat, provide recreational opportunities, and more. According to the City of Detroit (2016), the city's urban forest provides benefits worth an estimated $24 million annually, from increased aesthetic values, air quality improvements, carbon storage, energy savings, and stormwater reduction.

In Detroit, pest and disease outbreaks like Dutch Elm disease and the Emerald Ash Borer have resulted in a few species dominating much of the urban canopy. These include Norway maple (*Acer platanoides*), thornless honey locust (*Gleditsia triacanthos*), and silver maple (*A. saccharinum*), which together comprise roughly 45% of Detroit's canopy cover, with other maples composing approximately 41% of street trees in the city (City of Detroit 2016). This limited tree diversity makes the city's urban forest more susceptible to potential new outbreaks caused by species-specific pests. For example, an outbreak of an invasive pest which attacks maple species – such as the ever-looming Asian Long-Horned Beetle – could decimate the current urban forest canopy (Hu et al. 2009). Therefore, it is important to prioritize the restoration and stewardship of diverse species mixes in the urban forest to improve resilience to climate change and reduce impacts from species-specific pests and diseases.

American Forests Tree Equity Score

A measure of how well the benefits of the urban tree canopy reach at-need communities. Scores consist of: Tree canopy, building density, income & employment, race, surface temperature, health, language, & age.

Figure 4 shows Detroit tree canopy cover in areas surveyed by American Forests in 2020. The analysis found that average canopy cover across these areas was only 25% (American Forests 2020). Much of this coverage was concentrated in the western portions of the city, with districts five and six to the southeast having the lowest rates of coverage. Lower canopy coverage corresponds with a lower Tree Equity Score. Tree Equity Scores are based on a series of indicators compiled by American Forests to aggregate an overall score for an area, ranging from 1 to 100 (see Fig. 5; American Forests n.d.). A score of 100 means a neighborhood has a healthy distribution of tree canopy, which should be continuously cared for to maintain it. This includes monitoring trees for health issues – like the Emerald Ash Borer – and taking action to address them. Using the Tree Equity Score helps identify areas that would benefit the most from tree-planting efforts, thereby increasing communities' access to the social and environmental benefits of trees.

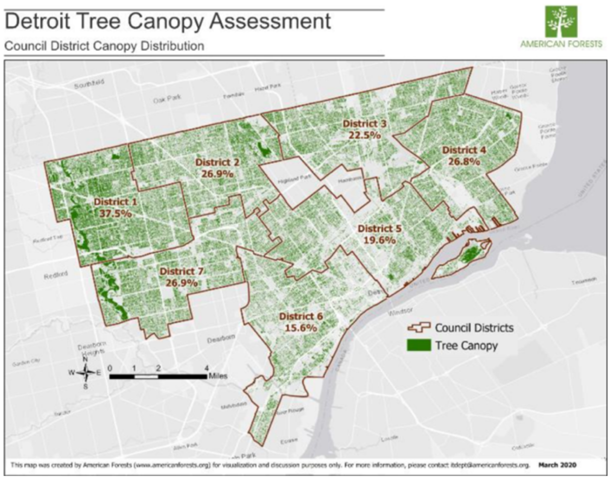

Figure 2: Canopy cover in Detroit. Source: American Forests 2020

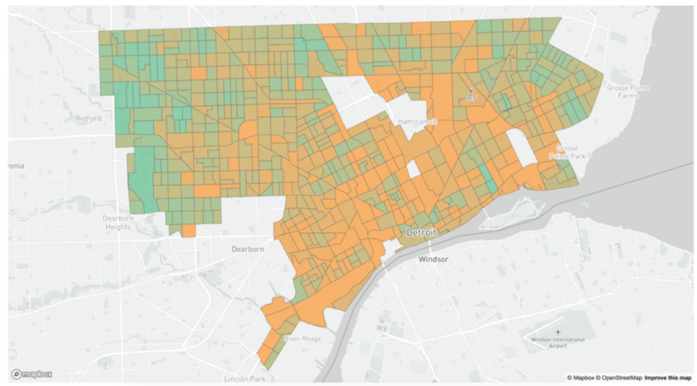

Figure 5: Tree Equity Scores in Detroit, orange indicates lower scores, green higher. Source: American Forests

Climate Change Threats and Impacts

Restoring and stewarding the urban canopy becomes even more important – and more challenging – in light of the emerging impacts of climate change.

Vulnerability and resilience are two key factors in determining the impacts of climate change on an urban forest. Assessing climate change vulnerability means understanding the ways in which an area is likely to be affected by projected changes. Published papers, such as the Detroit Region Vulnerability Assessment and Synthesis (Rutledge et al. 2024), produced by the Northern Institute of Applied Climate Science (NIACS), identifies key vulnerabilities of Detroit's urban forest to climate change, such as extreme heat, invasive species, and air, soil, and water quality challenges.

Meanwhile, resilience to climate change refers to the ability of an area to survive – and thrive – in the face of a changing climate. Areas with higher levels of canopy cover, species diversity, and permeable surfaces tend to be more resilient to climate change impacts.

Table 1 outlines several key threats faced by urban forests. A city's built or "gray" infrastructure can create a harsh environment for trees to grow and thrive. When stressors caused by the built environment are compounded with the impacts of climate change, urban forests can become even more susceptible to mortality. Existing threats to the wellbeing of trees, such as extreme heat, flooding, and pests and pathogens, can be exacerbated by shifting climatic norms. For example, increases in annual average temperatures can increase the severity of the urban heat island effect, making temperatures in urban areas even hotter. Similarly, increases in annual precipitation caused by climate change can lead to additional surface runoff in developed areas, leading to increased frequency and severity of flooding events and higher levels of pollutants reaching waterways.

Climate change can contribute to pest outbreaks by increasing the length of the growing season and reducing winter temperatures that traditionally keep pest populations in check. Drought and extreme heat can decrease a tree's ability to fight off other stressors, like pests and disease. Trees are at the greatest risk of mortality when they are simultaneously impacted by multiple stressors. Co-occurring threats can create a multiplier effect, leading to more tree damage and higher levels of mortality, leading to subsequent reductions in the urban forest canopy.

Table 1: A summary of climate change intensified threats to urban forests, and strategies to mitigate risk

Climate Change Intensified Threat	Summary	Trees + Adaptation
Urban Heat Island Effect	Pockets of hotter temperatures in cities caused by high levels of concrete and low levels of canopy cover. Increasing average temperatures driven by climate change exaggerate the urban heat island effect.	Increasing canopy cover increases shade and reduces temperatures in the built environment. High levels of canopy cover can reduce temperatures and help offset the urban heat island effect.
Runoff, Flooding, and Reduced Water Quality	Cities have many impervious surfaces which can lead to high levels of surface runoff and flooding during severe precipitation events. Pollutants such as road salt, oil, and fertilizer can enter waterways and cause nutrient loading (an excessive buildup of nutrients) creating toxic conditions for many tree species. Climate change is increasing the frequency and severity of storms and flooding in urban areas.	Trees and shrubs intercept, absorb, and filter precipitation. Increasing urban forest coverage can significantly reduce the amount of surface runoff and flooding in urban areas while contributing to improved water quality.

Pests and Pathogens	Pests and pathogens can harm and kill trees and cause reductions in canopy cover and biodiversity in urban areas. Invasive species introductions and warming winters caused by climate change can increase the risk of pest and pathogen outbreaks. In urban forests where the canopy is dominated by only a few species, pest and pathogen outbreaks can be severe and lead to mass mortality events.	Planting and maintaining a diverse mix of tree species in the urban forest canopy improves its resilience to increasing threats from pests and pathogens.

Trees' characteristics and biological functions can mitigate climate change stressors in cities. For example, increasing canopy cover increases the amount of shade in an area, mitigating excessive heat from rising temperatures. Trees also absorb and store water in leaves, bark, and root systems, which can mitigate the amount of surface runoff caused during heavy precipitation events. This reduction in flooding can create more favorable growing conditions for trees while also improving the health and wellbeing of residents and reducing the risk of damage to private property and public infrastructure.

Increasing diversity in the urban canopy improves resilience, as many pests and pathogens, such as the EAB and Dutch Elm Disease, are species-specific. Diversifying the composition of trees minimizes the risk of mass pest outbreaks and subsequent loss of canopy cover. Restoring and maintaining species diversity is crucial to securing the health and sustainability of urban forests over the long term, especially as pest outbreaks are expected to intensify under projected climate change scenarios (Rutledge et al 2024). For example, trees affected by severe drought and warming temperatures are generally more susceptible to mortality from bark-boring pests, because they have a reduced ability to fight off infestations from insects and larva (Jactel et al. 2019). For management to have long-term impacts, continual monitoring and documentation on impacts to trees is needed (Rutledge et al 2024). Management plans must be flexible and adjust to unprojected changes, especially when considering the threat multiplier effect.

Creating healthy and resilient canopies is key to ensuring urban forest longevity and associated benefits to communities. Addressing inequitable access to these benefits will minimize health disparities, especially as climate change exaggerates the impact of existing stressors (Jennings et al. 2017 and Mate & Wyatt 2017 in Rutledge et al. 2024). The effects of climate change often interact in unpredictable ways, resulting in high levels of uncertainty for urban forest practitioners. Information and assistance provided by American Forests, the U.S. Forest Service, the Greening of Detroit, and other trusted sources can help communities achieve the best possible outcomes in urban forest restoration.

Addressing Canopy Loss: American Forests' Resistance Breeding & Planting Program & Tree Equity Score

American Forests and the U.S. Forest Service have formed a partnership to breed ash trees that have shown resistance to the Emerald Ash Borer to produce new EAB-resistant ash trees. This program identifies individual "lingering" ash trees that resisted the insect, and either creates clones via grafting or grows new trees from their seed bank, in hopes that EAB resistance will be passed from one generation to the next. This project focuses on identifying lingering ash in the Allegheny National Forest in Pennsylvania, with plantings being led by the Greening of Detroit (Pike et al. 2020).

"Lingering" ash

Trees with a diameter greater than 10 cm that maintained a healthy canopy two years after 95% of the surrounding population died (Koch et al. 2015)

Only 20 years after the initial EAB introduction, it is estimated that less than one percent of all ash trees survived the EAB outbreak (Herms et al 2009). Those that survived are likely to possess a rare natural ability to weaken or kill insect larvae feeding on bark tissue, or they may have leaves that are less desirable to the EAB as a food source (Koch et al. 2015). By breeding ash with these qualities, scientists hope to create a new generation of trees that are less prone to insect-induced mortality from EAB. This is a trial-and-error process, as not all lingering ash have resistant genetics (e.g., they may have coincidentally avoided EAB infestation). Deciding which parent trees to clone or breed creates another layer of difficulty, as ash trees that survived the outbreak by chance provide no benefit to the breeding pool.

Keys to success in resistance breeding (Pike et al. 2020):

1. A group of people committed to saving or restoring a species and its associated values—socioeconomic and ecological.
2. An array of researchers, usually including scientists at federal agencies, interested in the underlying science of the problem independent of the committed group.
3. Multiple sources of funding that provide enough buffer to compensate for year-to-year fluctuations.
4. A network of leaders (formal and informal) focused on obtaining effective resistance that maintains open communication by sharing information, including setbacks, progress, and data.
5. Effective public engagement, including active volunteers and interested citizens.

By planting EAB-resistant ash trees alongside other species in areas identified as 'high priority' based on their Tree Equity Score, restoration initiatives can work to maximize the impact of these efforts. By strategically selecting sites and planting diverse species mixes, restoration initiatives can contribute to enhanced environmental equity alongside increased resilience to pests and other climate change stressors. While it is impossible to eradicate the EAB from North America, planting resistant ash trees promotes the longevity and sustainability of an iconic species on the landscape. By identifying neighborhoods with the lowest Tree Equity Scores, urban foresters can concentrate limited trees and planting resources in places where they will have the greatest impact. A community with low canopy cover is likely to experience more significant benefits from tree plantings than a community which already has a high Tree Equity Score and a healthy urban forest canopy. Taking measures to restore resilient species, canopy diversity, and reduce inequities in urban forest communities, can increase the benefits and impacts of urban forest restoration initiatives.

Conclusion

Despite the significant impacts the Emerald Ash Borer has had on the urban forests of Detroit, Michigan, an extraordinary opportunity exists to restore equitable access to trees and their benefits. Increasing the diversity and coverage of the urban forest canopy enhances their ability to resist increasing stressors under changing climatic conditions. Research and restoration initiatives undertaken by American Forests, the U.S. Forest Service, and the Greening of Detroit support the sustainability of Detroit's urban forests, while improving equitable access to the many benefits they provide.

Resources

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