The education benefits of metropolitan tree cover: evidence from the emerald ash borer in Chicago

Alberto Garcia

May 20th, 2022

Abstract

Blah blah blah

Introduction

The Chicago region is the third-largest metropolitan region in the United States.

Background

Emerald Ash Borer in the Chicago area

The emerald ash borer is an exotic beetle first discovered in the United States in 2002 near Detroit, Michigan [@addcite]. The pest exclusively targets ash trees, and infestation is fatal to all north american ash trees.

The ash borer has been referred to as the most destructive forest pest ever introduced to the United States [@Nowak1], and ash trees have suffered extensively in the Chicago area. A Chicago region tree census revealed that the areas standing ash population nearly halved between 2010 and 2020, dropping from an estimated 13 million to under 7 million [@treecensus]. Of those 7 million standing trees, 4 million are either dead or in decline. Further, as of 2020, more than 30% of ash trees in the region are saplings, likely having regenerated from removed adults. Although many ash trees were replaced with alternative species, the overall number of large trees (> 6 in diameter) dropped nearly 2 percentage points across the region.

Greenery and education outcomes

Children are exposed to more green vegetation show enhanced cognitive development [@Reuben2019].

The association between the amount of trees and vegetation and improved test performance has been well documented [e.g., @wu2014]

Sivarajah2018plos

This may be through several different channels.

Green spaces to mitigate traffic-related air pollution [@Dadvand2018]

They may also reduce noise, allowing students to better focus [Gidlöf-Gunnarsson, E Öhrström, Noise and well-being in urban residential environments]

@Dadvand2015 show that increased vegetation, particularly at school is associated with increase scores on cogntive development tests.

Contribution

Data

Emerald ash borer survey

EAB infestation is fatal, however, it is difficult to detect until a tree is extensively damaged by the EAB and begins to show symptoms. After the first EAB detections in 2006, the Illinois Department of Agriculture (IDA) initiated survey efforts to determine the extent of EAB spread.

The IDA survey consisted of destructive bark peeling of selected trees. Selected trees were generally 4-8 diameters in width and in areas of easy and clear right-of-way access, with efforts to sample 1 tree per 4 square miles. Initially, the damage was minimal as the detection method results were mostly negative, but positive finds became more and more prevalent [@IDA]. Ultimately, the state stopped survey efforts in 2015, as EAB spread had become extensive. Figure XX displays the locations of confirmed EAB infestations by year through the survey.

Chicago metropolitan area tree cover

We utilize maps of urban and metropolitan tree cover developed in @mccabe2018. These yield annual tree canopy gain and loss at 30m resolution for the Chicago area from 1996 to 2016. They are based on Landsat imagery and 1m ground reference data from the Chicago Metropolitan Agency for Planning. Figure XX displays confirmed infestations within the Chicago metropolitan region for which we have tree cover data. Note that the majority of the confirmed infestations lie within both the Chcago metropolitan area as well as the extent of our tree canopy data.

Education and test score data

Test score data come from the Illinois Standards Achievement Test (ISAT), which was instituted for the purpose of identifying failing schools. Students were tested in reading and math from grades 3–8. The Illinois State Board of Education (ISBE) reported school-level performance on the test between 2003 and 2014, when the ISAT was retired. We geocode locations of each public school in the state of Illinois using addresses provided by ISBE. This allows us to understand the location of each school relative to EAB infestations.

Alternative outcomes of interest

In this draft, we have used test scores as the outcome of interest to explore the benefits of tree cover, however, tree cover provides ample benefits worth exploring in this context.

EAB infestation impacts tree cover loss and gain

In this section, I aim to establish that confirmed EAB infestations lead to reduced forest cover through two means: 1) increased tree loss and 2) reduced tree cover gain. There are two main channels through which EAB detection may result in tree loss. The first is through the EAB directly, as an ash tree will die between one and four years following infestation, depending on the size and health of the individual. The second is through intentional removal of infested trees. Most communities declare any confirmed infested tree a public nuisance and require that the tree be removed [e.g., @macomb]. As such, a confirmed infestation is likely to lead to quicker removal of infested or dead trees in the vicinity, in addition to death of trees due to EAB infestation.

EAB detection may also lead to lower levels of tree cover gain. Removal of damaged or dead trees is costly to individuals and communities. Macomb, a city in the Chicago metropolitan area, estimates a cost of $675 (2007 estimate, not adjusted) to remove and replant a single tree [@macomb]. More broadly, EAB had a massive impact on forestry budgets across the United States [@]. However, while budgets in states with confirmed EAB infestation saw massive increases in tree removal budgets relative to non-EAB confirmed states, budgets for tree planting did not change. Because most removed trees are likely replaced with new trees, it is plausible that trees that would've been established elsewhere in the absence of EAB were never established.

To estimate the impact of EAB infestation on tree cover, I use difference-in-differences methods developed in @callaway2020. Unlike the traditional two-way fixed effects regression, this estimator is robust to general treatment effect heterogeneity. I define treatment status using confirmed infestations from the IDA bark peeling survey described in section XX. An IDA confirmed infestation indicates that not only are trees in the vicinity infested and ultimately likely to die, but that community officials are aware of the need for tree removal and replacement.

In this section, I use 5km grid cells as the unit of analysis. A grid cell is valuable for several reasons. First, a confirmed infestation likely indicates that there are EAB in nearby trees as well. @science find that EAB females fly an average of … Further, local communities are likely to respond in the surrounding areas. For example, some communities might preemptively fell ash trees likely to become infected in the surrounding area. In the appendix, I show that these conclusions are robust when using a 3km grid cell as well.

Table @**??**tab:treegrid) shows results for both tree cover loss and tree cover gain in acres per year. Note that these estimates should be interpreted not as overall tree cover, but as the rate of tree cover gain and loss in a given year. These results indicate that a confirmed EAB infestation leads to a loss of XX acres of tree cover per year, and a reduction in tree cover gain of an additional XX acres per year within a 5km grid cell.

Tree cover loss	Tree cover gain
0.70472	-1.54045
(0.24413)	(0.63616)

Figure XX displays event study estimates using the @callaway2020 estimator in order to understand the dynamics of tree cover change following infestation. This figure also allows us to gauge the plausibility of the common trends assumption on which this identification strategy relies. I find the assumption to be plausible given the similar pre-trends in outcomes as well as the fact that the timing of EAB infestation confirmation was likely idiosyncratic and driven by the biological nature of the beetle.

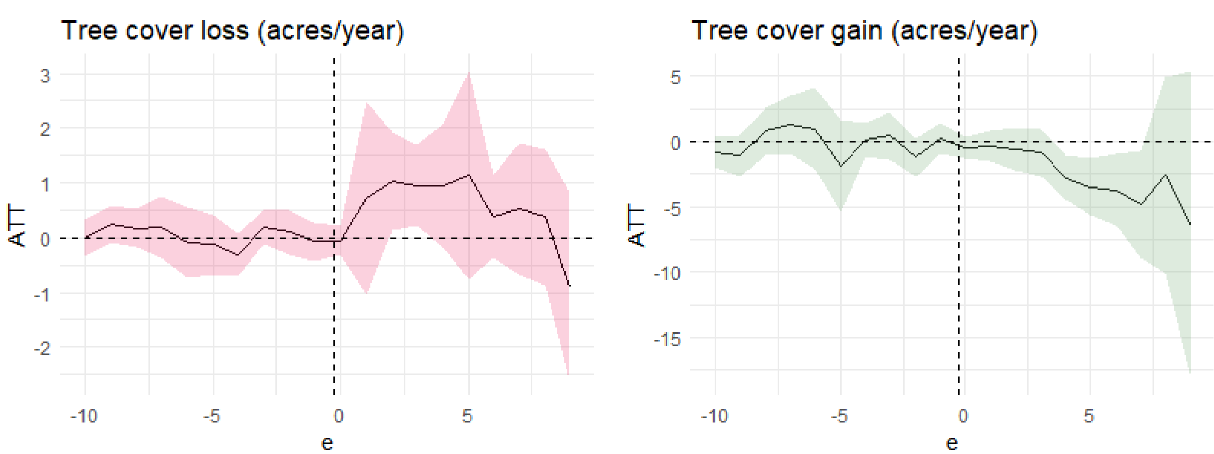

Figure 1: Left: Confirmed EAB infestation leads to a temporary increase in tree cover loss; Right: Confirmed EAB infestation leads to a decline in tree cover gain

Tree cover loss around schools

In the previous section, I showed that EAB infestation leads to a temporary increase in tree cover loss and a decline in tree cover gain in affected areas. I now focus on individual schools, and in this section, seek to show that infestation leads to tree cover loss in the vicinity of individual schools. I repeat the general analysis from the previous section, but now consider an individual school treated in the years in and after an EAB infestation was confirmed within 5km of the school. Tree cover impacts are measured in the 5km buffer surrounding the school location.

Table XX again shows that confirmed EAB infestation leads to increased tree cover loss and decreased tree cover gain. I also measure total canopy cover relative to 2003, the year in which I first observe test scores from Illinois schools.

Education impacts of EAB infestation

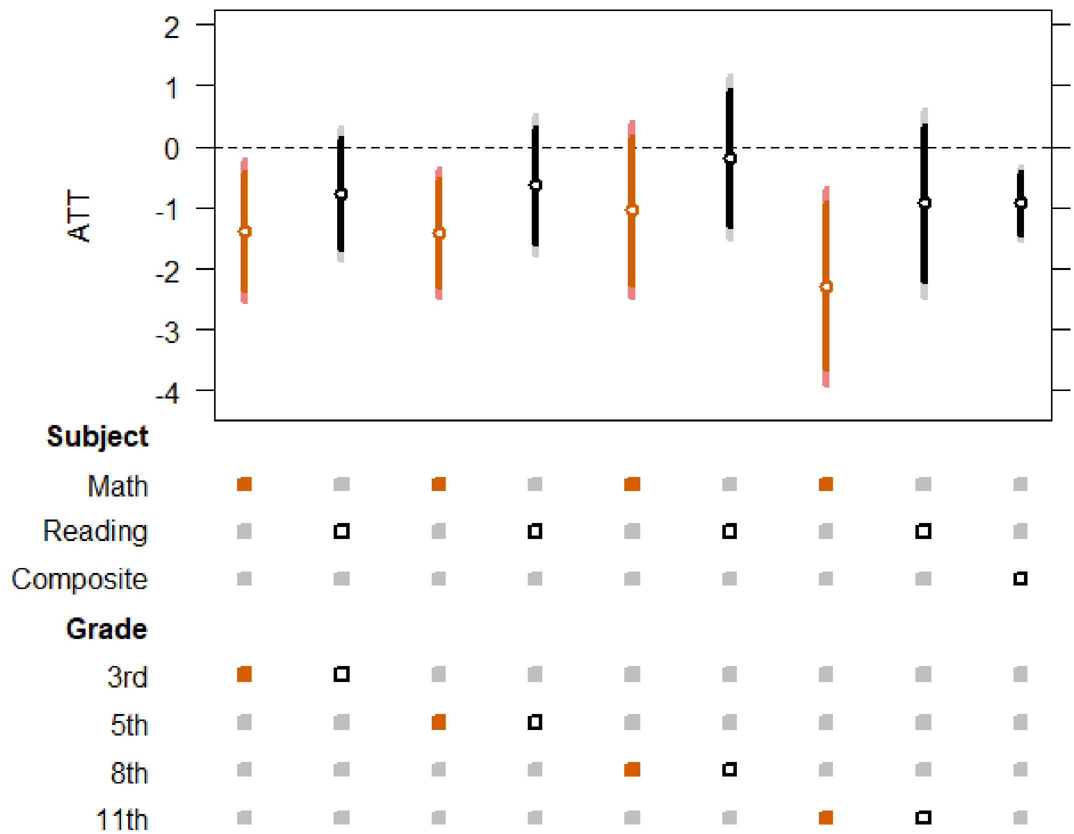

Figure 2: my caption

The impact of tree cover on test scores: evidence from instrumental variables

So far, I have shown that confirmed EAB infestation leads to loss of tree cover and lower test scores at exposed schools. In this section, I will seek to estimate the test score impacts of tree cover.

First stage

$$canopy_{st} = \beta_0 + \beta_1 \times infestation_{st} + \gamma_t + \lambda_s + \epsilon_{it} \tag{1}$$

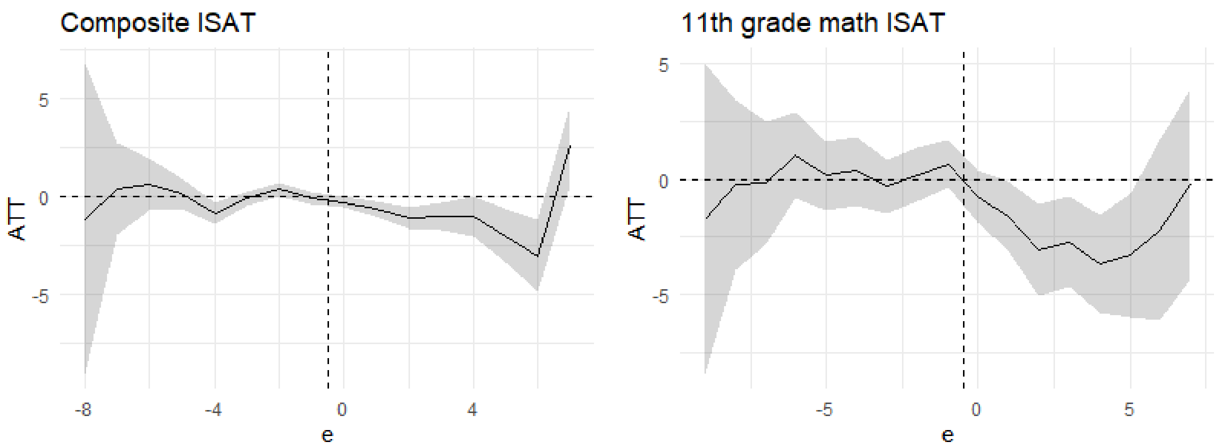

Figure 3: my caption

IV estimates

$$ISAT_{st} = \alpha_0 + \alpha_1 \times \widehat{canopy}_{st} + \gamma_t + \lambda_s + \epsilon_{st} \tag{2}$$