Motivation (Broader Impacts): Gun crime is a persistent concern in urban environments. The rates of gun-related homicides and emergency department visits are notoriously higher in the U.S. than in other developed countries. Gun violence disproportionately affects low-income and minority residents; homicide is the first (second) leading cause of death for young black (Hispanic) men **[1]**. Early death and incarceration contribute to staggering numbers of "missing" black men (83 black men per 100 black women), creating other social problems in minority communities [2]. Therefore, decreasing gun crime would reduce inequality by improving outcomes for disadvantaged minority groups. In addition, reducing gun violence would benefit taxpayers by decreasing Medicaid and Medicare spending on gun-injury related health care.[1] Therefore, governments have several reasons to examine potential policy solutions to reduce gun crime.

Background: Revitalizing urban areas with green spaces could be part of a policy solution to reduce gun violence, although the effects of vegetation on crime are theoretically and empirically ambiguous. On the one hand, trees and shrubbery could provide hiding places for criminals and inhibit neighborhood surveillance by obstructing views of the streets. On the other hand, greener spaces could deter crime (1) by providing community gathering spaces, thereby placing more eyes on the ground and (2) by dampening criminals' sense of aggression through the physiologically calming effects of nature **[3]**. Understanding how green spaces affect criminal activity has important consequences for safety in urban neighborhoods.

Intellectual Merit: A naïve comparison of gun crime between more and less green areas potentially includes selection bias, since more affluent, less crime-ridden areas also tend to be greener. Even a comparison across time for areas that become green can produce biased estimates if a confounding factor like gentrification of a neighborhood simultaneously increases green spaces and decreases crime. To circumvent such endogeneity, my research would exploit vacant lot renovation programs as close-to exogenous variation in green spaces, thereby identifying the causal impact of greening spaces on gun crime rates: a policy-relevant parameter.

By combining this policy-induced variation with objective, detailed data on gunshots and geographic imagery and data across several American cities, my proposed research seeks to uncover how greening urban spaces affects gun violence: one important category of crime. Studying this effect is challenging with typical, reported crime data since renovating lots might affect reporting rates (if more people are present to report crime, for instance) and actual amounts of criminal activity. My study will address this issue by using new data from ShotSpotter gunshot sensors (described below). Furthermore, existing studies on the effects of greening vacant lots on crime rely on relatively sparse crime data in a single locality **[4] [5]**. In contrast, I would utilize data on a long time horizon, with more frequent observations,[2] across several counties and municipalities.[3] Therefore, I could contribute longitudinal and more precise, generalizable estimates of the effect of greening spaces on gun crime to the existing literature.

Data: ShotSpotter is a technology that captures incidents of gunfire using audio sensors, providing comprehensive data on these events including precise geographic coordinates and timestamps. A key advantage of these data is that they are not subject to reporting bias or underreporting, thereby providing a more objective measure of gun crime: my outcome measure **[6]**. In order to measure

[1] Medicaid and Medicare picked up nearly half of the costs of caring for Chicago survivors of gunshot wounds among costs between 2009 and mid-2016 analyzed by the Chicago Tribune.

[2] According to Carr & Doleac, 911 reports of shootings (reports of assault with a dangerous weapon) capture just 12% (2-7%) of all gunfire incidents recorded by ShotSpotter.

[3] ShotSpotter has been employed in at least 90 U.S. counties or cities since 2000, of which I currently have access to over 1,500 locality-months' worth of data representing 27 unique localities.

the treatment (greening of vacant lots), I will utilize cities' databases on vacant lot renovations where readily available.[4] To allow for analysis in cities where such databases are not available, I will use machine-learning algorithms on high-resolution digital aerial imagery and LIght Detection and Ranging (LIDAR) data to classify areas as green spaces, trees, or other objects of urban spaces, akin to methods described by Zhou & Troy **[7]**. While I have not worked with these kind of geographic data before, my background in machine learning coupled with support from GIS experts at my university's library would allow me complete this step of my project. I will combine these data in ArcGIS to create a lot-time level panel dataset.[5]

Methods: The first part of the empirical analysis involves an event study, difference-in-differences (DD) approach before and after greening of vacant lots occur. Control observations will be vacant lots that were not renovated. The primary outcome measure will be the number of ShotSpotter-detected gunfire incidents within a specified radius from each lot. I will check the results using different radii from lots both (1) as a robustness check and (2) to determine how close to a green lot one should live to experience its effects: a question that remains underexplored in the current literature. Regression analyses will include year and month fixed effects (FE) and lot-, Census block-, or city-level FE. In specifications with city FE, I will control for Census block-level covariates available from the American Community Survey (ACS) including median income, home ownership rates, racial demographics, and other variables that could be associated with crime levels. I will cluster standard errors at the lot level: the level of treatment. Further analyses would adjust for spatial correlation. In addition to basic DD estimates, I will also employ methods of synthetic control to establish comparison groups that better demonstrate common pre-trends.

A potential concern with this quasi-experimental approach is that greening spaces might just push the same amount of crime to other areas of a city not-yet renovated. However, this phenomenon would attenuate my estimates of the treatment effect since crime would increase in control areas relative to treatment areas.[6] To further investigate the prevalence of this phenomenon, I could look at citywide impacts before and after periods of lot restoration.

Assuming encouraging findings, I would also complete a cost-benefit analysis. I would gather information on the average cost to turn a vacant lot green and maintain it, and associated administrative costs. On the benefits side, I will use estimates of the social costs of gun crime (criminal justice claims, loss of life, and other costs [8]) to estimate costs avoided because of decreased gun violence. More broadly, I will translate my findings into units like dollars and lives saved that are salient and easily interpretable for policy-makers. I will also submit my findings to peer-reviewed publications and present at crime, urban policy, and economics conferences.

This research has important implications for determining the potential of urban renewal policies, such as vacant lot restoration programs, to reduce crime. If vacant lot restoration programs are effective at curbing gun violence, minority populations would disproportionately benefit.

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[4] For example, Branas et al use such a database to study Philadelphia, PA.

[5] A lot-day dataset is possible for cities in which the exact renovations dates are known. Otherwise, I will create a dataset using whatever courser time level lot greening could be detected using aerial imagery and LIDAR data.

[6] To determine the effects of spillover effects more exactly, future randomized trials could consider varying the proportion of lots renovated within a city among a sample of several cities.