

# Urban green space and environmental health equity: the impact of green space exposure on all-cause mortality rates across Washington, DC

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## Introduction & Objectives

- Increased exposure to green space reduces rates of all-cause mortality by: increasing access to physical activity, improving mental health, and reducing ambient air pollution and the Urban Heat Island effect.<sup>1,2,3</sup>
- Green space density varies greatly, including in Washington, DC, potentially resulting in substantial health disparities.
- Life expectancy in DC by neighborhood ranges from 68.2 to 89.3 years, with Wards 7 and 8 having both the lowest life expectancy and the highest proportions of Black residents (91.74% and 91.84, respectively).<sup>4</sup>
- Green space is often measured using normalized difference vegetation index (NDVI), which ranges from -1 to +1. Values of 0 correspond to no vegetation, negative values correspond to water, and values near +1 indicate the highest possible density of green leaves.<sup>1</sup>
- Our goal was to estimate the avoided all-cause mortality attributed to green space exposure in Washington, DC at the DC Health Planning Neighborhood (HPN) level.

## Methods

- Avoided annual mortalities from all-causes resulting from exposure to green space is calculated using a health impact function based on a linear relationship between NDVI concentration (X) and response factor ( $\beta$ , derived from relative risk). We used long-term exposure to green space (measured using NDVI), mortality relationships from Rojas-Rueda et al. (2019), baseline all-cause mortality rate ( $y_0$ ) from CDC WONDER, exposed population (Pop) from CDC WONDER, and a median composite of Landsat 32-day NDVI from Jan-1-2018 to Dec-31-2018 at 30m from Google Earth Engine:

$$\Delta \text{Mort} = y_0(\beta X) \text{Pop}$$

- We applied this equation to the total adult population in Washington, DC and to each HPN to yield annual avoided deaths due to exposure to green space. We aggregated the aforementioned Landsat NDVI data to the HPN level.

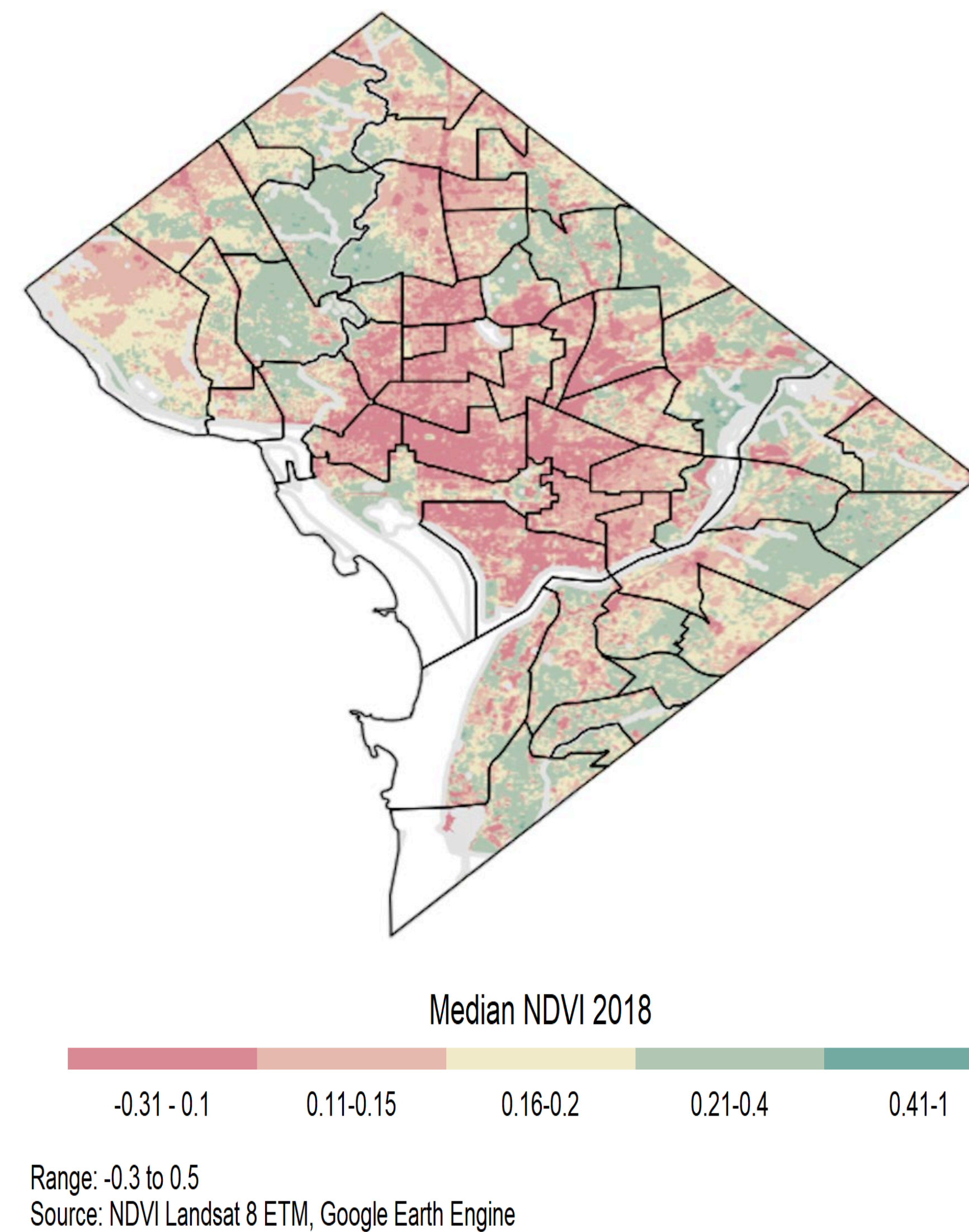
## References

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## Contact Information

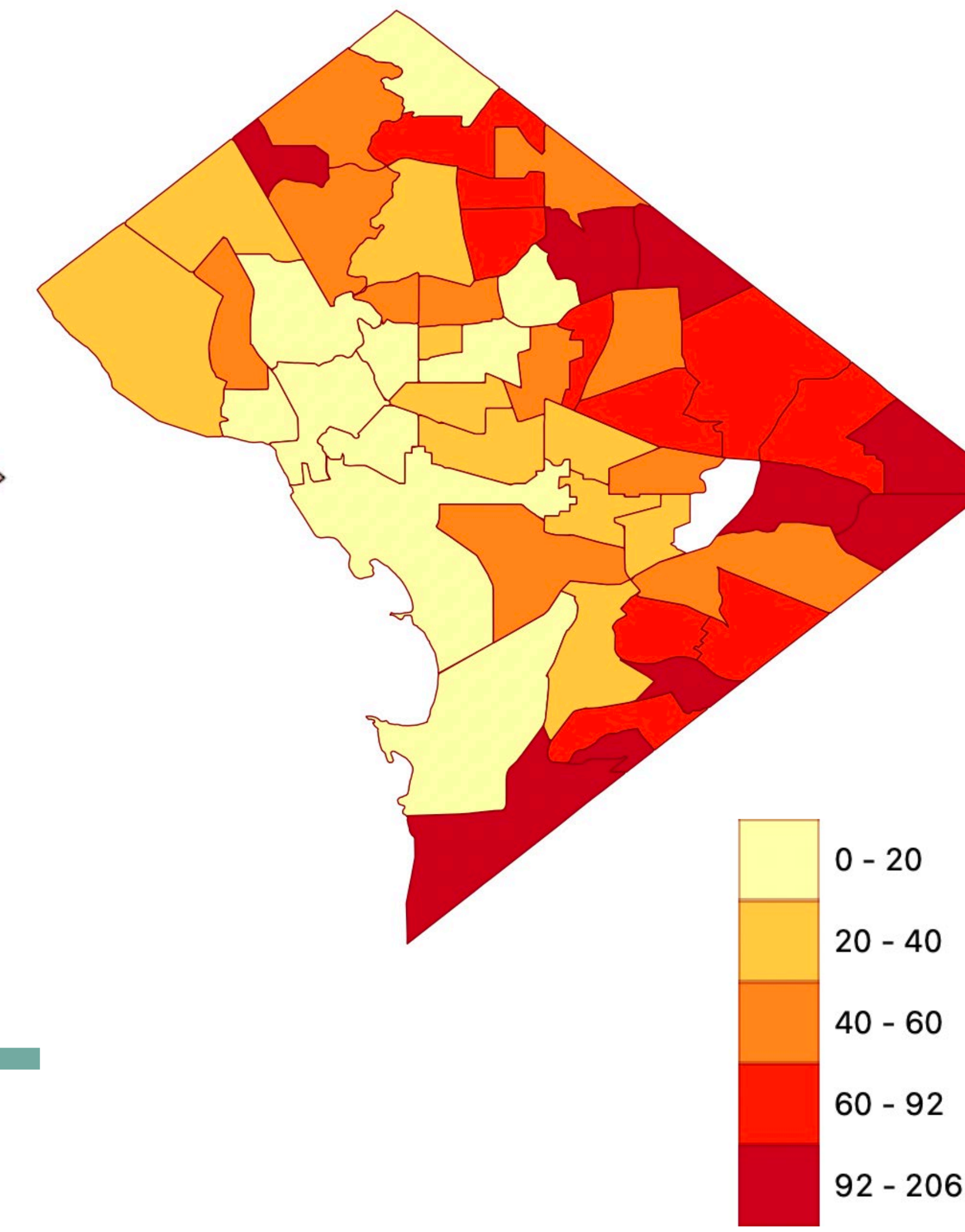
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## Results & Discussion



**Figure 1.** Green space density across DC, measured using normalized difference vegetation index (NDVI) at 100m buffer zones.

Premature deaths per 100,000 people attributable to lack of exposure to green space range from 0 in Georgetown to 206 in Fort Dupont. With the exception of one HPN (Chevy Chase in NW DC), every HPN with an attributable death rate per 100,000 people greater than 90 is located within Wards 5, 7, and 8.



**Figure 2.** Premature deaths per 100,000 people attributable to lack of green space exposure in DC at the HPN level.

Total population (2016)	Mortality rate (2016)	Average city-wide NDVI (2018)	Population-weighted NDVI (2018)	NDVI range (100m buffer zones)
681,170	7,390 per 100,000	0.152	0.147	[-0.29, 0.46]
Baseline Mortality (2016)	Green space-attributable mortality estimate	Average number of annual deaths attributable to lack of exposure to green space	Range of green space-attributable deaths per 100,000 people annually	Median number of annual deaths attributable to lack of exposure to green space
5,037.25 annual deaths	306.26 deaths annually	56.92 per 100,000	[0, 206]	49.5 per 100,000

**Table 1.** All-cause mortality results, population statistics, and green space data for Washington, DC.

## Results & Discussion

- In DC, NDVI at 100m buffer zones range from -0.29 to 0.46. This demonstrates that exposure to green space is highly variable in DC, as shown in Figure 1.
- Premature deaths attributable to lack of green space varies substantially across Washington, DC, as shown in Figure 2, with the highest rates of deaths attributed to low NDVI levels occurring in Southeast DC.
- We estimate that a total of approximately 306 adult deaths are attributed to low access to green space each year in DC.
- We applied the response factor used in our health impact function to data from a 2020 green space study in Philadelphia.<sup>5</sup> Results were consistent with published results, supporting the methodology used and findings reported in our study.
- Our findings suggest that inequitable access to green space in Washington, DC exacerbates racial and environmental health disparities, particularly in Southeast DC.
- Although Figure 1 shows relatively dense green space in Wards 7 and 8, where annual deaths attributed to lack of exposure to green space are highest, green space in these areas may not be functional, accessible, or safe.
- Limitations:** NDVI only measures green space density and not the quality or accessibility of green space, which may greatly contribute to the strength of association between green space and all-cause mortality.

## Conclusions

- The health impacts of exposure to green space in Washington, DC include lower all-cause mortality, with the largest health returns to green space occurring in Southeast DC.
- Urban green space can provide the dual benefits of climate mitigation and public health improvements.
- Confidence in our results would be increased with better measures of green space quality and accessibility.
- Despite limitations, our study suggests that green space has a significant protective effect on health and can be used as a tool to improve health equity.
- Understanding the health benefits of exposure to green space in cities, including in Washington, DC, will help policymakers understand the local improvements in public health and health equity that can be achieved via urban sustainability planning.