Zoning Policies and Carbon Emissions in Seattle, Washington

A Project Prepared for House Our Neighbors

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Executive Summary

For Spring Quarter, 2024, we worked with House Our Neighbors (HON), a local nonprofit that advocates for dense, multifamily housing through city level policy and grassroots advocacy. House Our Neighbors formed in 2021 to oppose Charter Amendment 29, a measure that would have allowed local agencies to forcibly remove homeless encampments from public properties. Since then, HON has led the coalition for social housing, a new model of publicly-owned affordable housing. Their advocacy led to the passage of initiative 135, which allowed for social housing development, and initiative 137, which funds social housing through a payroll tax (in the vote collecting phase).

Approaching the finalization of Seattle's 20-year Comprehensive zoning and development plan, House Our Neighbors aims to secure more multifamily zoning in currently single-family zoned areas. HON faces contention with single-family neighborhood groups resisting urbanization and removal of tree canopies. These influential groups argue that the tree canopy in their neighborhoods mitigates their carbon output and in turn helps to combat climate change. This disagreement has placed a wedge in HON's ability to effectively and expeditiously advocate for fundamental zoning changes in the Comprehensive Plan.

To overcome this obstacle, HON enlisted the assistance of the University of Washington's Geography and community partnership program to investigate the relationship between carbon emissions and tree canopy area across Seattle to confirm if regions with higher tree canopy experience lower emissions as proffered by these neighborhood groups.

Working with HON, we analyzed geospatial data representing single-family zones, tree canopy coverage, and consumption emissions by census tract to better understand the associations of zoning with climate variables. We calculated percentage values of spatial coverage by different zoning classifications and tree canopy to compare to estimated consumption emissions. In order to examine these relationships, we created a series of maps and scatter plots as final products to spatially represent the associations between these three variables.

Through our project, we found two main findings that counter arguments proffered by residential groups. First, we demonstrated that single family housing produces disproportionately higher carbon emissions than mixed-use or multifamily areas. This finding is in line with contemporary research that points to substantially greater transportation and spatial conditioning emissions compared to multifamily housing. Secondly, as a consequence of higher tree canopy area in single family zones in Seattle, we found that there exists a moderate positive correlation between tree canopy density and carbon emissions such that areas with the highest carbon emissions also tend to have the largest tree canopy.

The analysis we performed firmly repudiates the argument that a larger tree canopy implies a lower carbon emission for single family neighborhoods in Seattle. The findings and final advocacy poster will provide HON a strong foundation to dissuade public officials from reneging plans to convert single family zoning to multifamily zoning.

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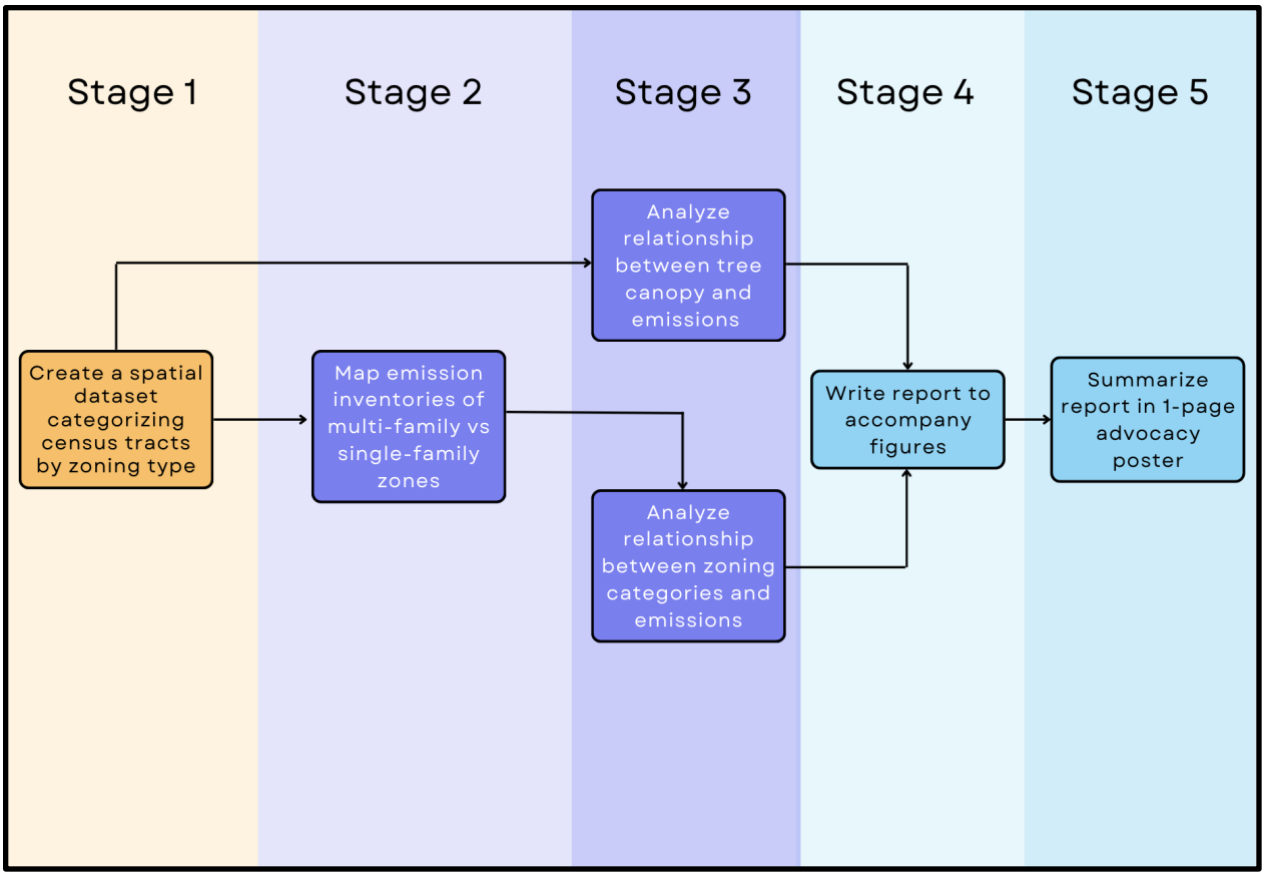
1. Background and Problem Statement

In the next year, the City of Seattle will update its guiding policy for land use practices for the next twenty years through a Comprehensive Plan (Seattle Office of Planning & Development, 2022). The new land use policy has the potential to resolve pressing issues in the City, primarily the lack of affordable housing and energy inefficiencies that both stem from insufficient multi-family housing (MFH) allocated in the current land use policy. Single-family residences are shown to require more heating, water, and electrical energy, largely increasing their carbon emissions (Timmons et al., 2016). Among the stakeholders involved in the discussions about the Comprehensive Plan is the nonprofit organization House Our Neighbors (HON). HON is advocating for a land use policy that allocates for far more MFH in current single-family housing (SFH) zones, such that the city can build publicly owned affordable housing, alleviating Seattle's housing crisis and reducing the excessive carbon emissions produced in SFH zones.

During ongoing policy discussions surrounding land use changes, HON faces pushback from neighborhood groups arguing that Seattle must preserve tree canopies in SFH zones to mitigate the effects of climate change and the Urban Heat Island effect. With effective management and care, tree canopies are shown to sequester dangerous carbon emissions in urban environments (Speak et al., 2020). Due to this contention between stakeholders, HON has faced difficulty in effectively campaigning for widespread land use changes in the new Comprehensive Plan. In order to support House Our Neighbors' mission, our project will provide data backed materials that support the argument that SFH produce far greater carbon emissions than MFH, Single family zones typically have greater tree canopy area, and high tree canopy areas have greater carbon emissions. These materials will provide House Our Neighbors with an effective tool for their advocacy work and support their mission to create affordable and sustainable public housing.

2. Data Analysis Strategy

We performed a series of geospatial data analyses to support House Our Neighbors' goal to advocate for denser multifamily housing in current single-family zones and counter arguments that tree canopy lowers carbon emissions. This project mainly consisted of collecting high quality data and effectively visualizing relationships between carbon emission, zoning, and tree canopy data in Seattle. The visualized workflow of this project is the following:



We began with the City of Seattle's Zoning shapefile, which provided detailed information on every zoned parcel in the city. Since the remaining data variables would be in census determined geographies, we performed a tabulated intersection analysis on Seattle census tracts using the zoning dataset. This analysis provided the percent and size of area for each zoning category present in each tract. Though there are 28 different zoning classifications present in the dataset, we condensed these classifications into our three primary interests: multi-family residential, single-family residential, and mixed-use, which included categories of "mixed-use/residential" and "Seattle mixed." The remaining categories: industrial, maritime, and large institutions (mainly referring to Universities or hospitals) were ignored for our purposes. We then joined the percentage values of single-family, multi-family, and mixed-use present in each census tract with the tract shapefiles themselves.

In the public report, "King County Communitywide Consumption Based GHG Emissions Inventory," there are several maps representing modeled estimates of carbon emissions by tract in King County. However, we were unable to access this data online for any geography smaller than zip codes. We reached out to the City of Seattle GIS team via email to request the data used for this report, who were able to provide us with a CSV file of the emissions data within two weeks. This file included all of the consumption behavior estimates used to calculate the emissions values, including hundreds of categories from flights taken to groceries bought. For the narrower focus of our group project, however, we primarily analyzed total consumption

emissions and total consumption emissions per capita. Given that single-family zones are inherently less densely populated. We then mapped the emissions values using Jenks natural breaks by census tract, which clearly demonstrated single-family census tracts as producing the most emissions.

At the same time, we relied on the City of Seattle's 2016 tree canopy dataset to represent an extremely accurate image of tree coverage in the city. We performed a similar analysis to assign a numeric percentage value of tree canopy coverage to each census tract. After joining the values with the existing census tract shapefile, we mapped the amount of tree canopy coverage by tract, which generally reflected the same geographic pattern as the distribution of single-family zoning. After successfully joining the percentage of tree canopy cover and single-family zones of each tract with the shapefile, we plotted the relationship between our two variables and percentage of single-family zoning, which all showed statistically significant correlations. Finally, we produced the map and chart layouts that we would use to form our final project conclusions.

3. Project Digital Environments

All geospatial mapping, analysis, and merging of datasets was performed in ArcGIS Pro. Team members shared datasets and maps using the ArcGIS Online groups function, which allows individuals to upload geospatial data that can be downloaded and manipulated by other members of the group. Correlations and scatter plots were also produced in ArcGIS. The final advocacy poster was designed using Canva, a free online tool for graphic design, and final map and chart designs were also created using Canva.

4. Data Acquisition

We were not provided with any datasets for this project from our sponsor, and all data was either retrieved from open data portals or directly from the City of Seattle. Our three variables of analysis were single-family zoning, tree canopy coverage, and consumption emissions. The zoning and tree canopy data were high in accuracy and precision as they are the same sets created and relied on by the city government. The consumption emission data had to be analyzed more carefully, given it was created using a statistical model and not literal measurement.

Zoning parcel data was acquired from the City of Seattle open GeoData portal from the dataset "Current Land Use Zoning," which contains information on land use zoning parcels both

in the formal legal codes and more general descriptions. It was last updated in February, 2024, as it is continuously updated to reflect changes in development.

Tree canopy data was also acquired from the City of Seattle's open GeoData portal from the data set “Tree Canopy 2016.” This dataset was created both from satellite imagery and in-person site visits, and is thus a very accurate representation of tree canopy coverage of the time. However, the dataset was also created in 2016, meaning significant changes may have occurred in the past seven years. For our purposes, however, the carbon emissions index was designed to represent 2017 values. Thus, these two datasets represent a similar period of time for the city, and can be relied on for our analysis.

Finally, we communicated with the GIS team at the City of Seattle, which provided us with a CSV file of the consumption emissions inventory used in the public report: “King County Communitywide Consumption-based GHG Emissions Inventory.” This data was created by EcoDataLab and Stockholm Environment Institute, two research institutes in Berkeley, California, and Seattle. The data was created using EcoDataLab’s “Consumption-Based Emissions Methodology,” a statistical model that uses national consumer surveys to build a predictive model that can accurately predict an individual household’s carbon footprint. While other emissions datasets may focus solely on emissions created in that specific geography, such as home energy, this method provides a more accurate image by analyzing activity outside the home. These larger sub-categories include gasoline, air travel, and food consumption. Though our analysis must remind our sponsor and potential audience that this data is only a model and not an exact measurement, it is still an overly reliable source, given the dedication and detailed methodology used by the researchers.

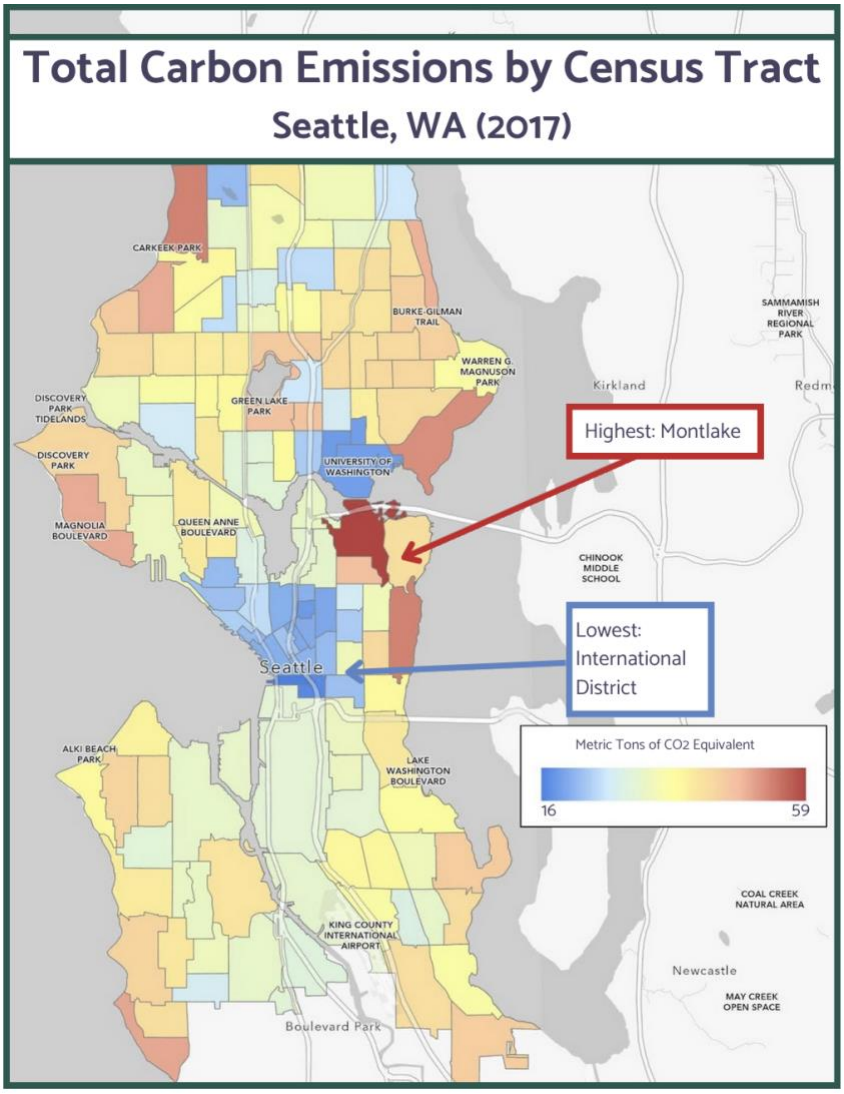
5. Findings

Our final graphics consist of two choropleth maps and three charts, representing the relationship between zoning coverage, tree canopy coverage, and consumption emissions. Our findings reflect clear geographic separations of consumption emissions that reflect the same spatial patterns of zoning policies and tree coverage.

Residential Zoning and Carbon Emissions

Our first finding demonstrates the relationship between single-family zoning and consumption emissions. As shown in the chart below, a clear geographic pattern exists for per capita consumption. Wealthy, single-family zoned neighborhoods like Montlake, Madrona, Magnolia, and Broadview all produce disproportionately high emissions, with lower-income

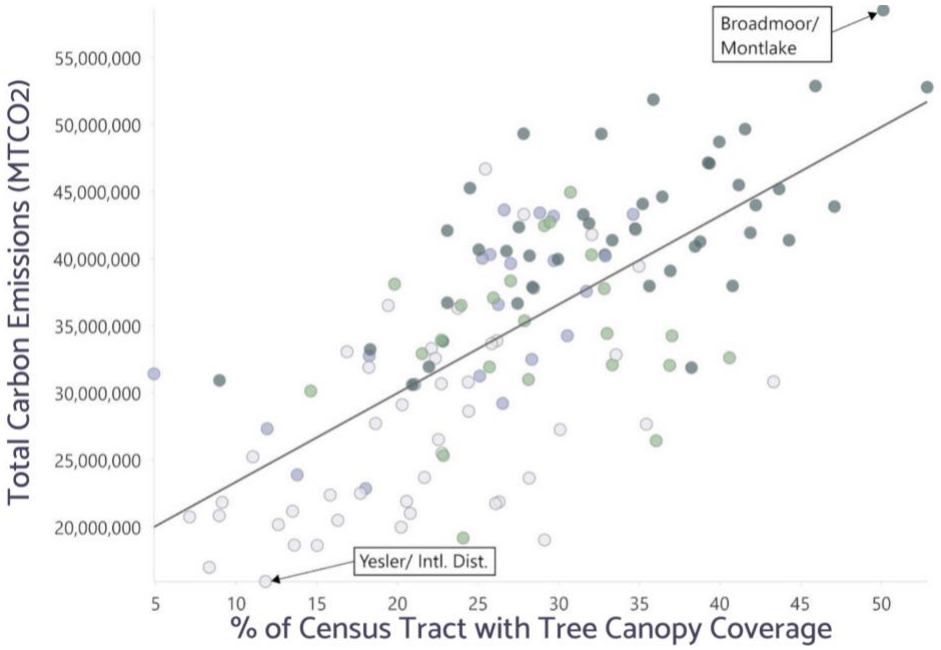
areas such as the U-District, International District, and areas of South Seattle producing the least amount of consumption emissions. The primary outlier to this trend exists in the SODO Industrial area's high emissions, but this is most likely due to the high level of industrial transportation and manufacturing activity occurring in the area.



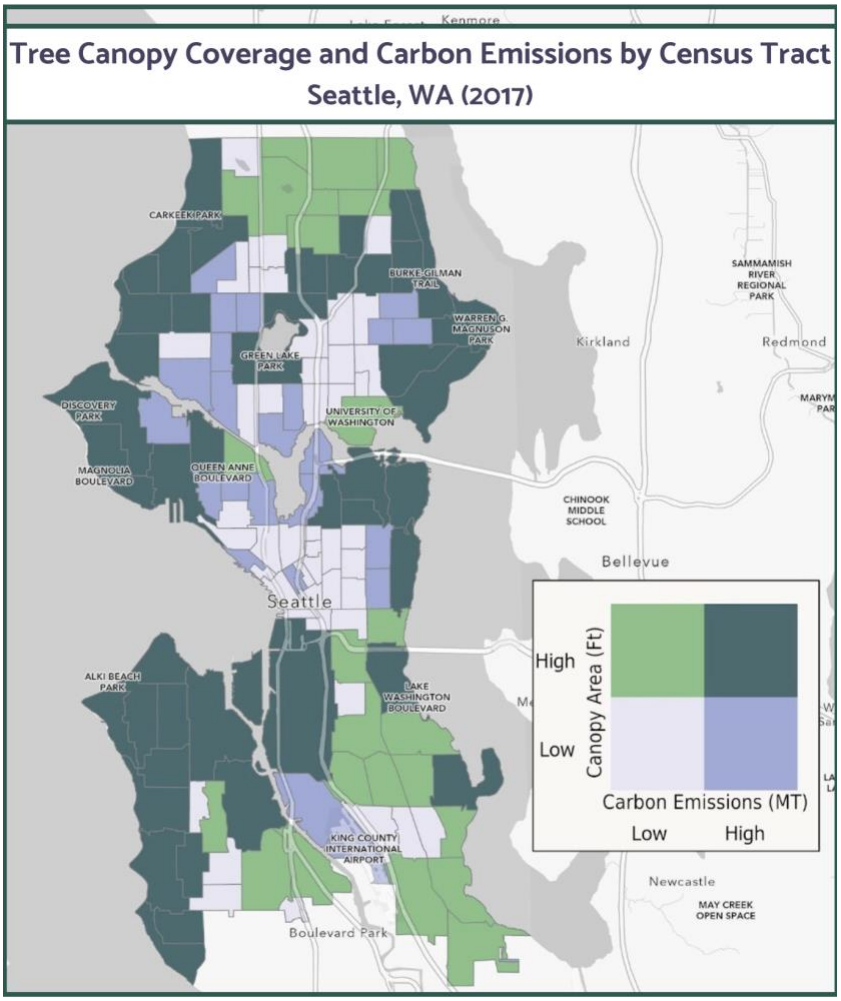
Next, we plotted the relationship between the percentage of the tract zoned as multi-family and the total consumption emissions. The scatter plot below charts this relationship, showing a clear negative correlation between the proportion of multi-family zoned parcels and consumption emissions. Though we cannot prove causation between the presence of multi-family zones and lower consumption emissions, this does prove a significant association. Additionally, this aligns with previous literature which details the aspects of multi-family dominated tracts that contribute to a lower carbon footprint, such as shared building energy and more use of public transportation.

Tree Canopy and Carbon Emissions

The relationship between percentage of census tract area covered by tree canopy and total carbon emissions was an even more significant positive correlation, with a correlation coefficient of 0.83. We also identified the neighborhoods which represented either extreme of these relationships, with the Montlake census tract representing the highest estimated carbon footprint and Yesler Terrace and the International District representing the lowest.



Finally, we mapped this same data onto a bivariate map, displaying census tracts with high or low carbon emissions and either larger or smaller tree canopies. As a bivariate map, this map does not attempt to show the same correlation, but rather highlight two aspects of the geographic distribution of these two variables. First, a very large area of Seattle consists of tracts with a very high tree coverage and very high carbon emissions. Second, we used this map to highlight areas of the city that were both high in emissions and low in tree canopy (seen in the purple color).



We summarized our findings in the advocacy poster below. The goal of this final product was to make our findings understandable to a general audience, so we included small bits of text to explain the process. Additionally, we attempted to explain the graphics as simply as possible such that HON could use the poster in their advocacy work.

Zoning in Seattle: Carbon Emissions

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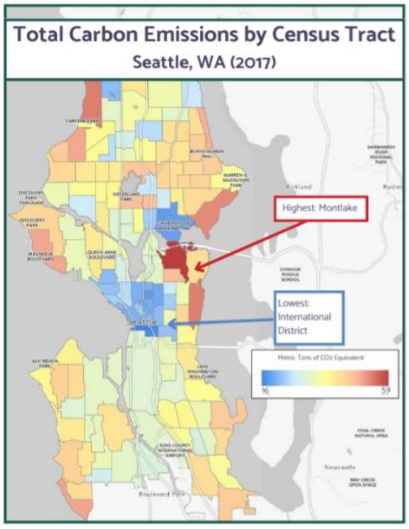
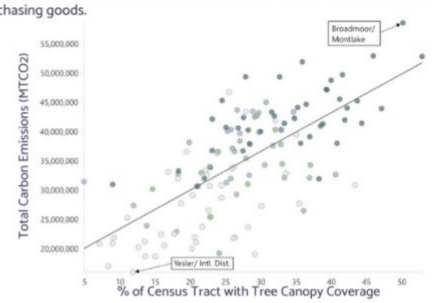
In the next year, the City of Seattle will update its Comprehensive Plan, a document that will dictate land-use practices for the next 20 years. The city is clearly experiencing a housing crisis, yet **64%** of Seattle is zoned as "Neighborhood Residential," a strict category that only allows for detached, single-family homes. Not only do single-family zones stand in the way of affordable, multi-family development, but they also have a disproportionately large carbon footprint. In order for House Our Neighbors to achieve their dual goals of climate action and social housing, the dominance of single-family zones must be addressed.

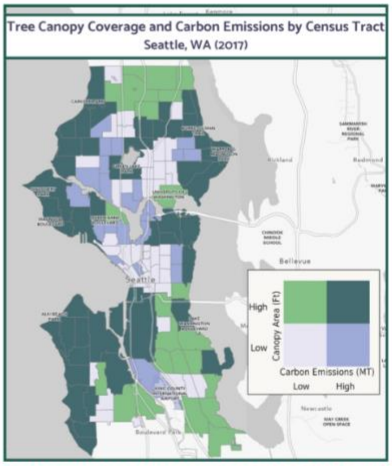


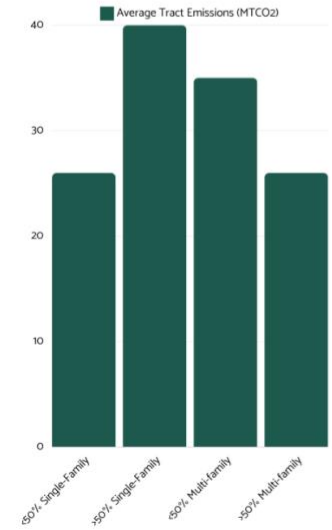
This map displays the "Consumption-Based Greenhouse Gas Carbon Emissions Inventory," a statistical model based on a methodology by EcoDataLab that represents estimated emissions by census tract based on consumption behavior. There are clear geographic patterns to the variation of carbon emissions, with wealthier, single-family residential neighborhoods producing the highest emissions.

While tree canopy coverage is a great tool for sequestering carbon from the atmosphere, the presence of trees does not mean that a neighborhood has a lower carbon footprint. Much of our individual carbon footprint comes from activities we do outside the home, such as driving, flying, and purchasing goods.



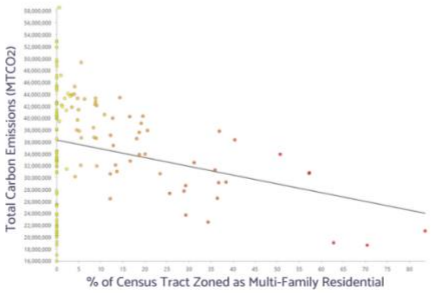
Since wealthier, single-family dominated census tracts generally have a larger tree canopy, there is a strong positive correlation between higher tree coverage and carbon emissions.





On average, majority single-family zoned neighborhoods have much higher carbon emissions. This is most likely due to the car-dependence and large home size common in single-family neighborhoods.

The map to the right labels census tracts as either being higher or lower than average in carbon emissions, and higher or lower than average in tree canopy coverage. This is useful for highlighting how many neighborhoods have both a large tree canopy and higher than average emissions, such as Magnolia, Montlake, and West Seattle.



Multi-family zoning is far less prevalent in Seattle than single-family zoning, where nearly half of all census tracts have no multi-family parcels at all. Census tracts with higher proportions of multi-family zoning have, on average, lower carbon emissions. While we cannot conclude a causal relationship between multi-family zoning and lower carbon emissions, aspects of multi-family residential neighborhoods, such as residential density and access to public transportation, are shown to lower emissions.

Geographic Data Sources:
City of Seattle. (2010). "2010 Census Blocks - Seattle". ArcGIS Online.
City of Seattle. (2024). "Current Land Use Zoning Detail". ArcGIS Online.
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6. Conclusions

Through a two-pronged geospatial analysis, we identified significant correlations between tree canopy coverage and single-family housing and higher carbon consumption emissions. Census tracts in Seattle that are primarily zoned for single-family housing have consistently larger carbon footprints, and these tracts also tend to have the largest proportion covered by tree canopy. While many tracts have little or no multi-family residential zoning, those that do have significantly lower carbon emissions. The lowest emitting areas of Seattle are also the most densely developed and populated, primarily Capitol Hill, the U-District, and the Downtown core.

Previous research has demonstrated that tree canopies mitigate the carbon emissions arising directly from the specific location of the canopy (Weissert et al., 2014). However, our research worked focused on emissions that occur anywhere geographically, such as driving or shipping emissions. It is clear that within Seattle, larger tree canopies are associated with wealthier, single-family homes that produce more carbon emissions on average than other tracts. Therefore, though tree canopies are a beneficial tool for mitigating carbon emissions, it is unknown if they are more beneficial than the mitigation of increased multi-family zoning.

Our work has clear limitations, primarily due to the carbon emissions inventory data source. Though this data is well-vetted in the scientific community and used by the Seattle and King County governments, it is still a statistical model rather than an exact measure. We, therefore, cannot conclusively determine that our mapping of carbon emissions by census tract represents the actual geographic variation. Additionally, as mentioned throughout the report, we cannot prove causation between single-family zoning, tree coverage, and carbon emissions. There are clear associations between these variables, and additional literature supports the claim that single-family zones produce higher, on average, carbon footprints.

However, Our findings align with House Our Neighbor's standpoint that multi-family residential zones are more environmentally sustainable than single-family zones. While it is not within the scope of this project to provide specific recommendations, our research supports the inclusion of more multi-family zoning within Seattle's next Comprehensive Plan to achieve the city's ambitious climate goals.

7. References

Geographic Data Sources

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8. Appendices

Appendix A: Project Contacts

Tiffani McCoy, Policy and Advocacy Director for House Our Neighbors

Served as our project sponsor and represented House Our Neighbors' goals for this project. Shared key background information and the current state of work within housing advocacy in Seattle. Provided feedback and recommendations in weekly check-in meetings on project progress.

Allen Grisom, City of Seattle GIS Enterprise Data Team

Contact point with City of Seattle GIS group. Sent CBEI Inventory data over email for project analysis.