Assessing Green Space Inequity in Chicago

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Policy Headline

Despite being one of the most racially diverse cities in the United States, Chicago's severe segregation places residents of color at an unfair disadvantage when accessing green amenities. This policy memo evaluates the extent to which residents of color are environmentally segregated compared to White residents and how well existing green initiatives improve the environment. Moving forward, Chicago must adopt demographic criteria in their green initiatives, involve local communities in the decision-making process, and conduct more thorough reviews on existing green spaces to improve the environment and enhance Chicago residents' quality of life.

Context

Chicago Demographics

With a toppling 2.7 million people inhabiting only 234 square miles, Chicago is one of the most densely populated cities in the United States.[1] The city grew massively during the nation's early years: its proximity to major waterways like Lake Michigan and the Mississippi River, combined with the fact that it served as a hotspot for political debate, cultural development, and technological advancement, caused the population to boom with businesses and immigrants throughout the nineteenth and twentieth centuries.[2] As a result, Chicago remains one of the most racially diverse cities in the country, where the population is about 33% Black, 32% White, and 29% Hispanic.[3]

Despite its immense racial diversity, however, Chicago ranks as the most segregated city in the country.[4] To illustrate this harsh divide, one can compare the racial majorities of Hyde Park and Washington Park, two side-by-side neighborhoods in the city center. Whereas Hyde Park contains predominantly White and Asian residents, 97% of Washington Park are Black residents.[5]

Chicago's segregation only exacerbates the social and economic issues that people of color disproportionately face compared to their White counterparts. In general, people of color are more likely to live in high-poverty neighborhoods, face unemployment, and earn less income than White individuals, and those are just a few of many issues and inequities.[6,7] In Chicago specifically, as a consequence of Chicago's racial segregation, neighborhoods dominated by

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[1] *Facts & Statistics*. (n.d.). City of Chicago. Retrieved July 31, 2024, from chicago.gov/city/en/about/facts.html
[2] *Early Chicago, 1833–1871 A Selection of Documents from the Illinois State Archives*. (n.d.). Illinois Secretary of State. Retrieved July 31, 2024, from ilsos.gov/departments/archives/teaching_packages/early_chicago/home.html
[3] Silver, N. (2015, May 1). *The Most Diverse Cities Are Often The Most Segregated*. 538 — Election Polls, Politics, and Analysis - ABC News. Retrieved July 31, 2024, from fivethirtyeight.com/features/the-most-diverse-cities-are-often-the-most-segregated/
[4] See Footnote 3.
[5] See Footnote 3.
[6] Sinclair, A. (2023, October 19). *How Chicagoans try to bridge the city's deep, persistent segregation*. CBS News. Retrieved July 31, 2024, from https://www.cbsnews.com/chicago/news/chicago-segregation/
[7] Grabinsky, J., & Reeves, R. V. (2015, December 21). *The most American city: Chicago, race, and inequality | Brookings*. Brookings Institution. Retrieved July 31, 2024, from https://www.brookings.edu/articles/the-most-american-city-chicago-race-and-inequality/

people of color are less likely to receive substantial financial assistance to alleviate these inequities, receiving only 13 cents to every dollar invested in White-dominated neighborhoods from financial institutions.[8]

Green Area Segregation

One amenity that people of color disproportionately receive less access to compared to White residents is green areas. Green areas are designated spaces of nature, such as parks and green roofs, aimed to mitigate air pollution, improve city residents' physical and mental health, cool down nearby areas during warm months, and enhance neighborhood aesthetics. While one study finds that people of color are not necessarily located further from green spaces than White individuals, people of color are more likely to be deterred from visiting and utilizing green spaces due to lack of "social access." [9] The study notes that residents of color are more likely to perceive public green areas as unsafe and less conducive for physical activity as a result if located in neighborhoods with greater crime rates, and they are less likely to have access to easy and safe transportation methods to these green areas.[10]

Furthermore, green areas also increase the average property value in nearby areas.[11] While increasing property value may be economically advantageous for more affluent city dwellers looking to sell their property, it ultimately worsens racial segregation in Chicago. Since residents of color considerably have lower income than White individuals, they are less capable of affording higher property values in neighborhoods encompassing green areas, deterring them from purchasing homes in those areas.[12] Given Chicago's severe racial segregation, it may be possible that there are spatial, economic, and social inequities regarding access to green areas, necessitating the reason for this policy memo,

CitySpace Program

Being such a highly populous city, Chicago inevitably experiences high levels of air pollution, from the thousands of people who rely on the trains and buses to commute to their school, job, or home, to the hundreds of businesses that contribute to air pollutant emissions in the city center. As a result, Chicago is considered to have one of the worst air qualities in the country according to the American Lung Association in 2019.[13] High levels of air pollutants like carbon monoxide (CO), hydrogen sulfide (H_2S), and nitrogen dioxide (NO_2) are not only dangerous to the environment by creating more ozone and worsening the effects of global warming, but they also have significant detrimental effects on residents' physical health. City residents exposed to higher levels of air pollution and ozone are more likely to suffer from asthma, heart disease, and

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[8] Ciesemier, K., & Amezcua, M. (2023, May 18). *The Consequences of Chicago's Segregated Housing History*. American Civil Liberties Union. Retrieved July 31, 2024, from aclu.org/podcast/the-consequences-of-chicagos-history-of-housing-segregation

[9] Wen, M., Zhang, X., Harris, C. D., Holt, J. B., & Croft, J. B. (2013). Spatial Disparities in the Distribution of Parks and Green Spaces in the USA. *Annals of Behavioral Medicine*, *45*(Suppl 1), 18–27. doi.org/10.1007/s12160-012-9426-x

[10] See Footnote 9.

[11] *CitySpace: An Open Space Plan For Chicago (What Chicago Needs Today)*. (1998, January). City of Chicago. Retrieved July 31, 2024, from chicago.gov/city/en/depts/dcd/supp_info/cityspace_plan.html

[12] See Footnote 6.

[13] Ruppenthal, A. (2019, April 24). *Chicago Among the Country's Most Polluted Cities, Study Finds*. WTTW News. Retrieved July 31, 2024, from news.wttw.com/2019/04/24/chicago-among-country-s-most-polluted-cities-study-finds

lung diseases.[14] In addition, people of color are more likely to suffer from these conditions than White individuals.[15] Thus, if green spaces are less accessible to people of color, they are less susceptible to experiencing the health benefits associated with utilizing green spaces.

Attempting to combat the city's dangerously heavy air pollution and improve its residents' physical health, Chicago's city government collaborated with non-governmental organizations and local neighborhood initiatives to found the CitySpace program in the 1990s, aiming to build more conservation areas and green roofs in city neighborhoods.[16] The cumulative success of this program over the past three decades led to Chicago being consistently ranked as one of the nation's greenest cities, where 70% of the city is green-certified.[17]

The Chicago city government outlined 21 actions they would take to implement the CitySpace program at its creation in 1990, detailing how they would physically and financially acquire diverse lands and vacant lots to build parks and conservation areas.[18] Most notably, however, the plan fails to consider Chicago's high level of segregation. They fail to mention specific actions they would take to ensure that all racial groups experience the benefits of these green spaces. Furthermore, recent government officials have deprioritized the execution and success of this initiative, suggesting that a quality assurance review is due that assesses whether green areas actually produce beneficial effects on local residents and the environment.[19]

Purpose of Policy Memo: Evaluating CitySpace Program Equity and Effectiveness

Although people of color are not disproportionately located further away from green spaces at the national level, it is important to investigate whether this pattern is consistent at the census tract level in Chicago, given the city's high level of racial segregation. Doing so can provide a benchmark of Chicago's environmental segregation compared to cities across the country, which can provide insight on how to improve these green spaces to be more effective and accessible for all racial and socioeconomic groups. Furthermore, the fact that the CitySpace program has been less prioritized by Chicago government leaders in recent years suggests that there may be quality issues in the conservation and green roof areas that have been built.

Thus, this policy memo intends to investigate the patterns in racial majorities, property value, and green space access across Chicago's census tracts. In doing so, it will evaluate the extent of which Chicago's green spaces and green roof initiatives have improved the local air quality. By the end of this policy memo, readers will have a clearer picture of the distribution of green areas between predominantly White neighborhoods and neighborhoods of color, as well as identify potential policy initiatives that will mitigate these harmful patterns.

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[14] See Footnote 13.

[15] Ndugga, N., Hill, L., & Artiga, S. (2024, June 11). *Key Data on Health and Health Care by Race and Ethnicity*. KFF. Retrieved July 31, 2024, from kff.org/key-data-on-health-and-health-care-by-race-and-ethnicity/?entry=social-determinants-of-health-experiences-with-racism-discrimination-and-unfair-treatment

[16] See Footnote 11.

[17] Mayor's Press Office. (2018, August 23). *Chicago Ranked as Nation's Greenest City by Green Building Adoption Index*. City of Chicago. Retrieved July 31, 2024, from chicago.gov/city/en/depts/mayor/press_room/press_releases/2018/august/GreenestCity.html

[18] See Footnote 11.

[19] Tan, N. (2022, November 16). *A Garden in the Sky: Chicago's Green Rooftop Revolution*. Midstory. Retrieved July 31, 2024, from midstory.org/a-garden-in-the-sky-chicagos-green-rooftop-revolution/

Data

Datasets and Methods

To investigate these issues, I leverage data from Chicago's Array of Things project: a city-wide initiative that installed remote sensing sensors at 115 bus stops to collect daily measurements of environmental conditions, including daily average air pollutant levels of NO_2, CO, and H_2S measured in parts per million (ppm).[20] It also includes daily average measurements of temperature, pressure, and humidity. These measurements are aggregated at the month level, and the period for analysis is February 2018 to February 2019. In addition, I utilize data from the Chicago 2022 census to spatially visualize each census tract and its associated demographics, including total population, racial composition, and median property value. Lastly, to measure each census tract's "greenness," I use two datasets that measure whether each census tract intersects with a conservation area and the total number of green roofs per tract. Analyzing these datasets both separately and combined will provide a clearer picture of the distribution of green areas across Chicago spatially and temporally.

[20] *Array of Things*. (n.d.). Retrieved July 31, 2024, from arrayofthings.github.io/

Analysis 1: Spatial Comparison of Racial Majority and Median Home Value

Figure 1. Racial Composition

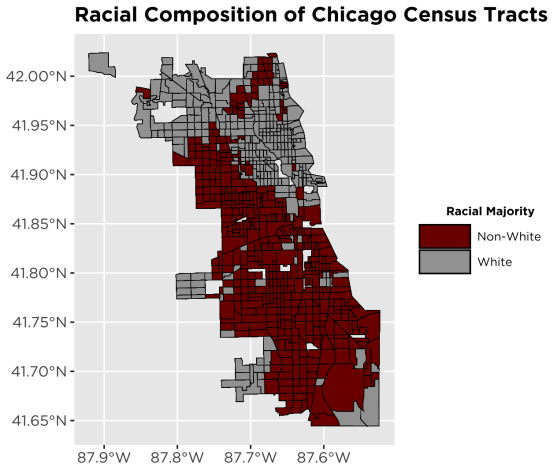


Figure 2. Median Home Value

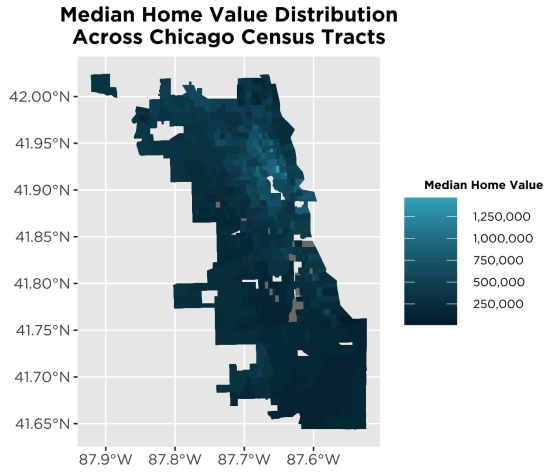
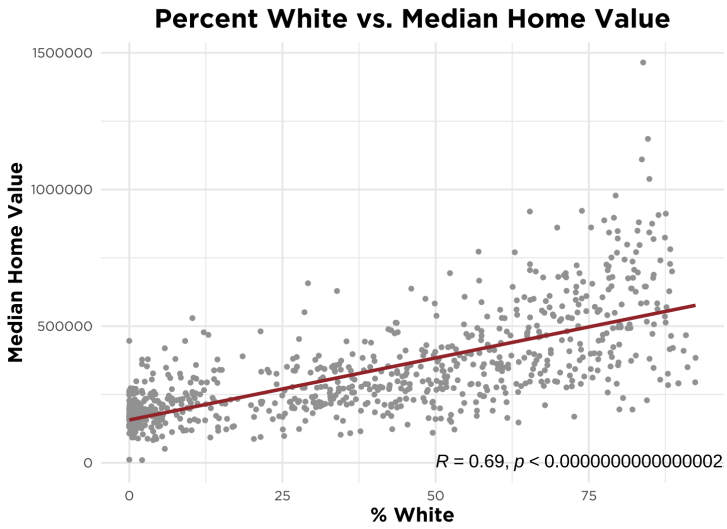


Figure 3. Percent White Vs. Median Home Value



Interpretation

Comparing Figures 1 and 2, white residents are the majority racial group in the tracts with the greatest median home value. Running a linear regression on the two variables, the results state that with each 1% increase in white residents, the median home value increases by $4,538, with a t-value of 26.47. Furthermore, Figure 3 illustrates the strong correlation between these two variables. These figures confirm that racial group significantly correlates with median home value within a census tract.

Analysis 1.5: Linear Relationship Between Median Home Value, Conservation Access, and Number of Green Roofs

Figure 4. Linear Regression Results

Variable	Estimate	t-value	p-value
Median Home Value	0.00000016897	7.1400	< 0.001

Interpretation

As the median home value of a census tract increases by $100,000 (adjusting the estimate by multiplying by 100,000), the probability of conservation access and the number of green roofs increase by 0.016. While this impact may seem minimal initially, the low number of tracts with conservation access and green roofs makes this increase significant. Therefore, it can be concluded that as median home value increases, green space access increases as well.

Analysis 2: Spatial Distribution Comparison of Green Roofs and Conservation Area Access Between Racial Majorities

Figure 5. Conservation Access Distribution

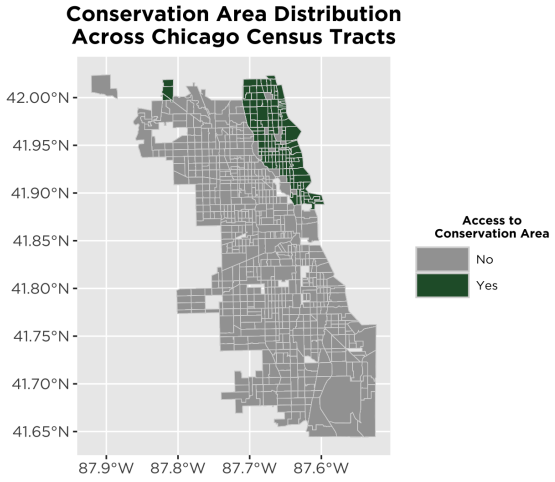


Figure 6. Green Roof Distribution

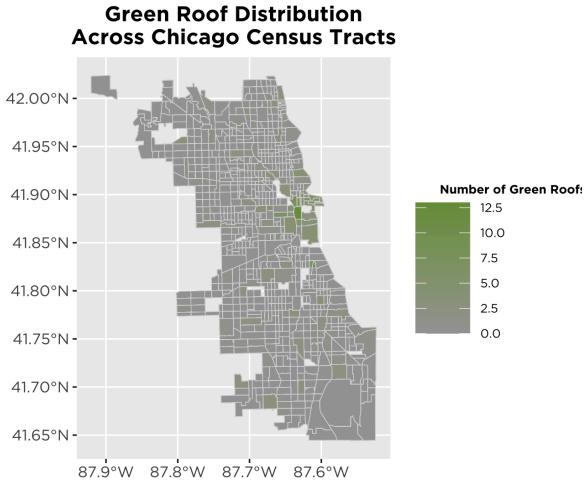
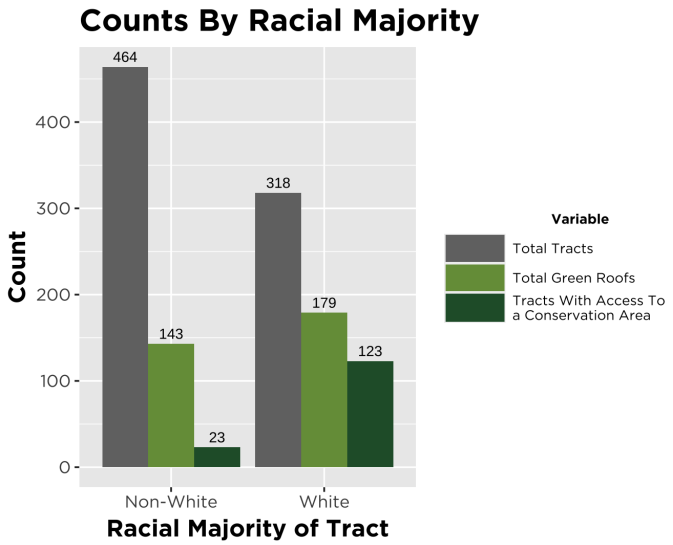


Figure X.

Figure 7. Counts by Racial Majority



Interpretation

Despite making up more than 60% of Chicago's census tracts, tracts with a majority non-white population have considerably fewer conservation areas and green roofs. Thus, the data confirms an unequal distribution of green areas between white and racially marginalized neighborhoods. When comparing the spatial distribution of conservation areas and green roofs (depicted in Figures 5 and 6) with the spatial distributions of racial composition and median home value (displayed in Figures 1 and 2), one can see that access to green areas primarily overlap with predominantly white populations and high property values and less with predominantly non-white populations and low property values.

Analysis 3: Linear Relationship Between Dominant Race, Number of Green Roofs, and Access to Conservation Area at Tract Level

Figure 8. Linear Regression Results.

Racial Group	Estimate	t-value	p-value
% Black	-0.4844	-4.1090	< 0.001
% Hispanic	-0.9036	-5.6480	< 0.001
% Asian	2.6268	5.7780	< 0.001
% Indian	-9.2946	-2.9480	< 0.05
% White	0.6133	7.9860	< 0.001

Significant decrease

Interpretation

As the percentage of Black, Hispanic, and Indian residents in a census tract increases, green roofs and conservation areas become less accessible and are built less frequently. As the percentage of Asian and White residents in a census tract increases, green roofs and conservation areas become more accessible and are built more frequently. These results indicate that green initiatives are more likely to be located in areas with more Asian and White residents, confirming that there is a spatial inequity in green area access between racial groups.

Analysis 4: Relationship Between Conservation Area Access, Number of Green Roofs, and Average Daily Air Pollutant Levels (NO_2, H_2S, and CO) By Month

Figure 9. NO_2 Levels

Month	Intercept Estimate	Conservation Estimate	Conservation t-value	Conservation p-value	Green Roofs Estimate	Green Roofs t-value	Green Roofs p-value
Feb. 2018	0.0174	-0.0015	-10.23	< 0.001	-0.0002	-4.22	< 0.001
Mar. 2018	0.0244	-0.0036	-25.58	< 0.001	-0.0002	-4.91	< 0.001
Apr. 2018	0.0248	-0.0032	-22.35	< 0.001	Not significant	-1.63	> 0.05
May. 2018	0.02	-0.0019	-21.12	< 0.001	-0.0001	-3.11	< 0.05
Jun. 2018	0.0066	0.0001	3.31	< 0.05	Not significant	-1.57	> 0.05
Jul. 2018	0.0103	0.0003	5.3	< 0.001	-0.00004	-2.11	< 0.05
Aug. 2018	0.0104	0.002	14.11	< 0.001	0.0002	4.74	< 0.001
Sep. 2018	0.007	0.0015	15.7	< 0.001	0.0001	3.04	< 0.05
Oct. 2018	0.0089	0.0011	13.73	< 0.001	Not significant	-0.69	> 0.05
Nov. 2018	0.0172	-0.0066	-6.43	< 0.001	-0.0009	-2.49	< 0.05
Dec. 2018	0.006	Not significant	0.48	> 0.05	0.0002	3.64	< 0.05
Jan. 2019	0.0049	-0.0015	-21.58	< 0.001	0.0001	6.26	< 0.001
Feb. 2019	0.0051	-0.0011	-10.61	< 0.001	Not significant	-0.91	> 0.05

Figure 10. H_2S Levels

Month	Intercept Estimate	Conservation Estimate	Conservation t-value	Conservation p-value	Green Roofs Estimate	Green Roofs t-value	Green Roofs p-value
Feb. 2018	0.0201	-0.0074	-16.55	< 0.001	-0.0003	-2.11	< 0.05
Mar. 2018	0.0337	0.002	5.56	< 0.001	-0.0005	-4.26	< 0.001
Apr. 2018	0.127	0.0471	22.76	< 0.001	0.0033	4.8	< 0.001
May. 2018	0.0691	-0.0133	-11.94	< 0.001	0.001	2.61	< 0.01
Jun. 2018	0.074	0.0658	4.32	< 0.001	-0.0122	-2.41	< 0.05
Jul. 2018	0.1312	N/A	N/A	N/A	Not significant	-0.92	> 0.05
Aug. 2018	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Sep. 2018	0.3432	-0.1833	-3.51	< 0.001	Not significant	-1.88	> 0.05
Oct. 2018	0.071	0.1603	13.76	< 0.001	-0.0108	-2.79	< 0.01
Nov. 2018	0.2048	-0.0431	-4.43	< 0.001	-0.0087	-2.68	< 0.01
Dec. 2018	0.1184	-0.0062	-5.03	< 0.001	0.0013	3.15	< 0.01
Jan. 2019	0.7226	-0.088	-5.16	< 0.001	Not significant	-1.8	> 0.05
Feb. 2019	1.4187	Not significant	0.13	> 0.05	-0.0106	-2.46	< 0.05

Figure 11. CO Levels

Month	Intercept Estimate	Conservation Estimate	Conservation t-value	Conservation p-value	Green Roofs Estimate	Green Roofs t-value	Green Roofs p-value
Feb. 2018	1.5624	-0.4214	-7.62	< 0.001	Not Significant	-1.6	> 0.05
Mar. 2018	1.1161	0.1406	20.05	< 0.001	-0.0067	-2.89	< 0.01
Apr. 2018	0.6836	-0.0068	-11.16	< 0.001	0.00007	0.37	> 0.05
May. 2018	1.8453	< -0.0001	-6.06	< 0.001	< -0.0001	6.14	< 0.001
Jun. 2018	0.3568	4.7646	9.21	< 0.001	Not Significant	-1.43	> 0.05
Jul. 2018	2.722	N/A	N/A	N/A	-0.48	-0.47	> 0.05
Aug. 2018	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Sep. 2018	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Oct. 2018	2.1834	9.6081	20.81	< 0.001	-0.5796	-4.56	< 0.001
Nov. 2018	3.2216	-1.4523	-6.88	< 0.001	-0.2304	-3.28	< 0.01
Dec. 2018	0.1967	-0.0174	-10.64	< 0.001	-0.0018	-3.34	< 0.01
Jan. 2019	0.3675	Not Significant	-1.49	> 0.05	Not Significant	-0.56	> 0.05
Feb. 2019	0.386	-0.0941	-5.04	< 0.001	-0.0201	-3.24	< 0.01

Key

Significant decrease	Significant increase	Not Significant

NOTE: Month data corresponding to entries with "N/A" were removed from the dataset, as they produced extreme values that may be associated with sensor error.
Interpretation

Interpretation
Contrary to what is expected, access to conservation areas and the number of green roofs do not consistently decrease air pollutant levels at a statistically significant level. While some months do show significant decreases associated with these variables, the impact is minimal, indicating that pollutant levels cannot be entirely predicted by these variables. In the remaining months, these variables have no effect or even increase the amount of air pollution. However, conservation areas seem to have a more substantial and consistent impact on air pollution than green roofs, suggesting they are slightly more effective in improving air quality. One possible explanation for these weak relationships is that the air pollution levels measured are already at low levels, which could limit the observable impact of these variables. Additionally, other factors not accounted for in this analysis may influence air pollution levels, mitigating the apparent effectiveness of green roofs and conservation areas.

Analysis 5: Relationship Between Conservation Area Access, Number of Green Roofs, and Average Daily Temperature By Month

Figure 12. Linear Regression Results

Month	Intercept Estimate	Conservation Estimate	Conservation t-value	Conservation p-value	Green Roofs Estimate	Green Roofs t-value	Green Roofs p-value
Feb. 2018	0.0174	-0.0015	-10.2338	< 0.001	-0.0002	-4.2206	< 0.001
Mar. 2018	0.0244	-0.0036	-25.5818	< 0.001	-0.0002	-4.9061	< 0.001
Apr. 2018	0.0248	-0.0032	-22.3476	< 0.001	Not Significant	-1.6292	> 0.05
May. 2018	0.0200	-0.0019	-21.1196	< 0.001	-0.0001	-3.1087	< 0.05
Jun. 2018	0.0066	0.0001	3.3071	< 0.001	Not Significant	-1.5678	> 0.05
Jul. 2018	0.0103	0.0003	5.3000	< 0.001	-0.00004	-2.1052	< 0.05
Aug. 2018	0.0104	0.0020	14.1073	< 0.001	0.0002	4.7440	< 0.001
Sep. 2018	0.0070	0.0015	15.6972	< 0.001	0.0001	3.0423	< 0.05
Oct. 2018	0.0089	0.0011	13.7345	< 0.001	Not Significant	-0.6933	> 0.05
Nov. 2018	0.0172	-0.0066	-6.4342	< 0.001	-0.0009	-2.4880	< 0.05
Dec. 2018	0.0060	Not Significant	0.4831	> 0.05	0.0002	3.6426	< 0.05
Jan. 2019	0.0049	-0.0015	-21.5796	< 0.001	0.0001	6.2565	< 0.001
Feb. 2019	0.0051	-0.0011	-10.6139	< 0.001	Not Significant	-0.9117	> 0.05

Interpretation

Similar to their effects on air pollution, access to conservation areas and the number of green roofs do not consistently decrease temperatures at a statistically significant level. While some months do show significant decreases, the impact is once again minimal, indicating that temperature also cannot be entirely predicted by these variables. Furthermore, temperature decreases are only found in the cooler months (except for July 2018), which is naturally expected due to the nature of the cooler climate; thus, it is difficult to identify whether conservation area access and green roof counts significantly contribute to these cooler temperatures at all. Additionally, other factors not accounted for in this analysis may influence air pollution levels, further mitigating the apparent effectiveness of green roofs and conservation areas in reducing temperature.

Policy Recommendation

The city of Chicago is clearly environmentally segregated along racial lines. Racially marginalized communities disproportionately lack access to green spaces, which are more frequently located in areas with greater property values, those of which residents of color are less capable of affording. Furthermore, conservation areas and green roofs have minimal impacts on reducing air pollution levels and temperature, demonstrating that these green spaces need to be thoroughly reviewed and dramatically improved.

Given these results, Chicago's CitySpace program must be revamped to incorporate demographic criteria in decisions about new green areas and green roofs. **Two** key initiatives can fulfill these goals:

I. **Develop Targeted Implementation Plans**: Prioritize the installation of green spaces in areas with little access to existing parks, which are primarily racially marginalized communities.
II. **Enhance Accessibility**: Ensure that new green areas are easily walkable by building them near existing amenities. Ensure that these spaces are located in "public rights of way" so that they are easily accessible for pedestrians.[21]

Furthermore, it is not enough to simply build conservation areas and green roofs in racially marginalized communities; rather, Chicago's city government must ensure that the green areas themselves exhibit a welcoming environment to all racial and socioeconomic cultures. As mentioned previously, even when green areas are built in majority racially marginalized communities, residents from marginalized backgrounds are still hesitant to attend due to "interpersonal, practical…factors," including "perceptions of safety and costs associated with travel and accessing green spaces, particularly for families."[22] **Three** key initiatives can improve the perception of green areas:

I. **Promote Safety and Engagement**: Implement safety precautions, such as increased lighting, security, and protective infrastructure, to build trust with residents that these facilities are safe. Employ security personnel who are well knowledged about local green area initiatives and can answer any questions residents may have, while also monitoring the safety of local residents using green space amenities.
II. **Foster Community Partnerships**: Collaborate with local organizations and activists to ensure that green spaces reflect the cultural and social needs of the communities they serve. Incentivize local organizations to host cultural events in these green spaces to foster a sense of community and increase green area utilization.
III. **Educate Local Residents**: Hold quarterly town hall meetings for residents to ask questions about the progress of green space initiatives and offer feedback in

[21] CDC. (2024, February 6). *Parks, Recreation, and Green Spaces | Active People, Healthy Nation*. CDC. Retrieved July 31, 2024, from https://www.cdc.gov/active-people-healthy-nation/php/tools/parks-rec.html
[22] Robinson, T., Robertson, N., Curtis, F., Darko, N., & Jones, C. R. (2022). Examining Psychosocial and Economic Barriers to Green Space Access for Racialised Individuals and Families: A Narrative Literature Review of the Evidence to Date. *International Journal of Environmental Research and Public Health*, *20*(1), 745. doi.org/10.3390/ijerph2

decision-making processes. This strengthens their trust by ensuring the spaces meet their needs.

These initiatives will not only create more awareness about the benefits of green spaces, but it will also foster community and inclusivity. Additionally, incentivizing local organizations and employing security personnel will create more employment opportunities for residents with difficulties finding new jobs.

Lastly, Chicago leaders must organize reviews on existing conservation areas to monitor these green areas' effectiveness, both in improving environmental conditions and serving local communities' needs. **Two** key initiatives can fulfill this goal:

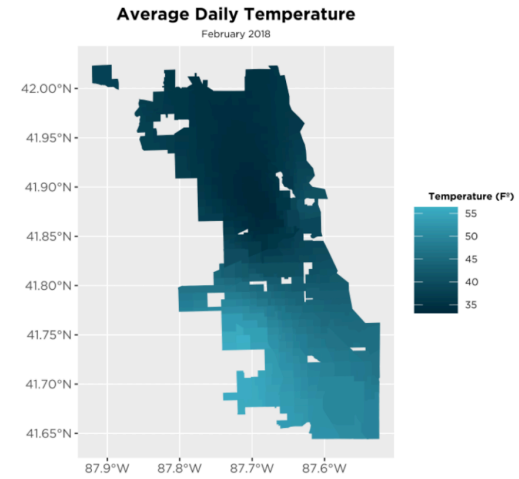
I. **Establish a Data Collecting and Monitoring Task Force**: Collaborate with local researchers, NGOs, and think tanks to form an official federal coalition dedicated to collecting and analyzing data on environmental conditions, urban design features, public health, and community feedback. The task force will create quarterly reports that evaluate the green areas' effectiveness at addressing local needs, cooling temperatures, and improving air quality.
II. **Build Sustainable and Accessible Urban Design Features:** Install shaded features that offset extreme temperatures while also serving as a space for residents to cool down. Increase vegetation and greenery within these areas to mitigate air pollution while offering residents opportunities to plant them, further fostering engagement, utilization, and a sense of community.

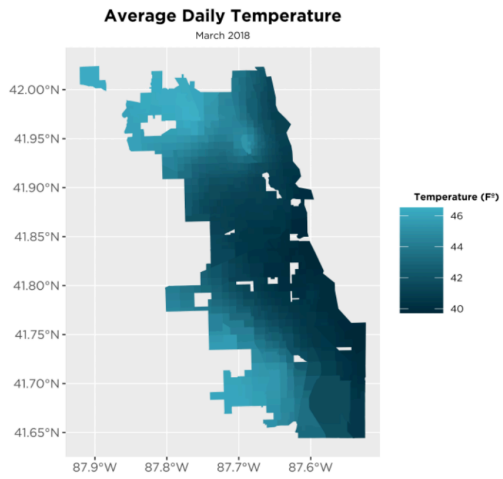
While there will be initial costs associated with developing new green areas and green roofs, redesigning streets to make them more accessible for green areas, and hiring employees to host events and monitor these spaces, these investments are likely to be cost-effective in the long run. Fostering community in these spaces can reduce crime rates, which reduces costs associated with enhanced security measures and disaster recovery. When green spaces are effective at reducing air pollution, they also reduce healthcare costs as residents live healthier lives.

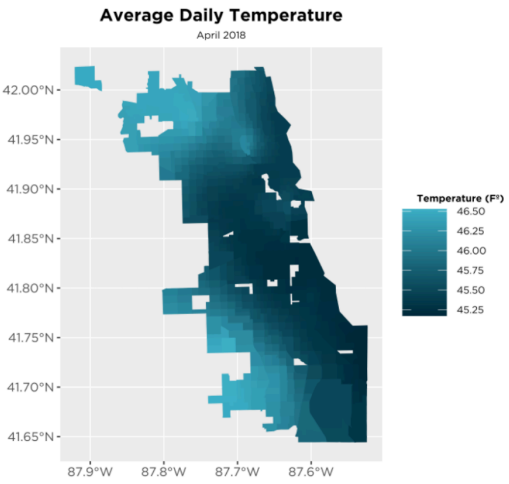
In summary, these policies can serve as a crucial step toward building a more sustainable and equitable city. They allow for meaningful and unique opportunities for environmental improvements and social justice to intersect and enhance the quality of life for all residents of Chicago, making considerable leaps to integrate the diverse and populous city.

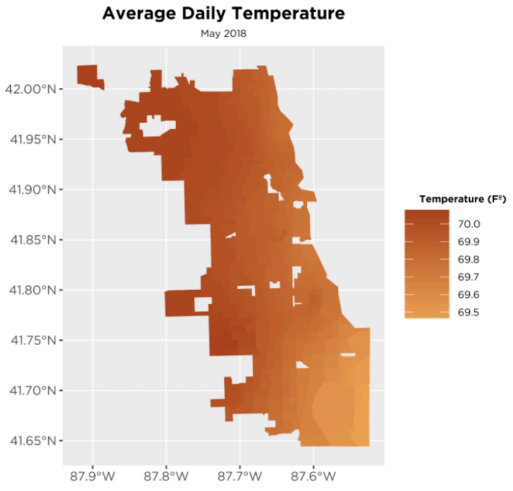
Appendices

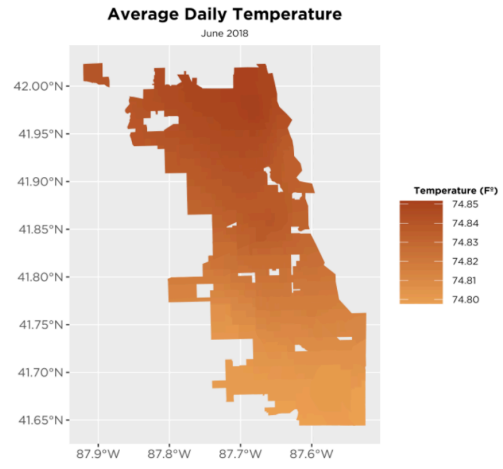
Appendix 1: Spatial Distribution of Average Daily Temperatures Per Month

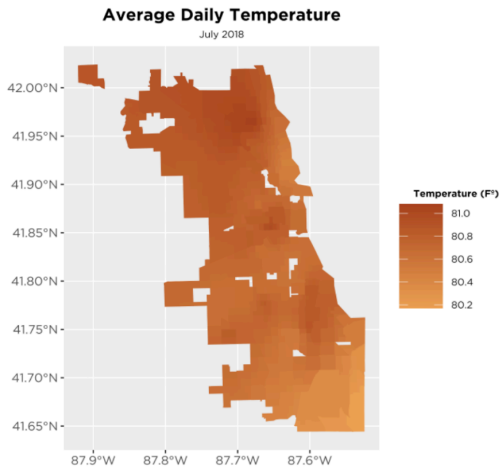


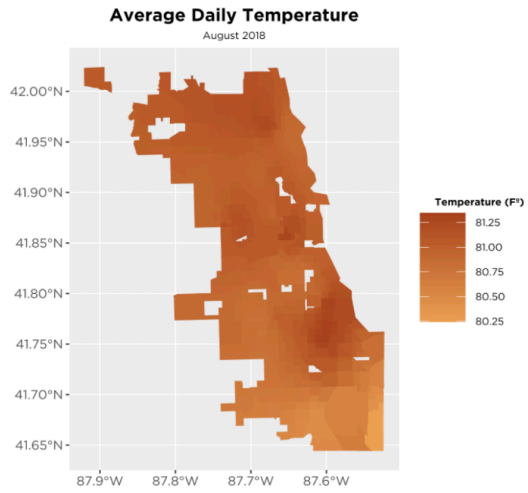


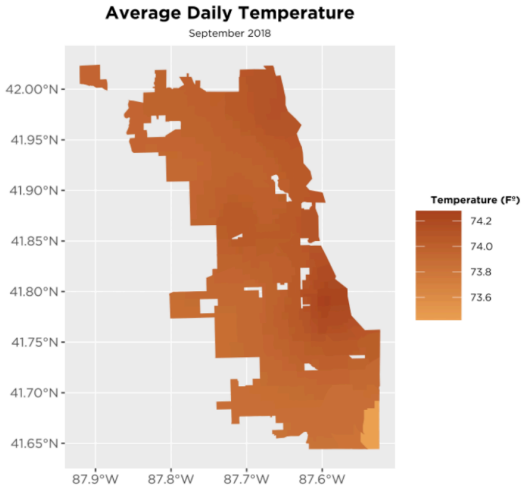


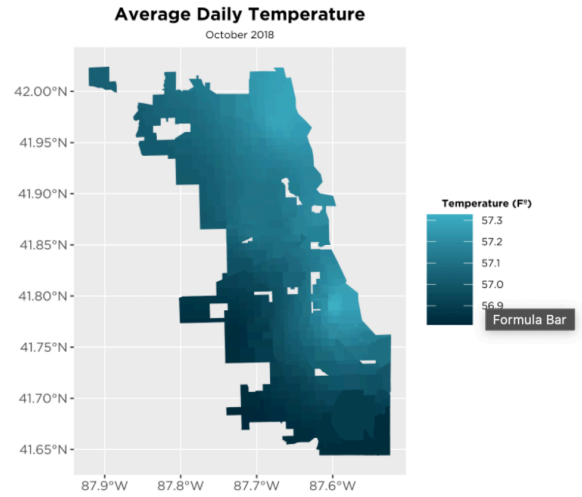


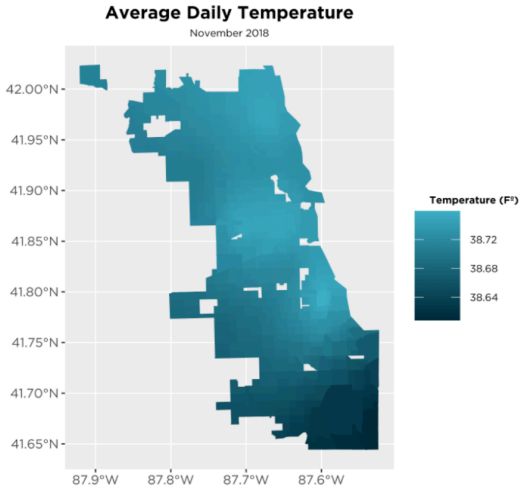


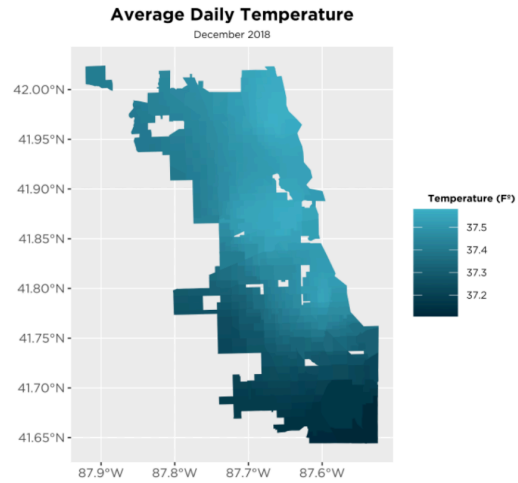


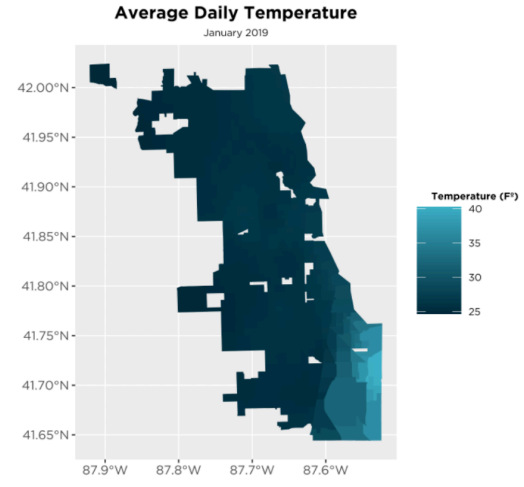

Average Daily Temperature
August 2018
42.00°N
41.95°N
41.90°N
41.85°N
41.80°N
41.75°N
41.70°N
41.65°N
87.9°W
87.8°W
87.7°W
87.6°W
Temperature (F°)
81.25
81.00
80.75
80.50
80.25

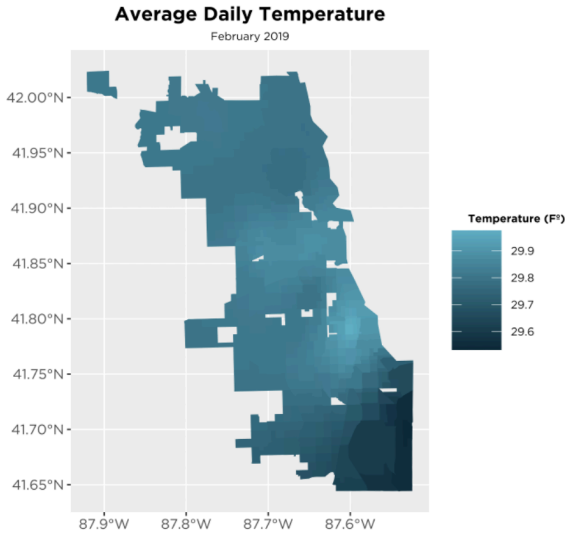

Average Daily Temperature
September 2018
42.00°N
41.95°N
41.90°N
41.85°N
41.80°N
41.75°N
41.70°N
41.65°N
87.9°W
87.8°W
87.7°W
87.6°W
Temperature (F°)
74.2
74.0
73.8
73.6


Average Daily Temperature
October 2018
42.00°N
41.95°N
41.90°N
41.85°N
41.80°N
41.75°N
41.70°N
41.65°N
87.9°W
87.8°W
87.7°W
87.6°W
Temperature (F°)
57.3
57.2
57.1
57.0
Formula Bar


Average Daily Temperature
November 2018
42.00°N
41.95°N
41.90°N
41.85°N
41.80°N
41.75°N
41.70°N
41.65°N
87.9°W
87.8°W
87.7°W
87.6°W
Temperature (F°)
38.72
38.68
38.64


Average Daily Temperature
December 2018
42.00°N
41.95°N
41.90°N
41.85°N
41.80°N
41.75°N
41.70°N
41.65°N
87.9°W
87.8°W
87.7°W
87.6°W
Temperature (F°)
37.5
37.4
37.3
37.2

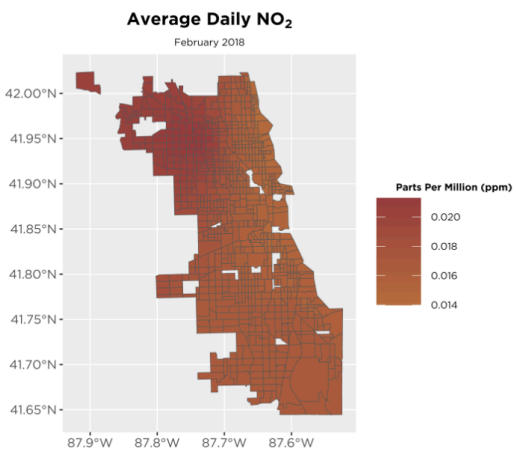

Average Daily Temperature
January 2019
42.00°N
41.95°N
41.90°N
41.85°N
41.80°N
41.75°N
41.70°N
41.65°N
87.9°W
87.8°W
87.7°W
87.6°W
Temperature (F°)
40
35
30
25

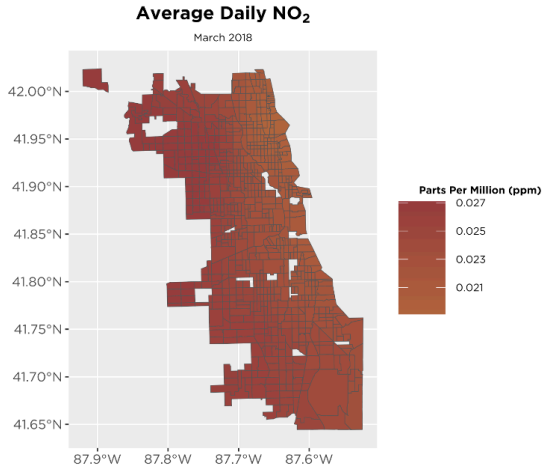


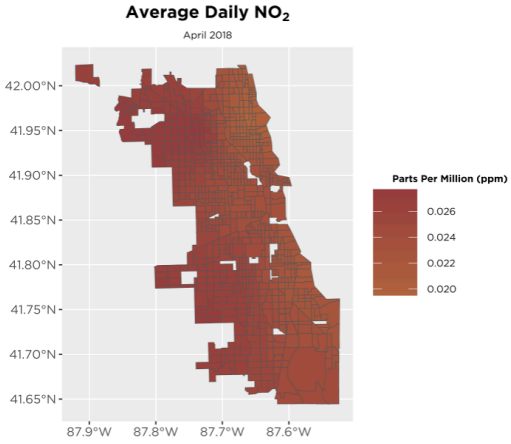
Interpretation

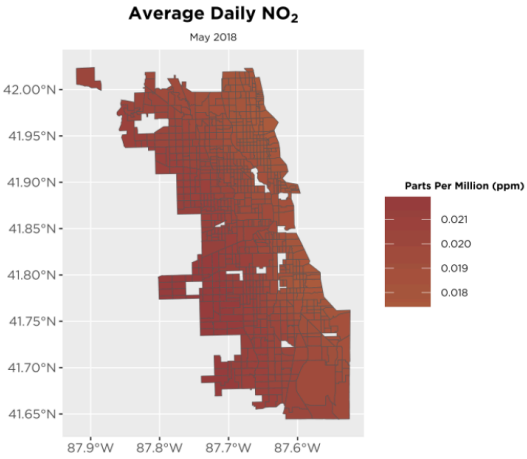
When comparing these maps to Figure X, it can be generally observed that the non-white majority census tracts overlap with the darker-colored temperatures (more extreme temperatures) more often. Since extreme temperatures are linked to climate change, further research can be done to determine whether non-white majority census tracts are more subject to climate change than white-majority census tracts.

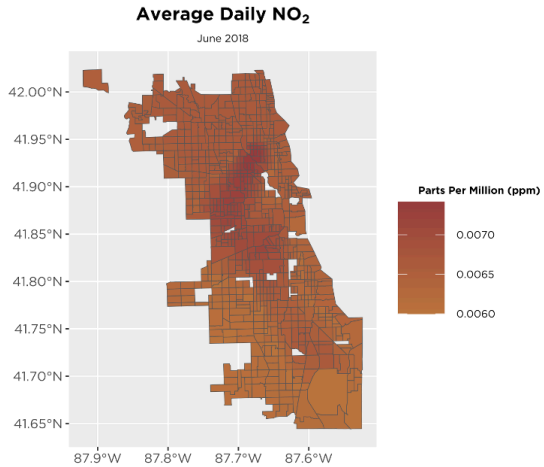
Appendix 2: Average Daily NO_2 Levels Per Month

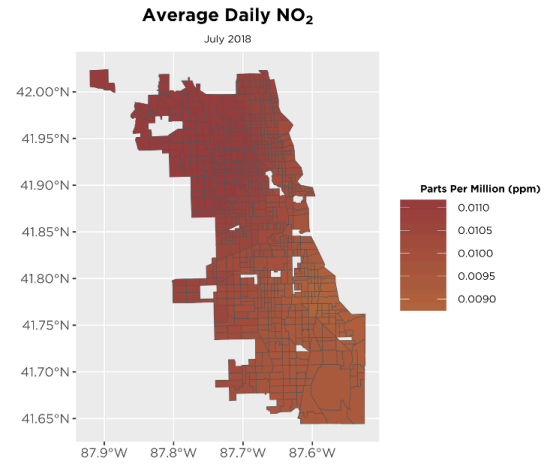


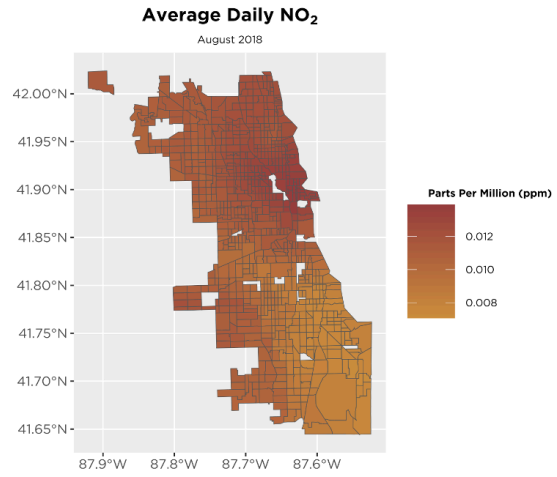


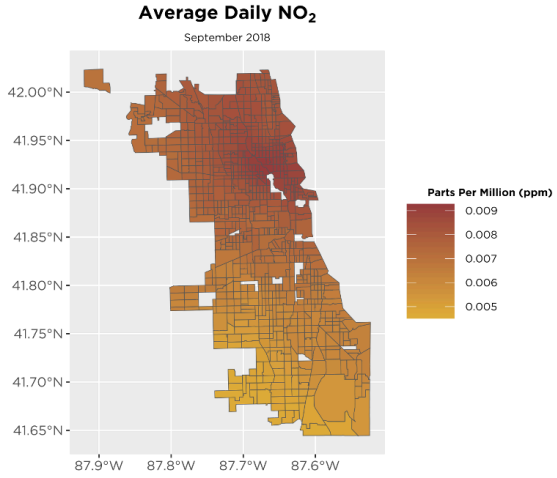


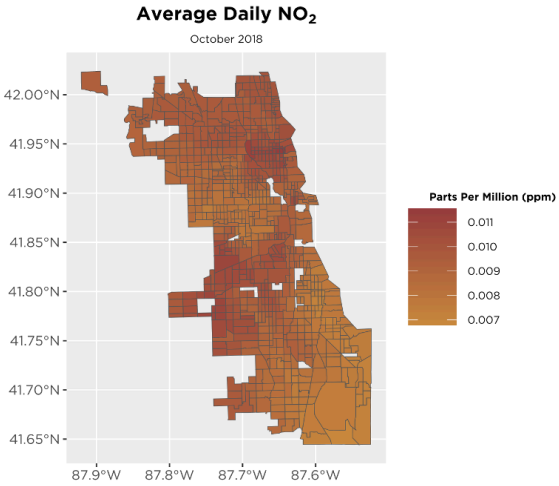


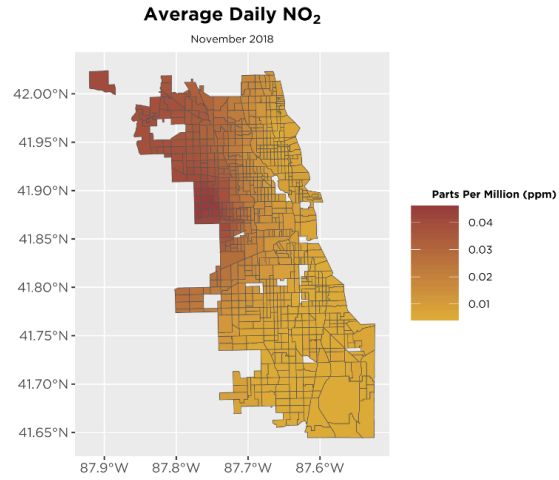


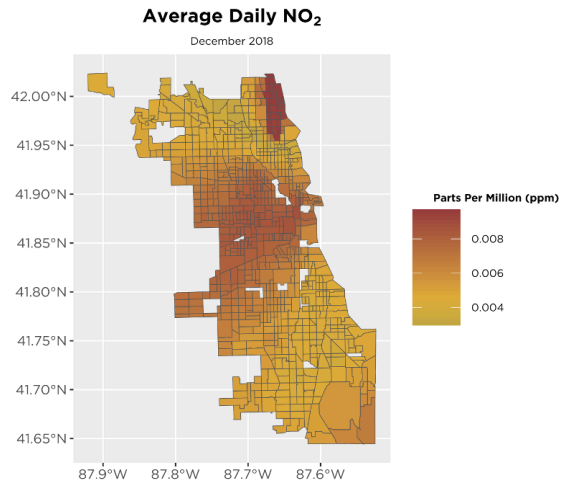


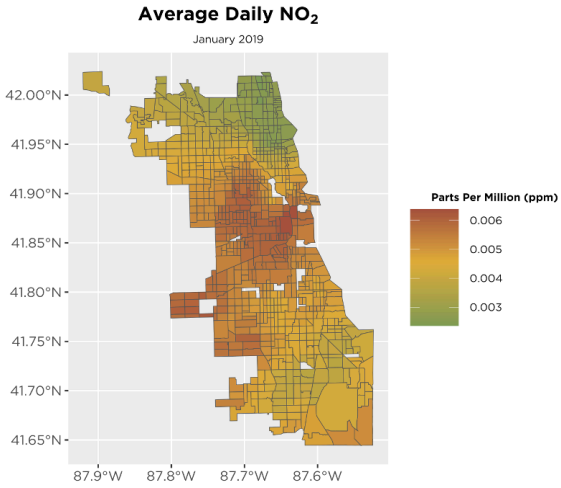

Average Daily NO_2
August 2018
42.00°N
41.95°N
41.90°N
41.85°N
41.80°N
41.75°N
41.70°N
41.65°N
87.9°W
87.8°W
87.7°W
87.6°W
Parts Per Million (ppm)
0.012
0.010
0.008

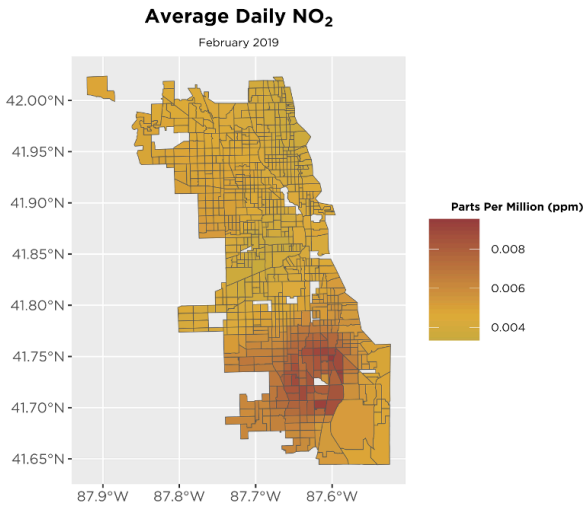

Average Daily NO_2
September 2018
42.00°N
41.95°N
41.90°N
41.85°N
41.80°N
41.75°N
41.70°N
41.65°N
87.9°W
87.8°W
87.7°W
87.6°W
Parts Per Million (ppm)
0.009
0.008
0.007
0.006
0.005


Average Daily NO_2
October 2018
42.00°N
41.95°N
41.90°N
41.85°N
41.80°N
41.75°N
41.70°N
41.65°N
87.9°W
87.8°W
87.7°W
87.6°W
Parts Per Million (ppm)
0.011
0.010
0.009
0.008
0.007


Average Daily NO_2
November 2018
42.00°N
41.95°N
41.90°N
41.85°N
41.80°N
41.75°N
41.70°N
41.65°N
87.9°W
87.8°W
87.7°W
87.6°W
Parts Per Million (ppm)
0.04
0.03
0.02
0.01


Average Daily NO_2
December 2018
42.00°N
41.95°N
41.90°N
41.85°N
41.80°N
41.75°N
41.70°N
41.65°N
87.9°W
87.8°W
87.7°W
87.6°W
Parts Per Million (ppm)
0.008
0.006
0.004


Average Daily NO_2
January 2019
42.00°N
41.95°N
41.90°N
41.85°N
41.80°N
41.75°N
41.70°N
41.65°N
87.9°W
87.8°W
87.7°W
87.6°W
Parts Per Million (ppm)
0.006
0.005
0.004
0.003



Interpretation

When comparing these maps to Figure X, it can be generally observed that areas with the lowest levels of NO_2 (primarily January 2019) are found in tracts that intersect with conservation areas. Further research should measure NO_2 levels and examine conservation areas in these tracts to identify factors contributing to reduced air pollution during the winter months. This could provide further insight on how to improve conservation areas so that they are more successful at reducing air pollution in the other months.