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The Legacy of Redlining: A Geospatial Analysis of Environmental Burdens in Portland, Oregon

by

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The Legacy of Redlining
A Geospatial Analysis of Environmental Burdens in Portland, Oregon

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Abstract
Historically-redlined neighborhoods across the metropolitan United States – most often socioeconomically disadvantaged communities of color – have been shown in multiple studies to be disproportionately affected by environmental burdens, having greater exposure to air, water, and ground pollution as well as being subject to the “urban heat island” effect, among other disparities. Studies into the continuing environmental inequity present in these communities in Portland, Oregon specifically have addressed this phenomenon, finding that these neighborhoods are 8 degrees Fahrenheit warmer on average than their wealthier and (mostly) whiter counterparts, in large part due to a lack of green spaces and tree canopy. While the effects of extreme heat are well-documented (recently illustrated by the record-breaking heatwave in the Pacific Northwest), in what other ways are socioeconomically disadvantaged communities affected by inequitable environmental and urban policies? This project will use the programming language R to create an interactive visualization of 1) recent air toxic emissions and their relation to formerly redlined communities using facility emissions data from the Oregon Department of Environmental Quality. Preliminary results suggest that vulnerable communities are exposed to air toxics at a concentration higher than the average, though this phenomenon is not confined to these formerly redlined areas.

1. Introduction
Decades of research have shown that environmental burdens do not affect all communities equally (Allen, 2001; Tessum et al., 2021). Years before the term “environmental justice” had been coined, researchers had already gathered a body of evidence that suggested low-income and – predominately – Black communities were at higher risk of exposure to pollutants and – in turn – the adverse health effects of such exposure than their wealthier and Whiter counterparts (Ard et al., 2016). Many of these communities were once demarcated as “redlined” communities, where redlining was “the practice of categorizing entire neighborhoods to determine the level of mortgage-lending and insurance-providing to be offered on properties within those neighborhoods” (Ryan, 2018). On the surface, redlining was simply the process of assessing risk, and in the 1930s, the Home Owner’s Loan Corporation (HOLC) was tasked by the federal government to assess this risk by categorizing neighborhoods in cities through the U.S. by their collective ability to secure a loan. In practice, this process discriminately targeted communities of color to disenfranchise them from owning homes and businesses.

As shown in Figure 1 below, neighborhoods were ranked on a scale from A to D, with A neighborhoods considered “Best” (marked in green on housing maps) and D neighborhoods (marked in red) as “Hazardous”. These predominately Black neighborhoods not only had a lower incidence of home ownership due to perceived “risks” that exacerbated wealth inequality in cities, but they also were often overlooked or ignored by commercial and governmental enterprises for decades after these maps were produced. Furthermore, these communities were purposefully disrupted by industry and urban
planning, often being chosen to host industrial facilities that produced air, water, and soil toxics as well as being bisected by freeway expansion projects (Gibson, 2007; Smith, 2009). Conversely, these neighborhoods were often ignored for environmental improvement projects that would have mitigated some of these burdens (Ause, 2016).

![Figure 1. The Home Owner's Loan Corporation (HOLC) Residential Security Map of Portland as it existed in 1934. Areas were ranked as “Best” (green), “Still Desirable” (blue), “Definitely Declining” (yellow) or “Hazardous” (red).](image)

While the practice of redlining was formally ended by the passing of the Fair Housing Act in 1968, the ramifications of the systemic denial of services to these predominantly minority neighborhoods is still being felt today, as these neighborhoods are not only poorer than surrounding areas but are more impacted by the effects of climate change than their wealthier – and often whiter – counterparts (Mitchell et al., 2018). For instance, formerly-redlined areas in Portland are up to 12 degrees Fahrenheit warmer than that city average due to a phenomenon known as “urban heat islands” (Figure 2) where the lack of tree canopy, green spaces, and investment in environmental resilience exacerbates an already warming atmosphere (Hoffman et al., 2020; Shandas & Beaudoin, 2016). Studies in other cities
have also shown that overall air quality is poorer in less-wealthy neighborhoods and that the legacy of low-income residents being forced to live alongside pollution-emitting facilities is still felt decades after these facilities have been decommissioned (Heblich et al., 2021), and poor air quality is directly linked to an increase in mortality across all demographic groups (Anderson, n.d.; Liu et al., 2019). Furthermore, nationwide analysis of pollutant exposure have shown that non-White minority groups are at greater risk of exposure to air pollutants – specifically, PM2.5 – despite producing less pollution than the White majority (Tessum et al., 2019).

Portland, especially, has a unique history of racial segregation. Oregon was one of only six states to not ratify the 18th Amendment, and until 1926, Blacks were not legally permitted to live within the state (Perry, 2020). Those that did live in the Portland Metro area were confined to either the Albina or Vanport neighborhoods, the latter of which was destroyed when the Columbia River flooded in May of 1948 (Geiling, 2015). Despite its modern-day reputation for being a relentlessly progressive city, Portland is still the whitest major city in the United States, and multiple reports show that minority communities are still largely discriminated against:

![Map showing the average temperatures across the City of Portland in the summer of 2015. Analysis showed that formerly redlined neighborhoods were on average 8 degrees Celsius warmer than formerly “greenlined” neighborhoods (Shandas & Beaudoin, 2016).](image)

Figure 2. Map showing the average temperatures across the City of Portland in the summer of 2015. Analysis showed that formerly redlined neighborhoods were on average 8 degrees Celsius warmer than formerly “greenlined” neighborhoods (Shandas & Beaudoin, 2016).
In more recent times, the city repeatedly undertook “urban renewal” projects (such as the construction of Legacy Emanuel Hospital) that decimated the small black community that existed here. And racism persists today. A 2011 audit found that landlords and leasing agents here discriminated against black and Latino renters 64 percent of the time, citing them higher rents or deposits and adding on additional fees. In area schools, African American students are suspended and expelled at a rate four to five times higher than that of their white peers. (Semuels, 2016)

This project seeks to look specifically at how the legacy of formerly redlined neighborhoods still informs racial, economic, and environmental disparities that exist in Portland today by comparing air toxic emitting facilities and overall toxicity relative to these historical areas. We developed a prototype of an open-source framework to encourage researchers to create a single repository of environmental burdens in the Portland area and/or modify to study similar relationships in their own localities.

2. Methodology

2.1 Visual Assets

![Image of the visualization in its current iteration. Visible is the Portland City Limits, the HOLC-grade neighborhoods, location of permitted facilities, and location of moss samples from the 2013 and 2015 heavy metal moss analyses.](image)

With the “open-source” nature of the project, all visual assets and data used were available from public resources and built using the R language (R Core Team, 2020). The basemap (Figure 3) was imported from CartoDB via RStudio, and the city limit boundaries (Figure 3) were retrieved from the City of Portland website in a shapefile format (Metro GIS, 2021; RStudio Team, 2019). The redlining map (Figure 1) was retrieved from the University of Richmond’s “Mapping Inequality” project as well as the shapefile that provided the “Redlined Zones” layer of the final visualization (Figure 3) (Nelson, 2016).

2.2 Air Toxics Emitting Facilities

The facilities inventory was procured from the State of Oregon’s Department of Environmental Quality and imported into R as a data frame. This data frame was then filtered to exclude any facilities not
residing in the Portland Metro Area, leaving 420 facilities in the study group. Using the Leaflet package in R, the latitude and longitude of each facility was used to create a circle marker that would be layered over the grayscale map of Portland. These sites were then clustered to better visualize the distribution of facilities throughout the city.

2.3 Air Toxics Inventory
The 420 facilities in the study group emit 2924 toxics of which 307 are unique. Of those 307, the Oregon Department of Environmental Quality has toxicity reference values (TRVs) for 261. Toxicity reference values characterize the health hazards of chemicals found in the environment and are often categorized as cancerous, non-cancerous, and acute, which indicates organ toxicity (US EPA, 2014). After merging these data sets, we found 1298 toxics in the Portland air toxics inventory that have a TRV defined. Finally, of the original 420 permitted facilities, only 59 sites meet the requirement for additional reporting and for which we have one or more TRVs (Figure 4).

![Diagram](Image)

**Figure 4.** While there are 420 permitted facilities in Portland, only 59 reported emissions above the threshold reporting requirement. Subsequent analysis seeks to determine how accurate this self-reporting method is.

2.4 Toxicity Risk Factor
Toxicity risk factor (TRF) values were calculated by dividing the net emissions in pounds per year of each air toxic from each facility by the TRVs provided by the EPA and the Oregon Department of Environmental Quality.

\[
Toxicity\ Risk\ Factor = \frac{Total\ Emission\ of\ Air\ Toxic\ (lb/year)}{Toxicity\ Reference\ Value\ (\mu m/m^3)}
\]

These values were then summed for each facility to get a gross value for TRF.

\[
Gross\ TRF = \sum Toxicity\ Risk\ Factor
\]
Values were then analyzed to find the mean, median, and maximum across all facilities and are presented in Table 1.

TRFs are useful for comparing the gross toxicity between individual facilities. A higher TRF indicates an increased risk to human health.

2.5 2013 and 2015 Heavy Metal Moss Analysis
Included in the visualization (Figure 3 above) but not included in the overall analysis is data from a study that quantified heavy metals in the environment by analyzing moss samples taken from two separate facility sites in 2013 and 2015 (Gatziolis et al., 2016). The analysis revealed that air toxics from the Bullseye Glass Co. facility were significantly higher than what was being reported. This led to increased scrutiny of and remediations by the company (Environmental Health Assessment Program, 2021). Additional moss analyses throughout Portland could further verify the reported emissions of other facilities.

3. Preliminary Results
As anticipated, there are significantly more permitted facilities in redlined versus greenlined areas - 22 vs. 2 - though the highest number of permitted facilities were in “yellow-lined” or “C-graded” neighborhoods at 72 (Figure 5 below).

![Total Number of Permitted Facilities Across All HOLC-Graded Neighborhoods](image)

![Percent Diversity by HOLC Grade (% Non-White)](image)

*Figure 5. Percentage refers to the total number of residents who self-identified as “non-white” (Hispanic, Black, Asian, or Native American) in the 2019 American Community Survey.*
making any comparison statistically insignificant. However, demographic analysis of these neighborhoods reveals a correlation between the number of permitted facilities and the racial and socioeconomic makeup of the communities in each “grade”. We found that C-graded neighborhoods had the highest population of non-white residents and the lowest median income by household (Figure 6 and 7 below).

![Median Household Income 2009 vs 2019](image)

*Figure 7. Median income correlates with the number of permitted facilities, with C having the most facilities and the lowest median income as of 2019.*

The median TRF value for cancer-causing air toxics was calculated at 922, which was significantly lower than the maximum value of 77,388. This indicates that there are a handful of facilities that produce significantly more toxic elements than the average facility.

Results of the initial statistical analysis are displayed in Table 1 below.

<table>
<thead>
<tr>
<th></th>
<th>Cancer TRF</th>
<th>Non-Cancer TRF</th>
<th>Acute TRF</th>
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<tr>
<td><strong>Mean</strong></td>
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<td>1287</td>
<td>153</td>
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<tr>
<td><strong>Median</strong></td>
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<td>147</td>
<td>8</td>
</tr>
<tr>
<td><strong>Max</strong></td>
<td>77388</td>
<td>33575</td>
<td>5356</td>
</tr>
</tbody>
</table>

*Table 1. Results of the rudimentary statistical analysis of toxicity across emitting facilities. Numbers were rounded to ease comparison, and all values have the same units though can be considered unitless for the purpose of comparison.*

**4. Discussion**

Our preliminary analysis shows a strong correlation between income, racial demographics, and air toxic emitting facilities. Whether there is causation cannot be confirmed at this stage of research, but similar studies throughout the U.S. have revealed a “feedback loop” of sorts, where lower income communities and communities of color are more likely to be permitted for air toxic emitting facilities which then dissuades further private and public investment (Gray et al., 2012). Further research should look at whether air pollution exacerbates income attainment, though prior research into this area has indicated a correlation between air toxics exposure and health and education outcomes (Mohai et al., 2011).
While the TRF technically maintains units of \(\frac{lb \cdot m^3}{\mu m \cdot year}\), it can be thought of as a unitless value for comparison’s sake. Cancer risk has not been assessed for some air toxics, but it is often considered the most valuable metric for the sake of determining the relative toxicity of a compound. As shown in Table 1, there are orders-of-magnitude between the median and mean values for cancer toxicity, indicating that most air toxic producers in Portland are at the lower end of the spectrum in terms of overall toxicity with some outliers that produce most air toxics in the city. These outliers should be studied in more detail.

5. Conclusion
The preliminary results of this project provide further evidence that historically redlined areas are more subject to environmental burdens than formerly greenlined neighborhoods in terms of both the number of facilities present as well as the overall toxicity, though this analysis is far from complete.

In terms of the visualization, the researchers would like to incorporate the urban heat island and tree canopy maps as well as more complete historical data regarding how Portland has changed since the HOLC map was first produced.

Finally, a more detailed statistical analyses of the facilities, toxicity, and geographic data are needed, and this information should be incorporated into the visualization.

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