Vulnerability and Climate Change Adaptation Planning: Heat and Floods in Portland, Oregon

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Reed College
Environmental Studies Department Junior Seminar
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Special thanks to Kristin Bott

Executive Summary

Climate change is not just a problem for polar bears. 7 K H & L W \ R I 3 R U W O D Q G ¶ V

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I. Introduction

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II. Overview of Relevant Literature

Urban flooding is differs from other types of flooding because it occurs quickly and over a more localized area, making it particularly difficult to predict and manage (Ochoa-Rodriguez,

by increases in temperature and urban heat islands due to global warming (Karner et al. 2015). Currently, few transportation plans consider equity when proposing future development (Lee et al. 2017). In contrasW 3RUWODQG¶V 7UDQVSRUWDWLRQ 6\VWHP 3ODQ to transportation as a goal (City of Portland, 2016). The city should work toward this goal when developing and improving climate-adaptive active transportation infrastructure such as sidewalks

Vulnerability Core Maps

The figures in this section introduce the climate hazards and Social Vulnerability Index that we use to address climate vulnerability in Portland.

Figure 1: Urban Heat Island Effect. Urban Heat Island (UHI) effects represented along a scale of 1 to 10 for the city of Portland. a gradient of the coolest (dark blue) to warmest (bright red) places in Portland. Gradient represents

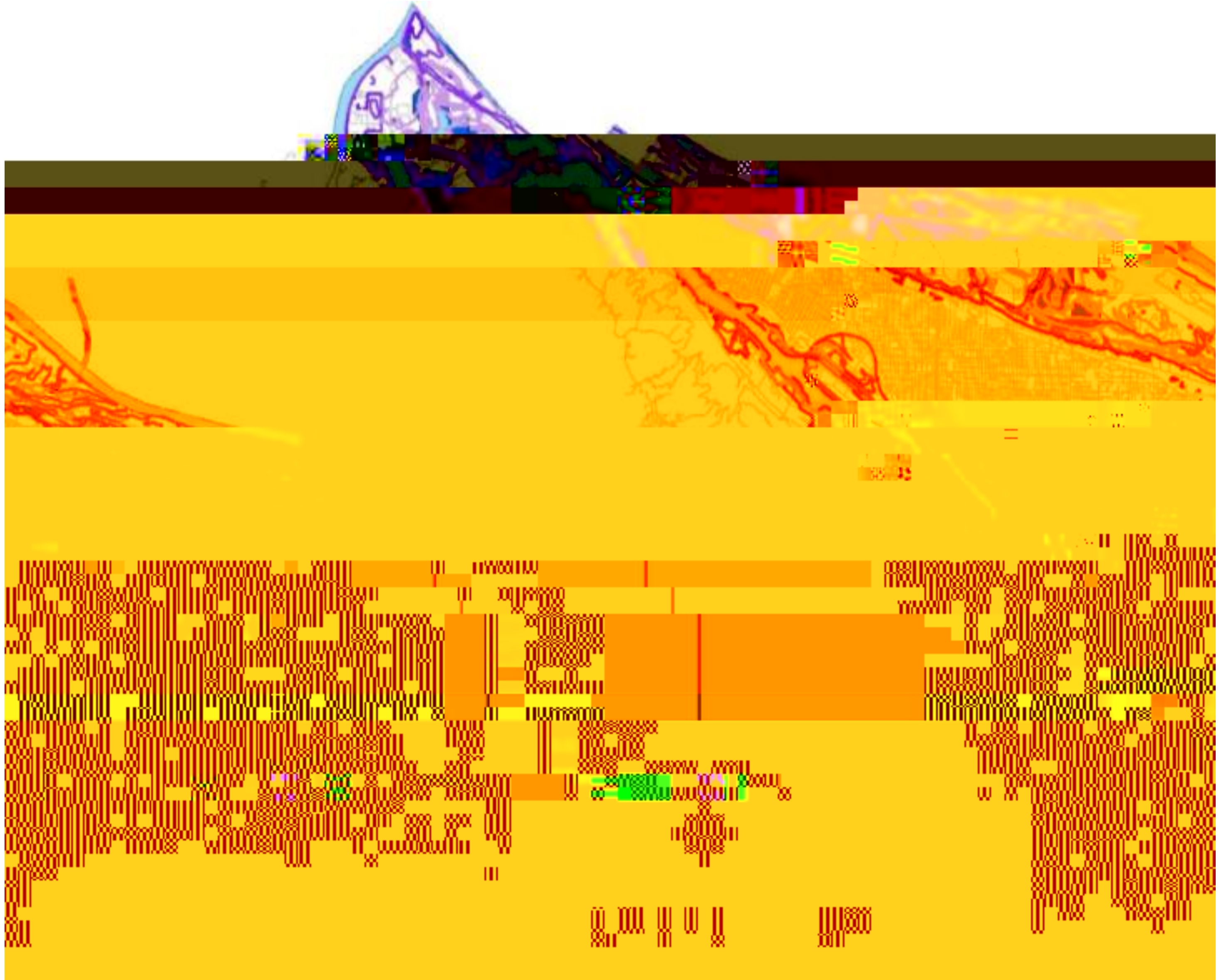


Figure 2: Flood Risk Areas.Risk determined by the FEMA 100-year floodplain (dark blue) and elevation less than 30 feet (purple scale). Creator credit: Anna Miller and Hunter Wise. Data sources: PortlandMaps.com, Portland Bureau of Planning and Sustainability, 2007 LiDAR data.

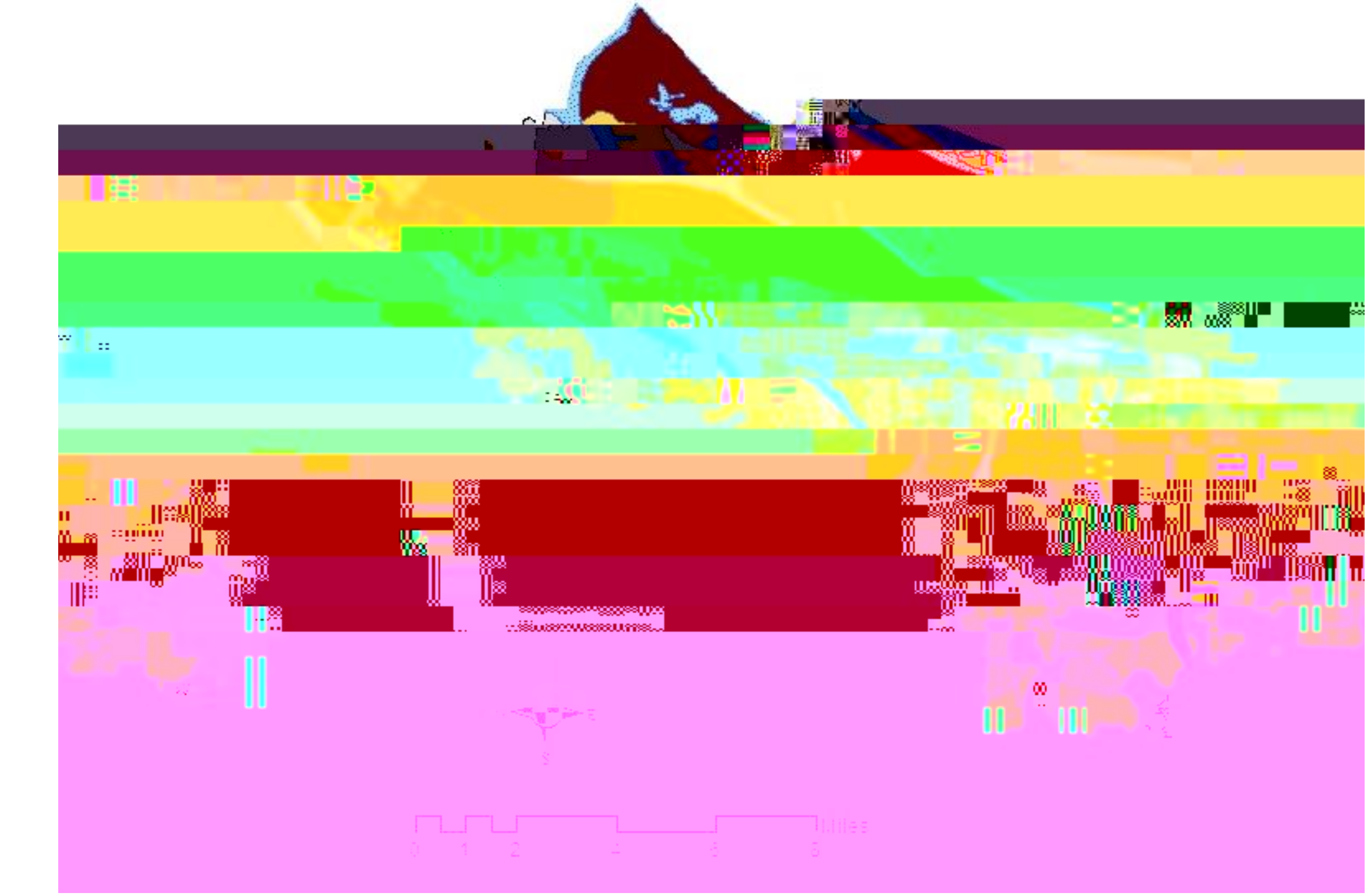


Figure 4: Social Vulnerability Index. Our index of social vulnerability (SoVI) is an aggregate of fifteen vulnerability factors (see Table 1). For each vulnerability factor, only the highest (or lowest) quintile of census tracts was used. (For example the lowest median income tracts were selected, while the highest ³QRZQLWH´ WUDFWV were selected.) These top 15 quintile layers were equally weighted and then added to generate a total vulnerability score of 0-15 per census tract. For analysis, the data was broken into quintiles again: 1 least to 5 most vulnerable. Gray areas indicate zero vulnerability. For subsequent data analysis, we identified Quintile 5 as most relevant. Note: data is not normalized by population or size of tract. Creator credit: Sandy Witte, Maggie Davies and Kim Dyke. Data Source: US Census ACS 2015

Amenities and Resilience

In this section, we map parks, transportation, street trees, and food access. These amenities help vulnerable populations adapt and proceed in the face of growing climate change risks.

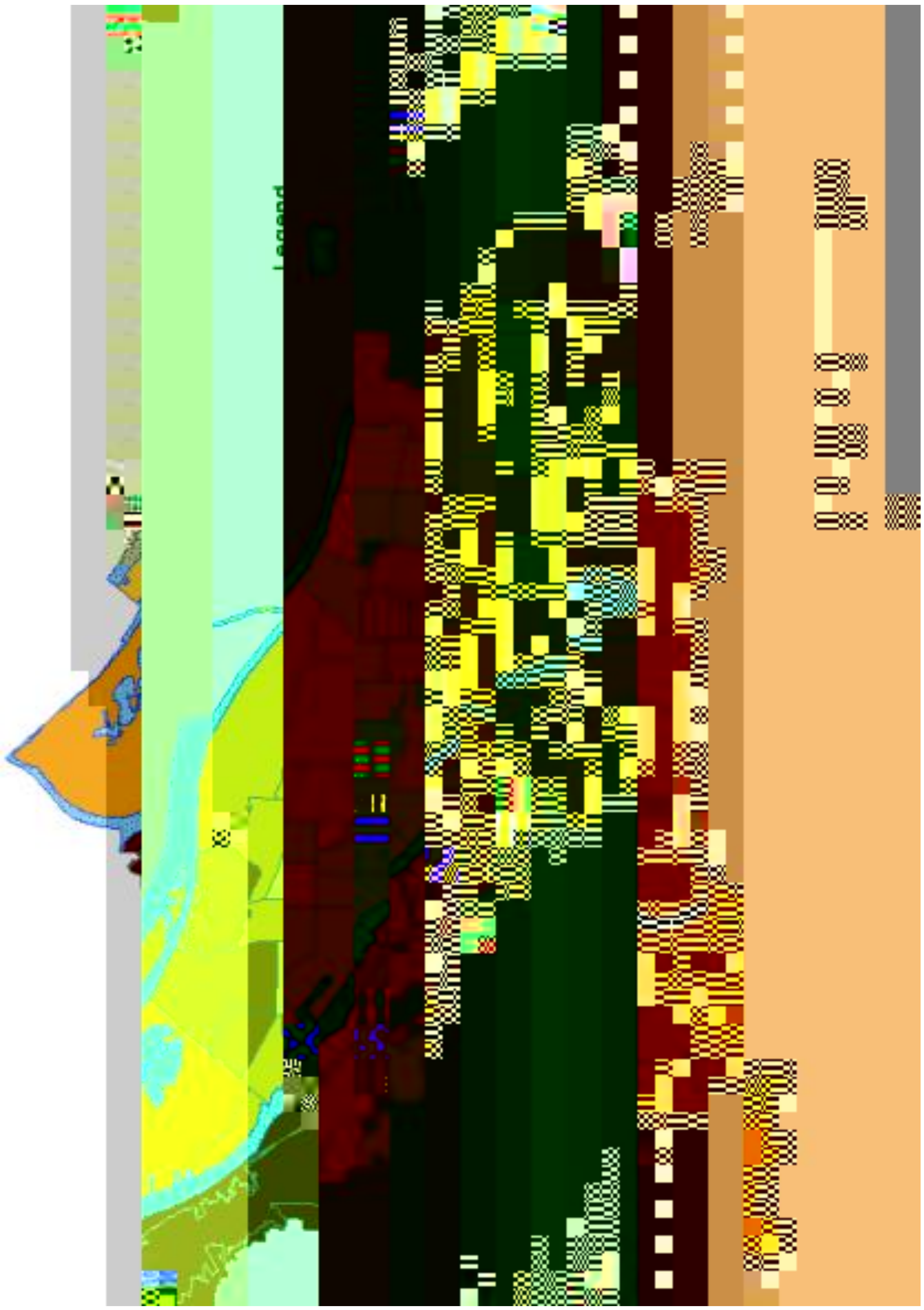


Figure 5: Park Density by Neighborhood.Sum of acres of park area within each neighborhood was normalized by neighborhood area. D values were sorted and displayed by quintile.

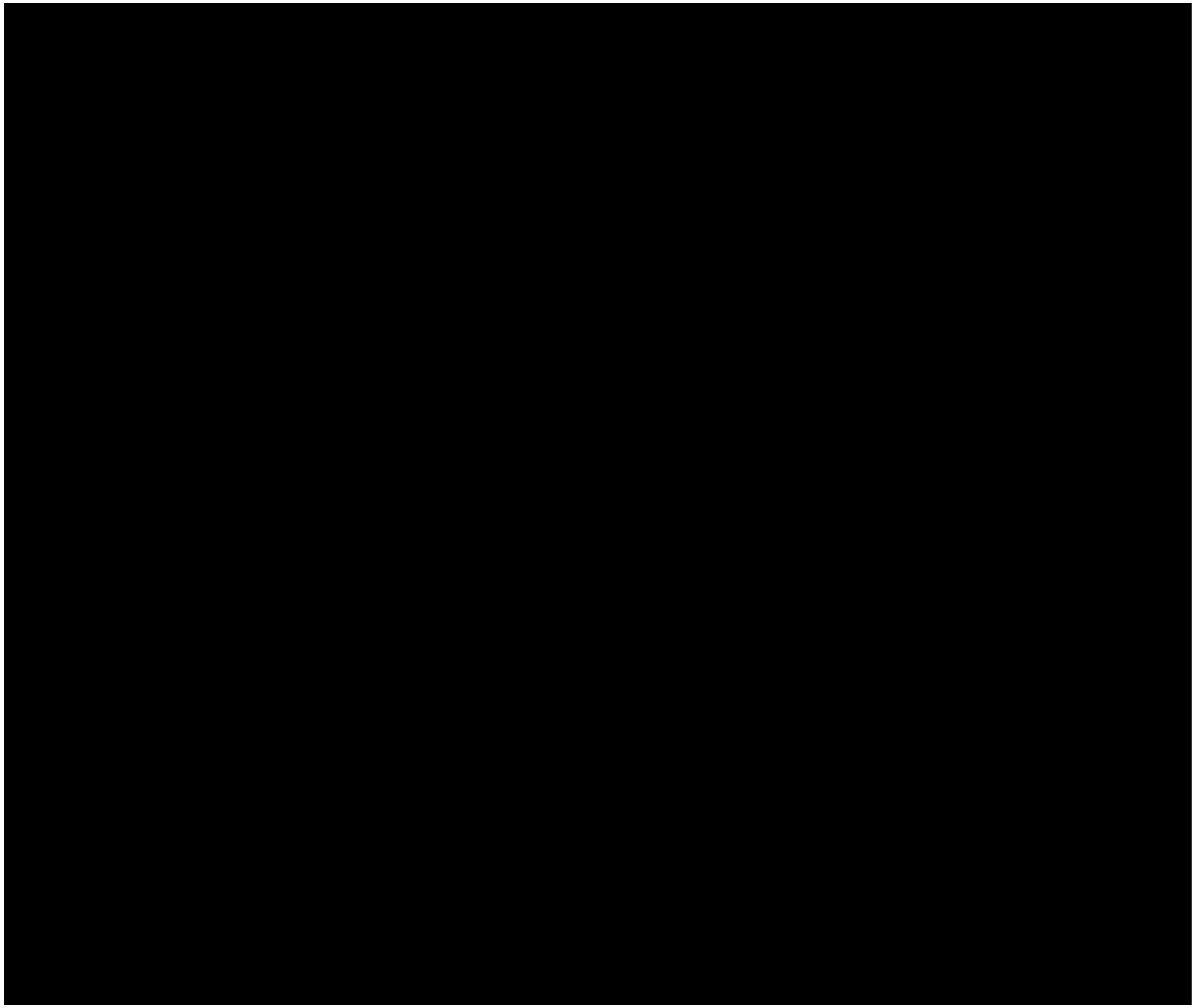


Figure 8: Food Availability by Neighborhood. Built by merging four layers representing the types of food access sites studied, each joined to a layer of neighborhood boundaries. 1HLJKERUKRRG IRRG VLWH GHQVLW\ UDWHG E\ TXLQWLOH ZLWK QHLJKERUKRRGV LQ WKH WRS TXLQWLOH … City Limits. Credit: Anthony Bencivengo. Data source: RLIS Discovery, Regional Equity Atlas, Portland Parks and Recreation, The Gateway Center, Oregon Food Bank, Portland Maps Open Data.

Food Availability by Neighborhood

Access to food options is an important aspect of community climate resilience. A complex set of factors impact food access, including price and cultural appropriateness. This map shows food availability, reflecting the proximity of food sites to residences. Residents in neighborhoods with lower food site density are less likely to have a source of fresh produce within walkable distance of their home. Figure 8 shows that sites providing access to nutritious food are highly concentrated in areas around downtown Portland, and still reasonably dense in much of East Portland. Of the neighborhoods with low food availability ratings, Forest Park and industrial North Portland have low food demand, while Eastmoreland is not zoned for commercial use but still has easy food access across neighborhood borders.

Grocery stores are most sparse in Northeast and far East Portland, indicating clear disparity in food 21(u)-20(n)21(d d)-20(o)21(w)0.00000912 0 612d 792 re th

Figure 10: Urban Heat Island Effects in Census Tracts with a High Proportion of People Living Alone. Census tTracts in the highest quintile of proportion of residents who live alone was overlaid on urban heat island effects data. Scores from 1 to 10 represent a difference from median regional temperature, with scores 1 and 2 representing a lower than median average temperature, and 3 through 10 a higher temperature, ranging from 0.9* above for a score of 3 and 4.6* above for

Urban Heat Island Effect in Census Tract with a High Proportion of People Living Alone

Many of the regions most impacted by urban heat island have high density of individuals living alone. Individuals living alone do not have immediate household support for emergencies that stem from high temperatures like heat stroke. Figure 14 displays the high proportions of people living alone along with urban heat island effects. Note the effect of considering living alone: this map highlights different areas as high priority compared to the earlier heat island maps. Our overall SoVI indicates that the most vulnerable people live in East or Northeast Portland. The population living alone differs from the population of the old and young because there is a high concentration of single-occupant households concentrated in the urban core. In particular, the nHLJKERUKRRGV RI 6XOOLYDQ¶V *XOFK %URRNO\Q possess high proportions of people living alone in high heat regions. The city should consider living alone separately from general social vulnerability since living alone elevates different areas of concern. For example, people living alone may need more social services such as an ambulance in case of heat-related illness.

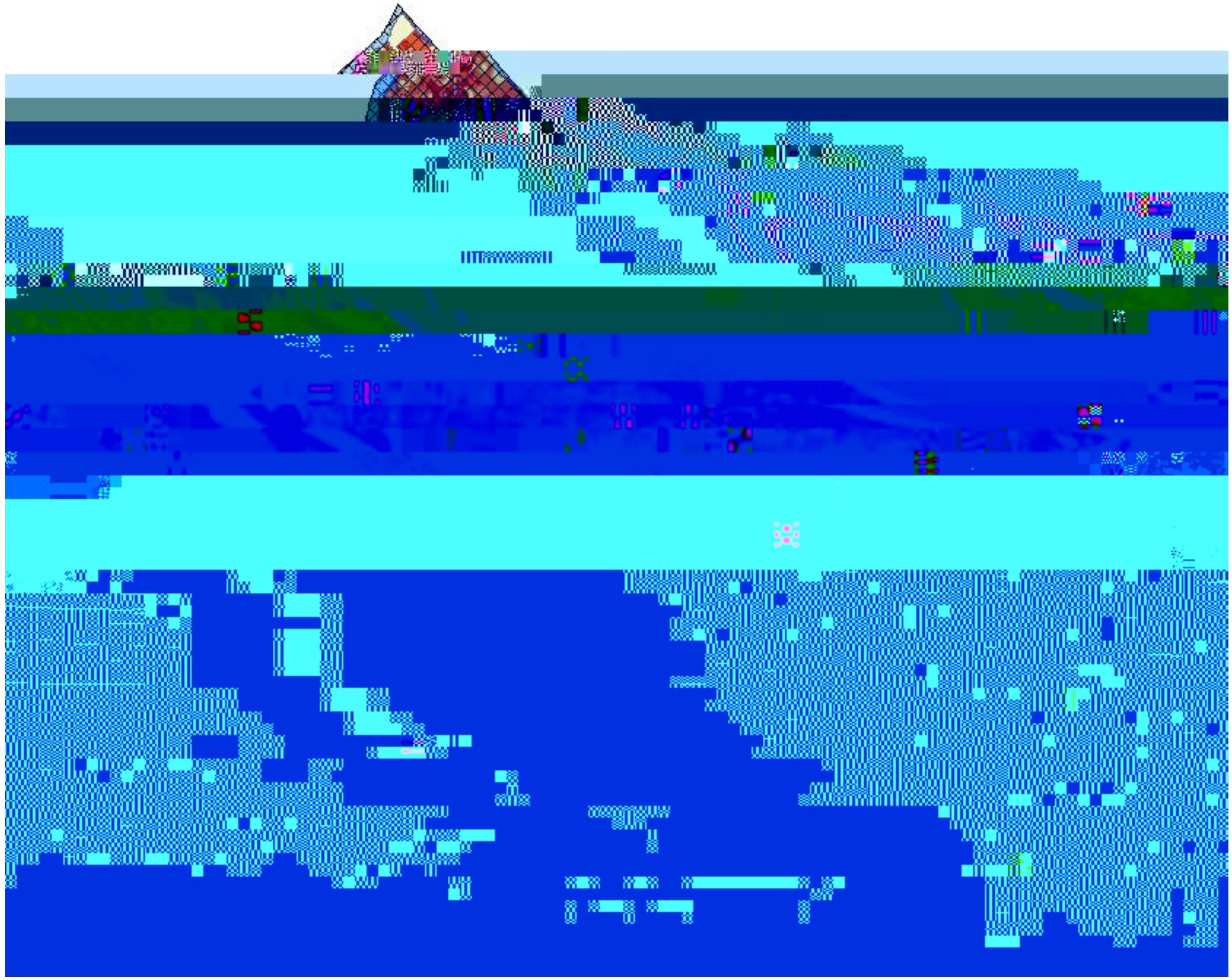


Figure 11: Urban Heat Island Effects, Park Locations, and Vulnerable Populations3 R U W O D Q G ¶ V P R V W Y X O Q H U D E O H T X L Q W L O H D Q G S island effect data. Scores from 1 to 10 represent a difference from median regional temperature, with scores 1 and 2 a lower than median average temperature, and 3 through 10 a higher temperature, ranging from 0.9* above for a score of 3 and 4.6* above for a score of 10. Created by Clark, Maggie Davies, Sandy Witte. Data source: Portland Bureau of Transportation, Portland Bureau of Water, PSU Sustainable Urban Places Research Lab, US Census ACS 2015

Urban Heat Island Effects, Park Locations, and Vulnerable Populations

0DQ\ RI 3RUWODQG¶V PRVW YXOQHUDEOH SRSXODWLRQ observation is particularly concerning because these populations may not have access to amenities which would protect them from the heat. In particular, parks are one of the best ways to mitigate the UHI effect because they allow people to physically escape the heat and recuperate. Looking at the overlap of SoVI (crosshatching) with parks (light green), it is apparent that East Portland as well as Cully are characterized by low park access. In addition, the extensive heat island (orange) on the east and west sides of the Willamette has virtually no park space to break up the built landscape. (Note: the downtown heat island is not the subject of this report since we focus on the most vulnerable residents of the city of Portland. However it is

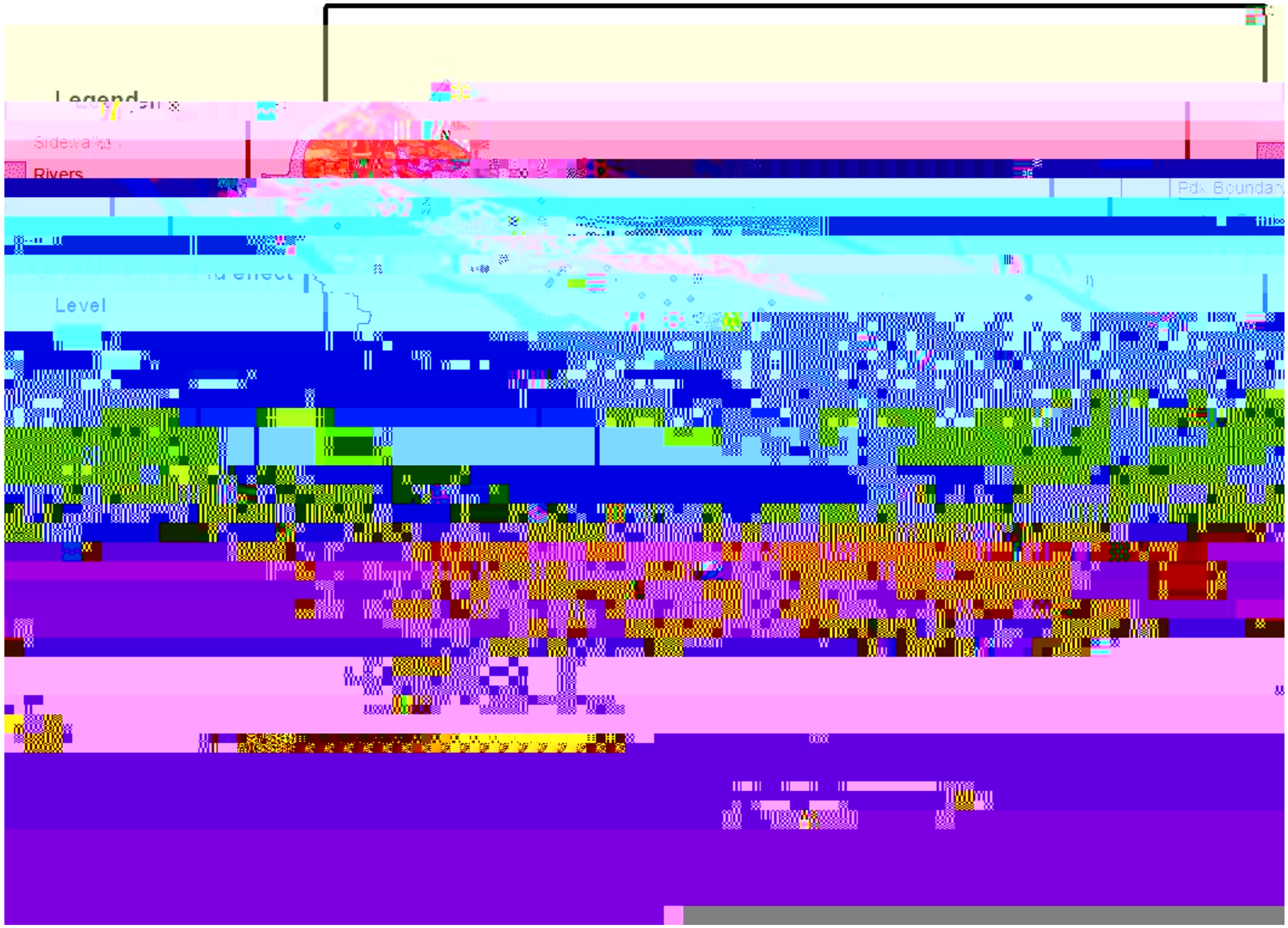


Figure 12: Vulnerable Populations, Urban Heat Island, Sidewalks and Food Access 3RUWODQG¶V PRVW YXOQHUDEOH TXLQWLOH SDLUHG ZLW shown with sidewalk data. Food access points are indicated in blue.. Creator credit: Emily Clark, [illegible] Davies, Sandy Witte. Data source: Portland Bureau of Transportation, Portland Bureau of Water, PSU Sustaining Urban Places Research Lab, US Census ACS 2015

Urban Heat Island Effects in Areas with Low Park and Drinking Fountain Access

Parks and water fountains both perform important functions in helping people cope with heat conditions. Lack of easily accessible parks may exacerbate heat risk to residents. This figure reveals several places where heat could be an issue. Areas along Interstate 205 are exposed to

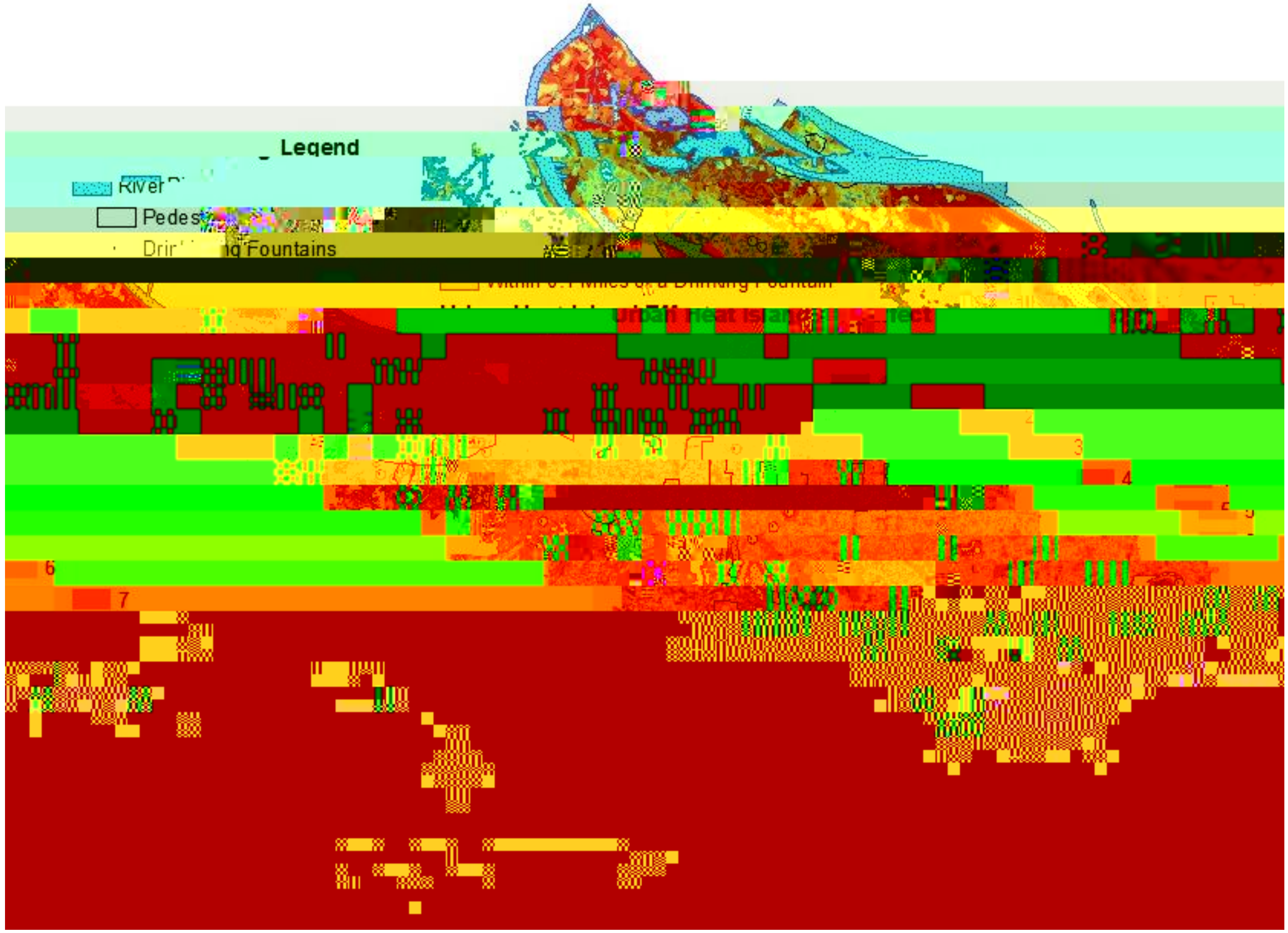


Figure 14: Pedestrian Districts, Water Fountain Placement, and Urban Heat Island Effect. Water fountains, along with a 0.1 mile buffer, and pedestrian district outlines were overlaid on urban heat island effect data. Scores from 1 to 10 represent a difference from median regional temperatures, with scores 1 and 2 representing a lower than medi

Pedestrian District, Water Fountain Placement, and Urban Heat Island Effects

Despite their official designation, many Pedestrian Districts (especially in East Portland) are in high heat regions without drinking fountains. Drinking fountains serve as an alternative to bottled water and accommodating a wide array of constituencies, including children, commuters, runners, unhoused individuals, and tourists. Figure 14 displays the placement of water fountains overlaid over urban heat island effects and shows the regions within Portland that lack water fountain access within 1/10 mile. Several locations on the map highlight the high temperatures that stem from the urban heat island effect that lack adequate water fountain infrastructure. These locations include Northeast Sandy Boulevard, Interstate 205, Southeast 82nd Avenue, and the eastern portions of the Buckman and Hosford-Abernethy neighborhoods along the Willamette. The intense urban heat island effect for NE Sandy Blvd, I-205, and SE

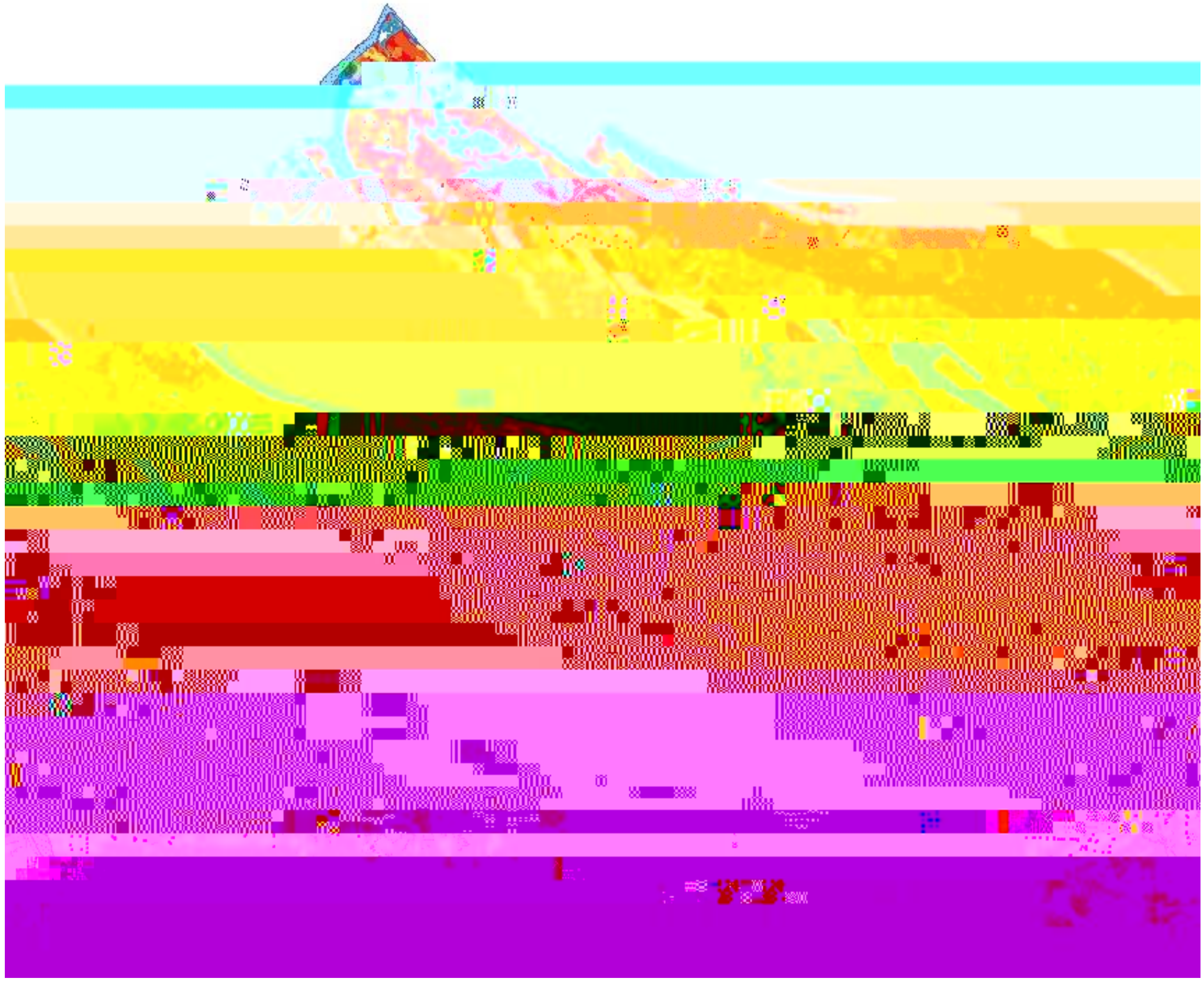
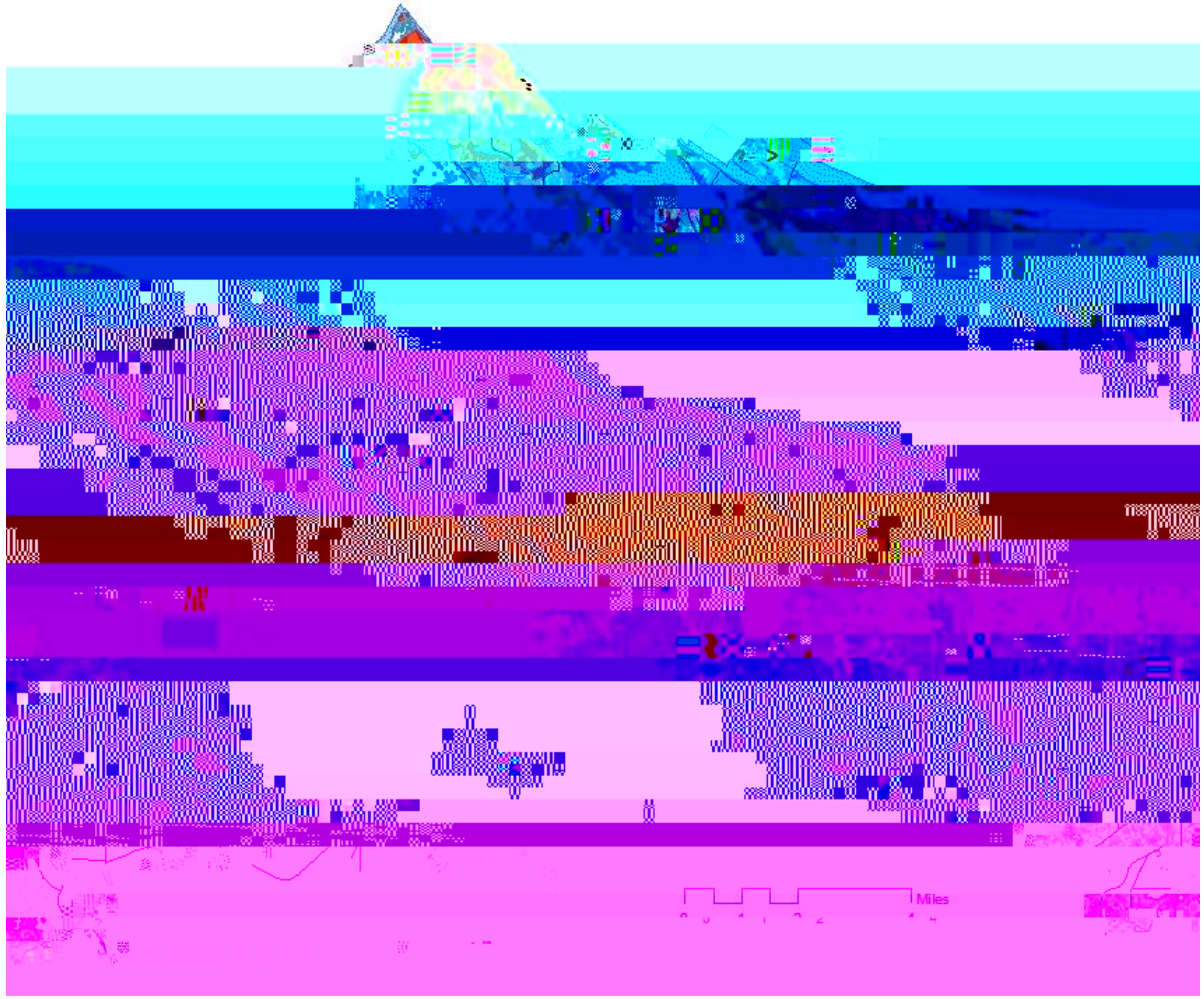


Figure 15. Bus stops and urban heat islands. Bus stop data was layered on top of Urban Heat Island (UHI) data. The UHI data is shown as a grad coolest (blue) to warmest (red) with the intermediate (yellow/orange) age deviation from the median temperature of the region (see Figure x for more details). Creator credit: Elaine Kushkowski. Data source: Portland Bureau of Transportation, PSU Sustaining Urban Places Lab Rese



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routes) was layered on top of Urban Heat Island (UHI) data. The UHI data is shown as a gradient of coolest (blue) to warmest (red) with the intermediate (yellow/orang
as a deviation from the median temperature of the region (see Figure x for more details). Creator credit: Fiona Marten. Data

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Many bicycle networks are in high temperature regions, making biking particularly uncomfortable. These data show only the active and planned bike lanes in Portland overlaid on data on urban heat. Neighborhoods along the I-205, in the central eastside, and especially along the Springwater Corridor (a major arterial bike path) are at high risk for heat, therefore inhibiting bike travel. Steps should be taken to help reduce the urban heat island effect on these high travel areas like the Springwater Corridor to encourage biking.

Flooding, Vulnerabilities, and Impacts

In this final section of maps, we look the risk of flooding in relation to overall social vulnerability and access to food.

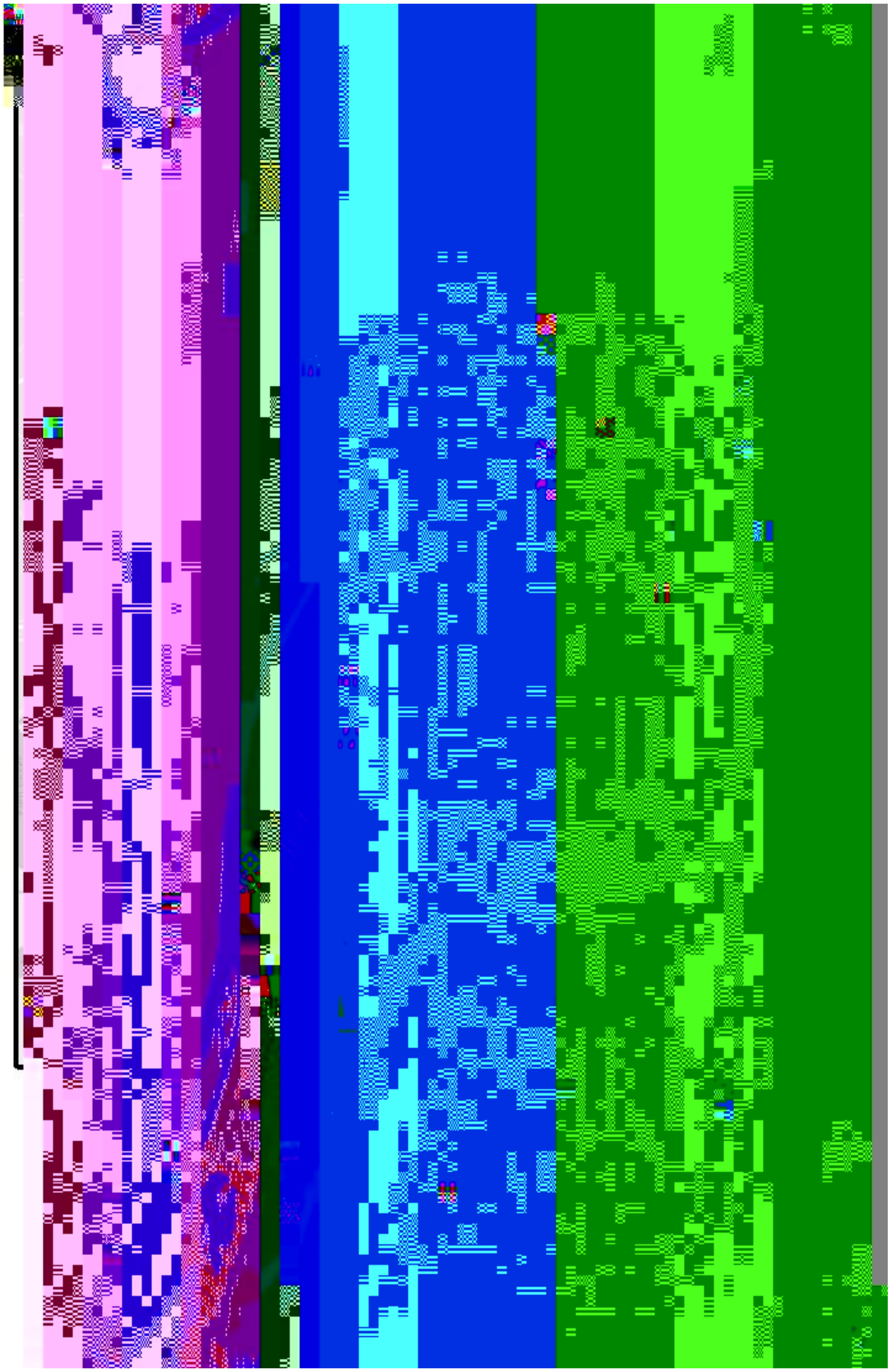

Figure 17: Flood Risk in Census Tracts with Vulnerable Populations Display shows 100

Flood Risk in Census Tracts with Vulnerable Populations

Flood risk is strongly dependent on proximity to the hazard, and therefore less associated with social vulnerability. The Johnson Creek floodplain in SE Portland covers much of Eastmoreland, which is one of the wealthiest neighborhoods in Portland. Although many of the most vulnerable populations are a not at significant risk of flood hazards, there are a few key vulnerable areas to note. East Portland neighborhoods such as Lents, Pleasant Valley, and Powellhurst-Gilbert are particularly susceptible to flood. Neighborhoods in the lowest quintile already have higher associated impacts, therefore it may be more difficult to evacuate. For this reason, our recommendation to the city is to focus flood preparation in the neighborhoods of Lents, Pleasant Valley, and Powellhurst-Gilbert.

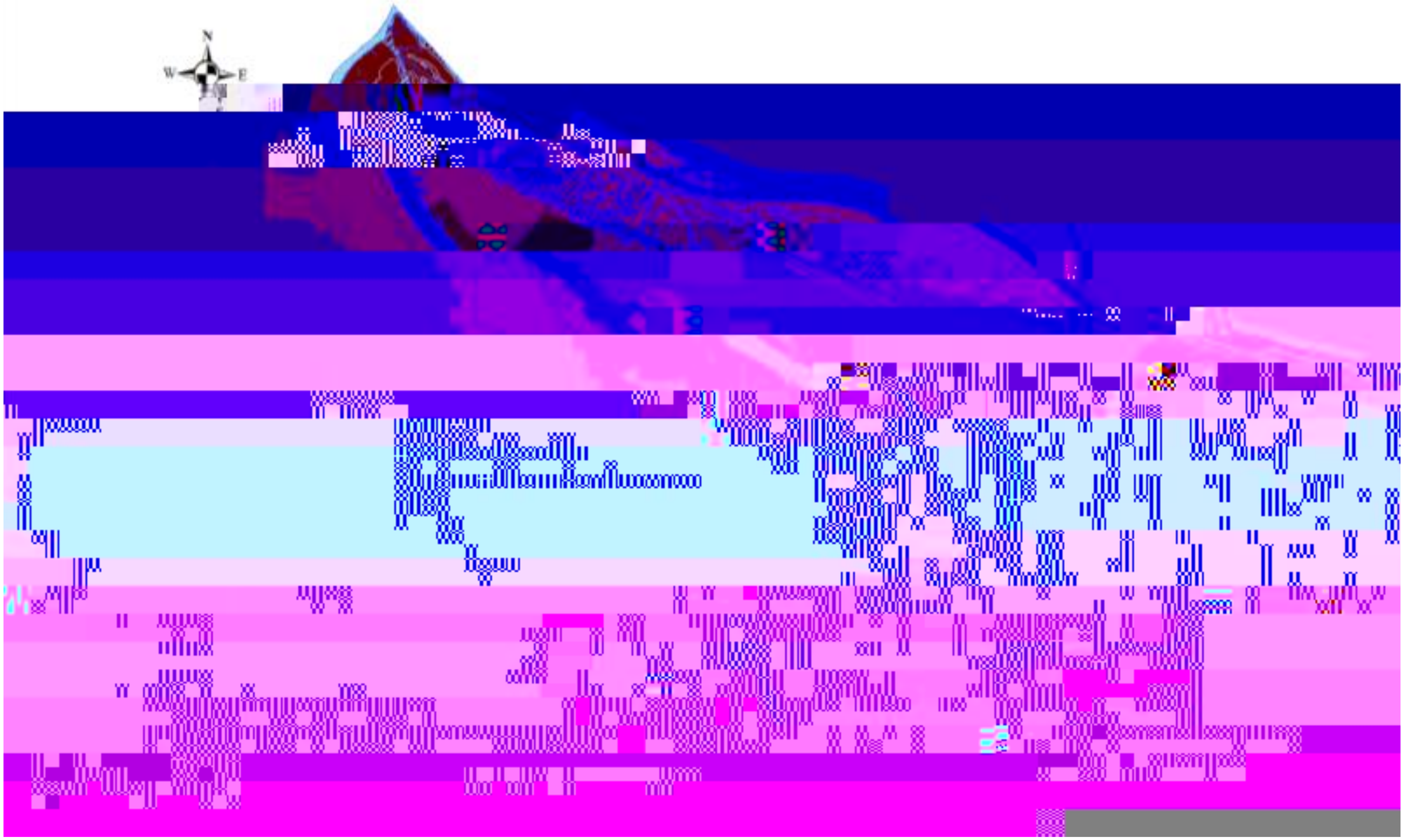

Figure 18: Flood Impact on Neighborhood Food Access. Flood hazard zones determined using 100-year floodplain projections, plus areas with elevation under 33 feet (10 meters) above river level (vulnerable to flooding during extreme rainfall).

Parks at Risk of Flooding

There are a number of parks in Portland which are susceptible to flood. Within North Portland and in Oaks Bottom, several parks lie in floodplain areas and low-elevation land (defined as less than 33 feet above sea level). We have focused on parks as a resource from urban heat islands, and it is not likely that the parks shown in Figure 19 will flood during high heat days in the summer. Flooding is typical of winter months when Portland receives heavy rain.

However,it merits a note that increased winter flooding may have larger impacts into spring and summer use of parks over time. A flooded park is temporarily unusable and may incur damage to its land, vegetation and facilities. Specific city actions will help mitigate flooding. These include park infrastructure improvements to prevent water collection and improve runoff efficiency. Green infrastructure includes permeable pavements, bioswales, and rain gardens.Since people depend on green spaces for heat relief, park maintenance is relevant (although not the first priority for climate action). Focused mitigation actions will ensure that parks remain in their best condition throughout the year, and provide a way to accommodate increased community needs for heat relief.

Conclusions

This project builds on 3RUWODQG¶V &OLPDWH 5LVN DQG 9XOQ looking at the spatial distribution of physical risks associated with climate change, alongside the distribution of vulnerable residents, and to amenities which are crucial in helping residents adapt WR FOLPDWH FKDQJH ,W LV DOVR D FRQWLQXDWLRQ RI WK &KDQJH 3UHSDUDWLRQ 6WUDWHJ\ ZKLFK SULRULWL]HV ³EX 3RUWODQG¶V)UDPHZRUN IRU (TXLW\ disproportionately impacted by SHRSOH climate change (City of Portland and Multnomah County, 2014). Our analysis generates specific recommendations for climate equity actions as a first step in addressing these goals. It also helps

Throughout our analyses, several areas of Portland stand out:

- North Portland along the Columbia River is at high risk for both increased heat and flooding. This area is primarily industrial, but there are small residential neighborhoods and these fall strongly in the upper quintile for social vulnerability. North Portland is a place where people both live and work, and so the climate change hazards in these neighborhoods will impact a significant population. The neighborhoods along the Columbia also have the lowest density of urban amenities considered in these analyses. Neighborhoods of particular concern

Appendix

Table A1: Hazard data with sources and explanations.

Concept

Housing and Tenure	Mobile homes are easy to destroy. Renters have less home security than homeowners and can lack funds for recovery	x % renters (SE_T094_003)	Socialexplorer.com, US Census Bureau: American Community Survey (2011-2015)
Education	Linked to socioeconomic status and access to information	% pop. 25 yrs or older with no high school diploma (SE_T152_002)	Socialexplorer.com, US Census Bureau: American Community Survey (2011-2015)

Fig. 20: Portland Neighborhoods by Neighborhood Association Name. Creator credit: Portland Office of Neighborhood Involvement. Found at https://www.portlandoregon.gov/oni/28385.

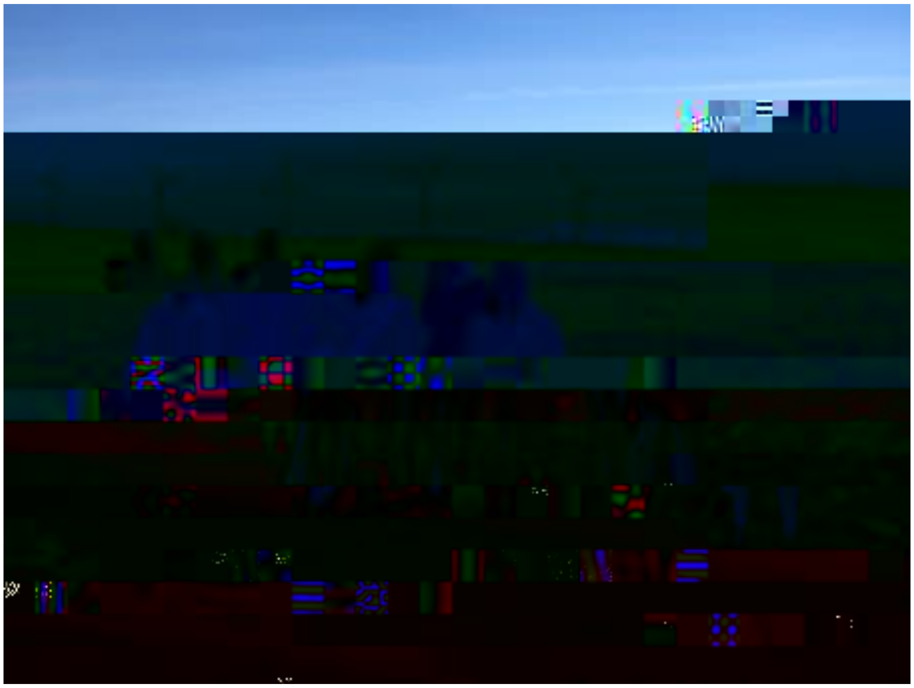

Figure 21. The Authors at the Bigelow Wind Farm. /HIW WR ULJKW $OH[³%LUG´ /RXNLGHV / Bencivengo, Fiona Marten, Maggie Davies, Anna Miller, Elaine Kushkowski (Not pictured: Emily Clark, Sandy Witte, Hunter Wise) Photo by Chris Koski.

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doi:10.2105/AJPH.2010.300021.
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no. 4 (2015): 451-59. doi:10.1016/j.jth.2015.10.001.
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and Urban Planning, Special Issue: Urban Ecosystem Services, 109, no. 1 (2013): 31-44.
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Proof, Addressing the Urban Heat Island Resources, Conservation and Recycling