

Integrating Detailed Population Data for Equitable Hazard Resilience Models

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June 19, 2024

Funding Acknowledgement

Funded by the National Institute for Standards and Technology (NIST) The Center for Risk-Based Community Resilience Planning is a NIST-funded Center of Excellence; the Center is funded through a cooperative agreement between the U.S. National Institute of Standards and Technology and Colorado State University (NIST Financial Assistance Award Numbers: 70NANB15H044 and 70NANB20H008).

The views expressed are those of the presenter and may not represent the official position of the National Institute of Standards and Technology or the US Department of Commerce.



This material is based upon work supported by the National Science Foundation under Grant No. (1760726). Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

Acknowledgements



**HAZARD REDUCTION
& RECOVERY CENTER**

The Hazard Reduction and Recovery Center
at Texas A&M University

<https://www.arch.tamu.edu/impact/centers-institutes-outreach/hrrc/>



The Center for Risk-Based Community Resilience Planning,
a NIST-funded Center of Excellence

<http://resilience.colostate.edu/>



Interdependent Networked Community Resilience Modeling
Environment (IN-CORE)

<https://incore.ncsa.illinois.edu/>

Overview

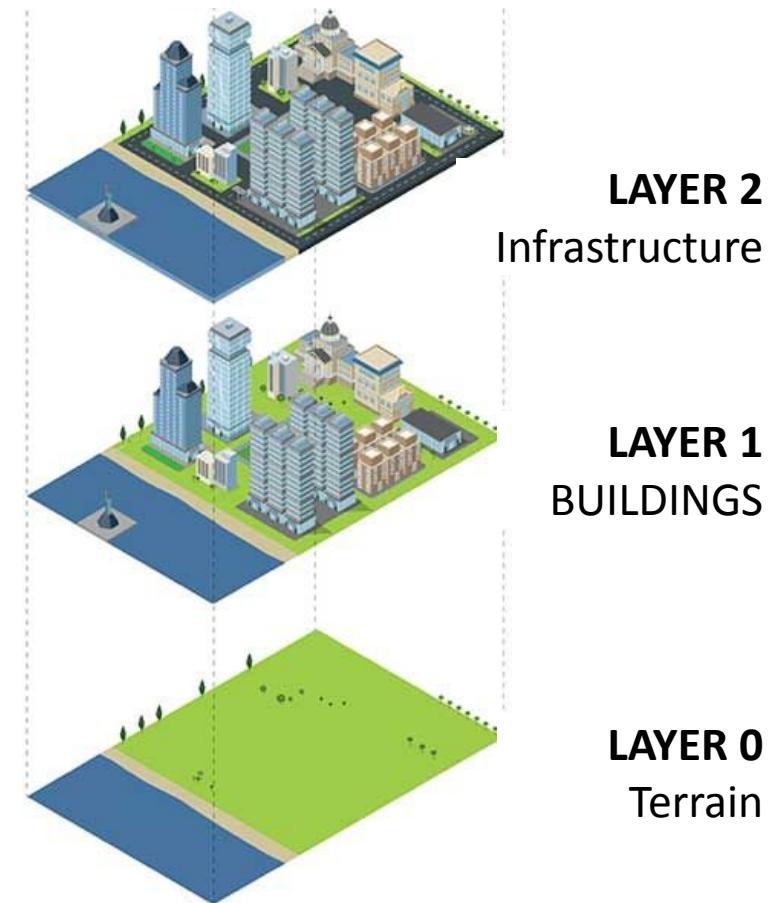
- What is missing from engineering hazard resilience models?
- What is detailed Population Data?
- Disasters and Detailed Population Data
- Example Application: IN-CORE Galveston, TX

Layers typically included in engineering hazard resilience models...

LAYER 2
Basic physical and organizational structures and facilities

LAYER 1
Current buildings in the city
(Building Information Modeling)

LAYER 0
Terrain and basic information about the city



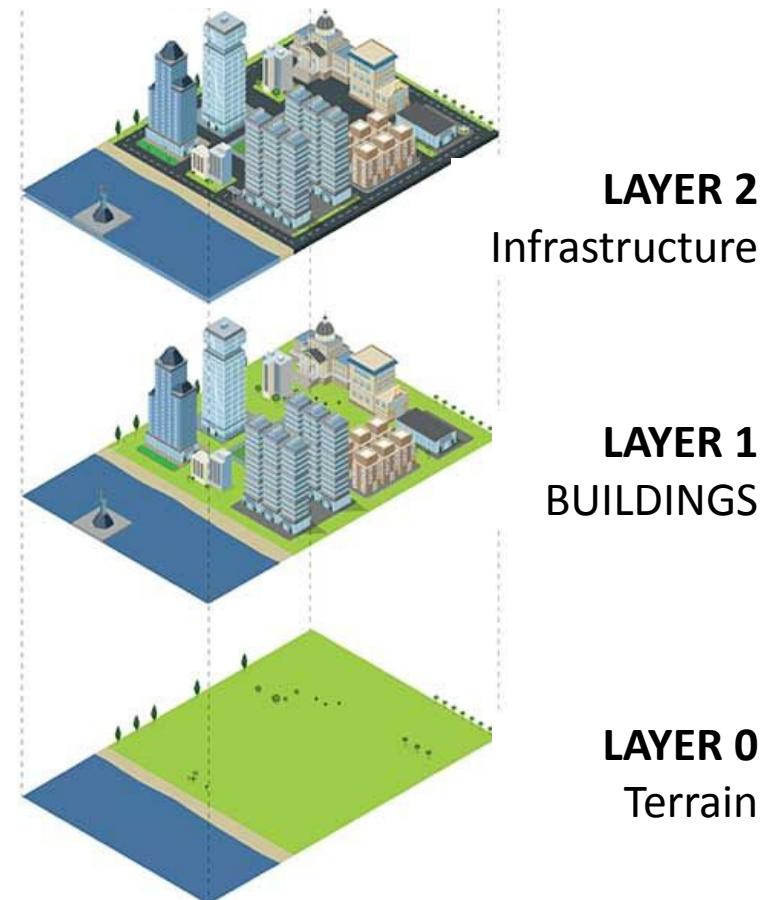
Layers typically included in engineering hazard resilience models...

What is missing?

LAYER 2
Basic physical and organizational structures and facilities

LAYER 1
Current buildings in the city
(Building Information Modeling)

LAYER 0
Terrain and basic information about the city



The People!



Put the People First

PRIMARY LAYER

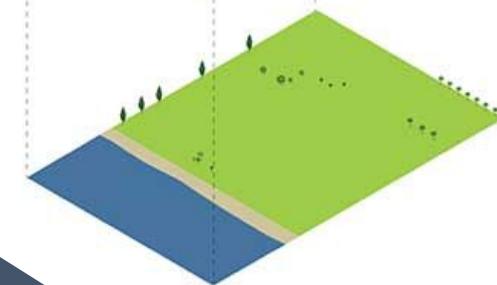
Population data with intersectional characteristics



LAYER 3
Infrastructure



LAYER 2
BUILDINGS



LAYER 1
Terrain

What is Detailed Population Data?

Detailed population data is:

- Disaggregated (unit of analysis = household, housing unit, or person)
- Intersectional (demographic and economic characteristics are correlated)
- Longitudinal (shows change over time)
- Links people to buildings

For More Details:

- Primary Journal Article:
 - Rosenheim, N., Guidotti, R., Gardoni, P., & Peacock, W. G. (2021). Integration of detailed household and housing unit characteristic data with critical infrastructure for post-hazard resilience modeling. *Sustainable and Resilient Infrastructure*, 6(6), 385-401. <https://doi.org/10.1080/23789689.2019.1681821>.
- Data Archive:
 - Rosenheim, Nathanael (2021) "Detailed Household and Housing Unit Characteristics: Data and Replication Code [Version 2]." *DesignSafe-CI*. <https://doi.org/10.17603/ds2-jwf6-s535>.
- Replication Code:
 - Nathanael Rosenheim. (2022). npr99/intersect-community-data (v2.0.1). Zenodo. <https://doi.org/10.5281/zenodo.6476122>.

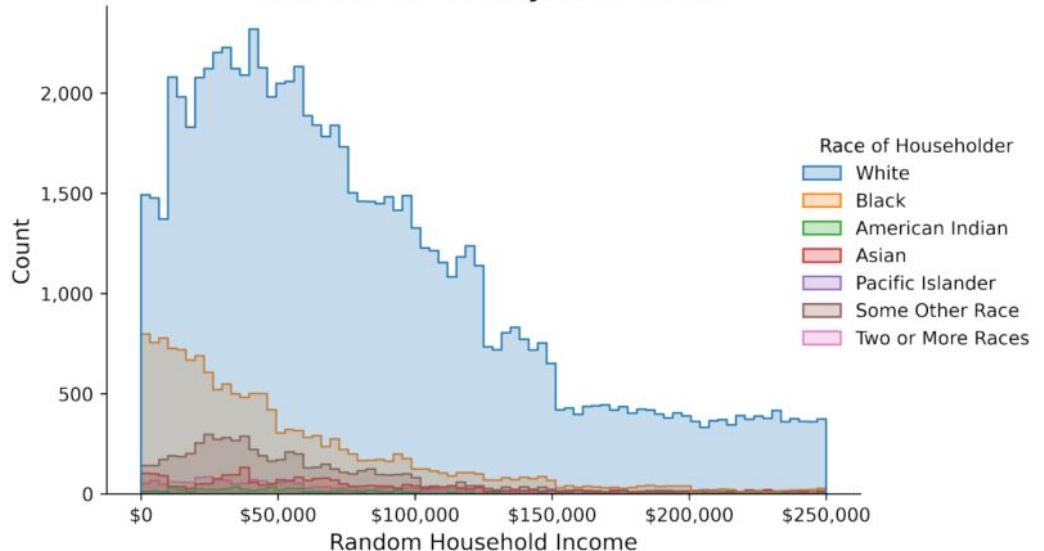
What does Detailed Population Data Look Like?

	huid	numprec	race	randincome	geometry
0	B481677240001040H002	2	1.0	58837.0	POINT (-94.79252 29.3092)
1	B481677240001040H005	2	2.0	15395.0	POINT (-94.79252 29.3092)
2	B481677240001040H001	1	1.0	59296.0	POINT (-94.79252 29.3092)
3	B481677240001040H003	2	1.0	131920.0	POINT (-94.79252 29.3092)
4	B481677240001040H004	2	1.0	238391.0	POINT (-94.79252 29.3092)

Intersection of race and income for Galveston County, Texas reveals pre-existing inequalities within the community.

Housing Unit Inventory Codebook for Galveston, TX, 2010

Random Household Income distribution by Race of Householder, Galveston County, TX, 2010.



Data and codebooks published on:

Rosenheim, Nathanael (2021) "Detailed Household and Housing Unit Characteristics: Data and Replication Code [Version 2]." *DesignSafe-CI*.
<https://doi.org/10.17603/ds2-jwf6-s535>.

Disasters and Detailed Population Data

Disasters provide a lens to help understand why detailed population data is important for resilient cities.

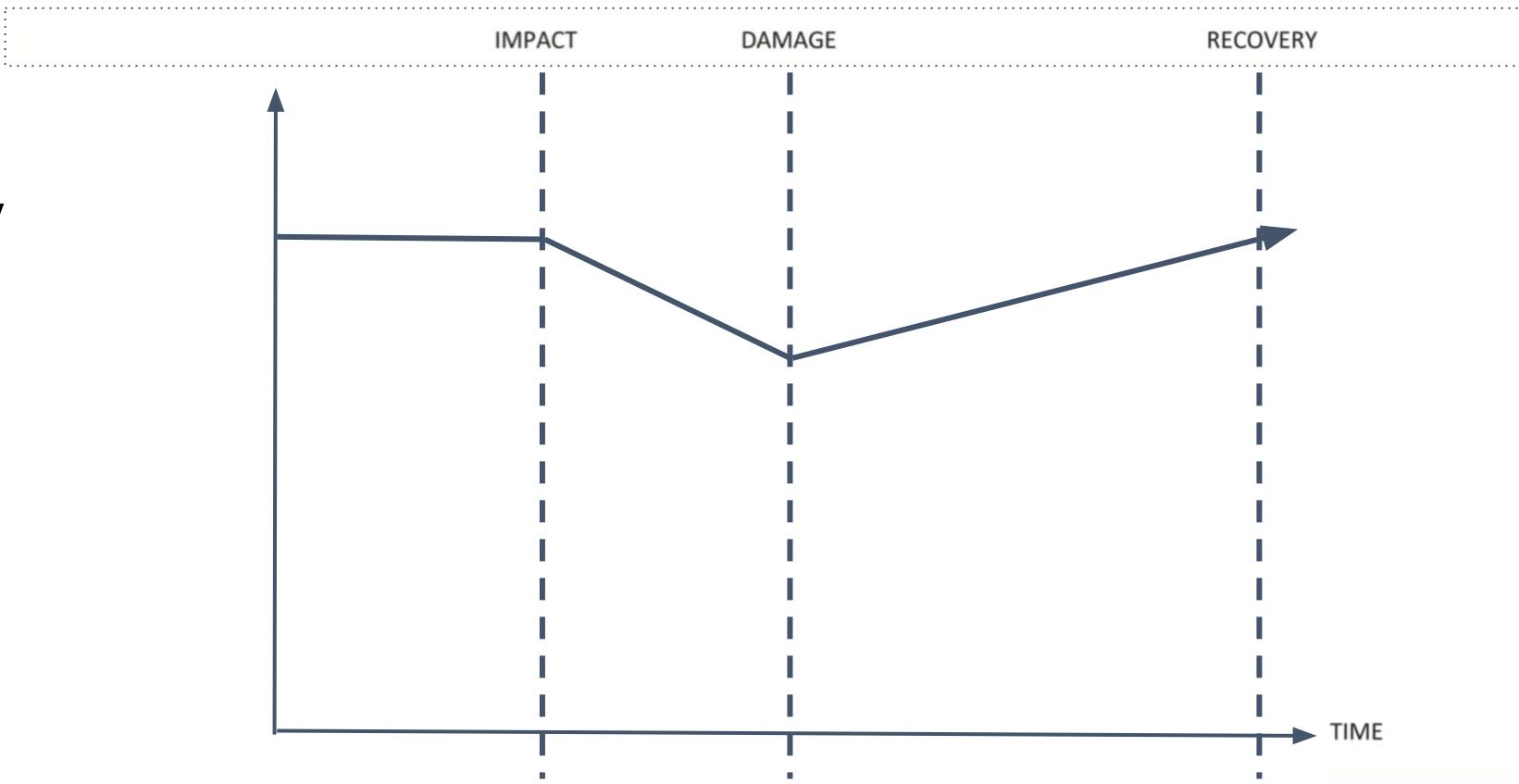
Disasters help reveal the ***internal complexities of cities***, along with ***chronic and pre-existing inequalities***.

Hazard resilience models aspire to guide ***resilient and equitable*** cities.

Traditional Disaster Resilience Model

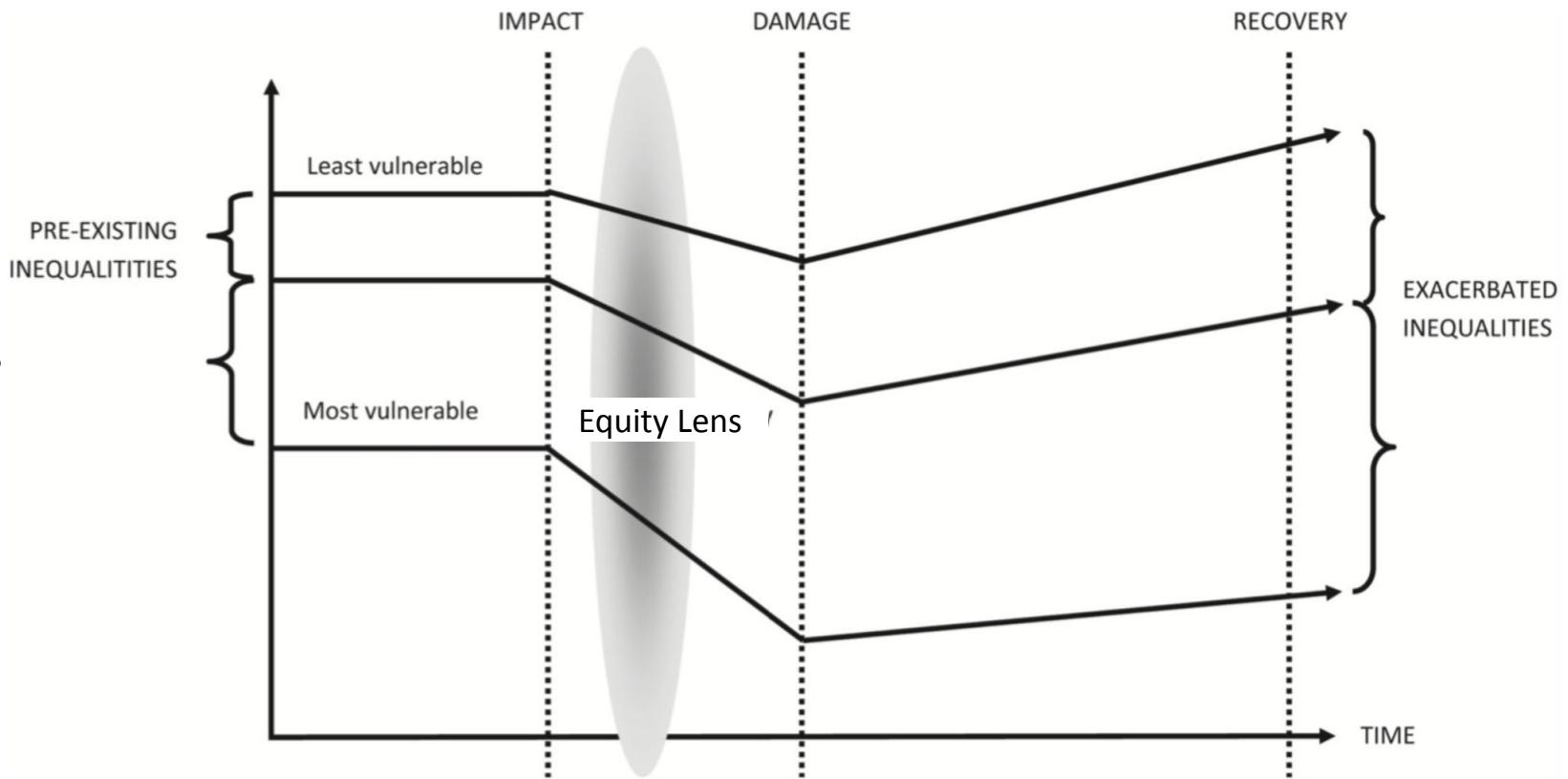
Traditional disaster resilience conceptual model for a community shows how a community is impacted, damaged, and recovers from a disaster.

It looks like everyone has recovered...



Disaster Resilience Model with Equity Lens

Resilience conceptual model with ***Equity Lens*** reveals how pre-existing inequalities may be exacerbated through the recovery process

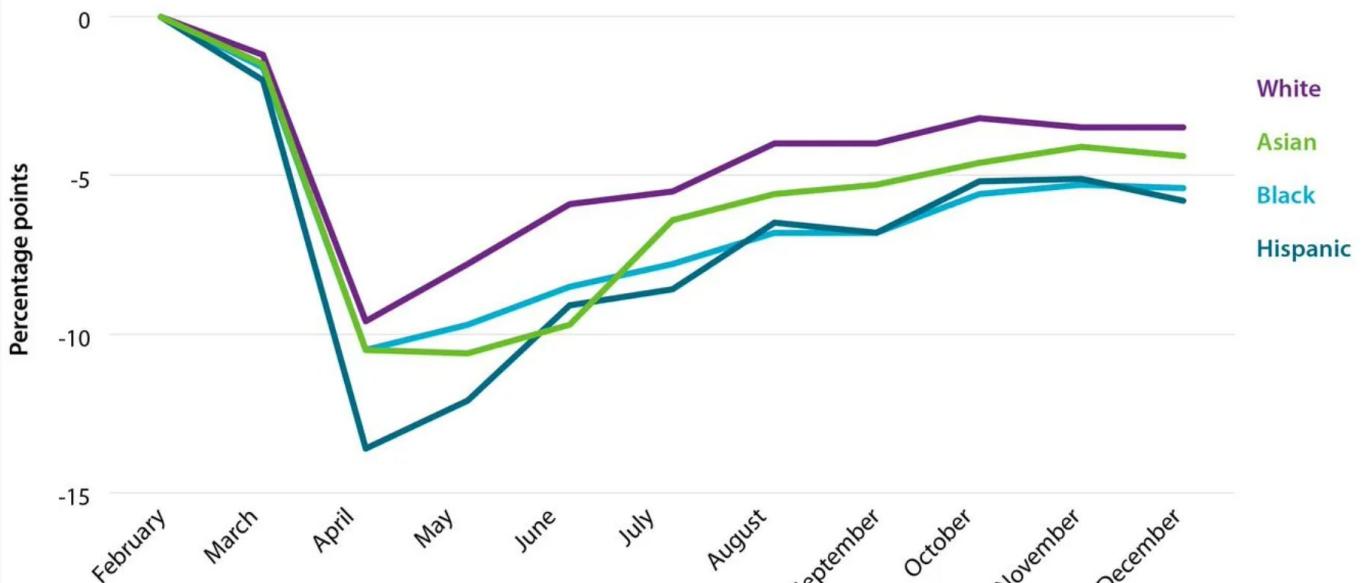


Why Intersectional Data is important...

Pandemic impacts and recovery on employment differed by race

Minorities experienced larger impacts and slower recovery

FIGURE 1.
Changes in Employment to Population Ratio Since February 2020, by Race and Ethnicity



Source: Bureau of Labor Statistics; authors' calculations.

Note: The employment to population ratio measures the civilian labor force currently employed against the total working-age population. Monthly changes in the employment to population ratio shown are relative to February 2020 for everyone in the labor force who is 16 or older. In February, the employment to population ratio by race were the following: White 61.1 percent, Black 61.3 percent, Asian 62.6 percent, and Hispanic 65.0 percent. We do not have the sample size to show this change for other races and ethnic groups.



Why Intersectional Data is important...

Pandemic impacts and recovery on employment differed by **sex and household composition**

Women with children experienced larger impacts and slower recovery

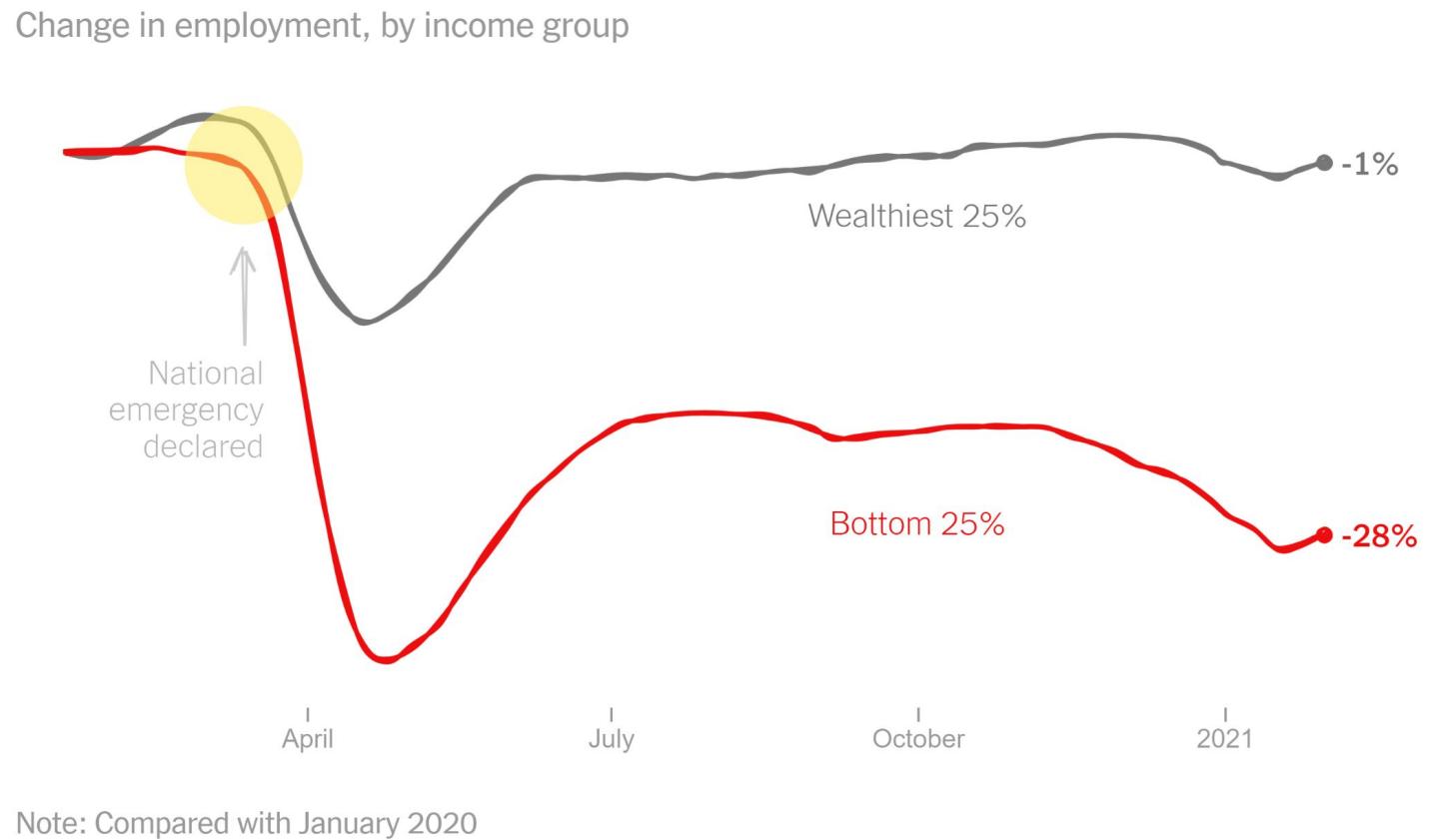
Figure 2: 2020 Change in Labor Force Participation of Women and Men 18–55



Why Intersectional Data is important...

Pandemic impacts and recovery on employment differed by **income groups**

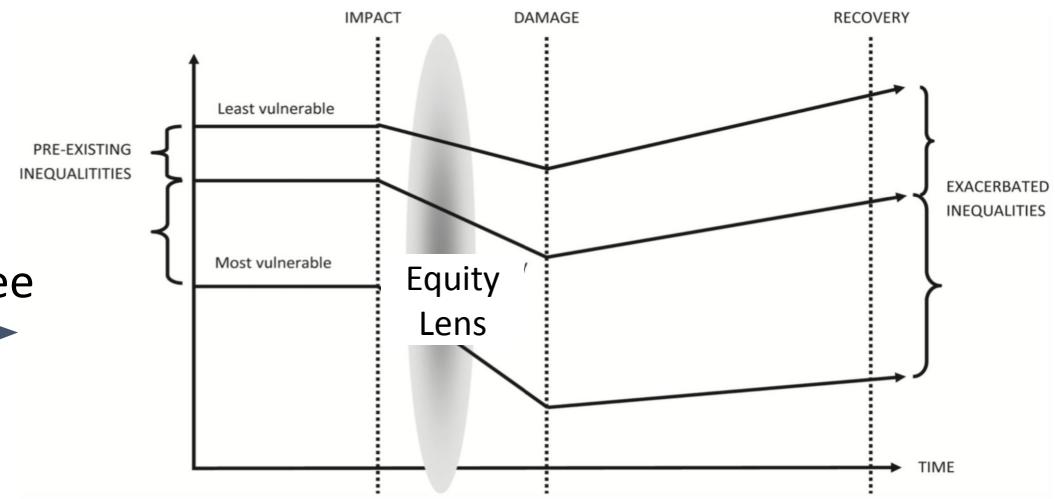
Lower income groups experienced larger impacts and slower recovery



Argument: Without detailed population data hazard resilience models will not help cities equitably improve resilience.

Detailed Population Data					
	huid	numprec	race	randincome	geometry
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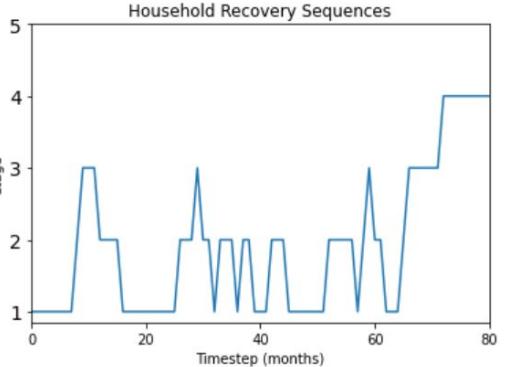
Without
you will not see



Example Application: IN-CORE Galveston, TX

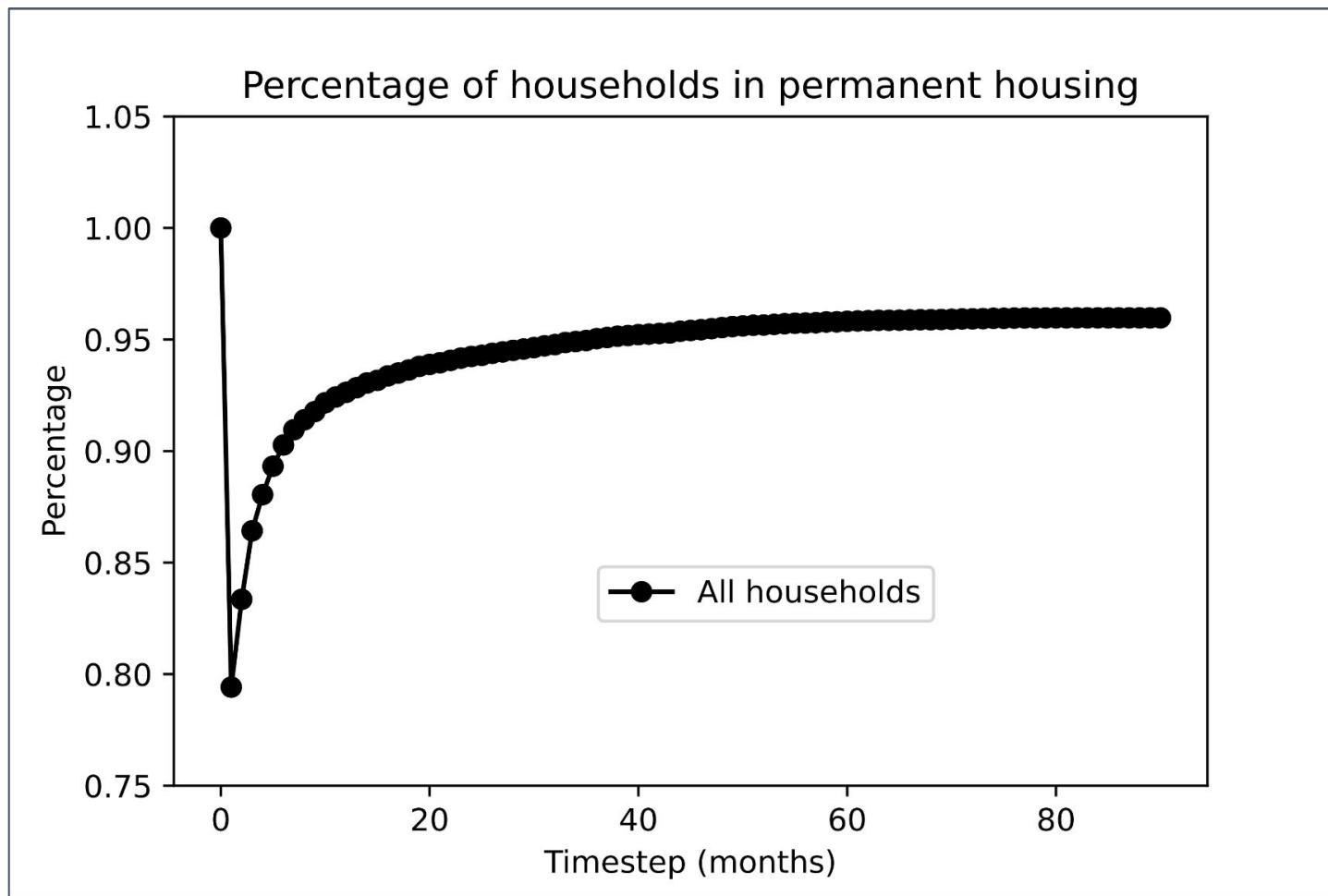
Digital Twin Layer	Layer Details
<h2>Detailed Population Data</h2>	<p>Housing Unit Inventory Codebook for Galveston, TX, 2010</p> <p>Random Household Income distribution by Race of Householder, Galveston County, TX, 2010.</p> <p>132,553 Housing Units 285,535 People Intersectional data: race, ethnicity, tenure status, household income, vacancy type, and group quarters type</p>
<h2>Terrain and Hazard</h2>	<p>Surge and Wave Height Rasters Simulated Hurricane Ike and local terrain</p>

Example Application: IN-CORE Galveston, TX

Digital Twin Layer	Layer Details
<p>Buildings linked with people</p>  <p>A map of Galveston, Texas, showing the coastline and various residential areas. Buildings are represented by colored dots (blue, red, pink, cyan) and are concentrated along the eastern and southern parts of the island. A legend in the top left corner indicates four categories: 1 (blue), 2 (red), 3 (pink), and 4 (cyan). The map also includes a grid of latitude and longitude coordinates.</p>	<p>18,962 residential buildings 32,501 Housing Units 45,422 People Intersectional data: race, ethnicity, tenure status, household income, vacancy type, and group quarters type</p>
<p>Mobility</p>  <p>A line graph titled "Household Recovery Sequences". The y-axis is labeled "Stage" and ranges from 1 to 5. The x-axis is labeled "Timestep (months)" and ranges from 0 to 80. The graph shows a series of discrete steps representing the recovery stages of households over time. The stages fluctuate between 1 and 4, with significant peaks around months 10, 30, 60, and 75.</p>	<p>Population dislocation due to building damage (Rosenheim et al, 2019) Time to return to permanent housing (Sutley & Hamideh, 2020)</p>

Example Application: IN-CORE Galveston, TX

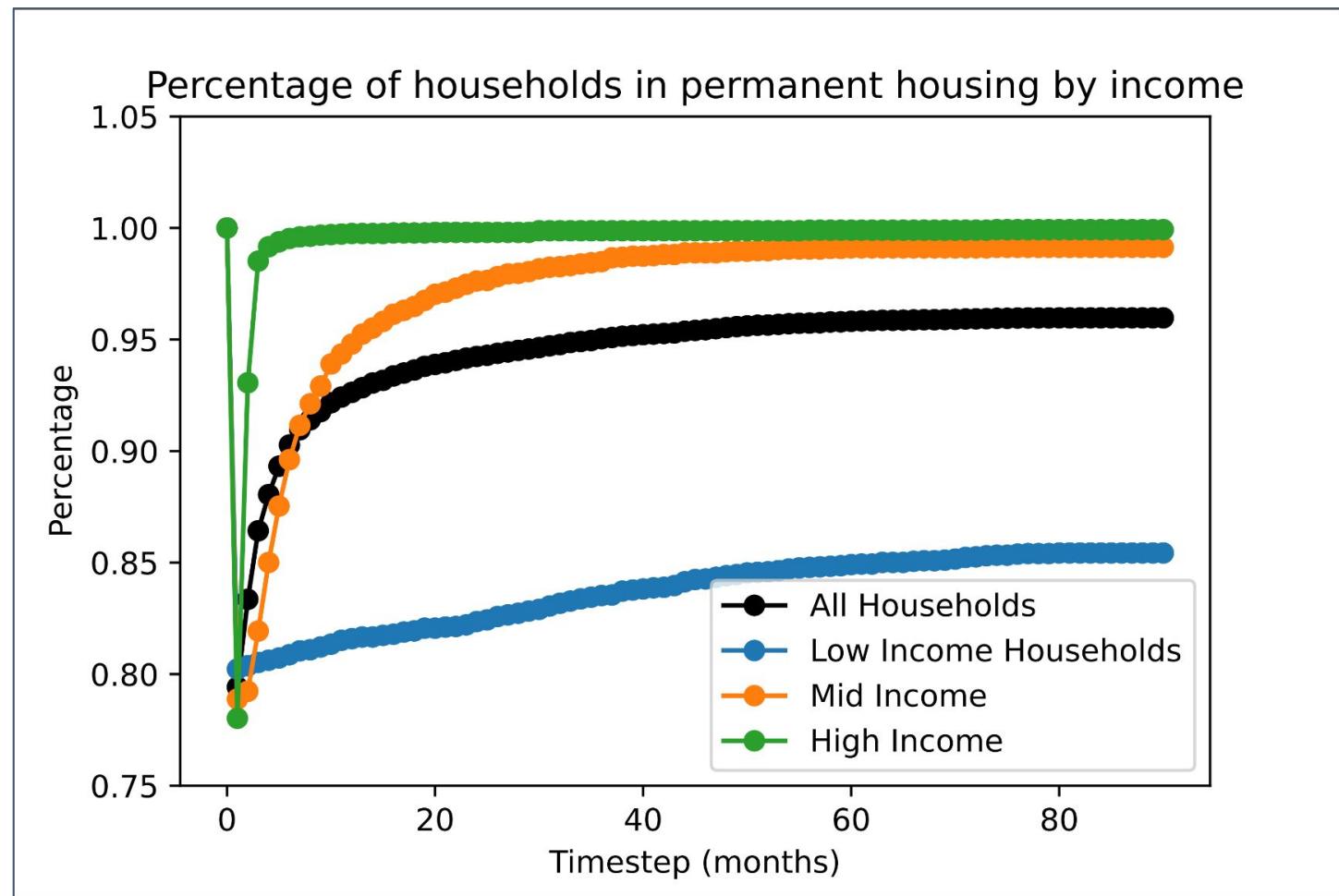
Model of Hurricane Impacts on Housing Recovery for Galveston, about 95% of households return to original housing after 3 years.



Example Application: IN-CORE Galveston, TX

Detailed Population Data reveals that Housing Recovery for Galveston, Texas differs by **income groups**

Less than 85% of lower income groups return after 7 years.



IN-CORE Model Reflects Reality:

Social vulnerability and participation in disaster recovery decisions: public housing in Galveston after Hurricane Ike

Sara Hamideh & Jane Rongerude

Natural Hazards 93, 1629–1648 (2018) | [Cite this article](#)

Ten Years After Hurricane Ike Hit Galveston, Money To Rebuild Public Housing Remains Unspent

BLOCKED OUT

"It's our form of apartheid": How Galveston stalled public housing reconstruction in the 10 years after Ike

Hurricane Ike ravaged Galveston in 2008 and touched off a fierce battle over whether to rebuild the city's destroyed public housing. A decade later, less than half of it has been replaced. The prolonged saga offers a cautionary tale for Texas as it launches the long-term recovery process after Hurricane Harvey.

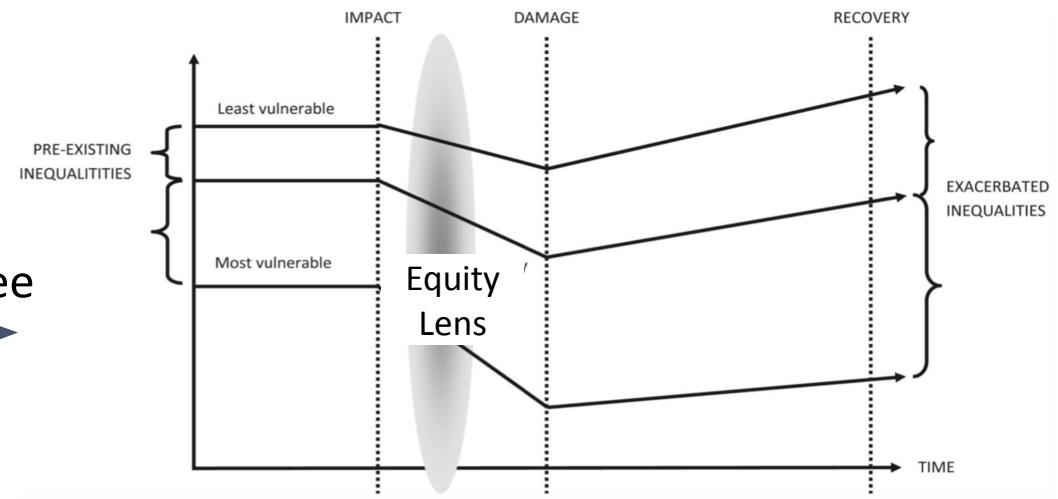
BY EDGAR WALTERS APRIL 16, 2018 UPDATED: 1 PM CENTRAL

ucracy and opposition from community members delayed or stopped construction of new public housing units.

Argument: Without detailed population data hazard resilience models will not help cities equitably improve resilience.

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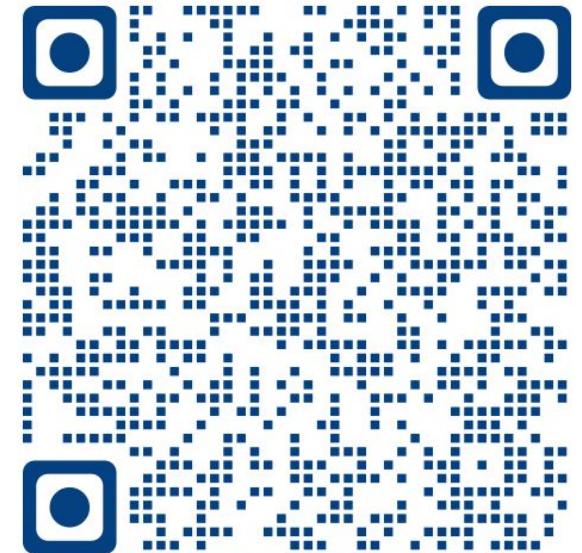


Let's Collaborate!

- Make your own Detailed Population Data
 - 2010 Housing Unit Inventory
 - United States Counties
- Help expand the GitHub Repository
 - Star the repository
 - Become a contributor to the project



GitHub



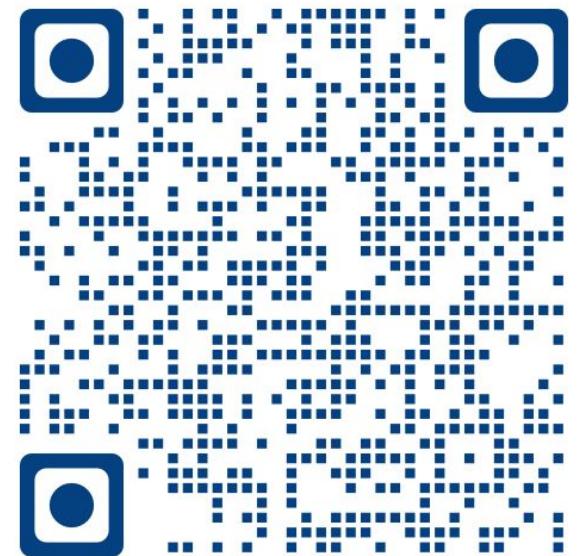
<https://github.com/npr99/intersect-community-data>

Let's Collaborate!

- Contact me if you have any questions or would like to use the data
- Let me know if you use the data in your work
- ***Please cite*** the journal articles, data archive and code repositories - I need the citation counts and it really helps!



GitHub



<https://doi.org/10.17603/ds2-jwt6-s535>

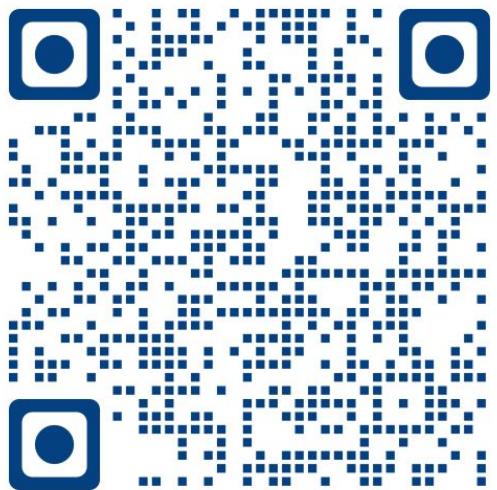
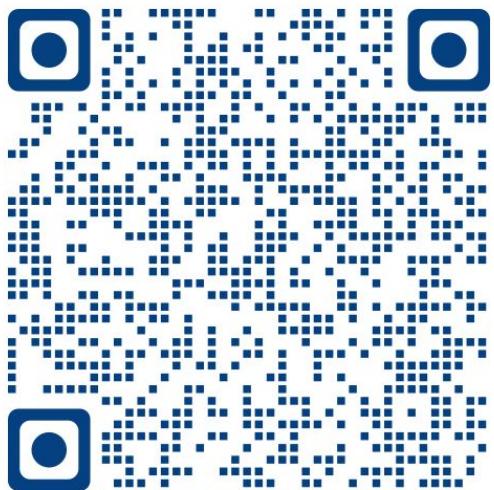
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Discussion time

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For More Details:

- Primary Journal Article:
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Housing Unit Allocation for Benton County, OR

Based on National Structure Inventory

2010 US Census Data

No input data required

Code downloads all required datafiles

- 60 US Census tables
- Census block, place, and puma shapefiles
- NSI spatial data

Code generates

- Housing Unit Allocation and Person Record Files

Table. Total Population by Persons by Race, Ethnicity, Benton County, OR, 2010.

Hispanic	0 Not Hispanic or Latino (%)	1 Hispanic or Latino (%)	Total Population by Persons (%)
Race			
1. White	71,552 (89.3%)	2,954 (53.8%)	74,506 (87.1%)
2. Black or African American	713 (0.9%)	46 (0.8%)	759 (0.9%)
3. American Indian and Alaska Native	485 (0.6%)	142 (2.6%)	627 (0.7%)
4. Asian	4,404 (5.5%)	25 (0.5%)	4,429 (5.2%)
5. Native Hawaiian and Other Pacific Islander	196 (0.2%)	17 (0.3%)	213 (0.2%)
6. Some Other Race	151 (0.2%)	1,834 (33.4%)	1,985 (2.3%)
7. Two or More Races	2,586 (3.2%)	474 (8.6%)	3,060 (3.6%)
Total	80,087 (100.0%)	5,492 (100.0%)	85,579 (100.0%)

P5 HISPANIC OR LATINO ORIGIN BY RACE		+3	Notes
Label	Benton County, Oregon		
▼ Total:	85,579		
▼ Not Hispanic or Latino:	80,112		
White alone	71,552		
Black or African American alone	715		
American Indian and Alaska Native alone	493		
Asian alone	4,404		
Native Hawaiian and Other Pacific Islander alone	199		
Some Other Race alone	156		
Two or More Races	2,593		
▼ Hispanic or Latino:	5,467		
White alone	2,954		
Black or African American alone	44		
American Indian and Alaska Native alone	134		
Asian alone	25		
Native Hawaiian and Other Pacific Islander alone	14		
Some Other Race alone	1,829		
Two or More Races	467		

Validate with US Census Data: Minor differences due to how the US Census reports race and ethnicity at the block level. Person Record File provides more detailed tabulation at the cost of some accuracy.

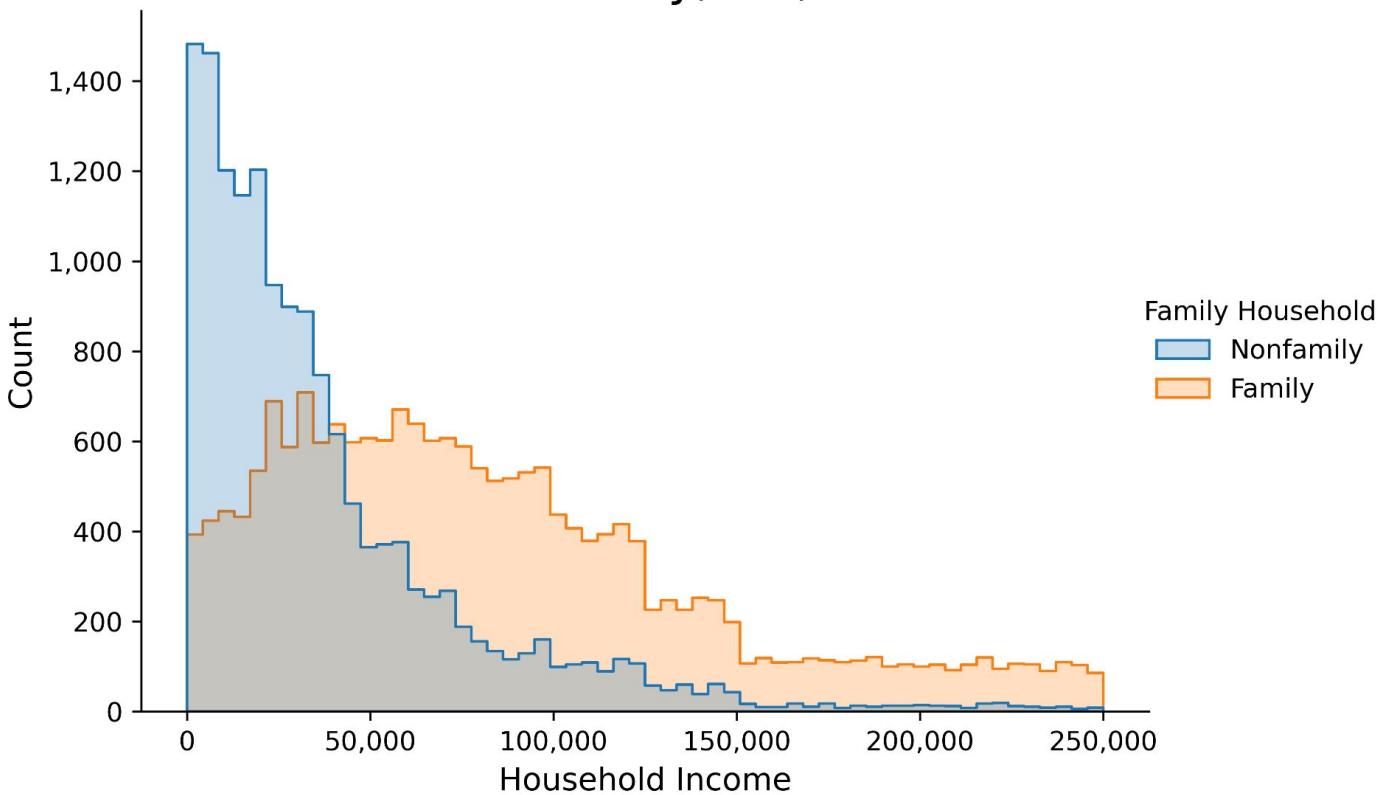
<https://data.census.gov/table/DECENNIALSF12010.P5?g=050XX00US41003>

Income by Family Household

The results of the Housing Unit Inventory provide a random income variable that is based on the 2012 5-year American Community Survey.

Distributions match by race, ethnicity, and family type.

Random Household Income distribution by Family Household, Benton County, OR, 2010.



Check the quality of building inventories

Notice that in Corvallis, while only 5% of households are missing building data... 99.9% of those are renters.

This is an equity issue.

Table. Total Population by Households by Tenure, Corvallis, 2010.

Building Data Availability_str	0 Missing Building Data (%)	1 Building Data Available (%)	Total Population by Households (%)	Percent Row 0 Missing Building Data
Tenure Status				
1 Owner Occupied	4 (0.1%)	22,551 (48.2%)	22,555 (45.6%)	0.0%
2 Renter Occupied	2,663 (99.9%)	24,219 (51.8%)	26,882 (54.4%)	9.9%
Total	2,667 (100.0%)	46,770 (100.0%)	49,437 (100.0%)	5.4%

Income by race and tenure status

The housing unit allocation provides unique insights into how income varies by race and income.

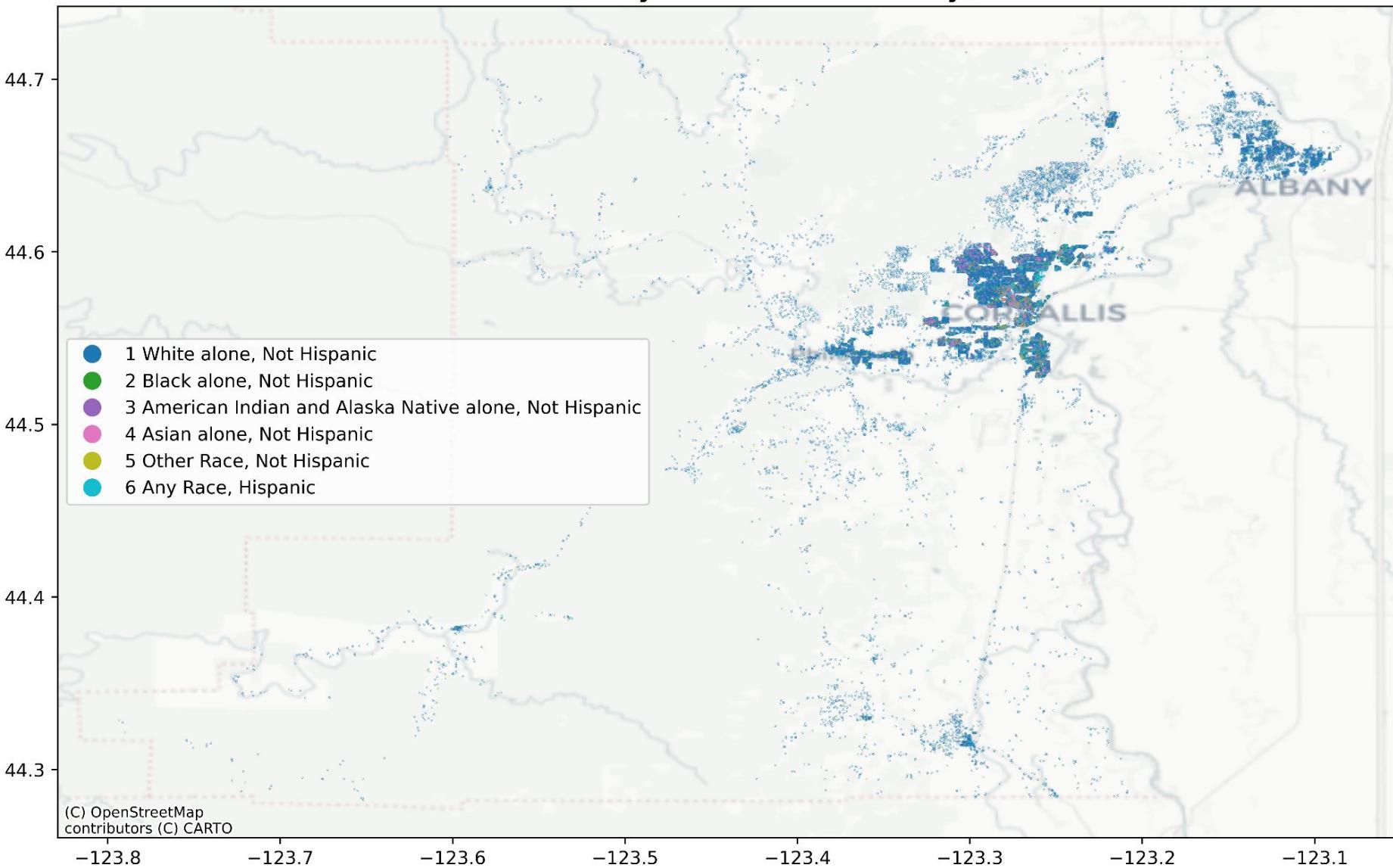
A significant improvement over median values.

Table. Median Household Income by Race, Ethnicity, Corvallis, 2010.

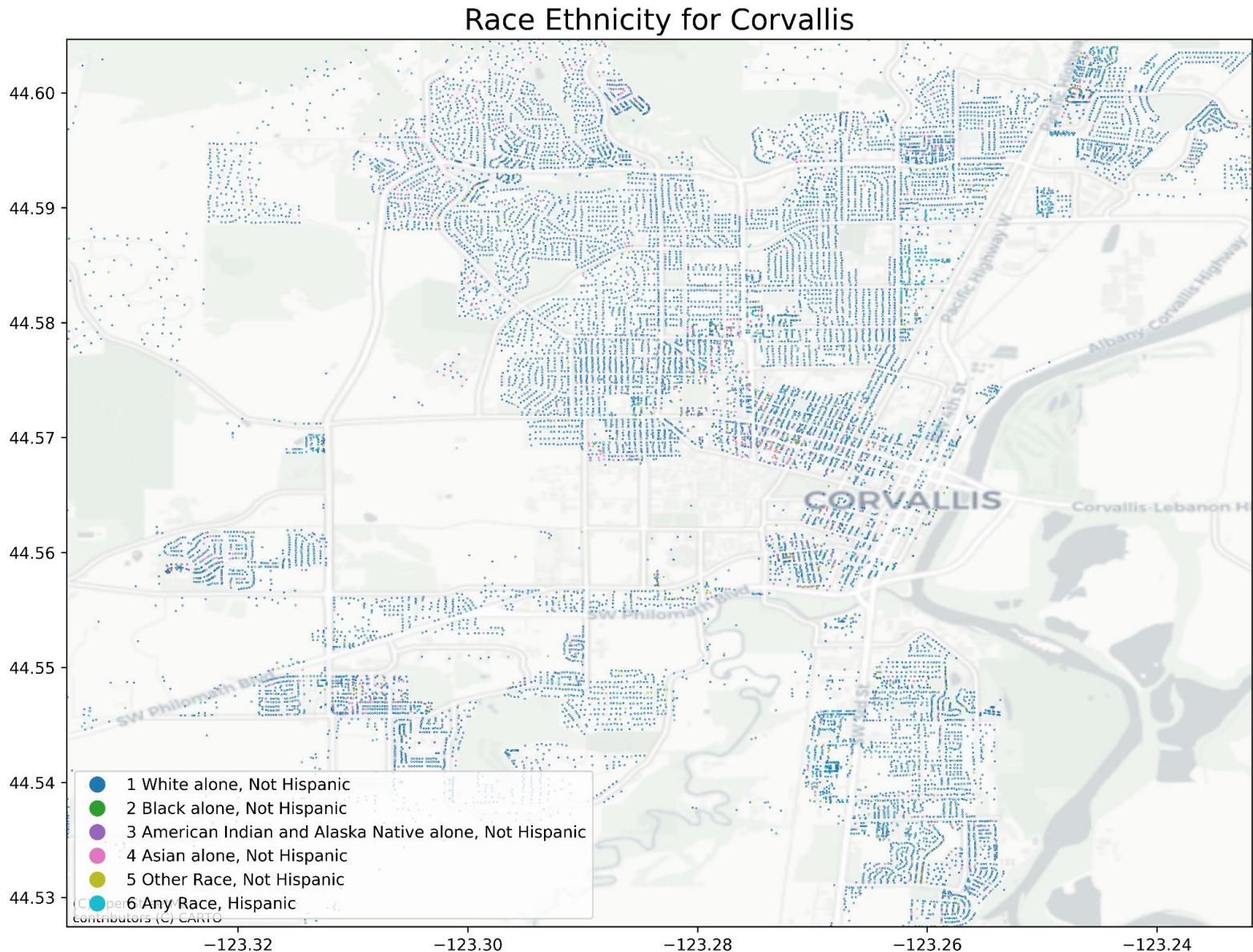
Tenure Status	1 Owner Occupied	2 Renter Occupied	Median Household Income
Race Ethnicity			
1 White alone, Not Hispanic	\$55,484	\$30,324	\$38,420
2 Black alone, Not Hispanic	\$36,315	\$22,893	\$26,389
3 American Indian and Alaska Native alone, Not Hispanic	\$54,570	\$48,810	\$51,073
4 Asian alone, Not Hispanic	\$54,892	\$19,812	\$24,435
5 Other Race, Not Hispanic	\$52,496	\$23,297	\$29,733
6 Any Race, Hispanic	\$48,829	\$28,250	\$31,939
Total	\$54,886	\$29,170	\$37,090

HUA data
is spatial

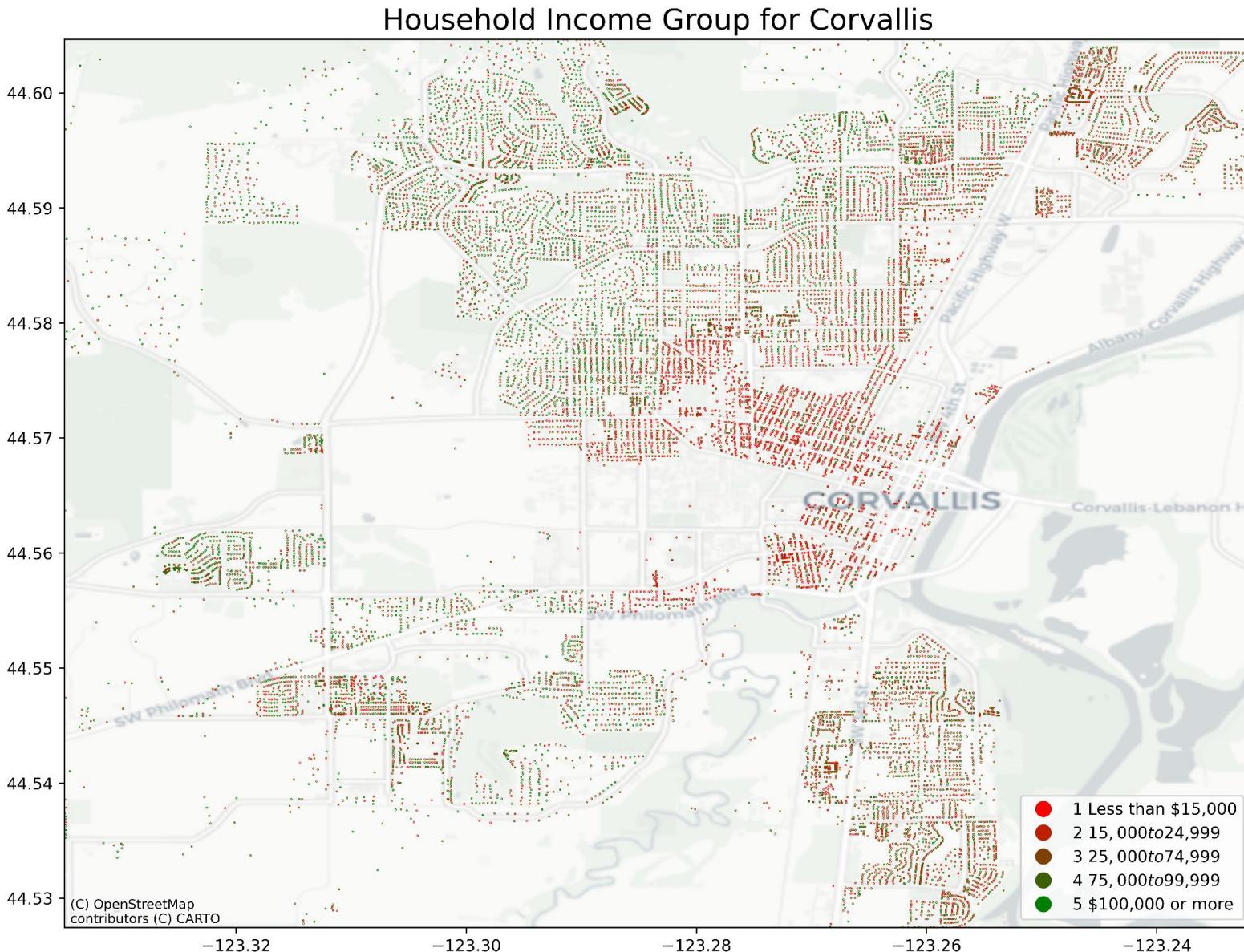
Race Ethnicity for Benton County, OR



Map shows the distribution of race and ethnicity within the community.

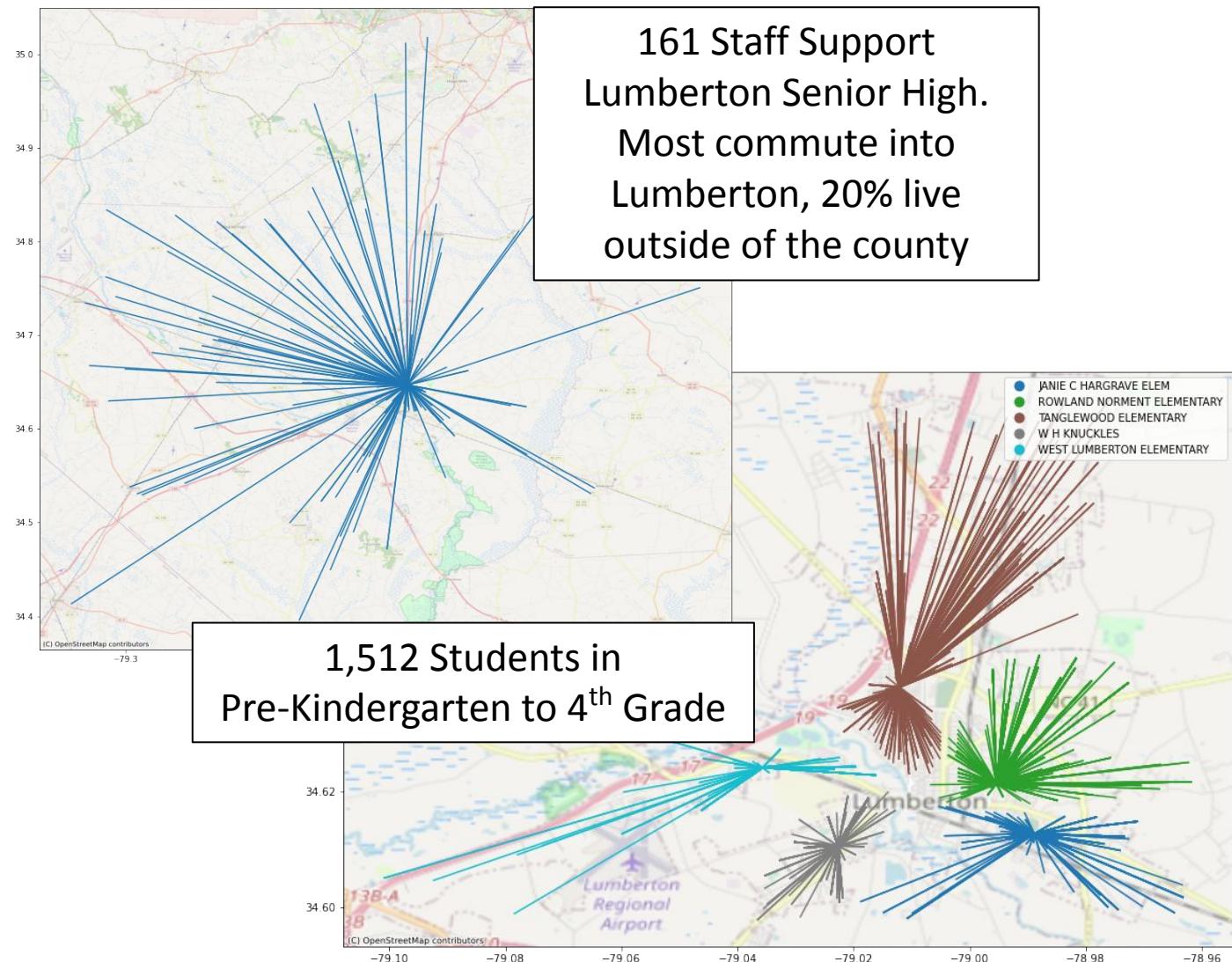


Map shows the distribution of 5 income groups.
Red = less than \$15,000



Students and School Staff Allocation

- Model provides community data of where 1,873 school staff and 4,758 students live. Each person is linked to a specific school
- Key characteristics: age, sex, race, ethnicity, earnings, grade level, job type
- Allocation to origin (home) and destination (work) building
- Data available in IN-CORE for all CoE members
- More details see Jupyter Notebook
https://github.com/npr99/IN-CORE_notebooks/blob/main/IN_CORE_CommunityDescription_Lumberton.ipynb



Link to Google Slides

<https://docs.google.com/presentation/d/1Pw3m9R5dbE-QiClk89pgAxw4VX27TleS8jhoVxpILw4>