Effects of Redlining on Residential Energy Efficiency and Resilience in Extreme Temperature Events

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Innovations in Climate Resilience Conference

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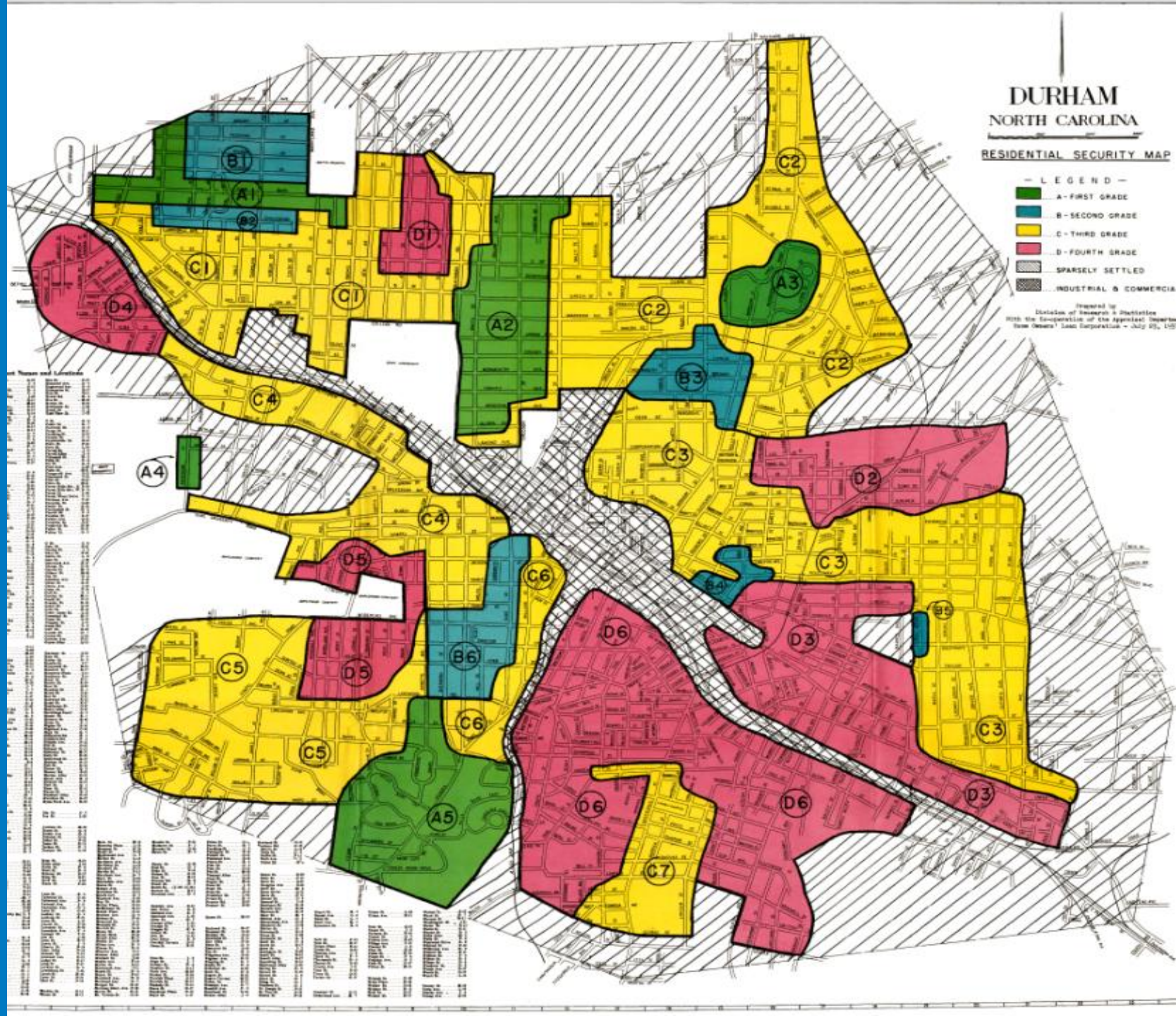
Background

Redlining was a practice used by the Home Owners' Loan Corporation where mortgage lending risk was assessed based on neighborhood sociodemographic data, including residents' **race/ethnicity and socioeconomic status**.

Decades of disinvestment in redlined areas have had long-term effects on home ownership, neighborhood development, and housing quality

→ **energy efficiency.**

Mapping Inequality, University of Richmond, 2023



WORLD ›

Earth just had its hottest summer on record, U.N. says, warning "climate breakdown has begun"

BY PAMELA FALK

UPDATED ON: SEPTEMBER 7, 2023 / 11:48 AM / CBS NE

Extreme heat harms health – what is the human body's limit?

As deadly heatwaves become more common, researchers are studying what people can tolerate.

Phoenix's newest heat record: A gruesome death toll in 2023

The hottest summer in human history – a visual timeline

Survey: Over 70 percent of Americans paid higher power bill due to summer's extreme heat

ice for this summer's scorching temperatures.

O'Connell-Domenech | Oct. 03, 2023

RACE

Extreme Heat Is Worse For Low-Income, Nonwhite Americans, A New Study Shows

July 14, 2021 · 2:43 PM ET

Climate change is exacerbating racial inequities. Boston is trying to change that.

Historically redlined Black and Brown communities can't escape the heat

ús Marrero Suárez, Melena Rodriguez, Emily Stevenson, Michael Walsh and Youmna Sukkar Updated July 27, 2023, 10:4

CLIMATE CHANGE

Discrimination Has Trapped People of Color in Unhealthy Urban 'Heat Islands'

f color, more than other groups, live in neighborhoods prone to excess heat and the illnesses that go with it

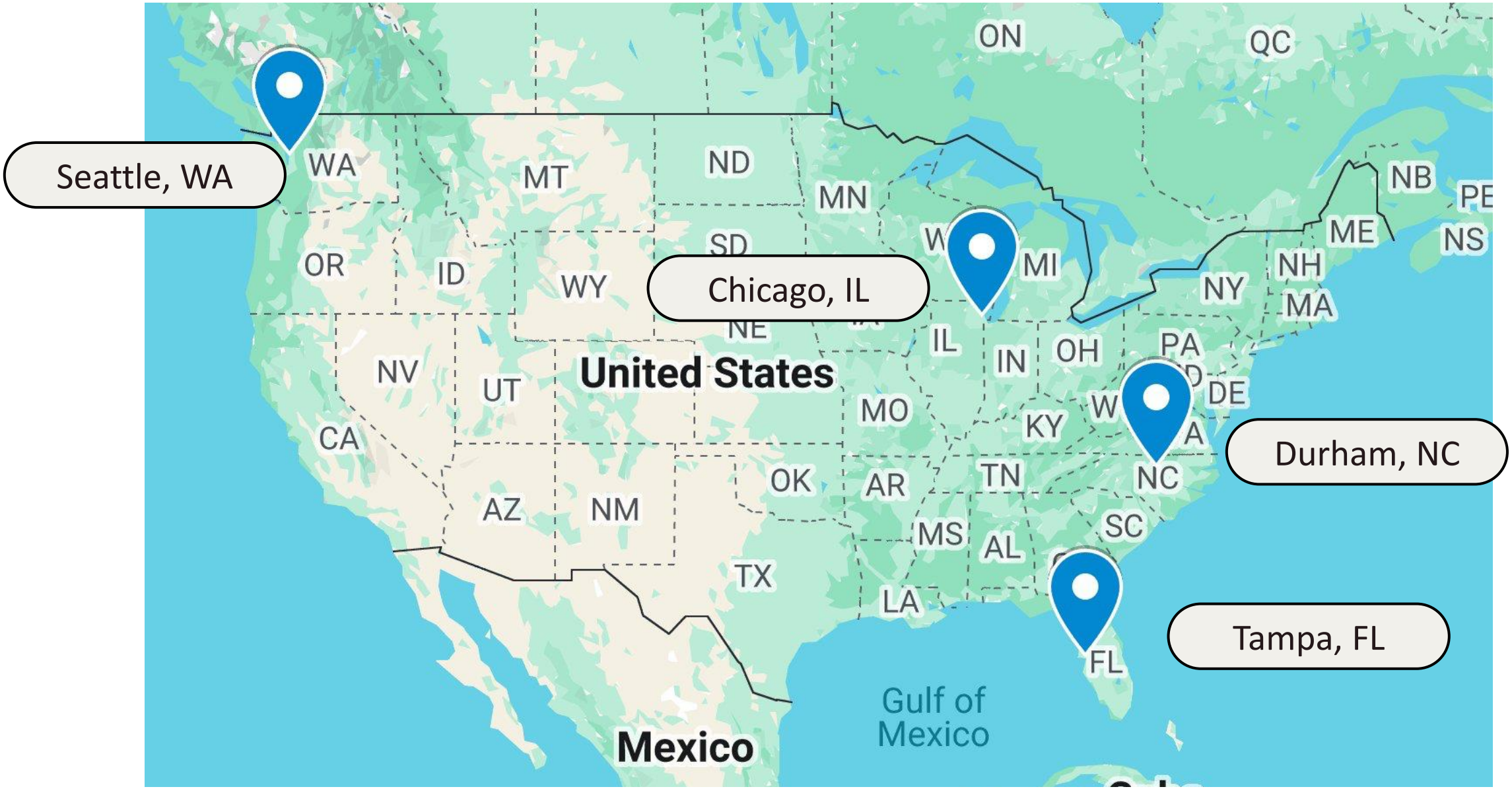
By Melba Newsome on September 19, 2023

Research Questions

1. Do homes in **historically redlined** neighborhoods perform less efficiently and, therefore, limit households' ability to withstand and adapt to extreme temperature events **compared to those in non-redlined neighborhood**s?

2. Do energy efficiency upgrades have the potential to **minimize building envelope gaps** and **reduce disparities** in residential energy efficiency?

Image from the National Archives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TX
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FL
Gulf of Mexico
Mexico

Methods

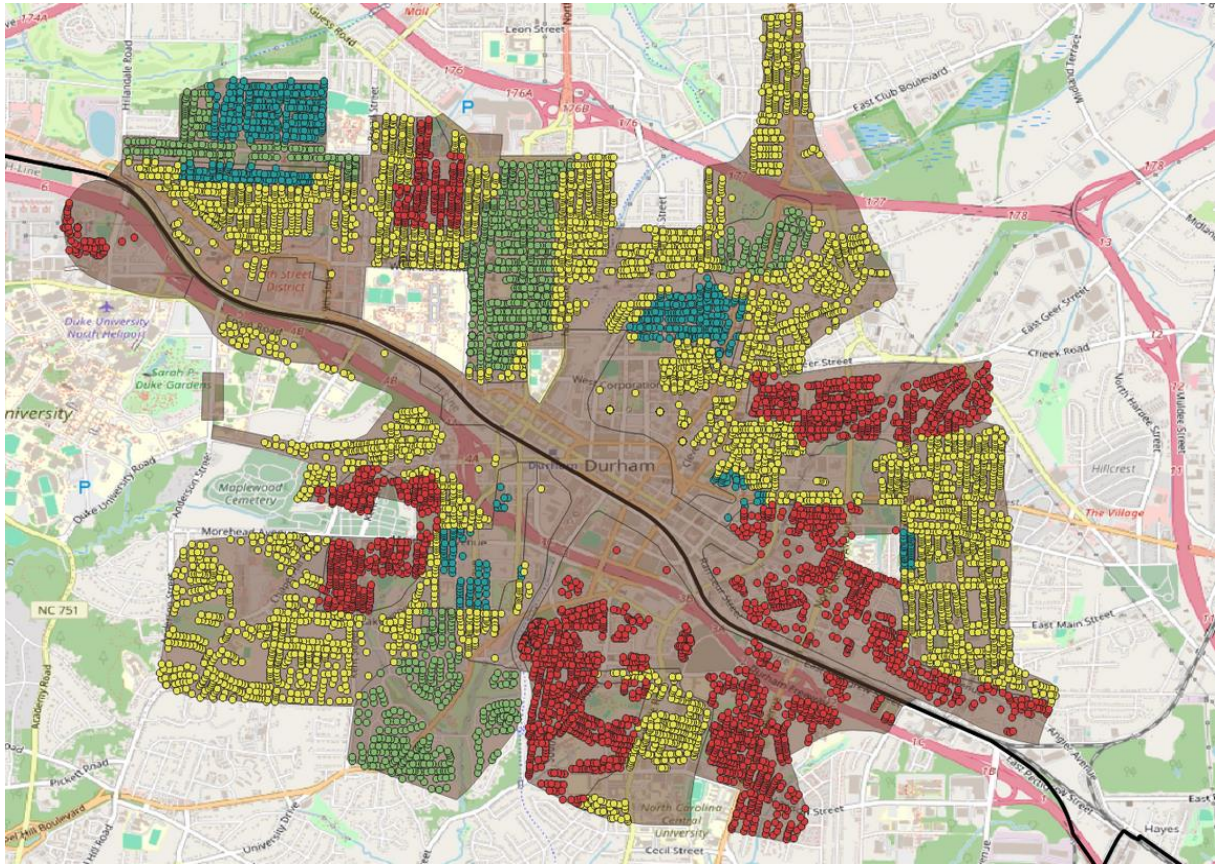
- NREL's ResStock tool was used to model housing stock performance under **coincident 3-day power outage and extreme temperature scenarios**
- Evaluated home performance under **five upgrade scenarios + outage-only control**
  - **Light Envelope**: attic insulation + general air sealing
  - **Advanced Envelope**: LE + robust air sealing + Energy STAR windows + exterior insulation
  - **Universal Cooling**: addition of HVAC for units without HVAC

Methods

- Thermal resilience of homes was determined using **Standard Effective Temperature (SET) Degree Hours**
- This metric tells you to *what magnitude* and for *how long* a home is outside a **“livable temperature” range of 54°F - 86°F**
- Higher SET Degree Hours = less thermal comfort and resilience

Methods

- Residential structure point data were gathered from the **USACE National Structure Inventory**
- Using HOLC map polygons from the **University of Richmond**, we spatially categorized homes by HOLC grade**: A (desirable), B, C, or D (hazardous)**



GIS map depicting categorization of residential structures by HOLC grade in Durham, NC. **Green = A, Blue = B, Yellow = C, Red = D**

Methods

Identifying differences in home type distribution and energy performance:

- Clustered homes into “types” based on **frame type, occupancy type, foundation type, and vintage** (e.g., “wood40res3a” = wood frame, 1940s, multifamily 2-unit)
- Identified home types **more and less prevalent** in redlined areas
- Compared **thermal resilience** (SET Degree Hours) by home type

Wood Frame, 1930s, Multi-Family 2-Unit

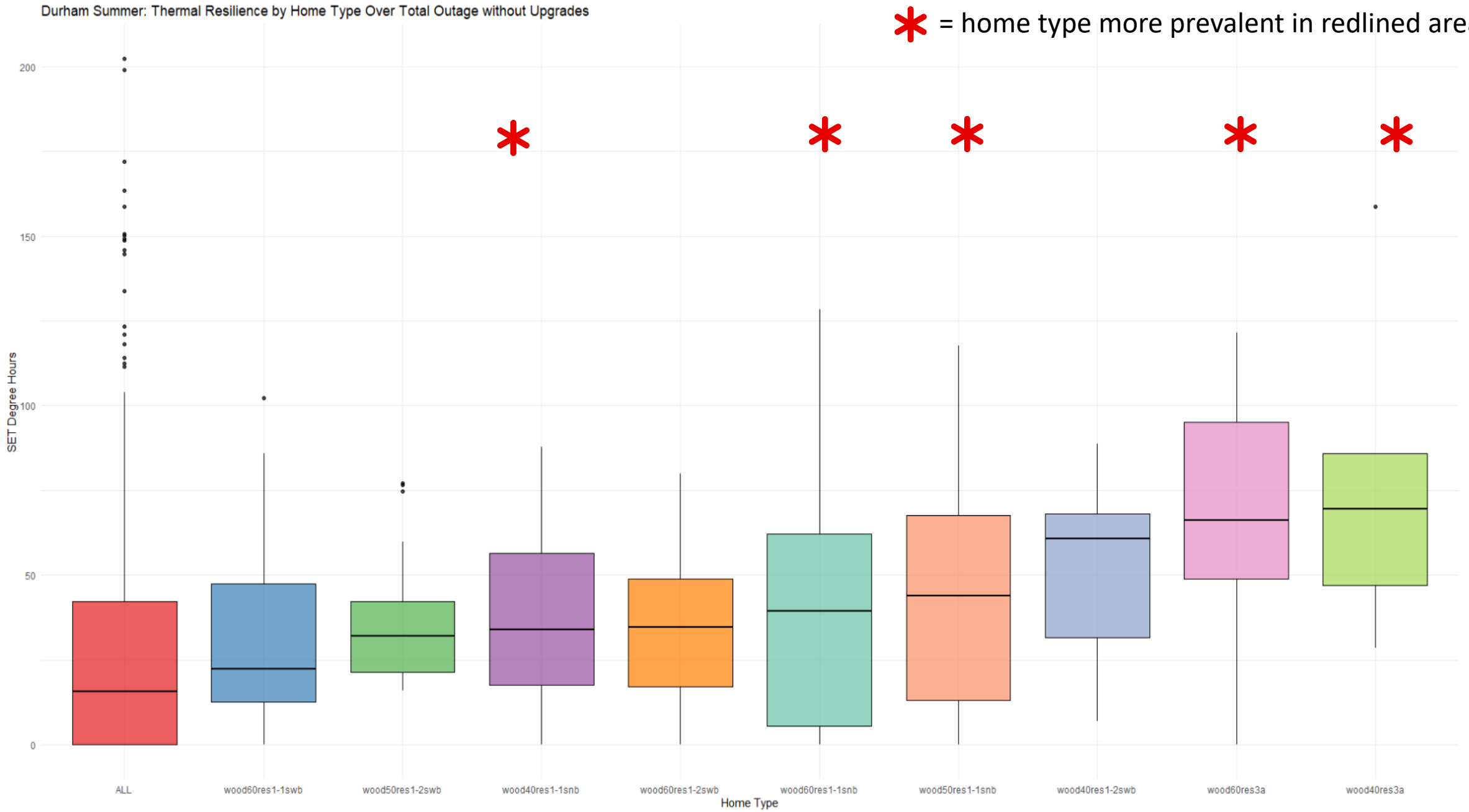
wood30res3a

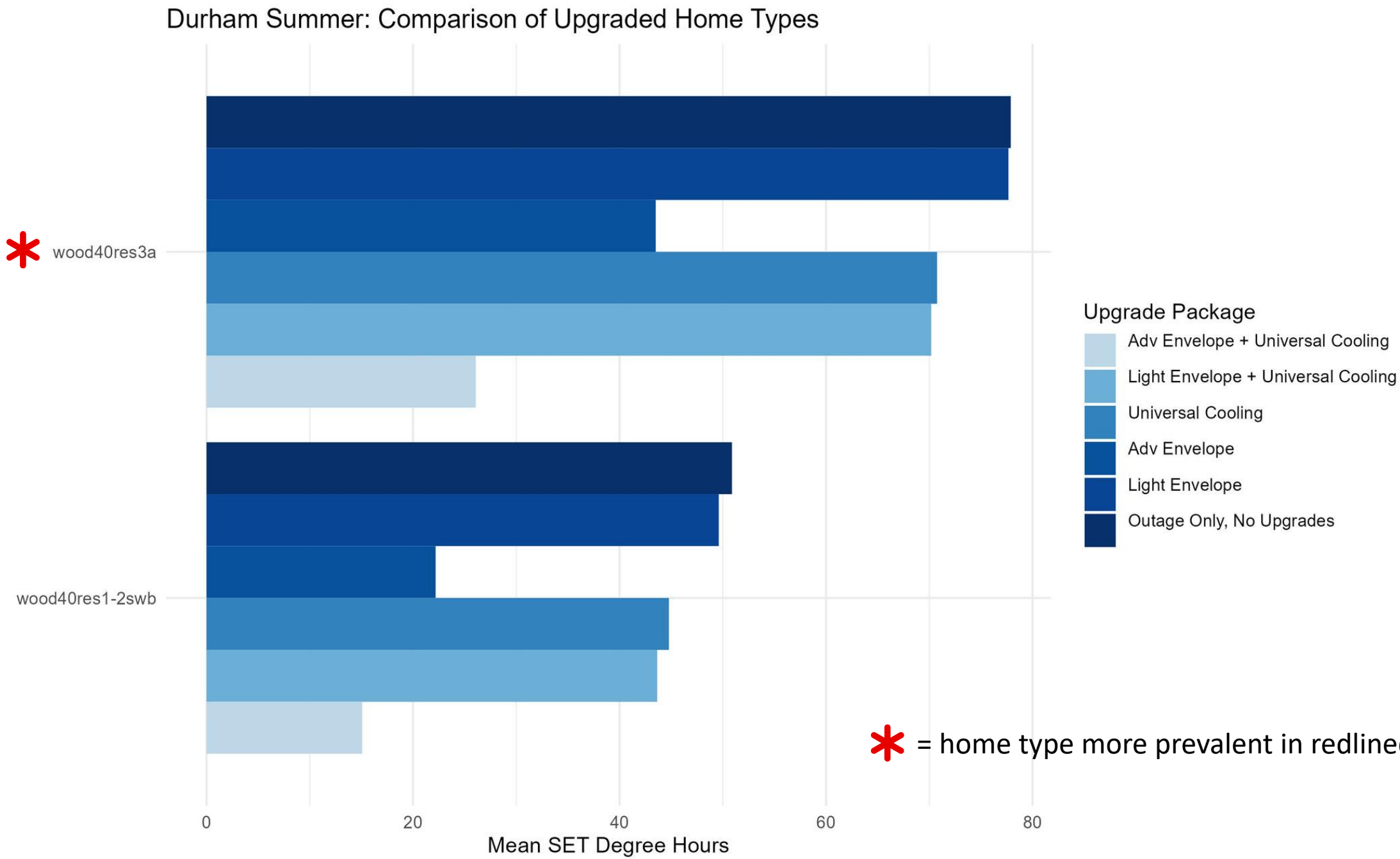
Wood Frame, 1920s, Single-Family, 2-Story, With Basement

wood20res1-2swb

Results

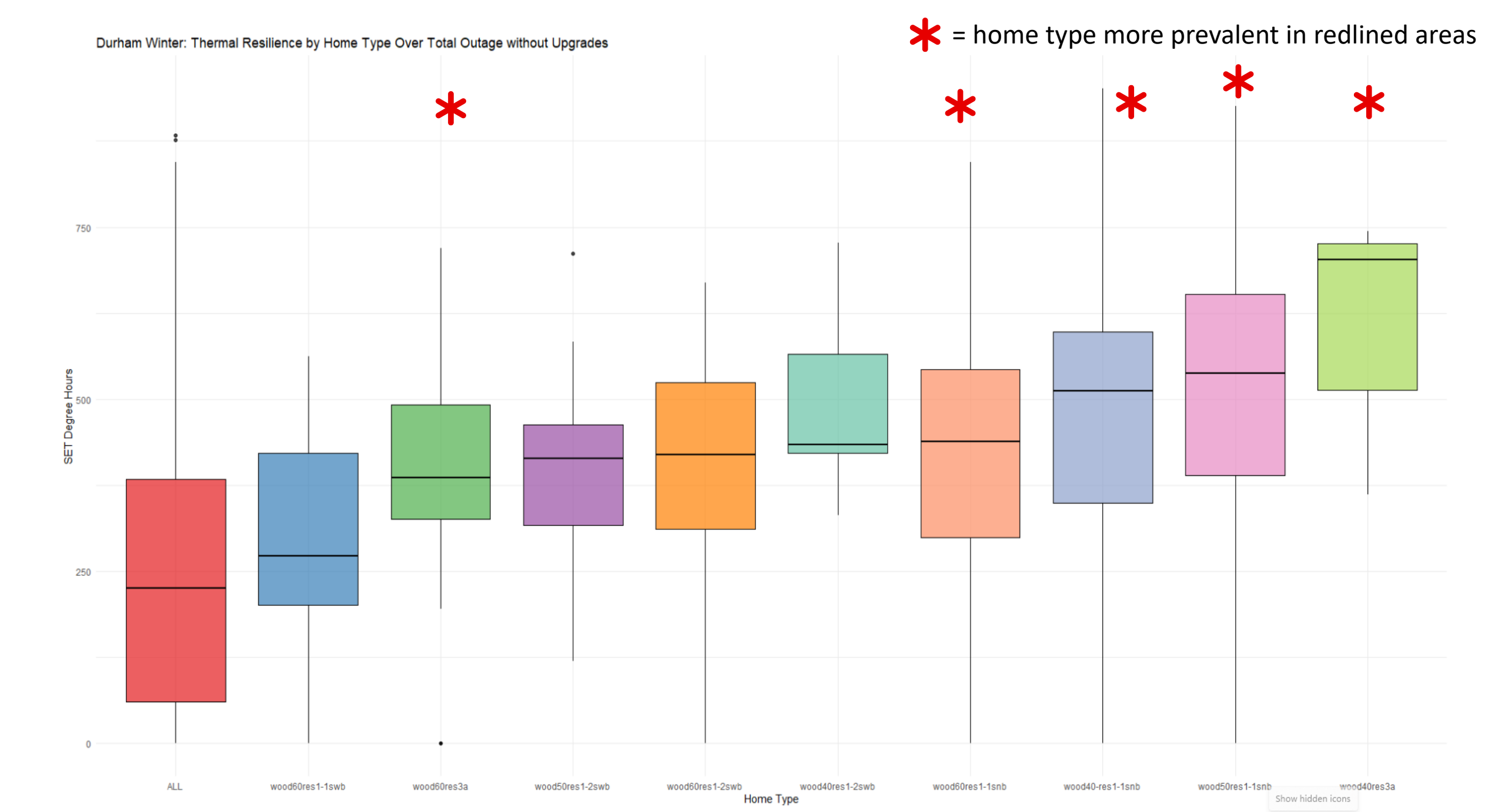
Durham, NC
Summer Outage

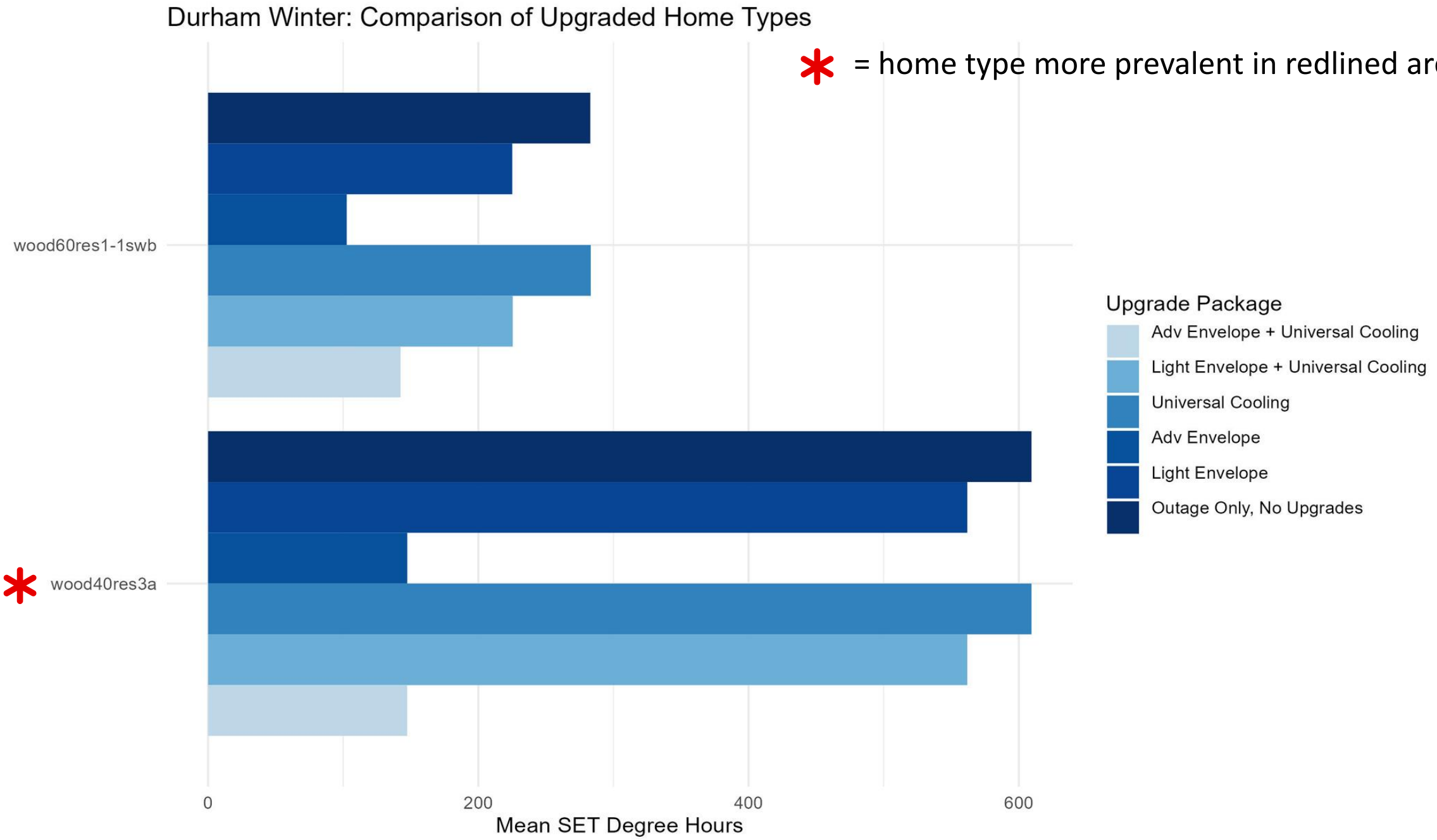

Durham Summer: Thermal Resilience by Home Type Over Total Outage without Upgrades
* = home type more prevalent in redlined areas
SET Degree Hours
200
150
100
50
0
ALL
wood60res1-1swb
wood50res1-2swb
wood40res1-1snb
wood60res1-2swb
wood60res1-1snb
wood50res1-1snb
wood40res1-2swb
wood60res3a
wood40res3a
Home Type


Durham Summer: Comparison of Upgraded Home Types
wood40res3a
wood40res1-2swb
0
20
40
60
80
Mean SET Degree Hours
Upgrade Package
Adv Envelope + Universal Cooling
Light Envelope + Universal Cooling
Universal Cooling
Adv Envelope
Light Envelope
Outage Only, No Upgrades
= home type more prevalent in redlined areas

Results

Durham, NC
Winter Outage


Durham Winter: Thermal Resilience by Home Type Over Total Outage without Upgrades
* = home type more prevalent in redlined areas
SET Degree Hours
0
250
500
750
ALL
wood60res1-1swb
wood60res3a
wood50res1-2swb
wood60res1-2swb
wood40res1-2swb
wood60res1-1snb
wood40-res1-1snb
wood50res1-1snb
wood40res3a
Home Type
Show hidden icons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wood60res1-1swb
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Mean SET Degree Hours
Upgrade Package
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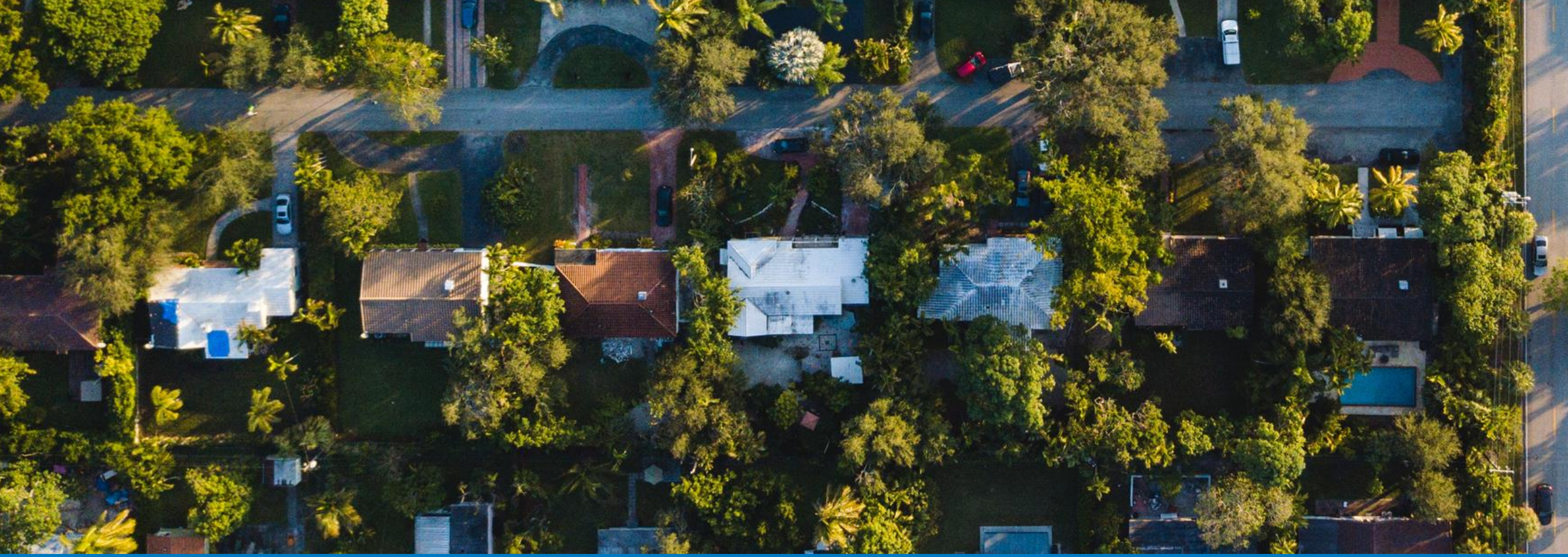
Universal Cooling
Adv Envelope
Light Envelope
Outage Only, No Upgrades

Discussion

- Several home types identified that are notably **more prevalent in redlined areas** and vice versa
- Most home types ***more*** **prevalent** in redlined areas show ***higher*** **average SET Degree Hour measurements** compared to *less* prevalent home types
- Upgrades show promise for **reducing SET Degree Hours** during a coincident power outage and extreme temperature event
- Further analyses are needed to understand discrepancies in prevalence vs. energy efficiency



Challenges & Limitations

- Data availability and resolution
- ResStock modeling limitations
- Neighborhood and city changes (i.e., gentrification and expansion)

Future Research & Potential Applications

- Expand analyses to additional locations
- Model additional upgrades (e.g., heat pumps)
- Evaluate retrofit costs and benefits to translate findings into investments
- Layer other relevant patterns (e.g., health, energy burden)
- Inform policies, weatherization and energy/technical assistance programs

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