Motivation

- Extreme heat events are becoming more frequent and severe due to climate change. Fatal extreme-heat events are forecast to increase over the next decades, especially in urban areas due to the urban heat-island effect (UHI).
- It has been well documented that certain groups are relatively vulnerable to these events because they often lack air conditioning, access to information, or other resources to avoid health problems from heat.
- Trees have been shown to effectively mitigate these effects in urban areas, especially where few trees already exist.
- Thus, there is a need to create a comprehensive index that can be displayed on a map to identify the zones where residents' health would benefit most from a tree-planting program.

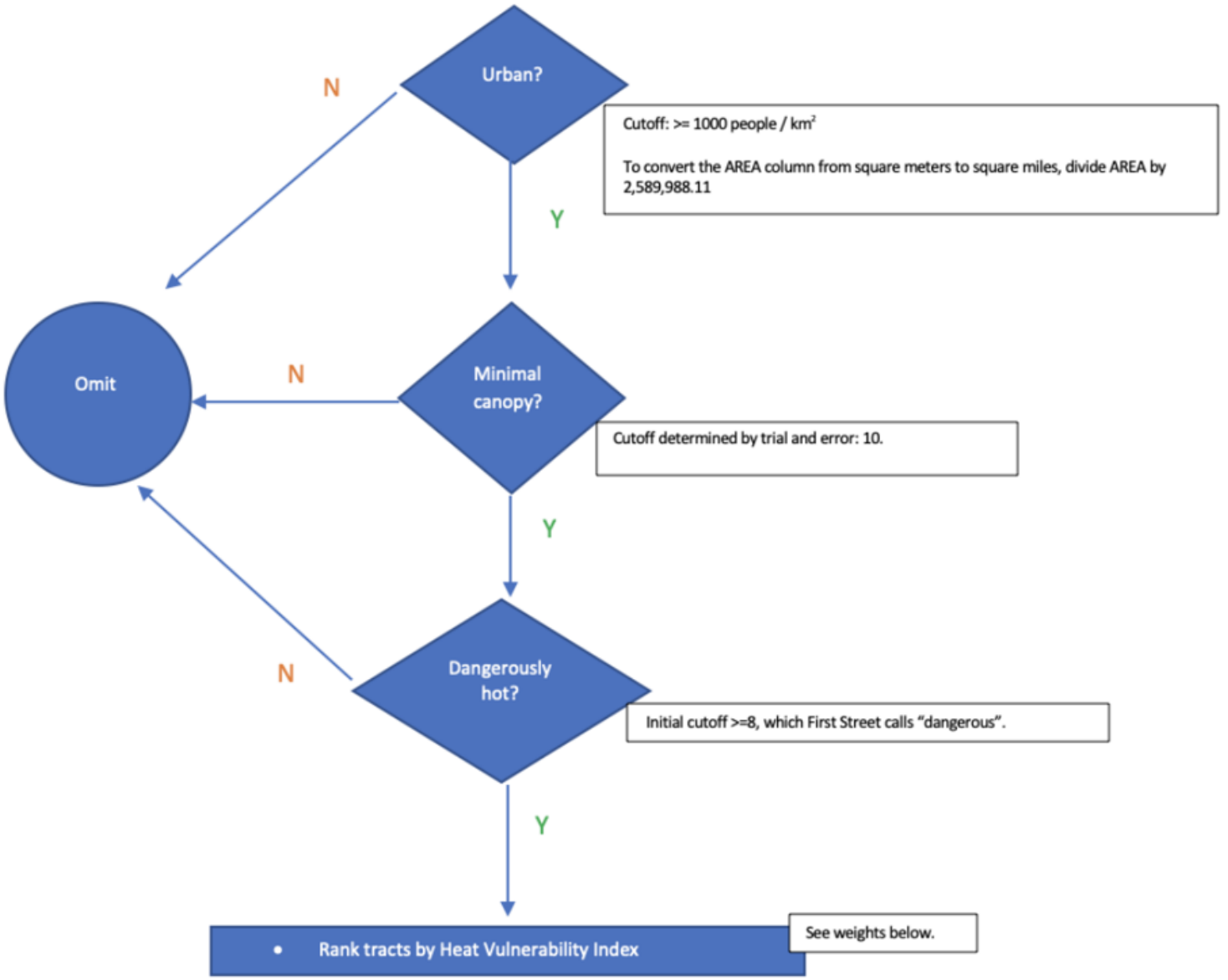
Approaches

Innovations

- Unified analysis of census data, satellite data regarding tree cover, and an index of the likelihood of future heat events.
- Nationwide analysis
- Use of the state-of-the-art First Street Heat Factor dataset to guide tree-planting

Ranking locations

- We created an index for tree-planting that is displayed at the census-tract level on an interactive map of the continental U.S.
- This tool presents a unified analysis of census data, satellite data regarding tree cover, and an index of the likelihood of future heat events.
- A decision tree selects census tracts only if they have sparse tree cover, an urban population-density, and a predicted heat level in 2053 of “dangerous.”
- Then it ranks tracts by a Heat Vulnerability Index (HVI). The HVI was derived by applying the findings of previous studies of individual places to the mix of residents in each selected tract across the country.

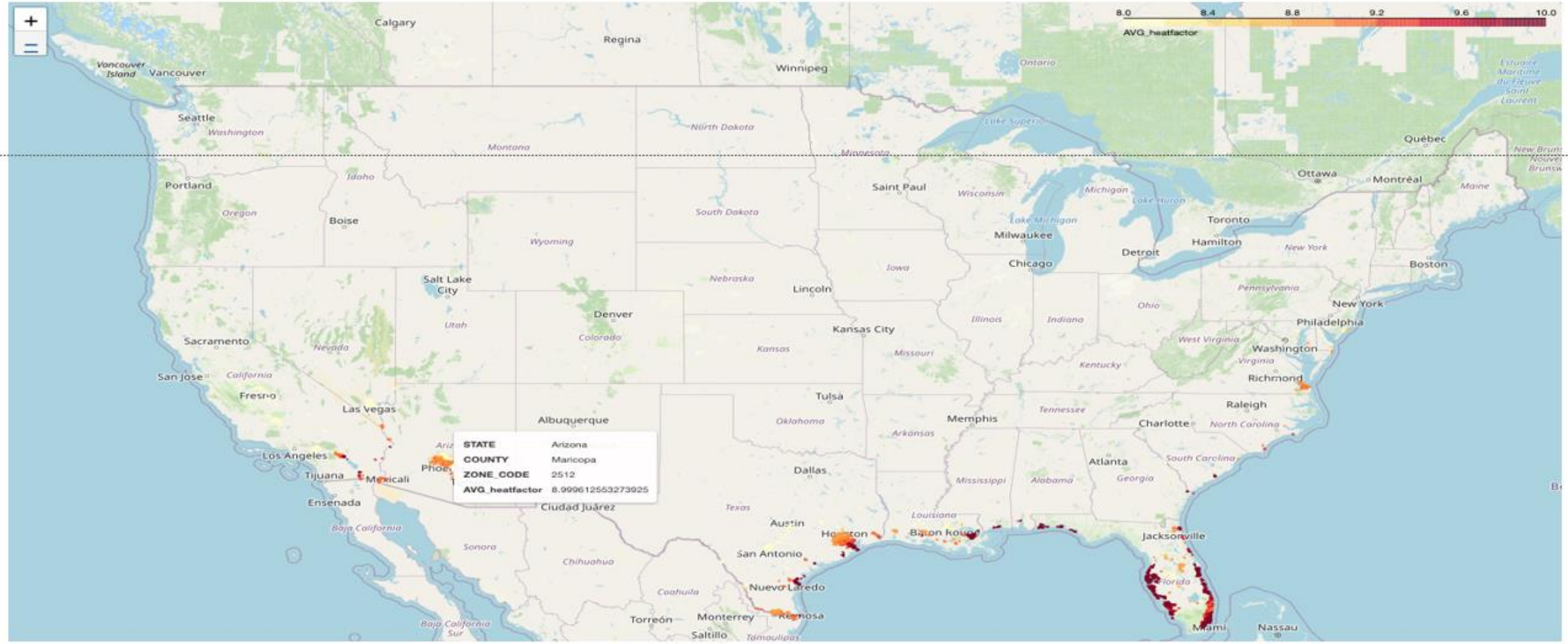


	Poverty	*LTHSE*	*Minority*	*Live alone*	*65-plus*	*65-plus, alone*	*Immigrant*	*Disability*
Weights (sum to 1)	0.1375	0.1424	0.0747	0.1857	0.1875	0.1607	0.1115	0.1804

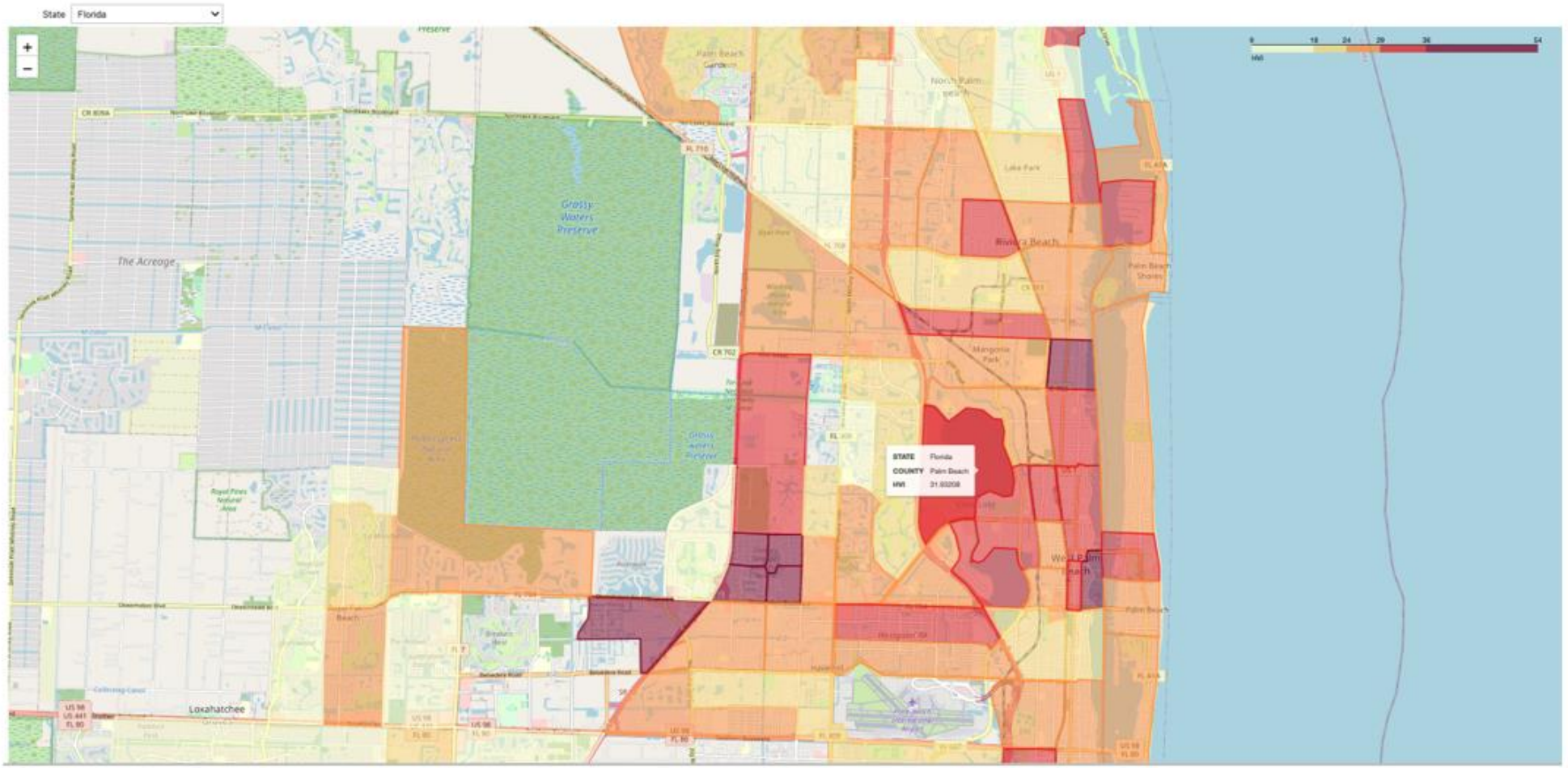
Decision tree and weights of HVI indicators

Creating maps

- The satellite data of tree cover was aggregated to the census-tract level using ArcGIS Pro and exported into a shapefile.
- The database of predicted heat and the census data were imported into a Pandas dataframe in Python. Then we calculated the HVI and tract-level heat values.
- The first three steps of the decision tree filtered out inappropriate census tracts.This avoided unacceptable lag in drawing the interactive maps.
- GeoPandas was employed to produce two series of interactive maps for each factor in the decision tree, including the HVI's components:
    - HTML maps of the entire country
    - Inline maps in a Jupyter notebook, with a dropdown menu to select each state and with a popup showing key information about each tract.
- The key maps used color to displayed the relative strength of the HVI values, thus indicating the relative need for tree-planting to prevent health problems from extreme heat.



Interactive HTML map showing the census tracts that most need tree-planting. The popup shows the predicted heat for a county in Arizona.



Inline map in Jupyter notebook with a dropdown menu, showing the heat vulnerability index values for selected census tracts in Florida. Darker tracts have more vulnerable residents.

Data

- *Satellite data of tree cover:* 21 GB of 30m x 30m pixels for the entire United States, downloaded from the U.S. Geological Survey.
- *Census tract boundaries:* 82 MB shapefile downloaded from U.S. Centers for Disease Control
- *30-yr prediction of heat:* First Street Heat Factor CSV dataset, ~80,000 records, downloaded from AWS.
- *Census data:* American Community Survey 5-yr estimates for 2017-2021, downloaded from ESRI Living Atlas using ArcGIS Pro, ~ 80,000 records for each of 8 categories.

Evaluation and Results

- *Analytical evaluation:* Comparing our HVI to a published analysis of hospitalizations from heat in Phoenix, we found general agreement about zones within the city but minor variations regarding the ranking of the at-risk census tracts within each zone.
- *Functional evaluation:* We recruited a climate-change professional to test the maps' operation. She had no difficulty navigating or interpreting the map but did suggest adding tabular data.
- *Overall:* Thus, our product appears generally successful, although further testing and additional features are warranted.

General result

- Our final map shows that, because of humidity's deleterious effects, the urban areas having sparse tree-cover and facing extreme heat are clustered along the southern coasts and border.
- Our HVI distinguishes among all such census tracts based on dangers to human health.
- This differs from current practice, which focuses on individual cities, such as Boston, without asking whether those cities need tree-planting compared to others.

Conclusion

- Our interactive maps provide a visual representation of the most impactful locations for tree planting to mitigate health problems from extreme heat events. It will help decision-makers to maximize the benefits of tree-planting programs.