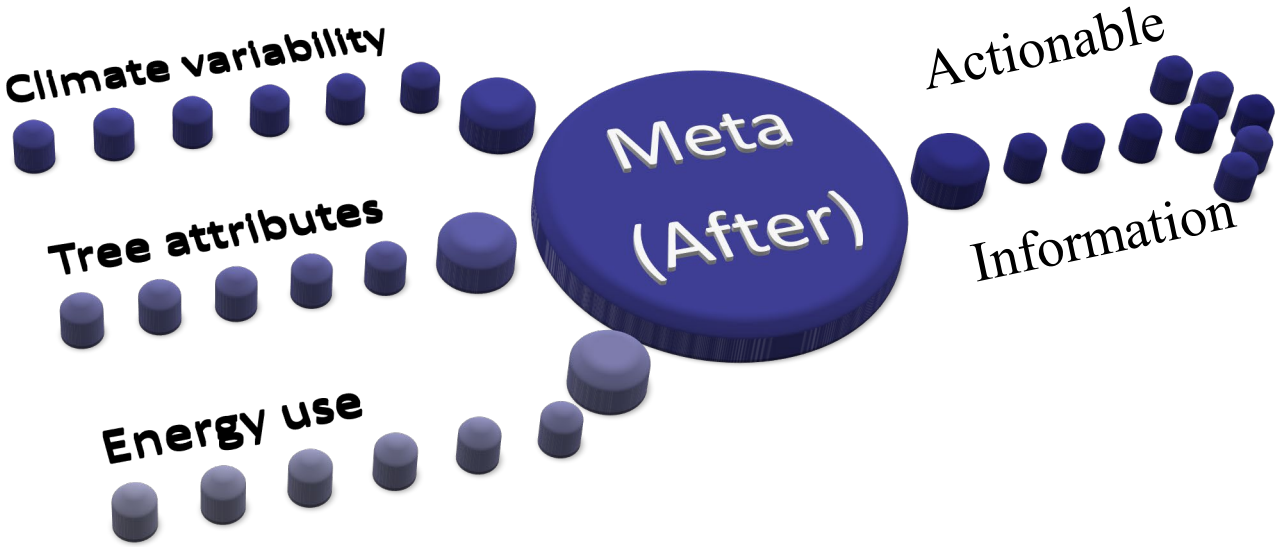
The Role of Urban Forests
in Sustainable Communities

Decision Support Tools to Increase Resilience in Urban Neighborhoods

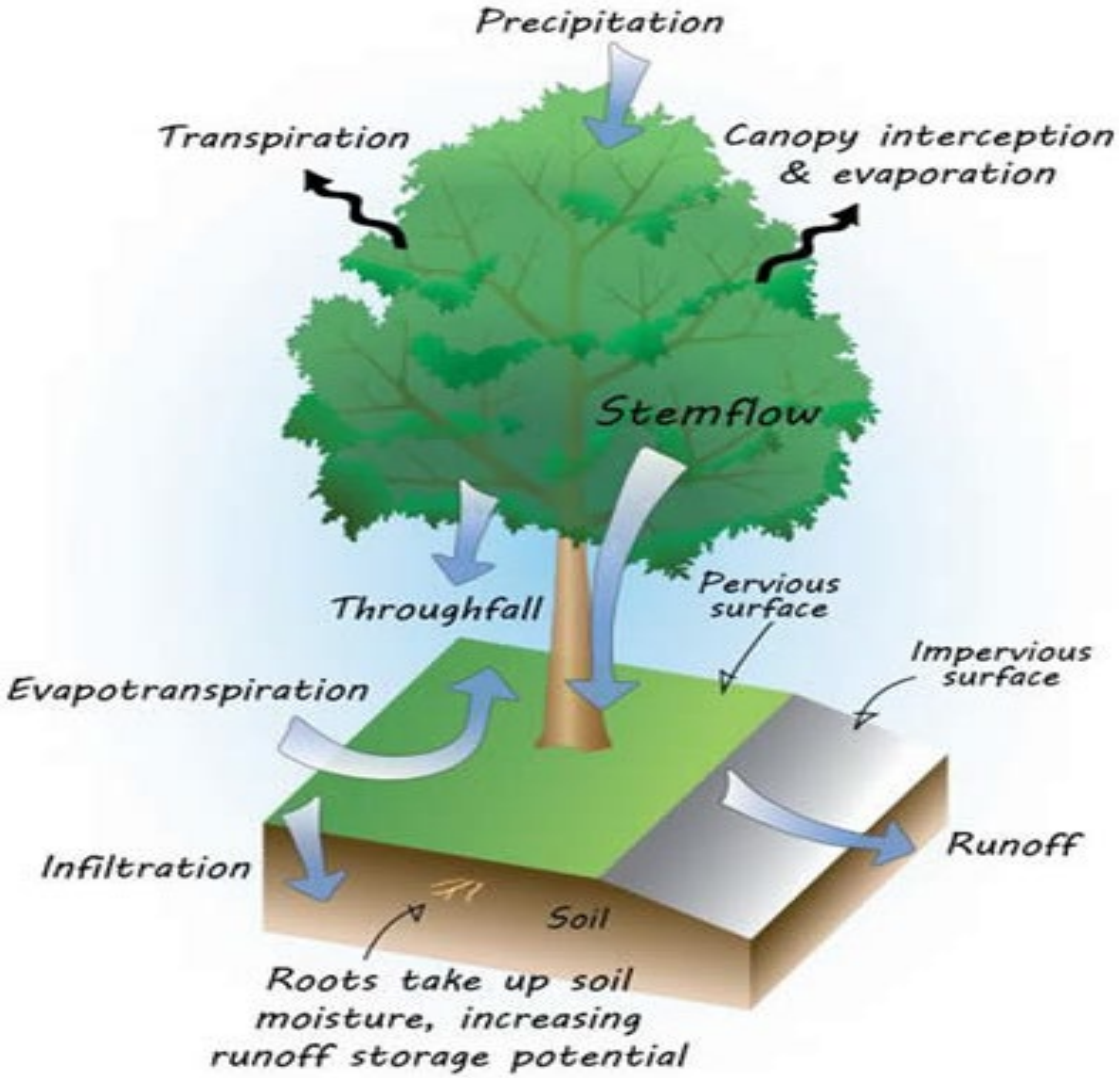
Ulrike Passe, Iowa State University
&
David Jahn, City of Des Moines Urban Forestry



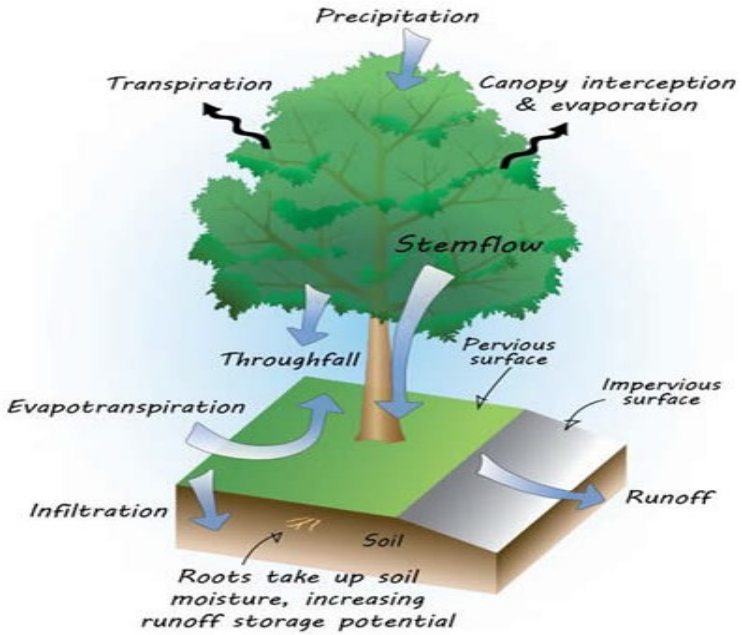
PLANT MORE TREES

Stormwater Benefit of Trees

- Intercept rainwater on leaves and branches
- Divert rainwater into soil
- Use rainwater, increasing the runoff storage potential
- Release rainwater back into the atmosphere through transpiration = cool the air



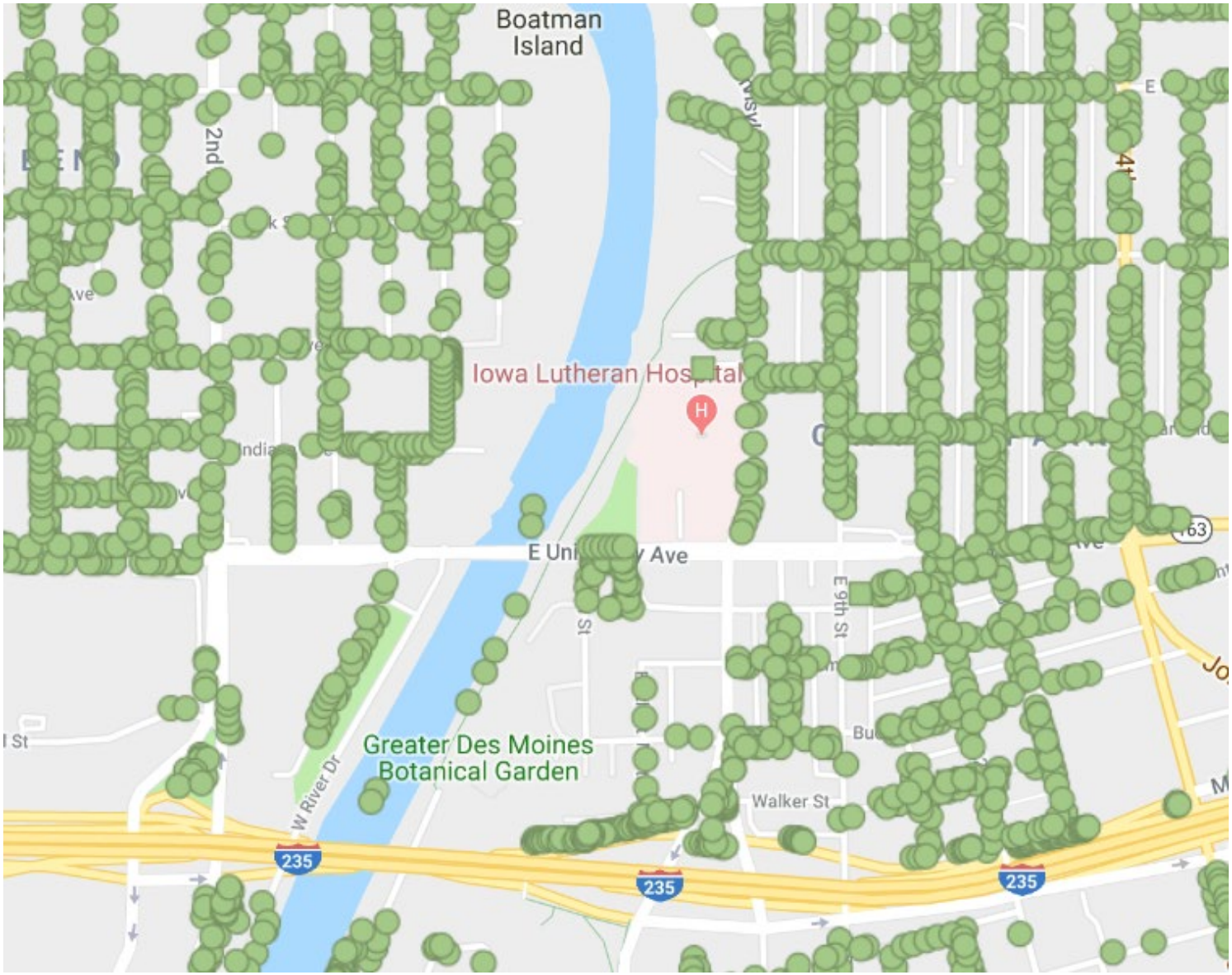
Make TREES part of the SOLUTION!

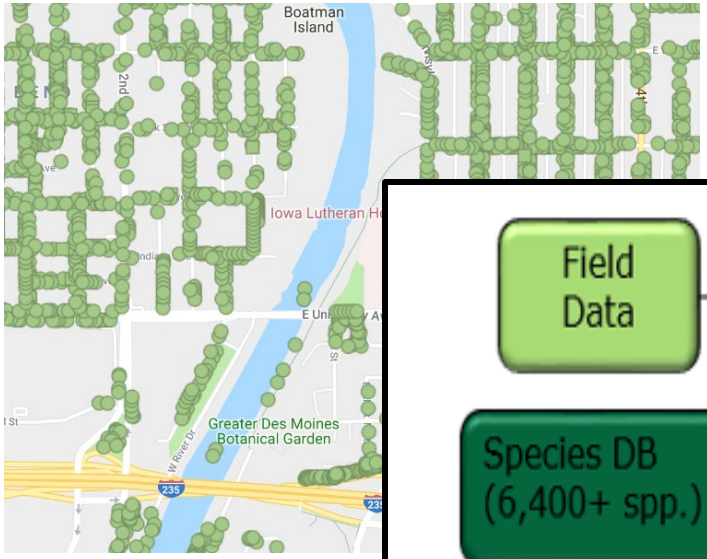


Gray Solutions to 2008 Flood in Des Moines:

- Levee Upgrades
- Ten New Stormwater Pump Stations
- Seven Stormwater Pump Station Upgrades
- Storm Sewer Improvements

Cost? $77,000,000


Boatman Island
2nd
Iowa Lutheran Hospital
E Uni Ave
E 6th St
Greater Des Moines Botanical Garden
W River Dr
Walker St
235
235
235
63



Field Data

Species DB (6,400+ spp.)

Location DB (City info)

Hourly Pollution Data

Hourly Weather Data

i-Tree™ Eco

Carbon

Air Quality

Avoided Runoff

Energy Effects

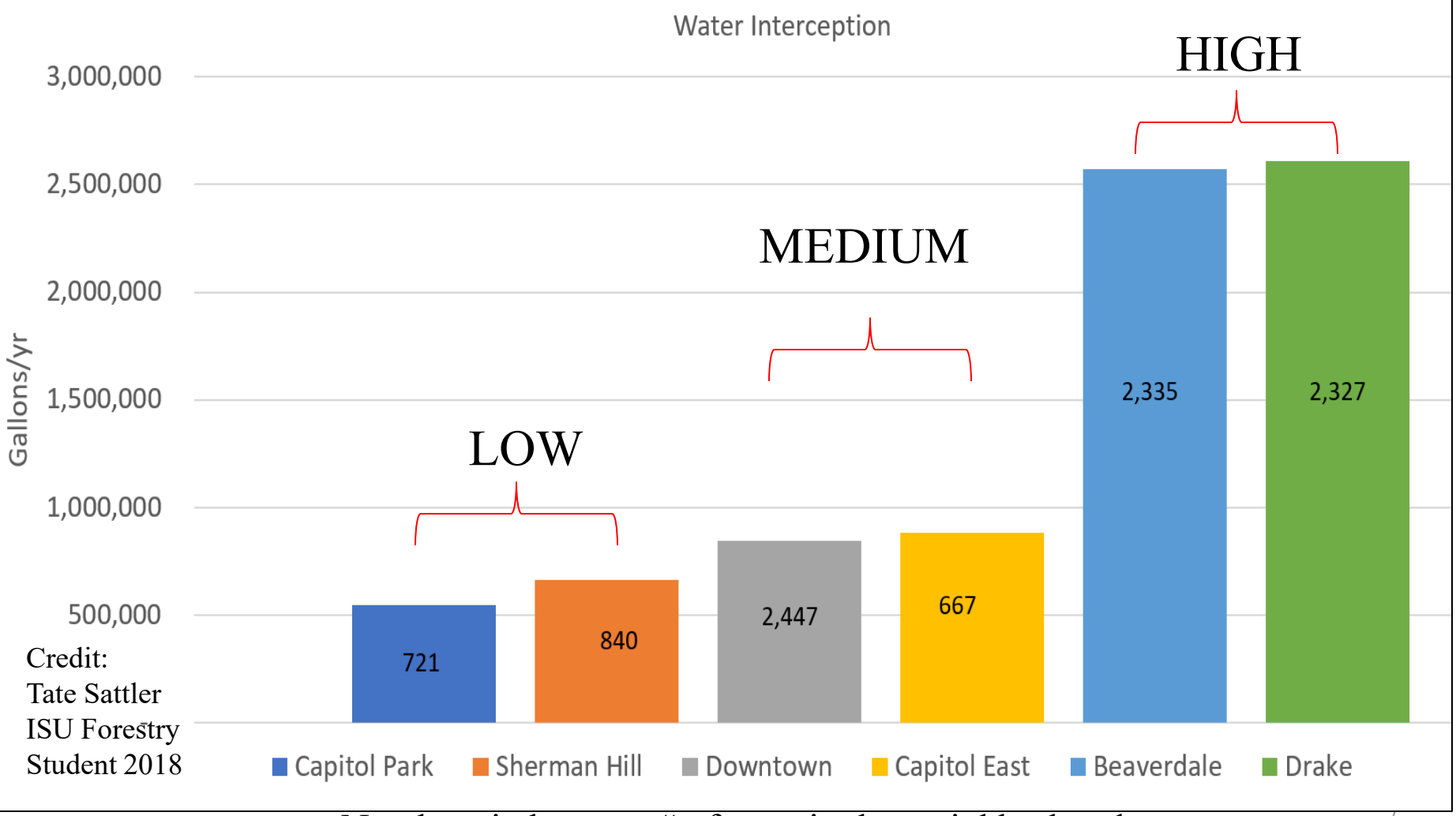
Volatile Organic Compounds

Structure

Value

Forecast

Annual amount of water interception



Credit:
Tate Sattler
ISU Forestry
Student 2018

Numbers in bars are # of trees in that neighborhood

Build resilient ecosystems that foster resilient socioecological systems

Justice is the core of sustainability

Environmental Justice

Knowledge, awareness, community building

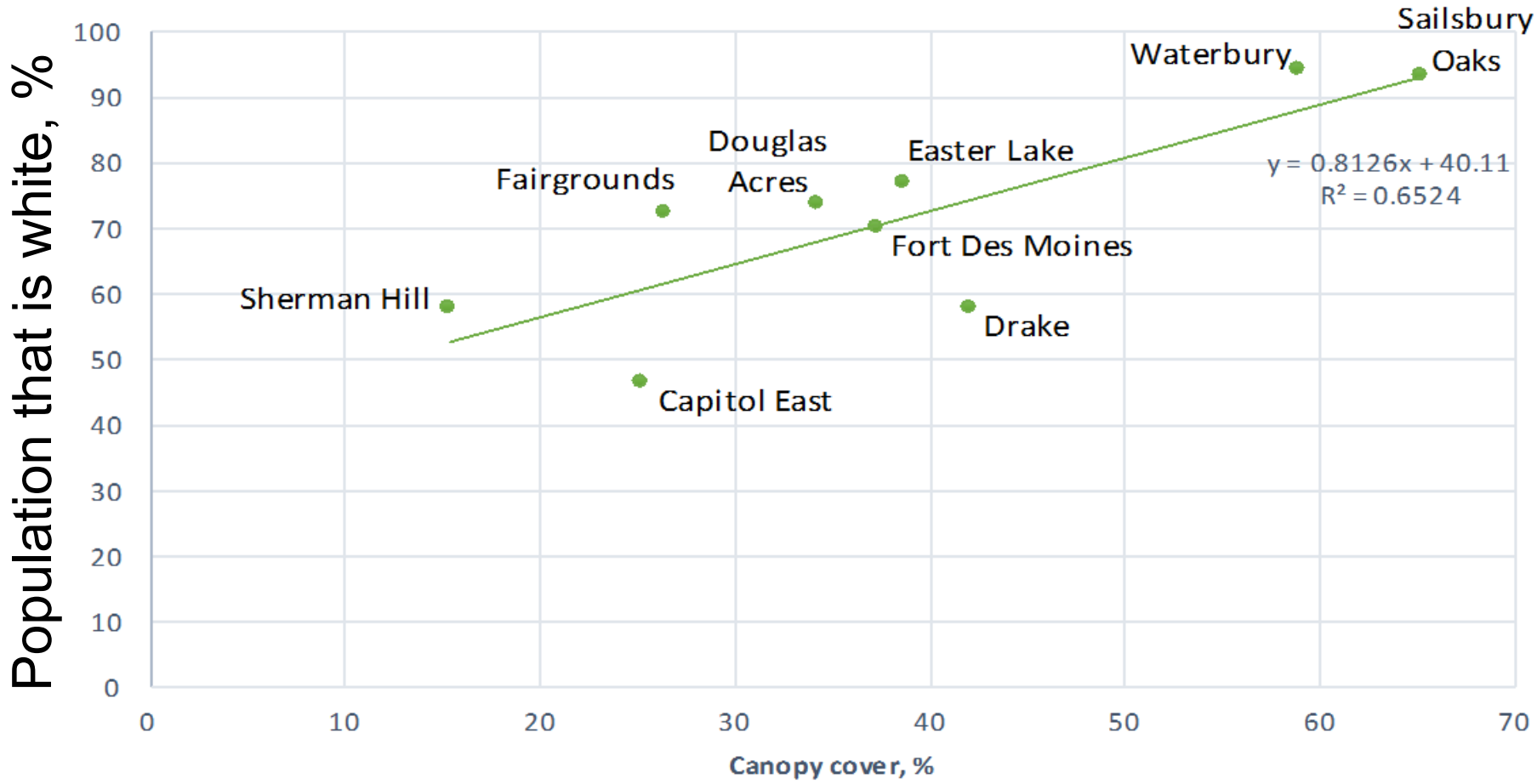
Equal distribution of ecosystem services

Work towards being proactive rather than reactive

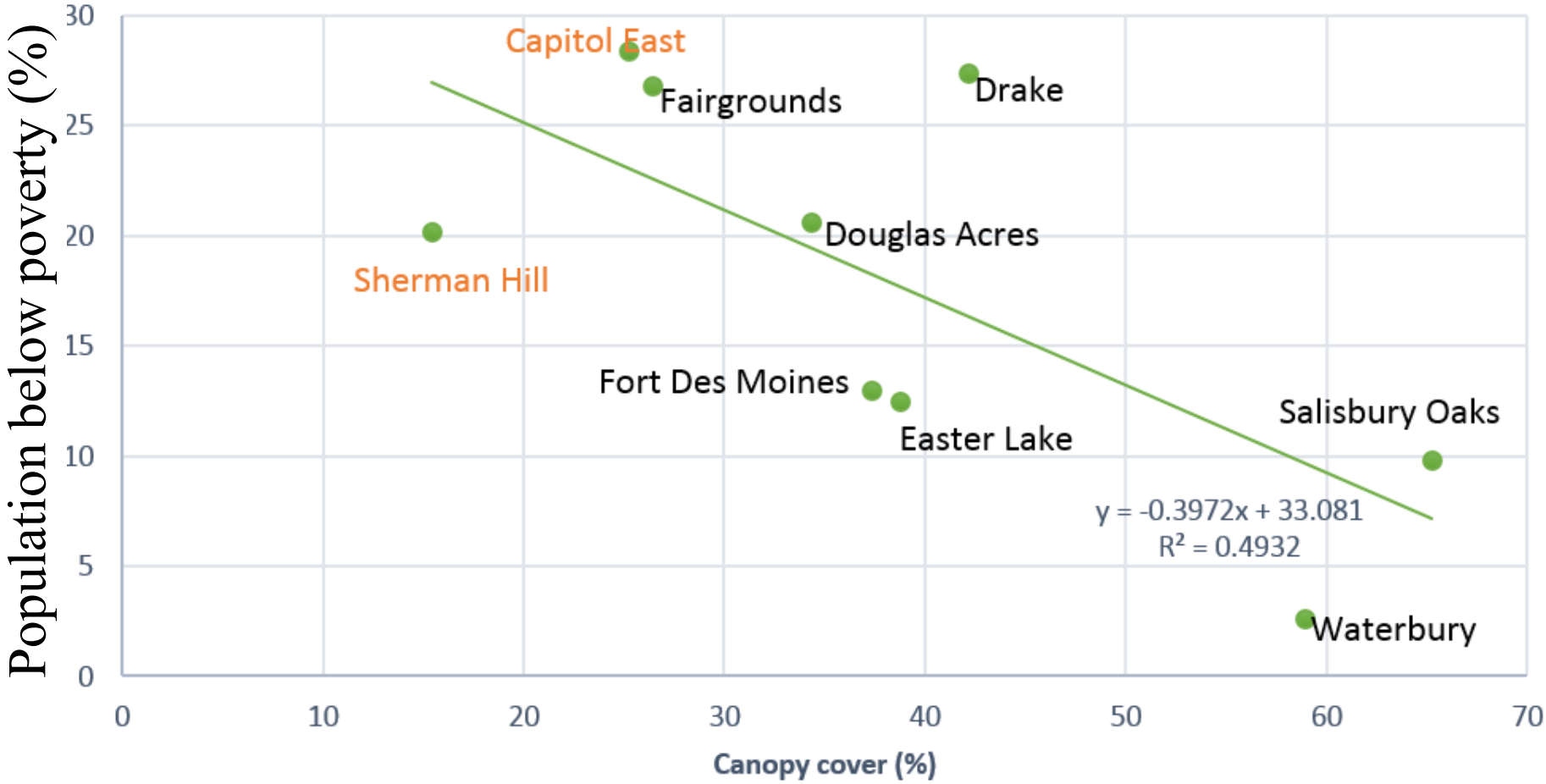
EPA Definition

"The fair treatment and meaningful involvement of all people regardless of *race, color, sex, national origin*, or *income* with respect to the development, implementation and enforcement of environmental laws, regulations, and policies."

Credit:
Hanna Hampton
ISU Forestry
Student 2018



Population below poverty (%) vs. Canopy cover (%)



Recommendations

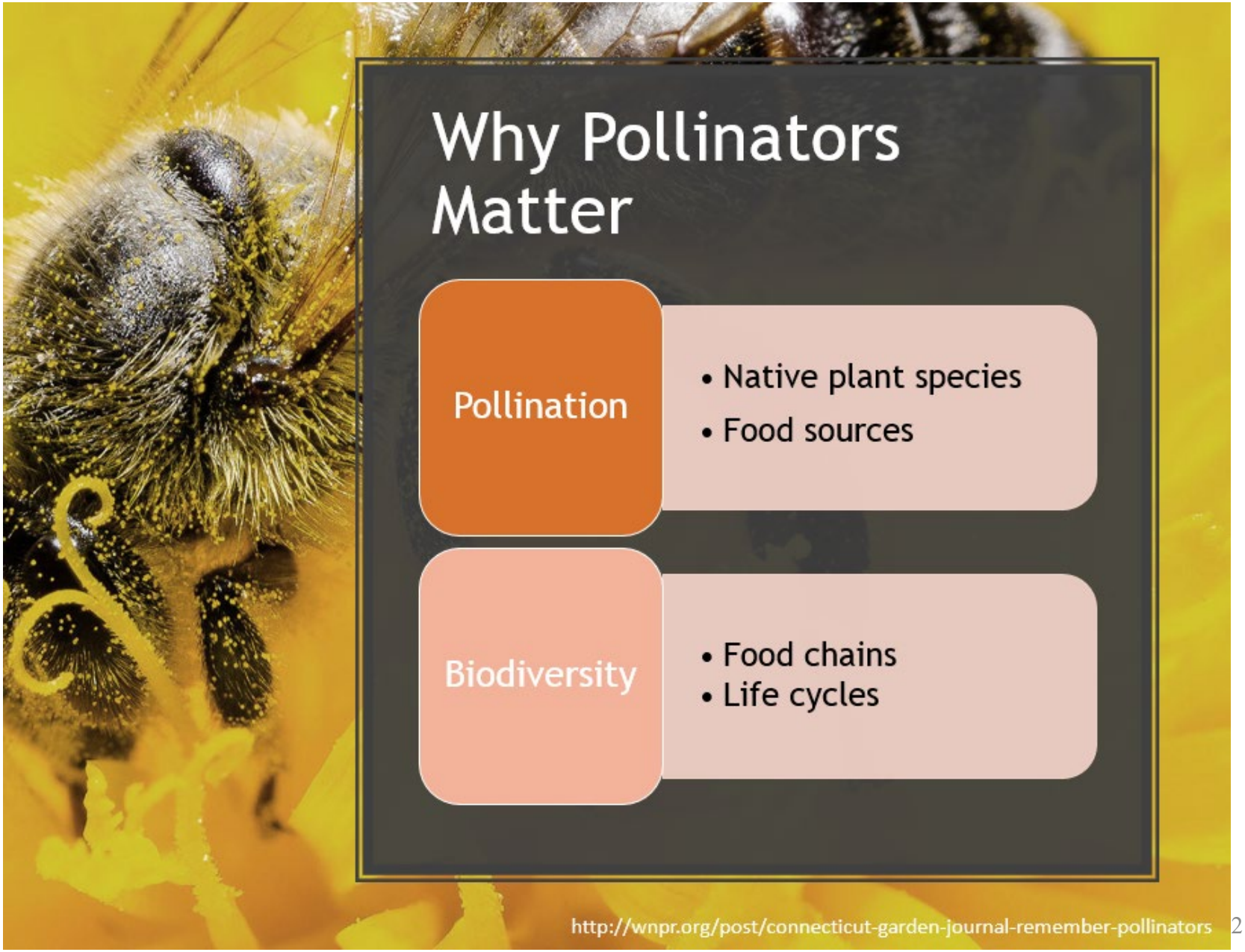
- Go to neighborhood association meetings to talk to people and see what they think about the canopy in their neighborhoods. This will help you put faces behind the numbers.

- Prioritize increasing canopy cover in low income neighborhoods

- Engage more people from marginalized communities with Growing Futures and Tiny Trees programs to improve canopy cover.

- Follow up on this research to try to get an answer for why the canopy cover in high income neighborhoods that are white is greater than in low income neighborhoods of color.

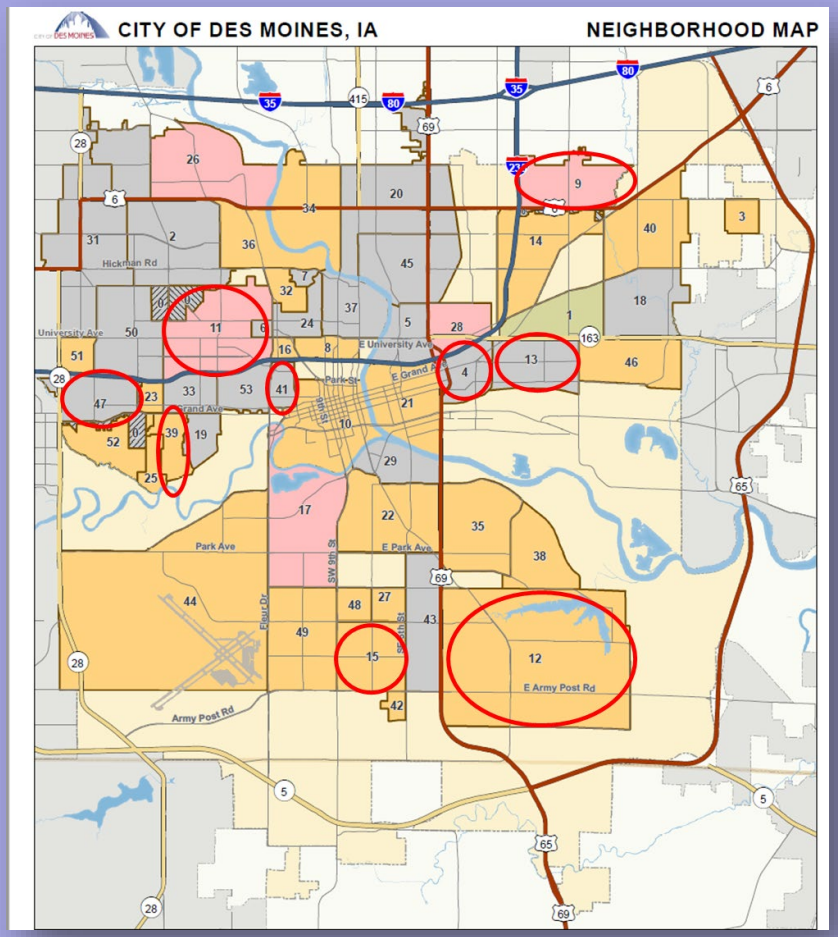
- Identify neighborhoods who are more at risk due to pollution, and target those neighborhoods to increase canopy cover and ecosystem benefits for those who pollution will affect.


Why Pollinators Matter
Pollination
• Native plant species
• Food sources
Biodiversity
• Food chains
• Life cycles
http://wnpr.org/post/connecticut-garden-journal-remember-pollinators

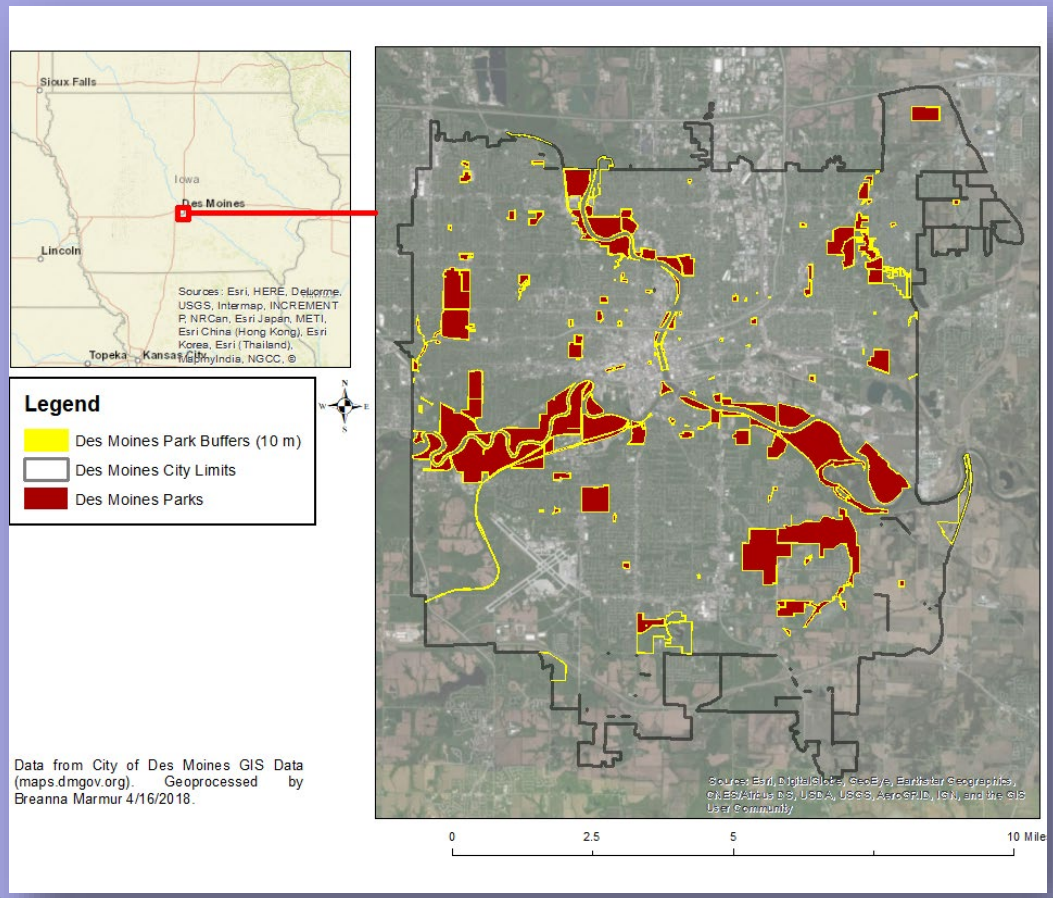
Des Moines Urban Forest Areas & Pollinators

Street trees:

- *Quercus* or *Acer* (or both) in every neighborhood
  - *Celtis* in two
- DSM Backyard Beekeepers
- No laws preventing bees



Des Moines Urban Forest Areas & Pollinators



Natural areas and woodlands:

- Abundant natural areas
- About 627 acres of linear buffer "edge habitat" (10 m from area border)
- Natural areas provide both food and shelter

Recommendations

- Focus on fringe
  - Reduce sprays
  - Use as opportunity to increase shrubs like elderberry and other native perennials
- Include canopy and mid-story trees
  - Acer, Amelanchier, Celtis, Cercis, Quercus
- Partner with existing organizations for continuing education and programs
  - Backyard Beekeepers, Greater Des Moines Botanical Garden
- Native plants are key

Credit:
Rachel Sporer
ISU Hort Student
2018

Developing a complex framework for urban energy modeling and simulation

A partnership between Iowa State University and The City of Des Moines Iowa

Based on Hashemi, F., Marmur, B. Thompson, J., Passe, U., (2018) Developing a Workflow to Integrate Tree Inventory Data into Urban Energy Models, Proceedings of the 2018 Simulation in Architecture and Urban Design Conference, SimAUD 2018, June 05-07 at TU Delft, the Netherlands. Society for Modeling & Simulation International.

Impact of trees

Reduction of

- Wall surface temperature
- Blocking radiation
- Air temperature
  - through
- **evapotranspiration**

(Ein Harod, Israel)

Temperature reduction depends on ….Distance ….Evapotranspiration rate

Shashua-Bar, L., O. Potchter, A. Bitan, D. Boltansky, and Y. Yaakov. 2010. Microclimate modelling of street tree species effects within the varied urban morphology in the Mediterranean city of Tel Aviv, Israel. International Journal of Climatology, 30, 44–57. doi:10.1002/joc.1869

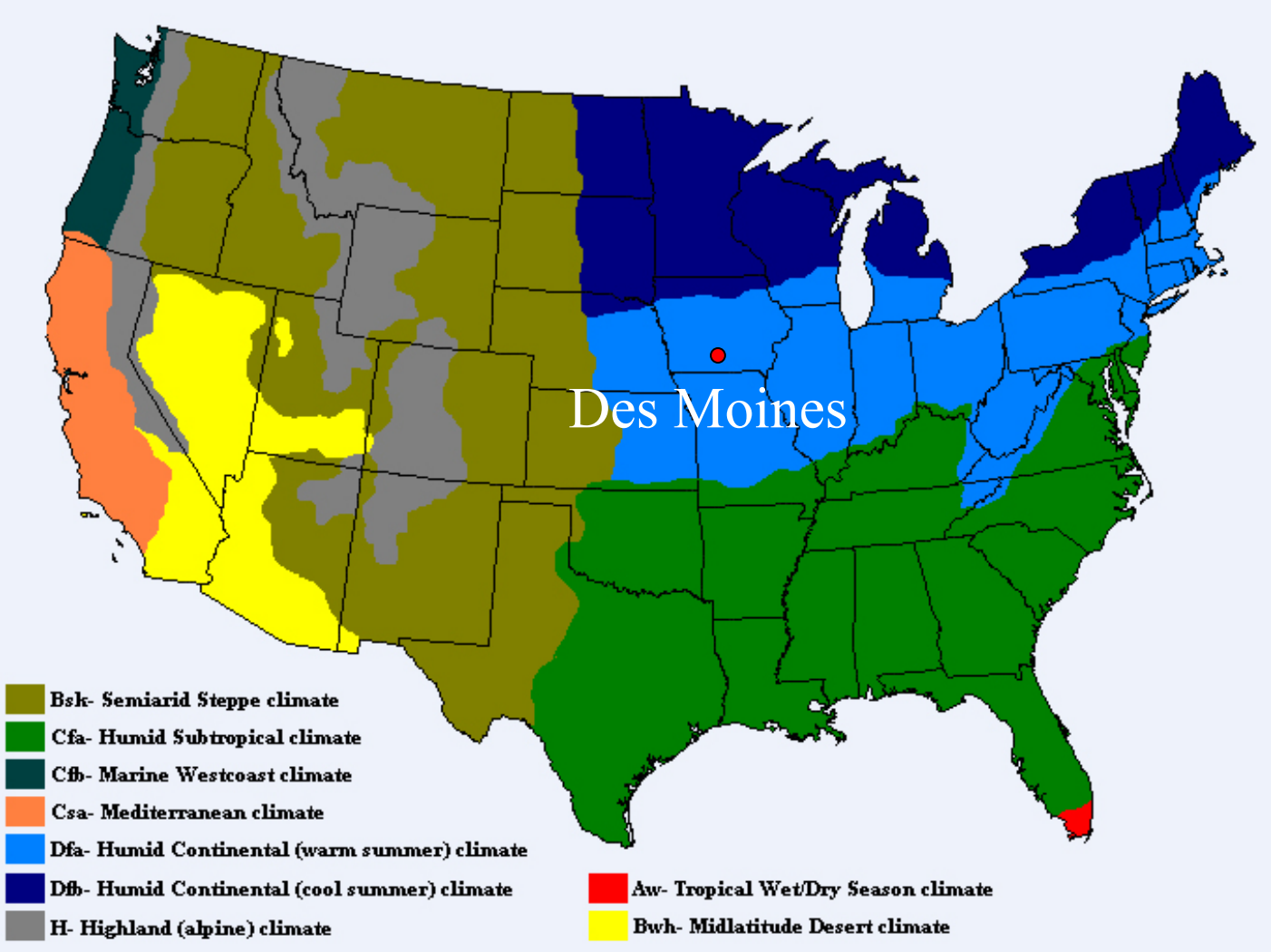
(Ames, Iowa)

Overview

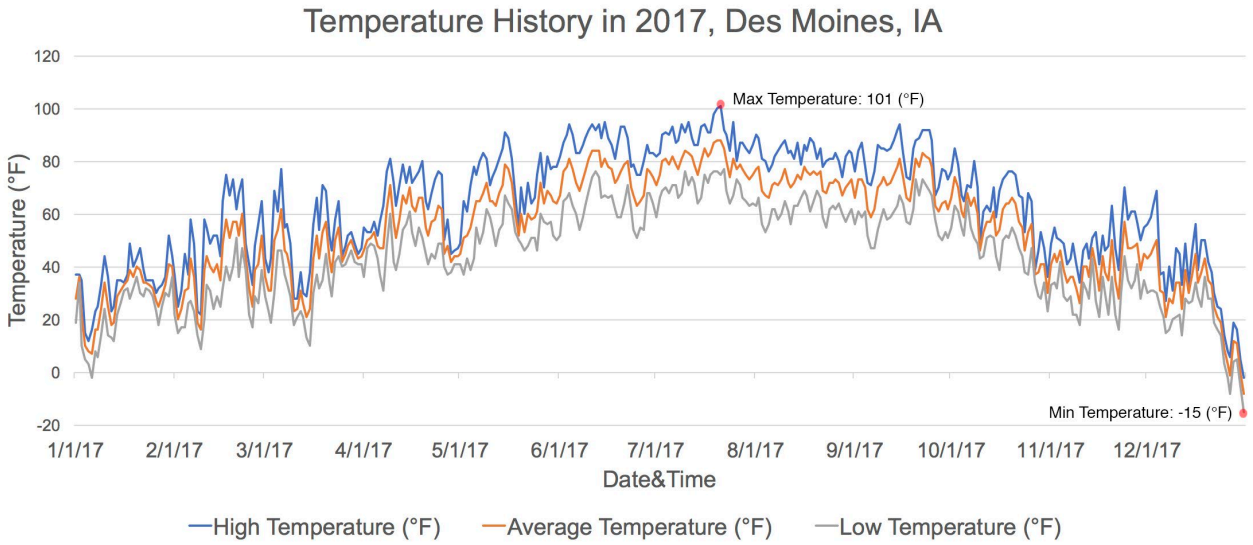
- **Introduction:**
  - effects of urban trees on building energy consumption have long been recognized,
  - Integration of of trees in dynamic energy modeling is a fairly recent endeavor.
  - Provide an advanced method to update 3-D models according to changes in GIS shapefile data from site-based surveys.
- **Goals:**
  - Describing the process of integrating urban forest inventory data into a 3-D energy model for a US Midwest neighborhood, including building footprint, parcel and tree data.
  - Importing the model in the Urban Modeling Interface (umi) tool to analyze the effect of tree shading on building energy performance.
- **Methodology:**
  - Using Grasshopper 3-D, the Meerkat plug-in, and GIS shapefiles for construction of the model.
  - Using umi-Urban Modeling Interface as the simulation tool, The process for creating of building templates and properties are described in : (Jagani, C. and U. Passe. 2017. Simulation-based sensitivity analysis of future climate scenario impact on residential weatherization initiatives in the US Midwest. *Proceedings SimAUD 2017*, 345-352).
- **Results:**
  - Cooling energy consumption of the neighborhood under 2 scenarios: with and without trees.

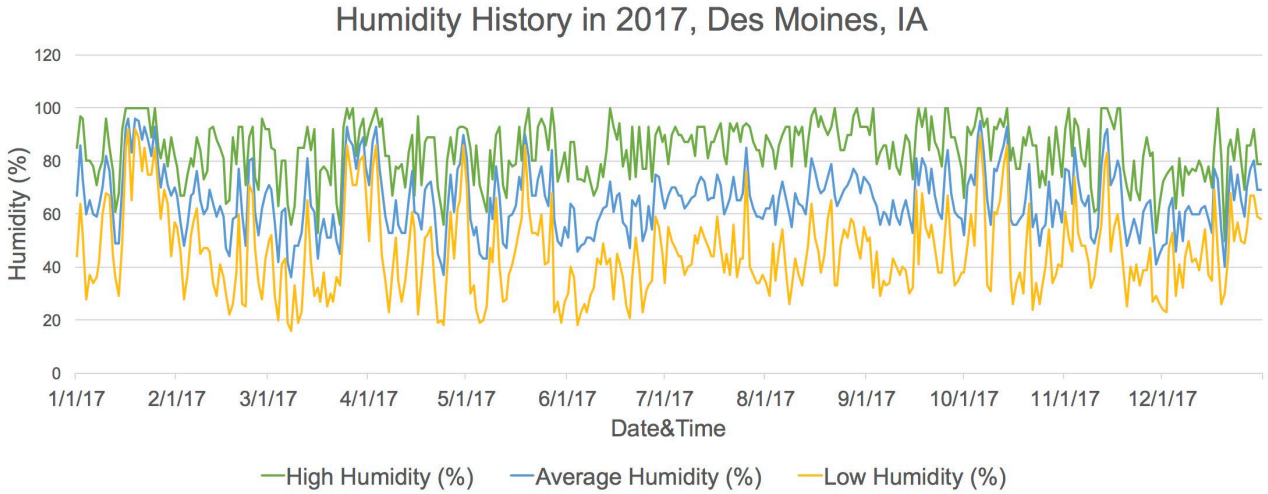
Study Area

Des Moines, Iowa, United States
Humid Continental (warm summer) climate



Weather History for Des Moines, IA





Study Area

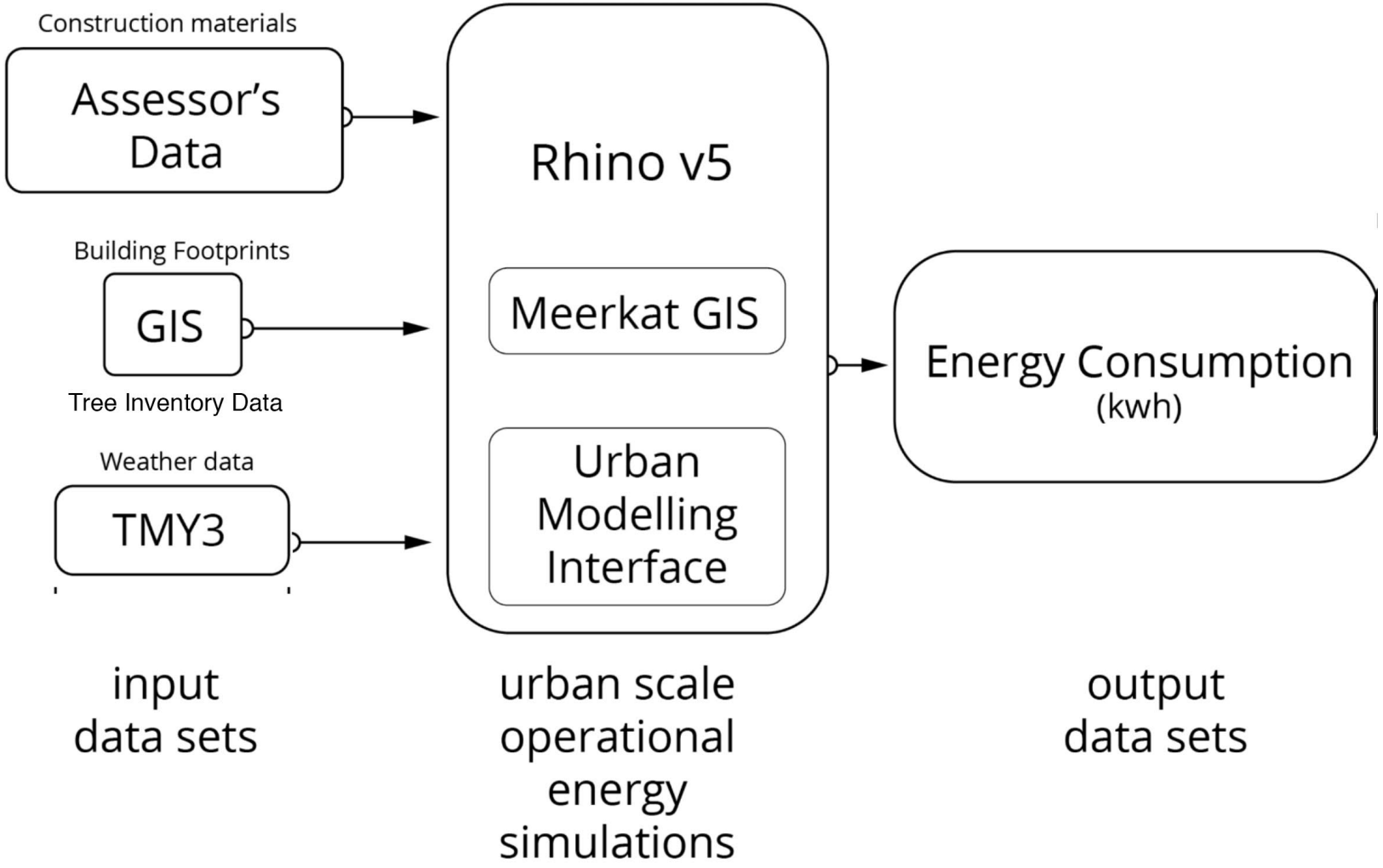
Capitol East Neighborhood, Des Moines, IA: 1142 trees and 340 buildings

Tree inventory

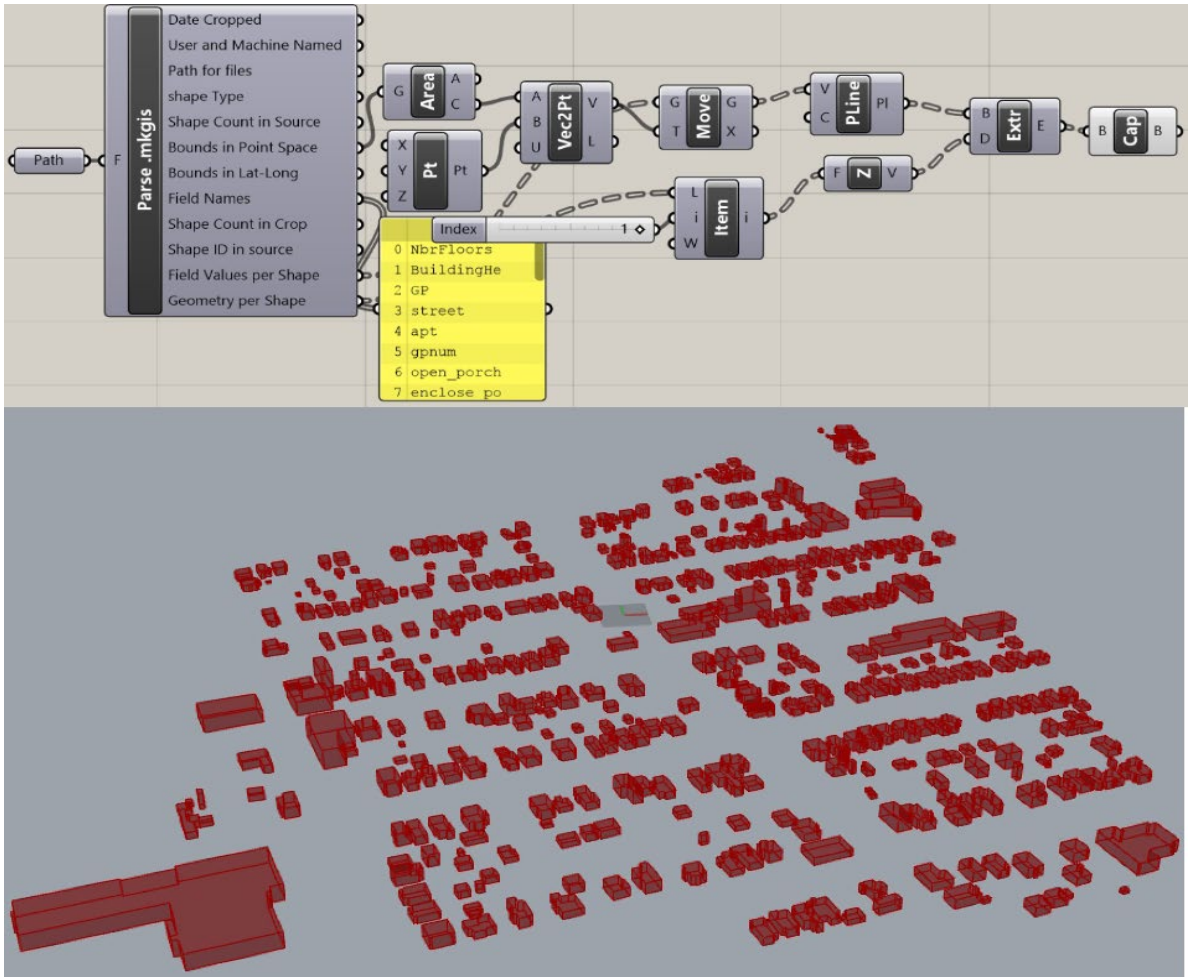
	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	New_Tree_ID	Land_Use	Street_Yard	Species	%_Canopy_Filled	Shape_1	DBH (in)	Height_to_top (ft)	Height_to_live_crown (ft)	Canopy_North_South (ft)	Canopy_East_West (ft)	Comments	Latitude	Longitude
2	1001	Residential	Yard	Mulberry spp	60	Umbrella	16	26	8	18	16		41.593210108	-93.590604187
3	1002	Residential	Yard	N. Hackberry	90	Ellipsoid	5	16	1	8	9		41.593210727	-93.590693415
4	1003	Residential	Yard	Silver Maple	65	Paraboloid	25	36.9	12.1	40.2	36.2		41.592823056	-93.590591690
5	1004	Residential	Yard	Mulberry spp	85	Umbrella	13	24.5	7	19	27	12	41.592912068	-93.590616213
6	1005	Residential	Yard	Silver Maple	80	Paraboloid	29.5	63.1	13	41	43		41.592919988	-93.590642176
7	1006	Residential	Yard	Jap. Lilac	90	Umbrella	3	14	1	13	12	2	41.592958102	-93.590709942
8	1007	Residential	Yard	Swamp W. Oak	75	Ellipsoid	14	47.2	16	27	28		41.593006890	-93.590722754
9	1008	Residential	Yard	Siberian Elm	75	Paraboloid	32.5	54.2	20.3	41.3	44		41.593015729	-93.590754270
10	1009	Residential	Yard	Tree of Heaven	80	Umbrella	37	65	13	39	41		41.593134643	-93.590789050

Urban Forestry students conducting inventory supervised by Dr. Janette Thompson and Breanna Marmur

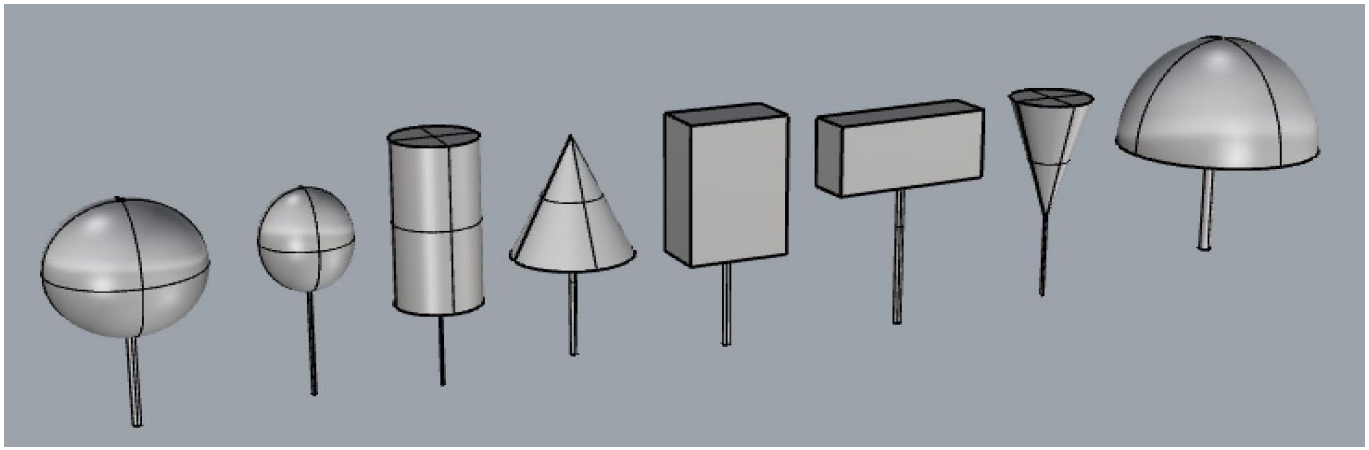
Workflow


Construction materials
Assessor's Data
Building Footprints
GIS
Tree Inventory Data
Weather data
TMY3
Rhino v5
Meerkat GIS
Urban Modelling Interface
Energy Consumption
(kwh)
input data sets
urban scale operational energy simulations
output data sets

Buildings and parcels script

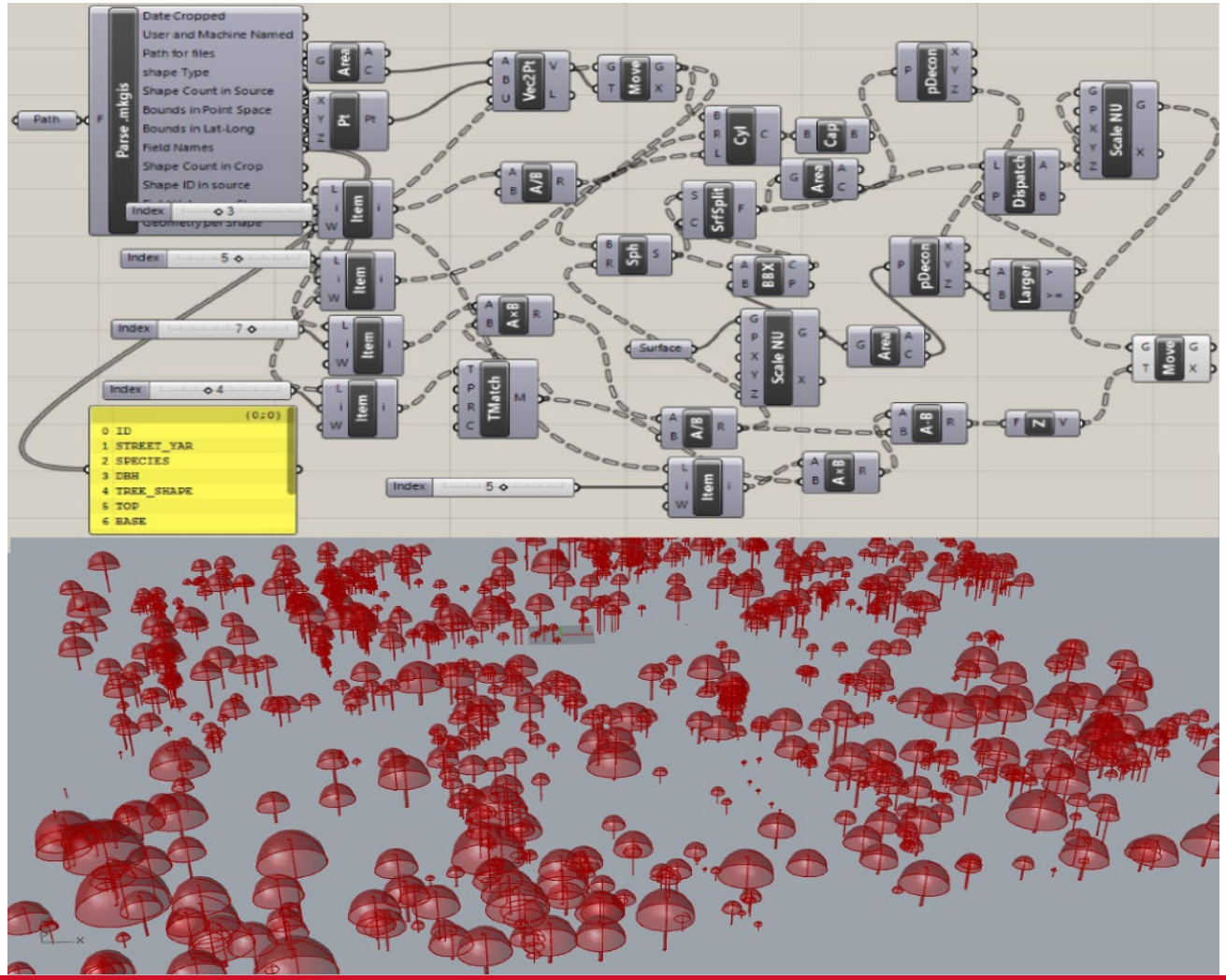


8 Tree shapes

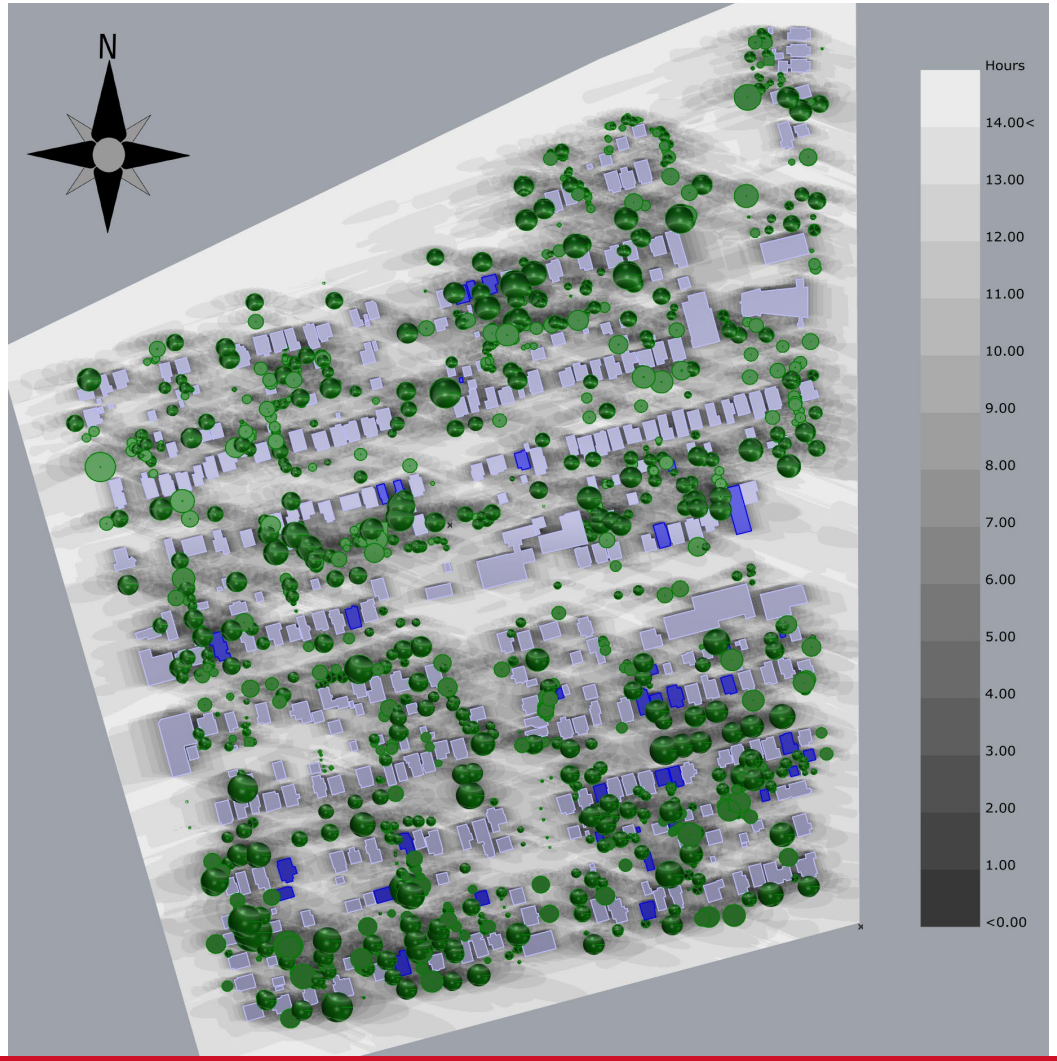


spheres, ellipsoids, cylinders, cones, horizontal rectangular cuboids, vertical rectangular cuboids, paraboloids, and umbrella shapes,

Trees script



“Baked” visualization model in Rhinoceros



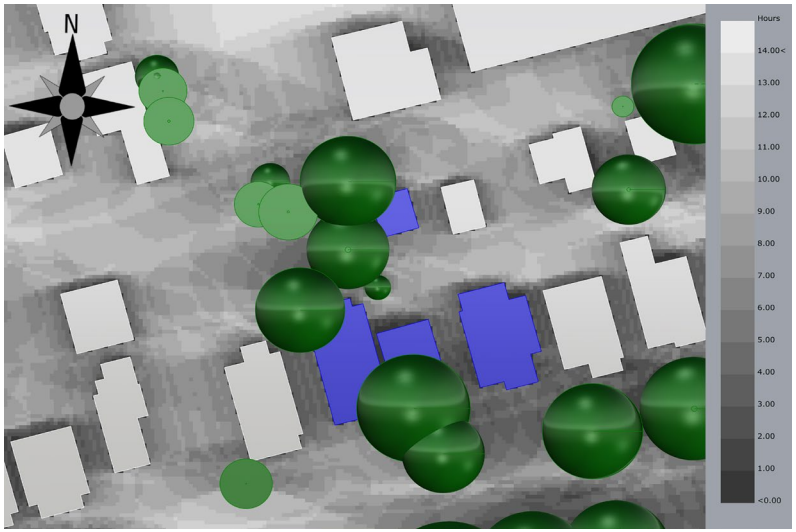
Buildings indicated in blue are those with more than 5% reduction in cooling demand for the scenario with trees.

Umi, Rhino based design environment http://www.urbanmodeling.net/.

Results

- Trees resulted in 1% to 20% potential active cooling energy savings for spring and summer months (May to September).

- There were approximately 40 buildings with potential cooling energy savings more than 5%.



- Nearly all buildings showing substantial differences in cooling demand in the model with trees are well shaded by trees, especially those located south of buildings.

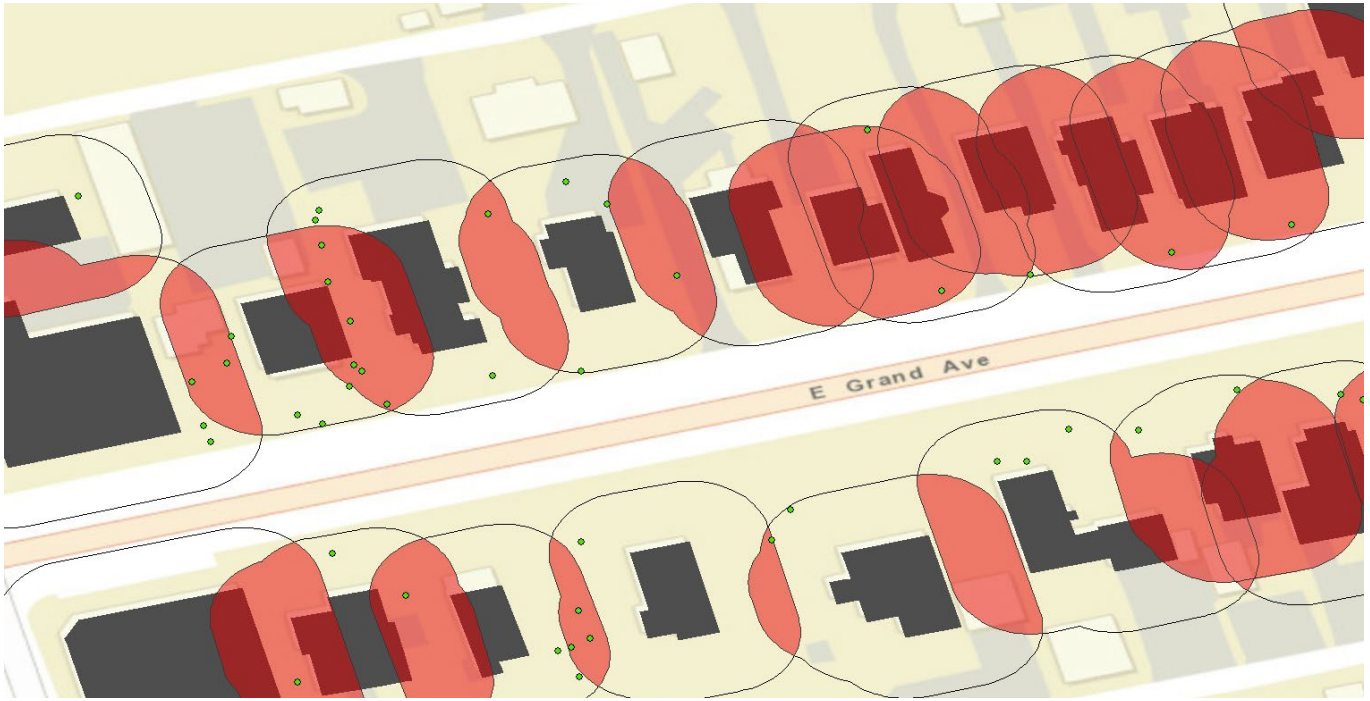
Conclusion

- Our preliminary results indicate a modest effect of tree shading effect particularly, on potential cooling savings dependent on time of exposure and distance

- The method shows great promise for development of more comprehensive energy models for buildings and near-building environments for any location for which GIS data are available.

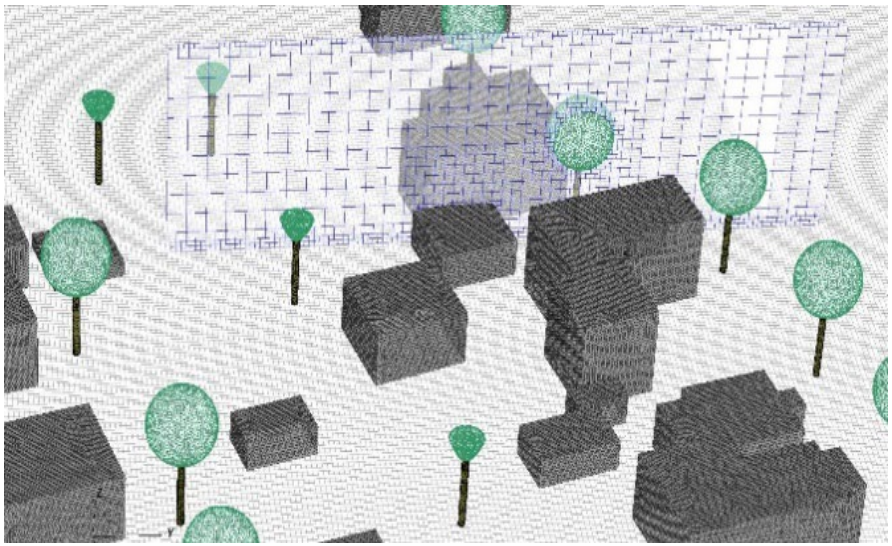
Current ongoing work

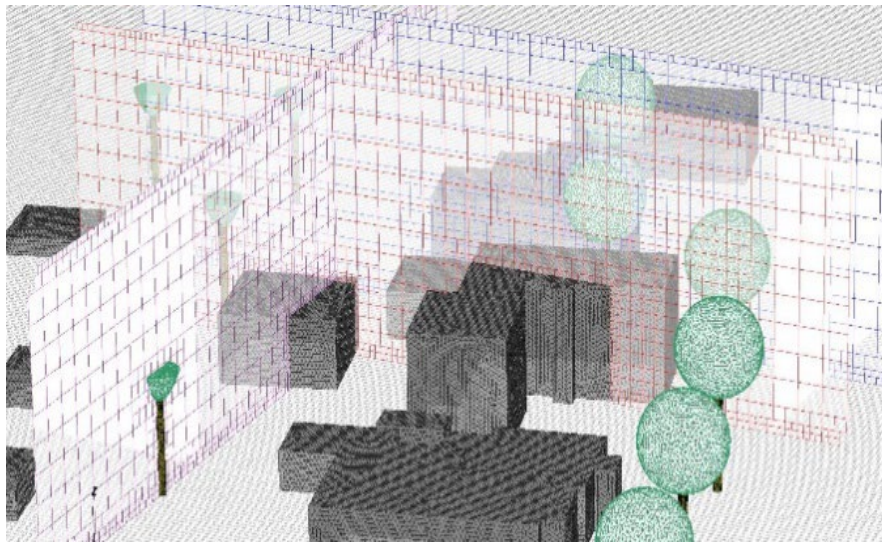
- EVAPOTRANSPIRATION: The model and simulation does not yet include evapotranspiration, which is likely to increase the effect of trees on building energy dynamics



Current ongoing work

- Integrate with probabilistic computational fluid dynamics (CFD) techniques that incorporate other tree canopy characteristics (percent canopy filled, leaf area and density) (with Dr. Baskar Ganapathysubramanian and Boshun Gao, Himanshu Sharma)

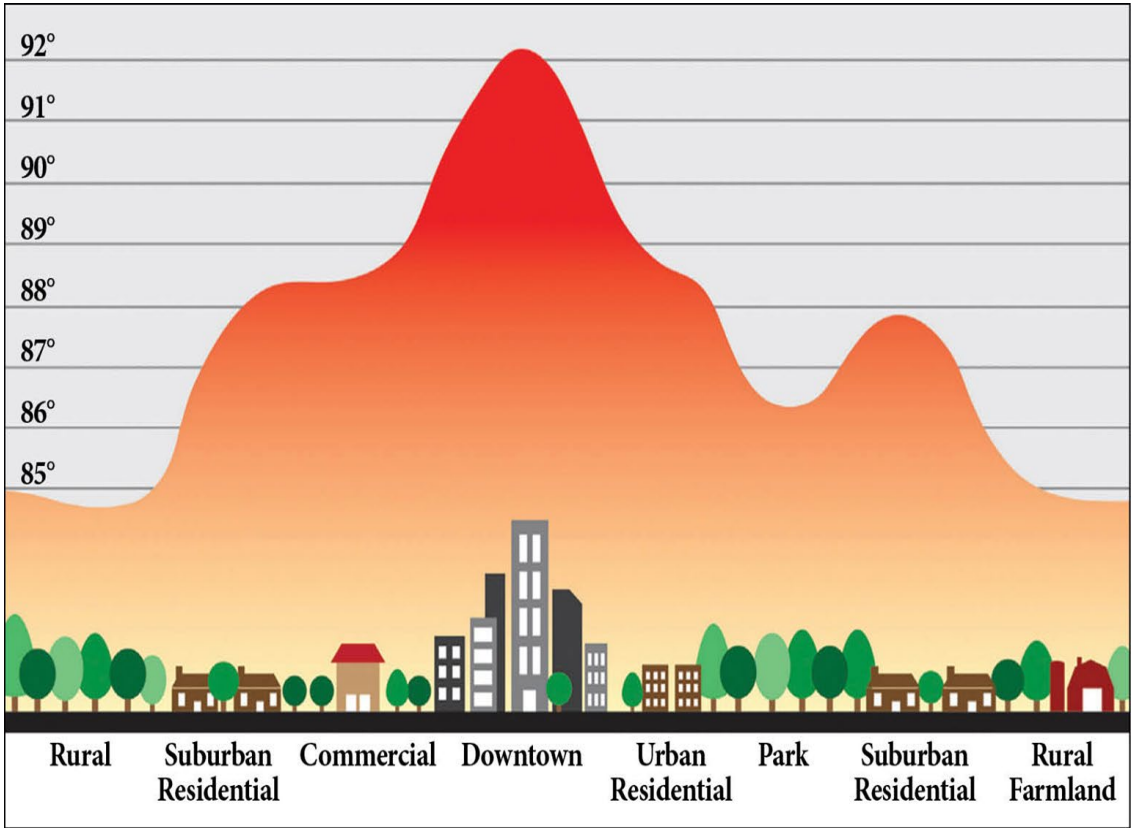




- Using LiDAR imagery with detail for tree canopy shape and size) for collecting comprehensive tree inventory data in the future.
- Integrate with urban heat island (with Dr. Yuyu Zhou)

Urban Heat Island

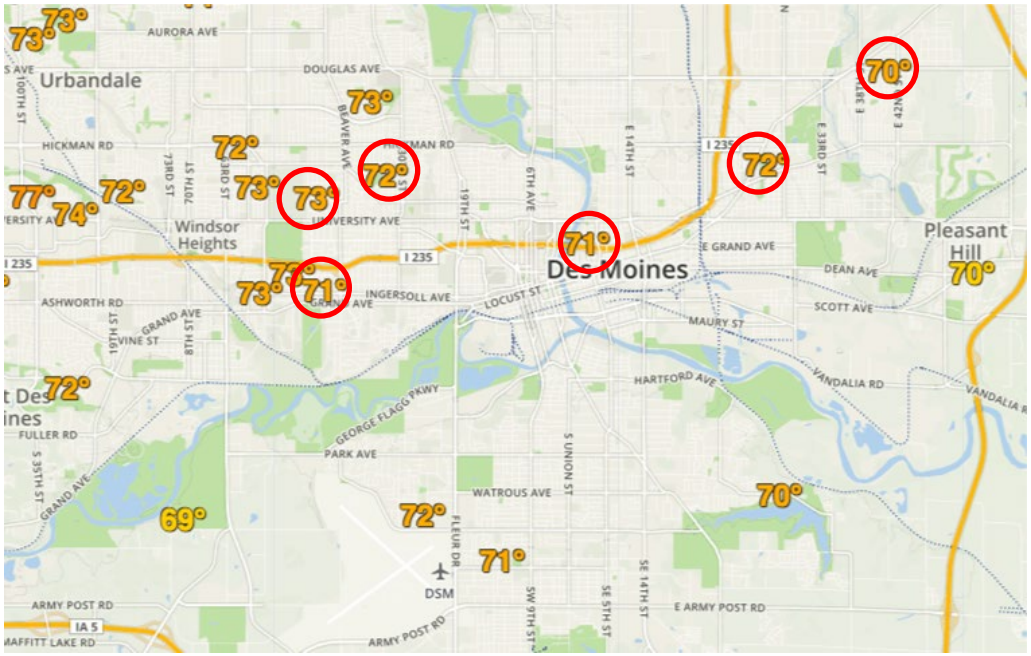
- ”heat island" describes built up areas that are hotter than nearby rural areas
- Day city temps 1.8–5.4°F warmer than rural surroundings
- Nightime up to +20°F
- creates energy demand for cooling in summer
- causes both acute and chronic negative health effects



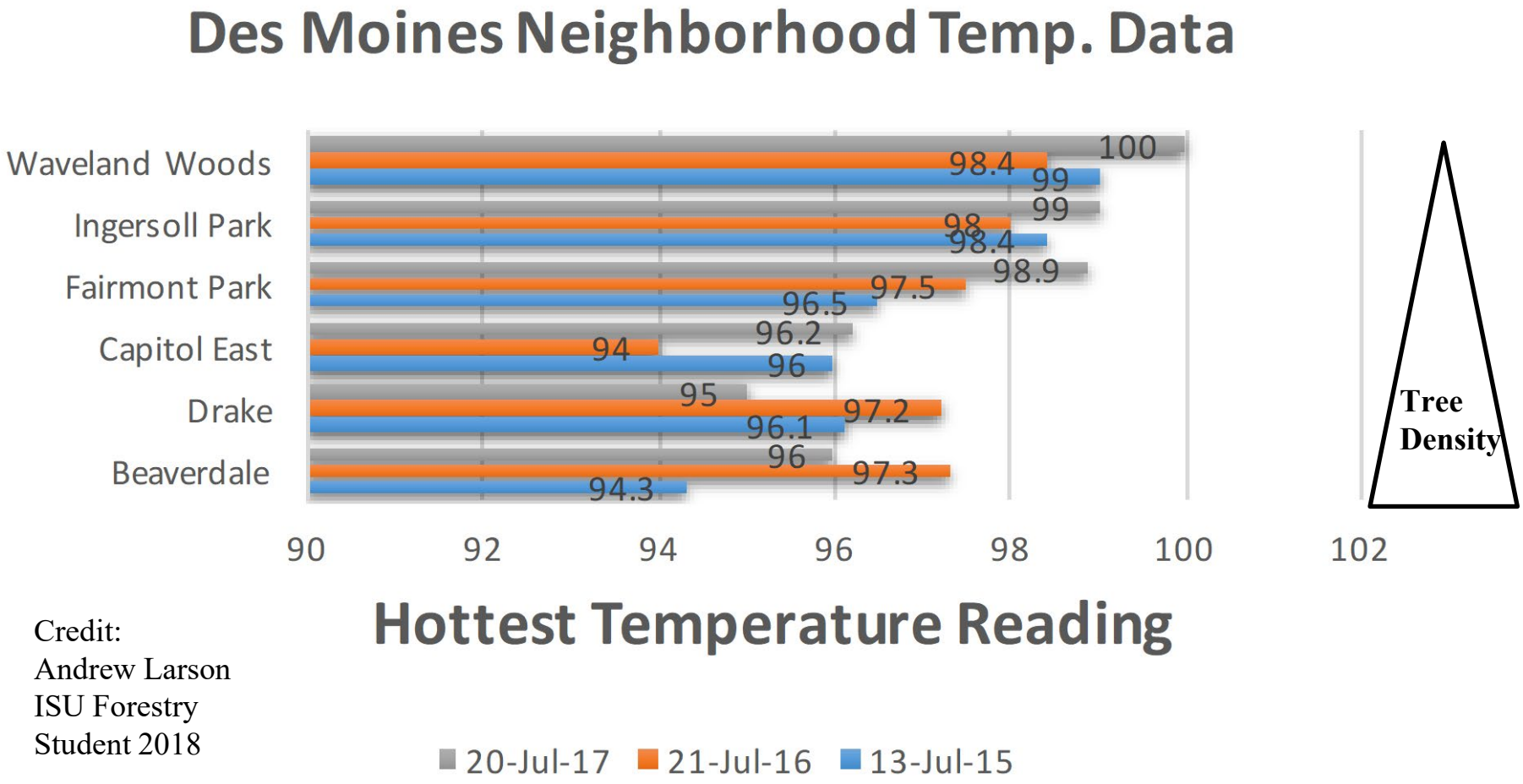
https://www.epa.gov/heat-islands

ISU Student Research Methods

- Examined neighborhoods with high, medium, and low density tree populations
- Gathered data from independent Weather Underground affiliated weather stations
- Identified hottest recorded days for 2015, 2016, and 2017



Urban Heat Island in Des Moines



Credit:
Andrew Larson
ISU Forestry
Student 2018

Des Moines Forestry - Solution

- Focus on care of trees near or next to pavement
- Target tree planting campaigns towards low tree density neighborhoods
- Design city in to encourage walking/biking and reduce car traffic
- Capitalize on funding opportunities from external funding groups (eg. EPA)

https://geoscapecontracting.com/why-do-we-plant-street-trees/

https://www.rykon.ca/dos-donts-yard-construction/

A TREE

The ultimate model of sustainability

- it runs on solar energy
- it recycles nutrients and water
- It is highly adaptable to local conditions

Decision Support Tools
to Increase Resilience in Urban Neighborhoods

- **Urban trees are essential** and becoming more important as population continues to migrate to urban areas
- **Combining diverse data sets can help make the case** for the 5 W's
  - Who? All of us
  - What? Plant trees. Native when possible
  - Where? On every square inch of ground
  - When? As soon as possible
  - Why? To be sustainable and resilient

Acknowledgment

The ISU research work presented was funded by the 2016 Iowa State University Presidential Interdisciplinary Research Initiative (PIRI) on Data-Driven Science. The authors are grateful for the support.

Contact and Questions:

Ulrike Passe Dipl.-Ing.
Associate Professor of Architecture
Director, Center for Building Engineering
Iowa State University
upasse@iastate.edu

http://www.sustainablecities.cber.iastate.edu/