i-Tree Tools Help Strategically Manage Urban Forests: Letting Nature Convert Stormwater into Cooler, Resilient Cities

Center for Watershed Protection Webinar Series

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Urban Forestry: Modeling Nature-Based Solutions

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Assistance from i-Tree Consortium of Colleagues & Students

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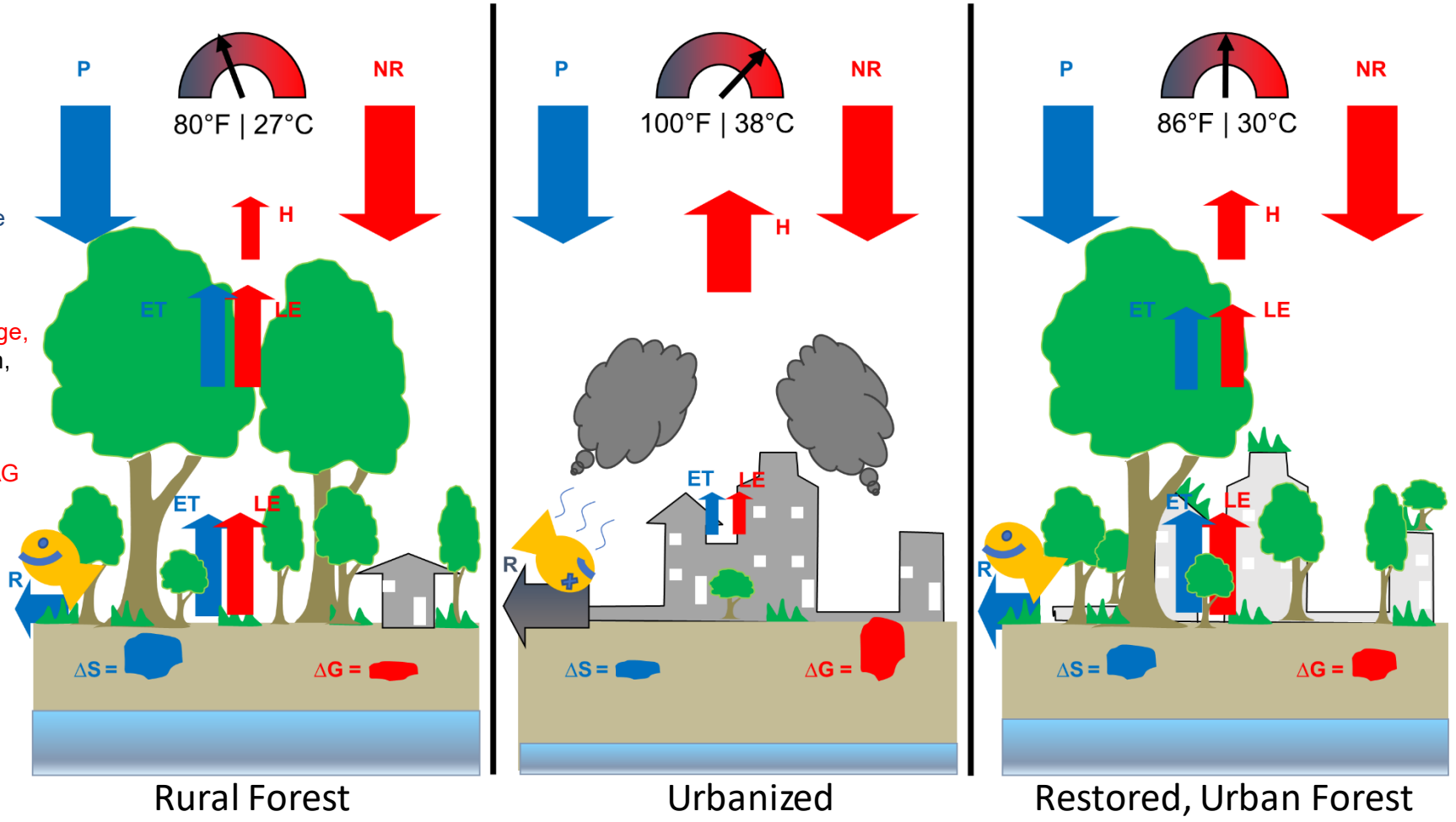
i-Tree is a Cooperative Initiative

Motivation: Urbanization impairs well-being by disrupting delivery of ecosystem services

Legend:

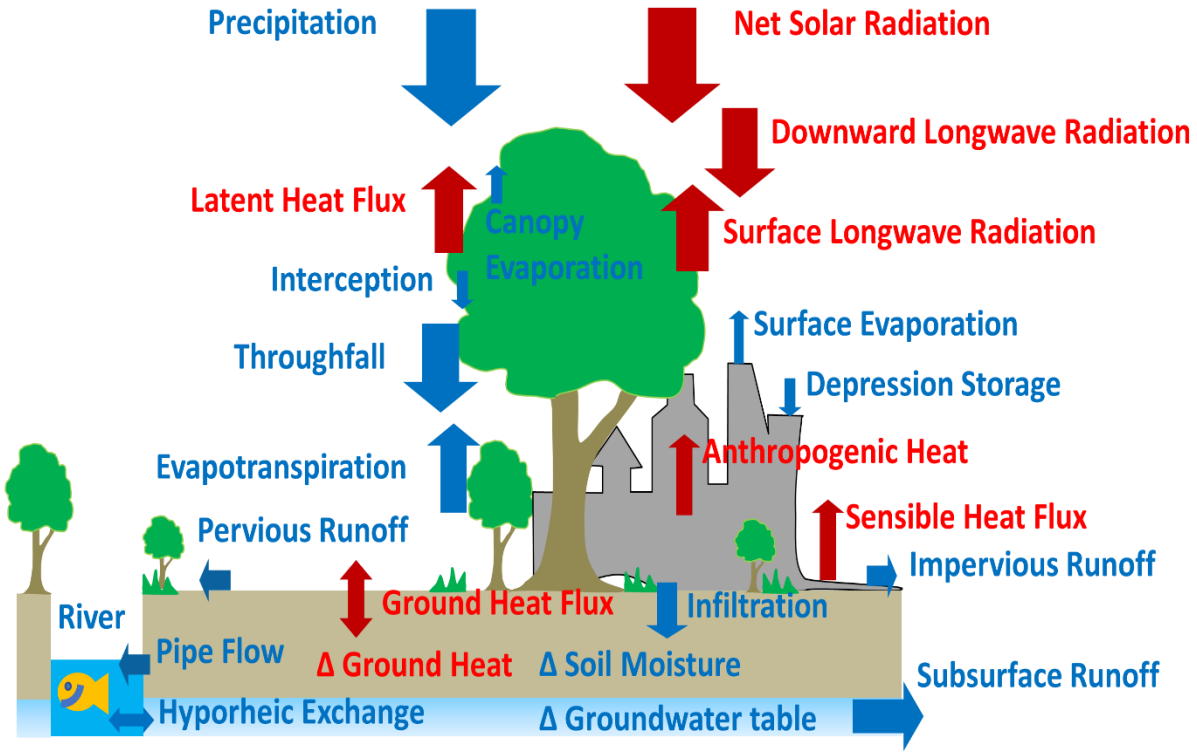
P = precipitation,
R = runoff,
ET = evapotranspiration,
ΔS = change in water storage
NR = net radiation,
H = sensible energy,
LE = latent energy,
ΔG = change in energy storage,
λ = latent heat of vaporization,
ρ_w = density of water

Water Balance: P=R+ET+ΔS
Energy balance: NR=H+LE+ΔG
ET = LE / (λ ρ_w)

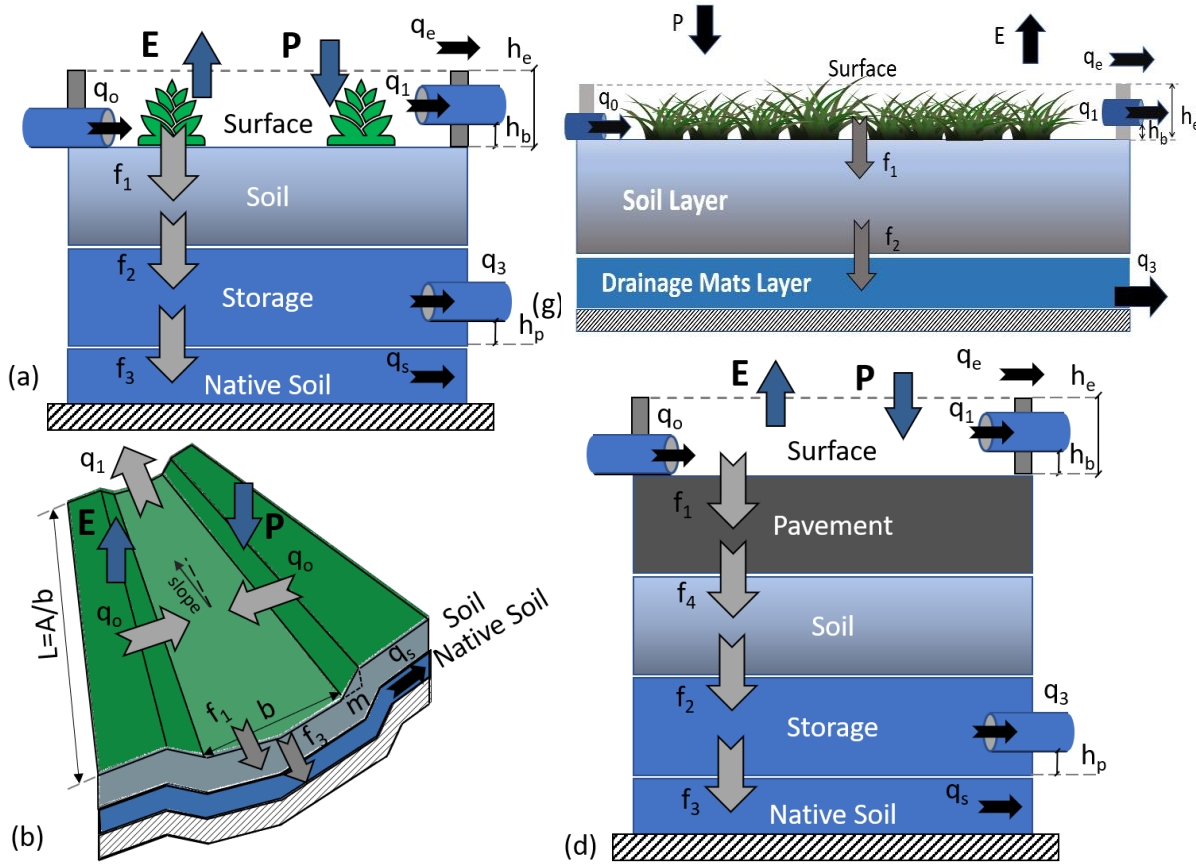


Endreny, T. A. (2018). Strategically growing the urban forest will improve our world. *Nature Communications, 9*(1), 1160. doi:10.1038/s41467-018-03622-0

Goal: Develop i-Tree tools for the restoration of water, energy, & biogeochemical cycles



i-Tree HydroPlus Toolkit Conceptual Model



Green Infrastructure within i-Tree Hydro Model

Endreny, T. A. (2022). i-Tree Tools Assist with Strategically Designing Tree Cover and Improving Community Resilience. *Clear Waters - New York Water Environment Association, 52*(1), 46-50.

Methods: i-Tree Tools for Nature-Based Solutions

User Support

City Benefits Viewer

City Benefits Calculator

Block Benefits Calculator

Site Benefits Calculator

Land Cover & Benefits Estimator

Tree Species Selection

Research Suite HydroPlus

Managing Stormwater

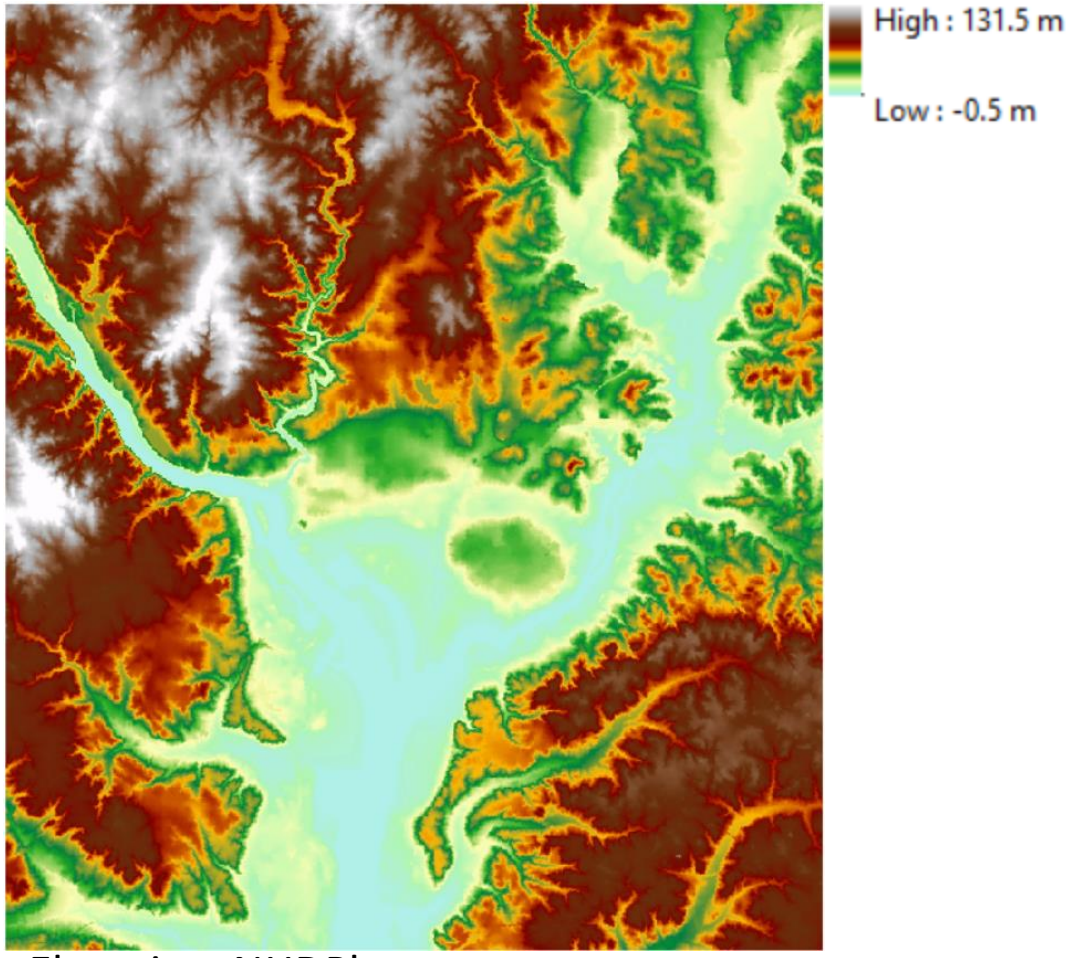
Cooling Heat Islands

Cooling River Waters

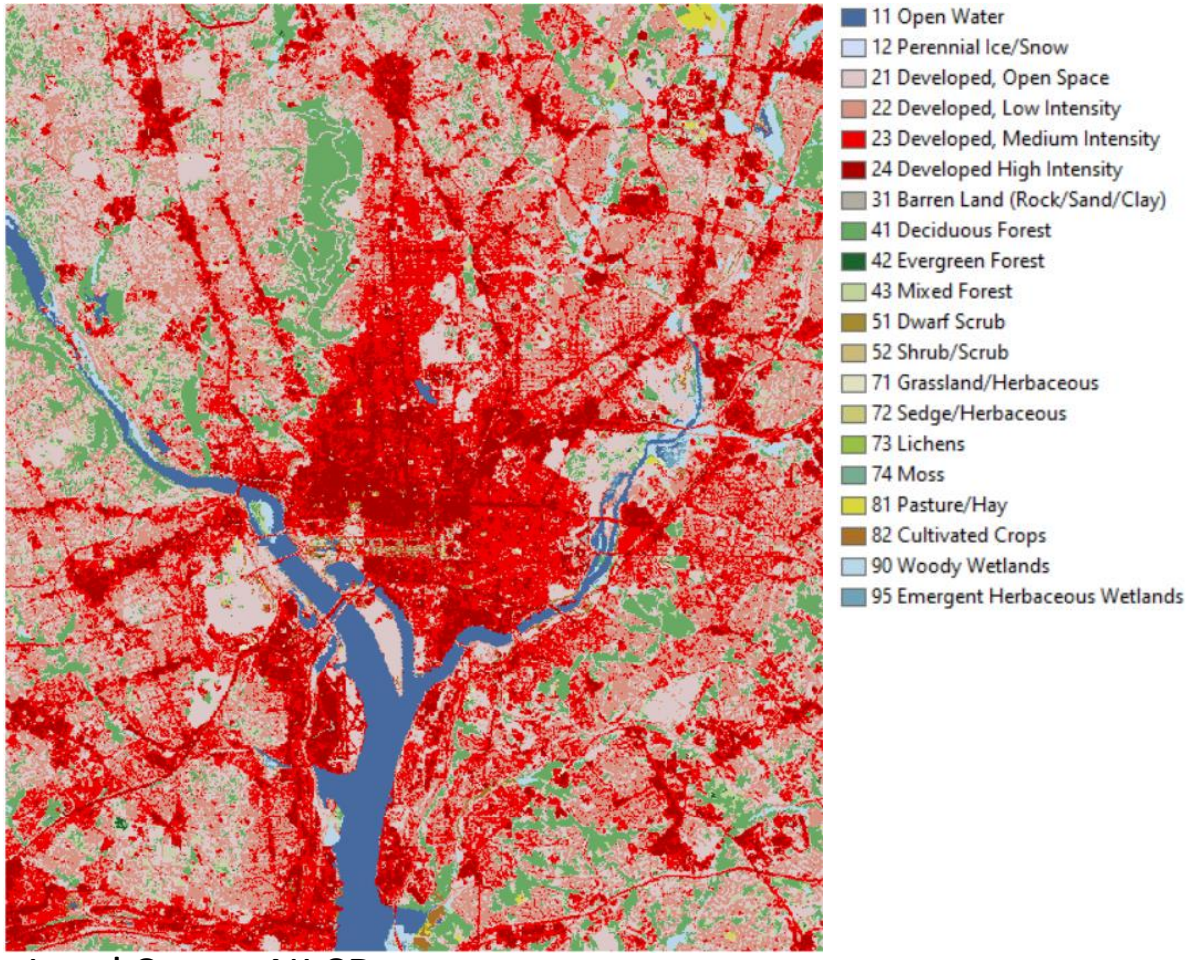
Reducing Energy Use

Mapping Nutrient Runoff

Inputs for i-Tree Cool Air: Elevation and Land Cover for Washington, DC

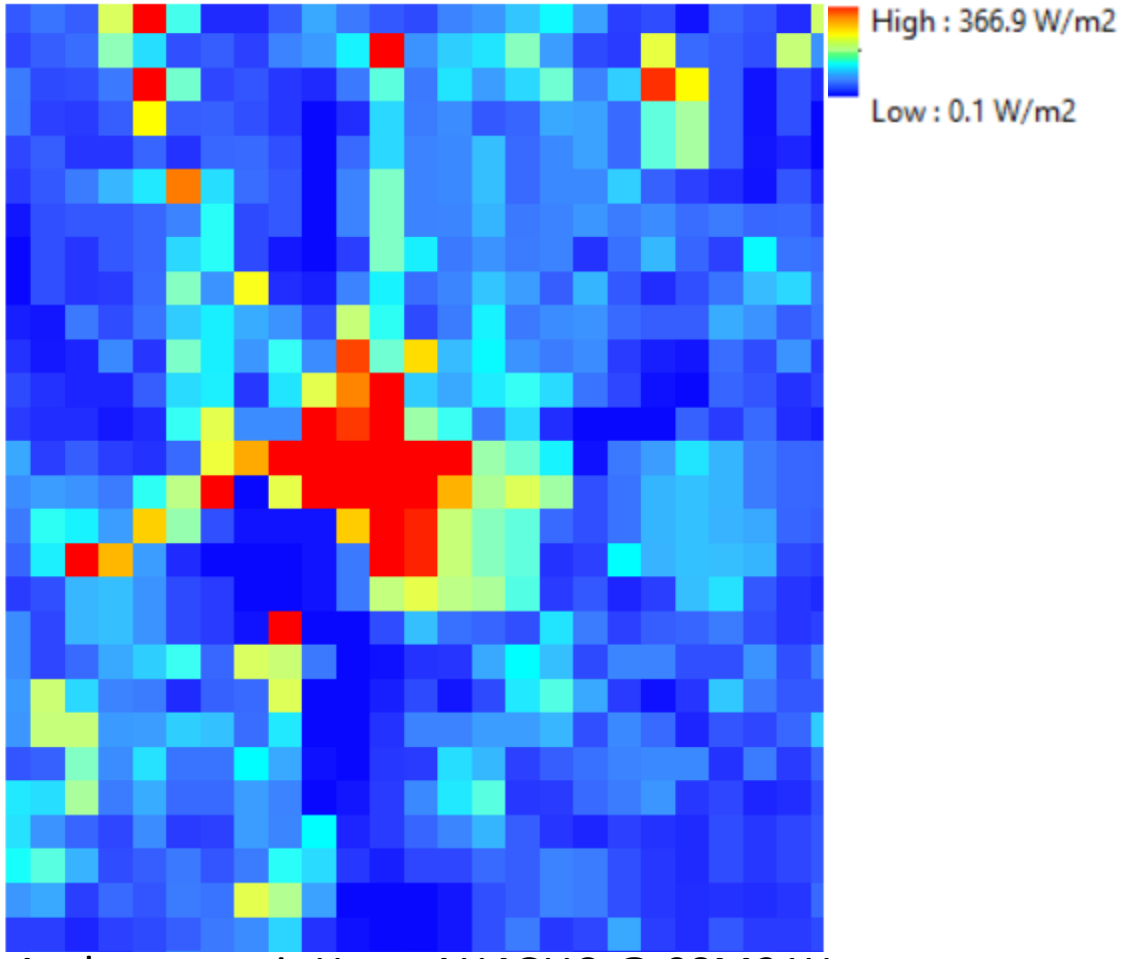


Elevation: NHDPlus

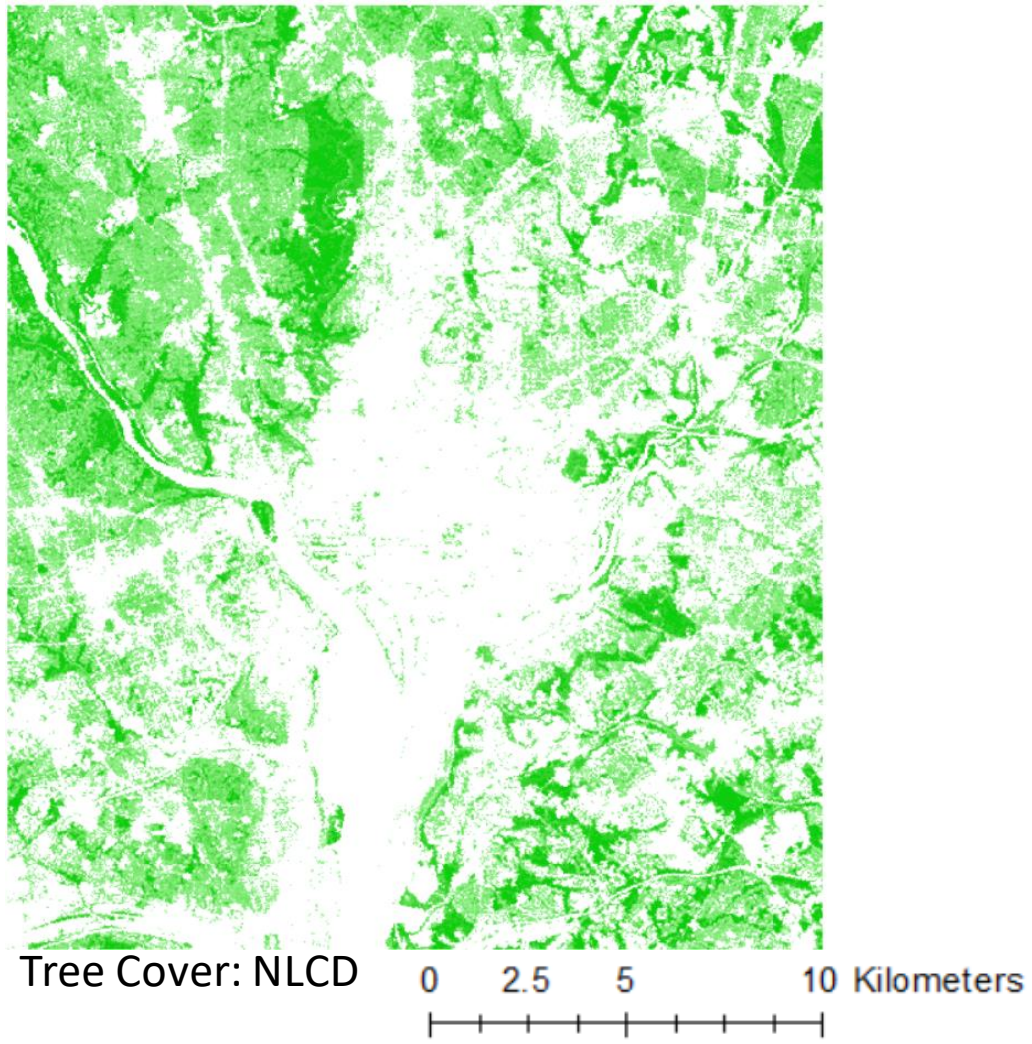


Land Cover: NLCD

Inputs for i-Tree Cool Air: Anthropogenic Heat, Tree & Impervious Cover for Washington, DC

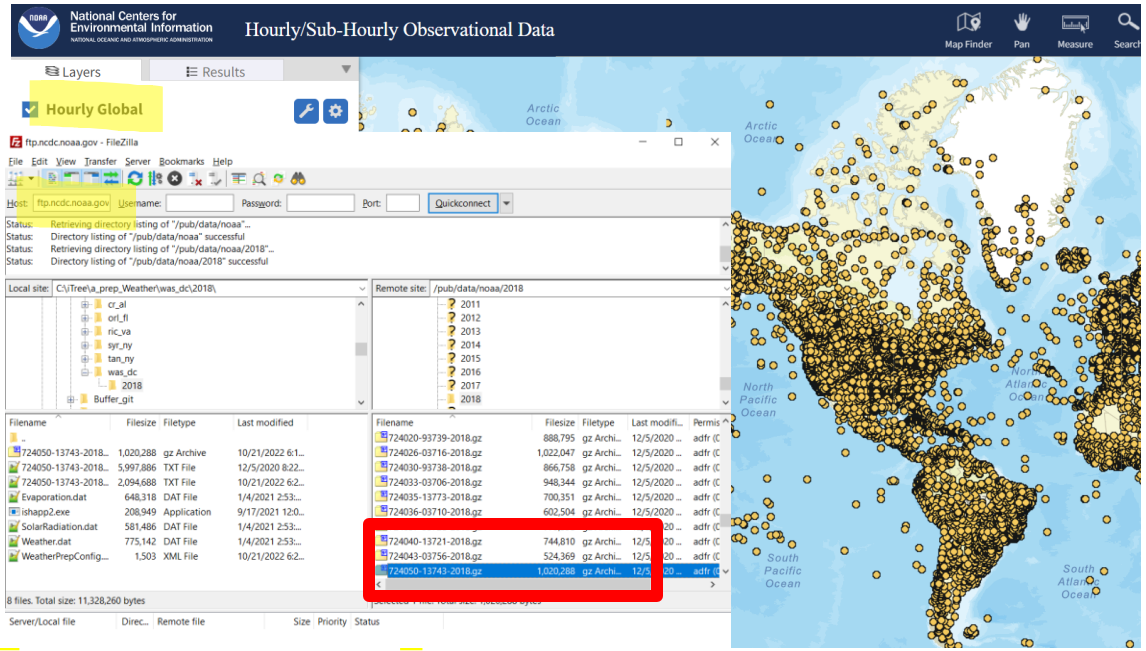


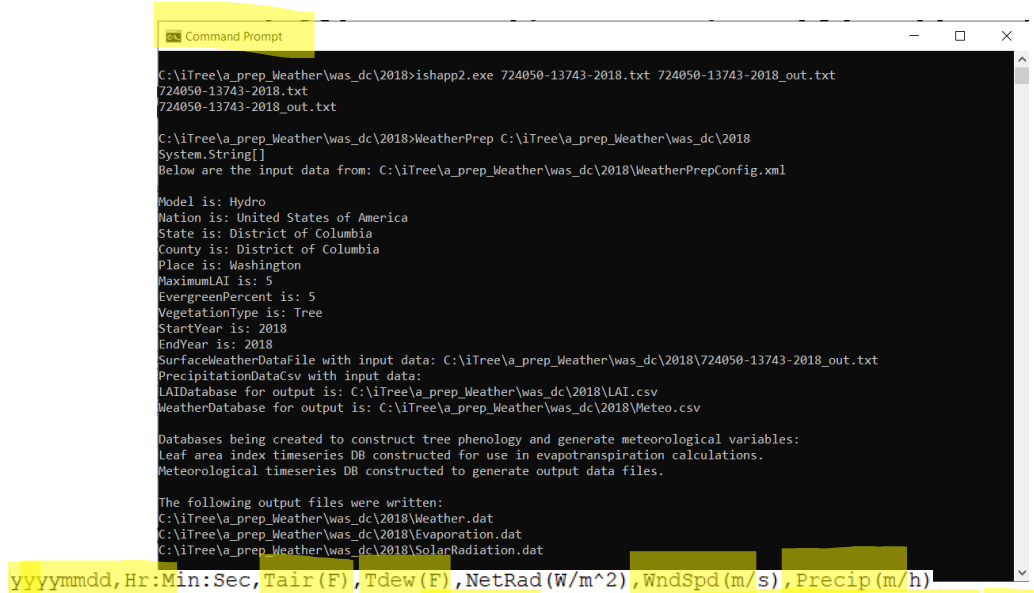
Anthropogenic Heat: AH4GUC @ 08M21H



Tree Cover: NLCD

Input Meteorological Data: Single Pixel Time Series of Observations using WeatherPrep.exe. Flow …



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i-Tree HydroPlus Configuration File w/ Parameter Settings, Visual Studio Editor, Batch Runs. Flow …

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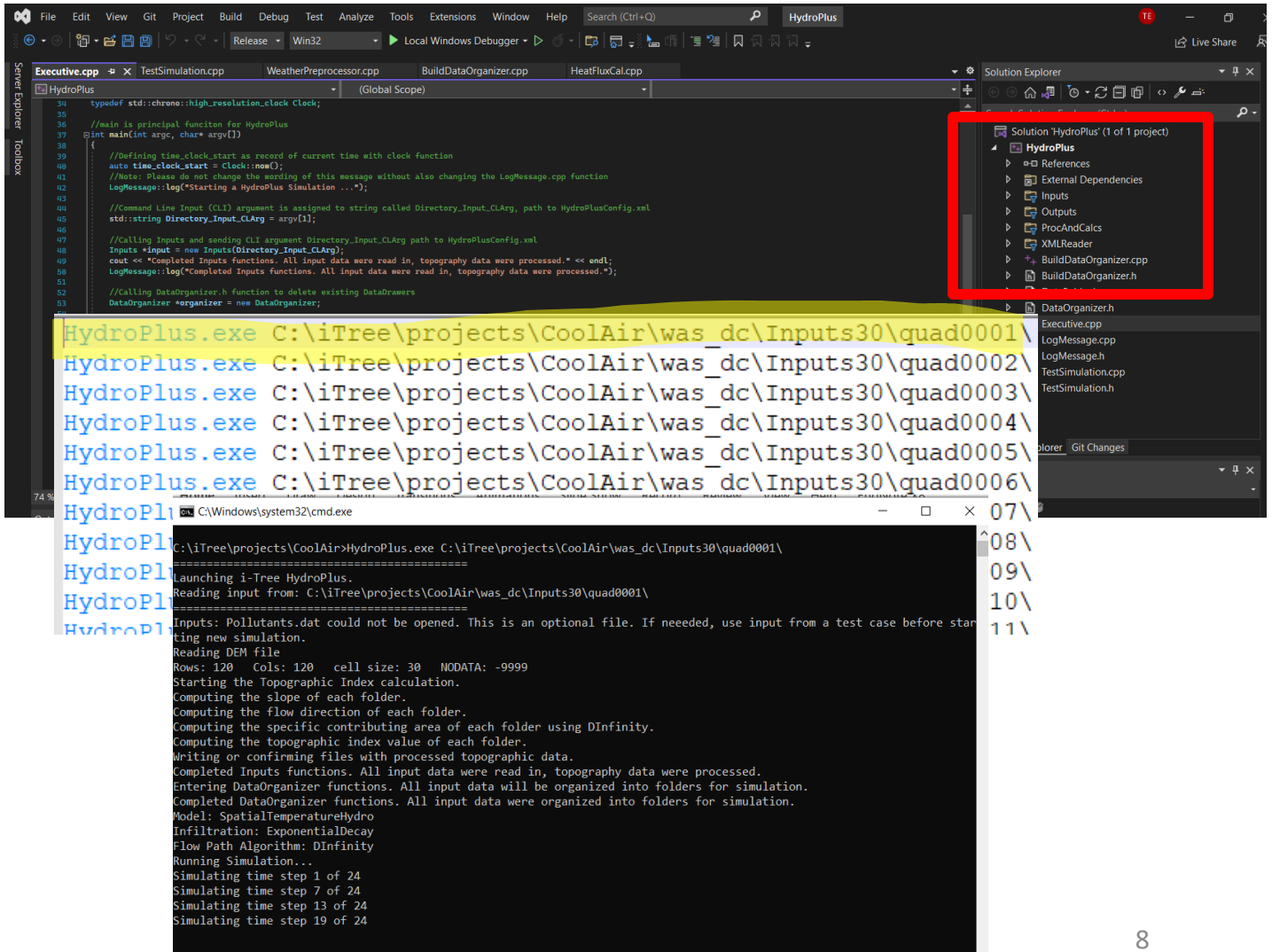
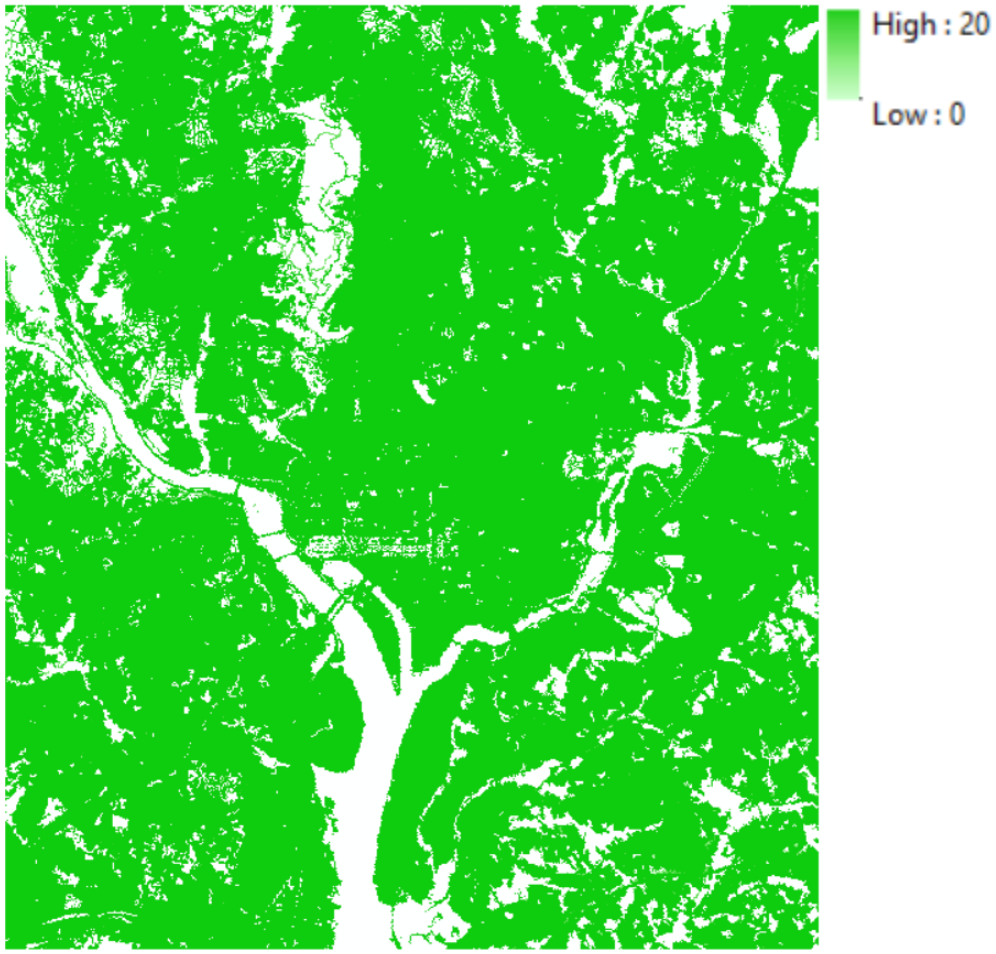
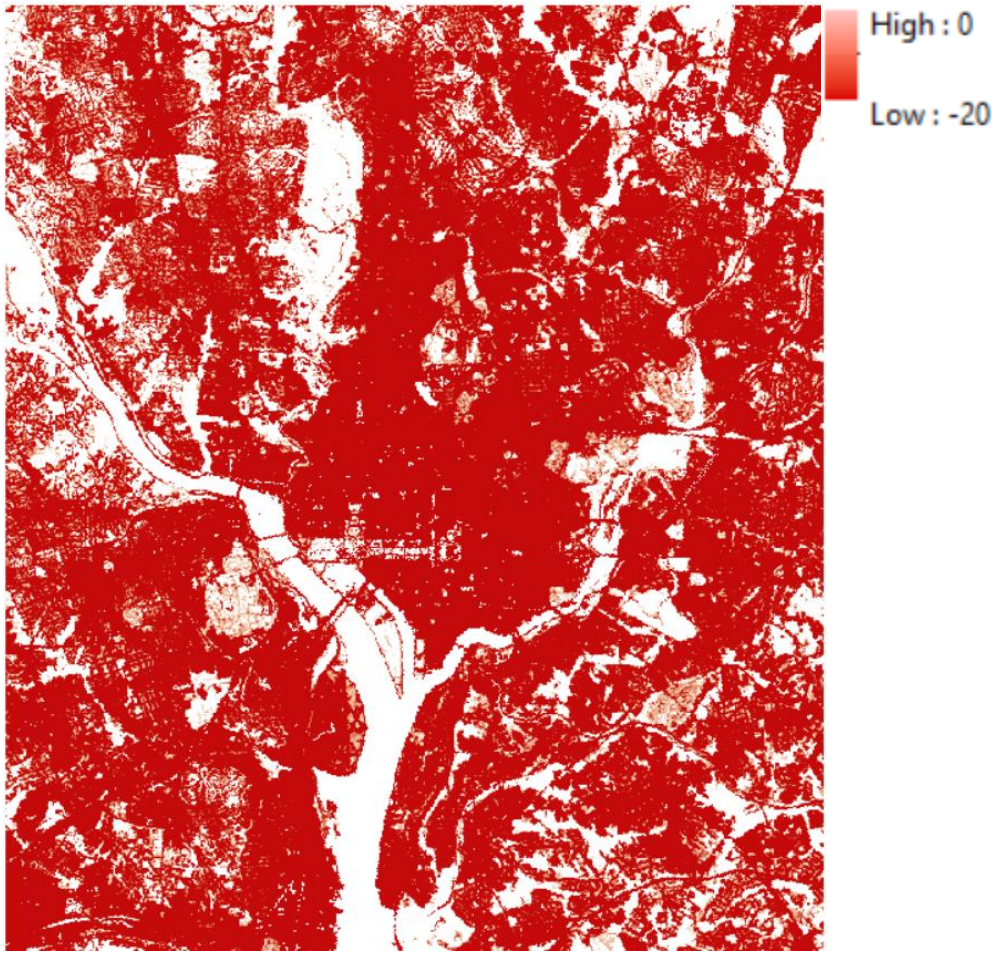


Model Scenarios: Base Case vs Increase Tree Cover 20%, Decrease Impervious Cover 20% on Urban Land

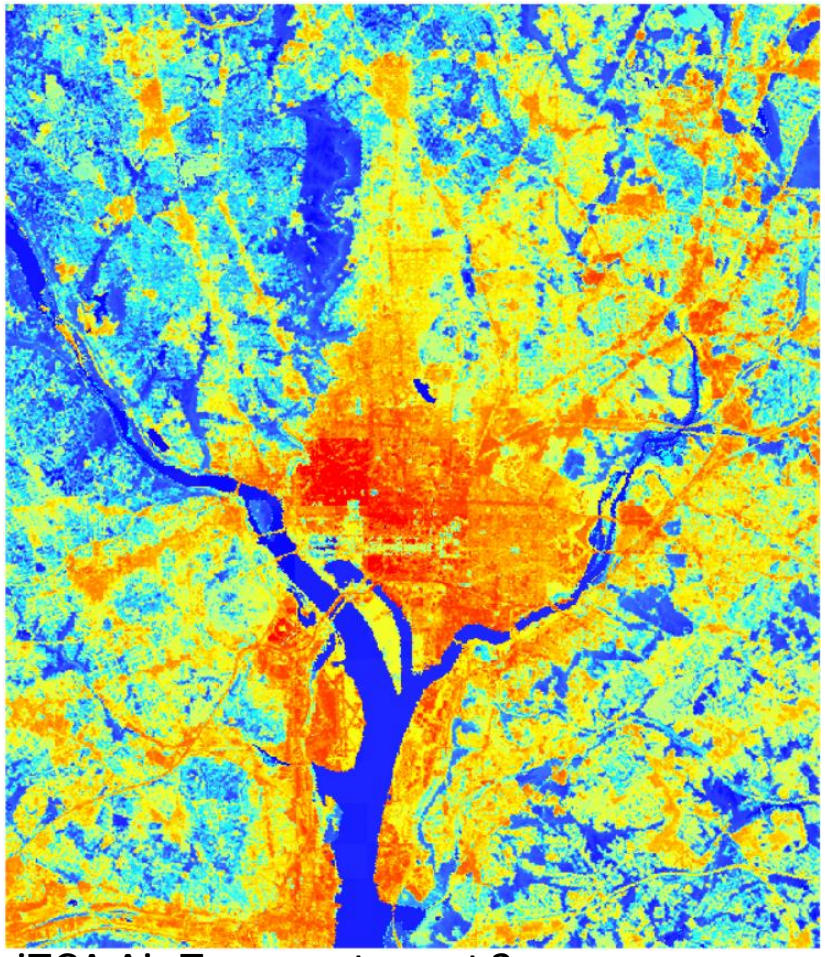


Increase in Tree Cover 20% on urban land

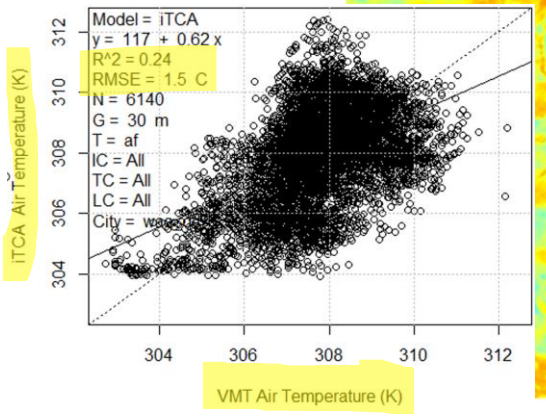


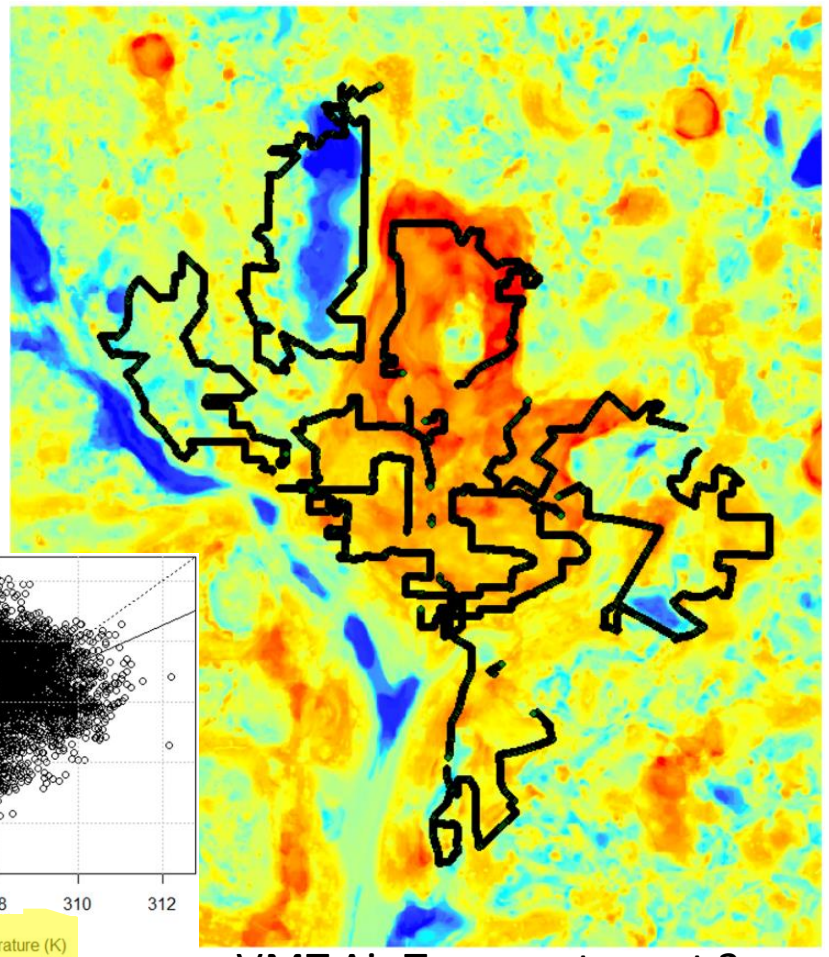
Decrease in Impervious Cover 20% on urban land

Validating i-Tree Cool Air: Washington, DC @ 6AM, 3 & 7 PM 8/28/18, Data from Prof. V. Shandas



iTCA Air Temperature at 3 pm



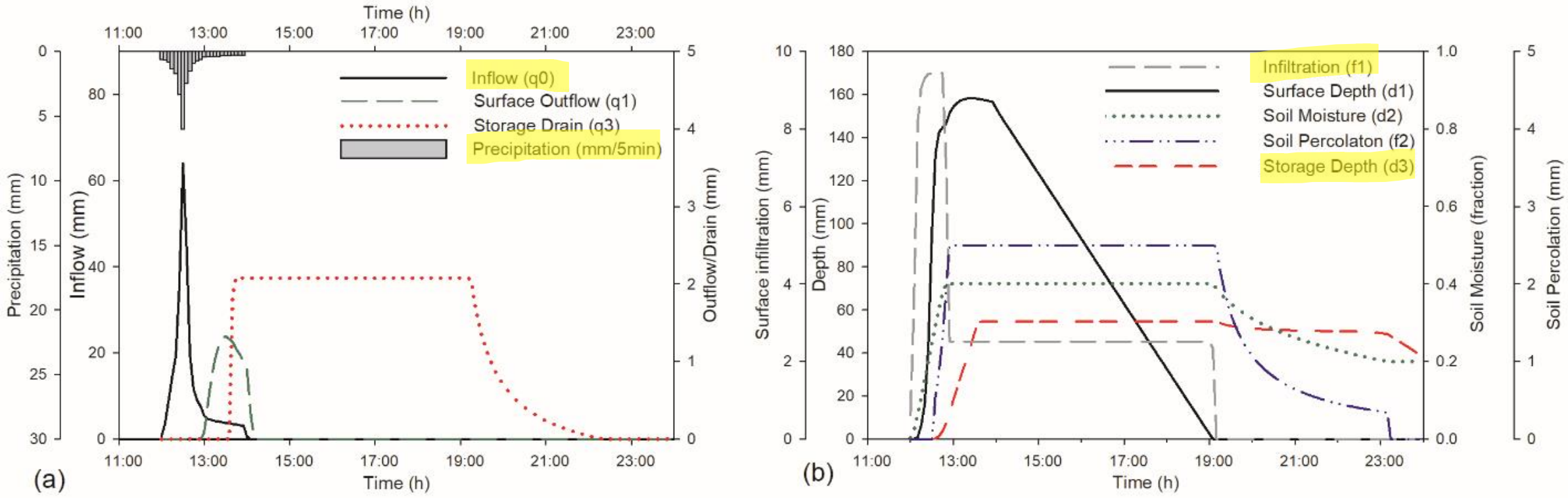


- 22,163 VMT observations

VMT Air Temperature at 3 pm

Shandas, V., Voelkel, J., Williams, J., & Hoffman, J. (2019). Integrating Satellite and Ground Measurements for Predicting Locations of Extreme Urban Heat. *Climate, 7*(1), 5.
Yang, Y., Endreny, T. A., & Nowak, D. J. (2013). A physically based analytical spatial air temperature and humidity model. JGR-Atmospheres, 118(18), 10449-10463. doi:10.1002/jgrd.50803

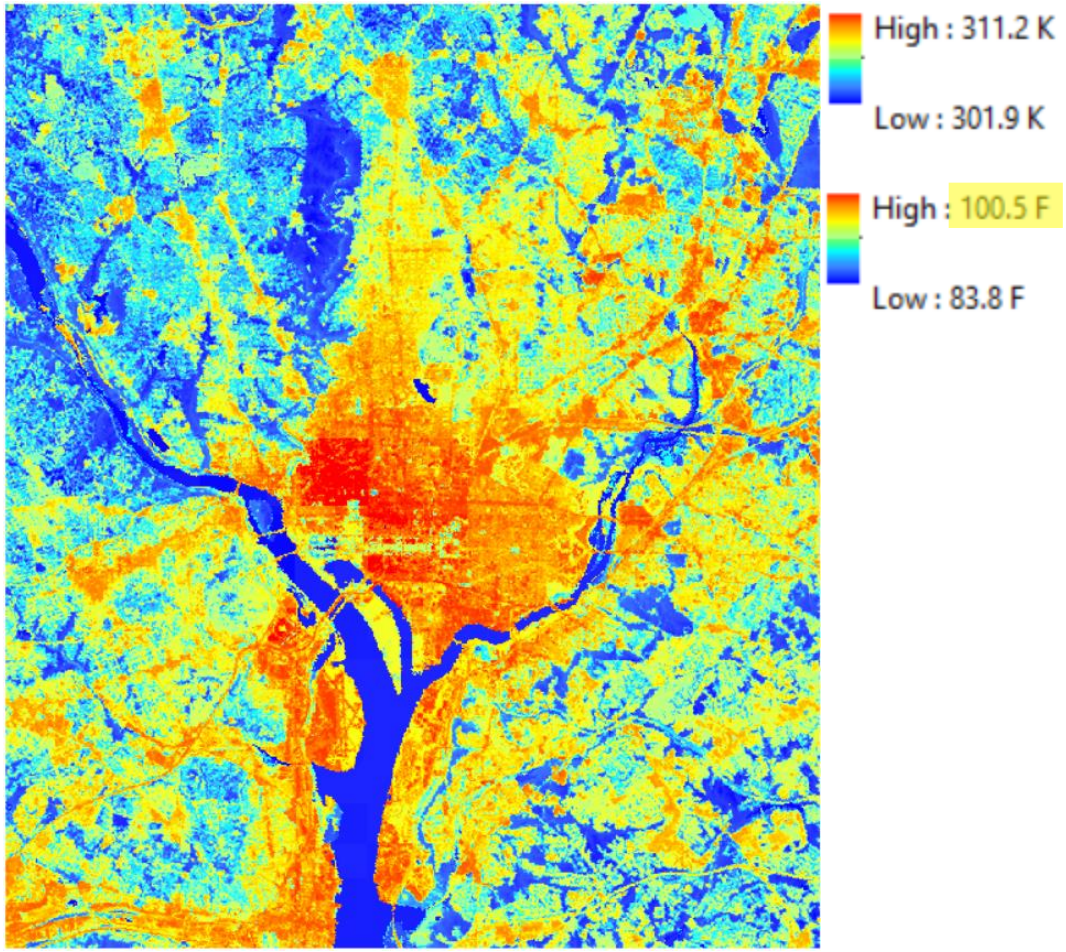
Validating i-Tree Cool Air Hydrology: Detailed Analysis of Water Balances



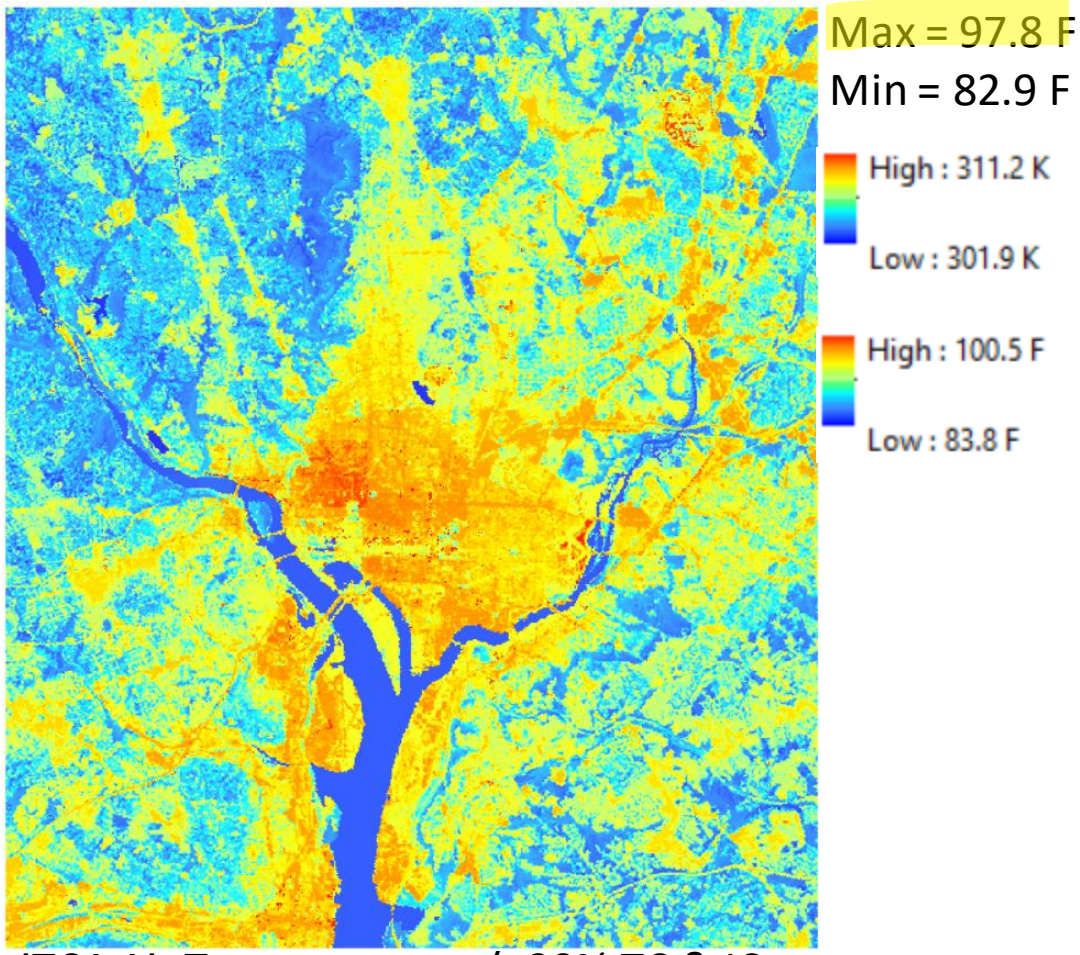
Wang, J., Endreny, T. A., & Nowak, D. J. (2008). Mechanistic Simulation of Tree Effects in an Urban Water Balance Model. Journal of the American Water Resources Association, 44(1), 75-85. doi:10.1111/j.1752-1688.2007.00139.x

Abdi, R. (2019). Computer Algorithms to Simulate Nature-Based Restoration of Urban River and Stormwater Systems. Ph.D. Dissertation Supervised by T. Endreny, SUNY ESF, Syracuse, NY.

Output of Scenario Differences: Map of Temperature for Base Case vs +/-20% TC & IC



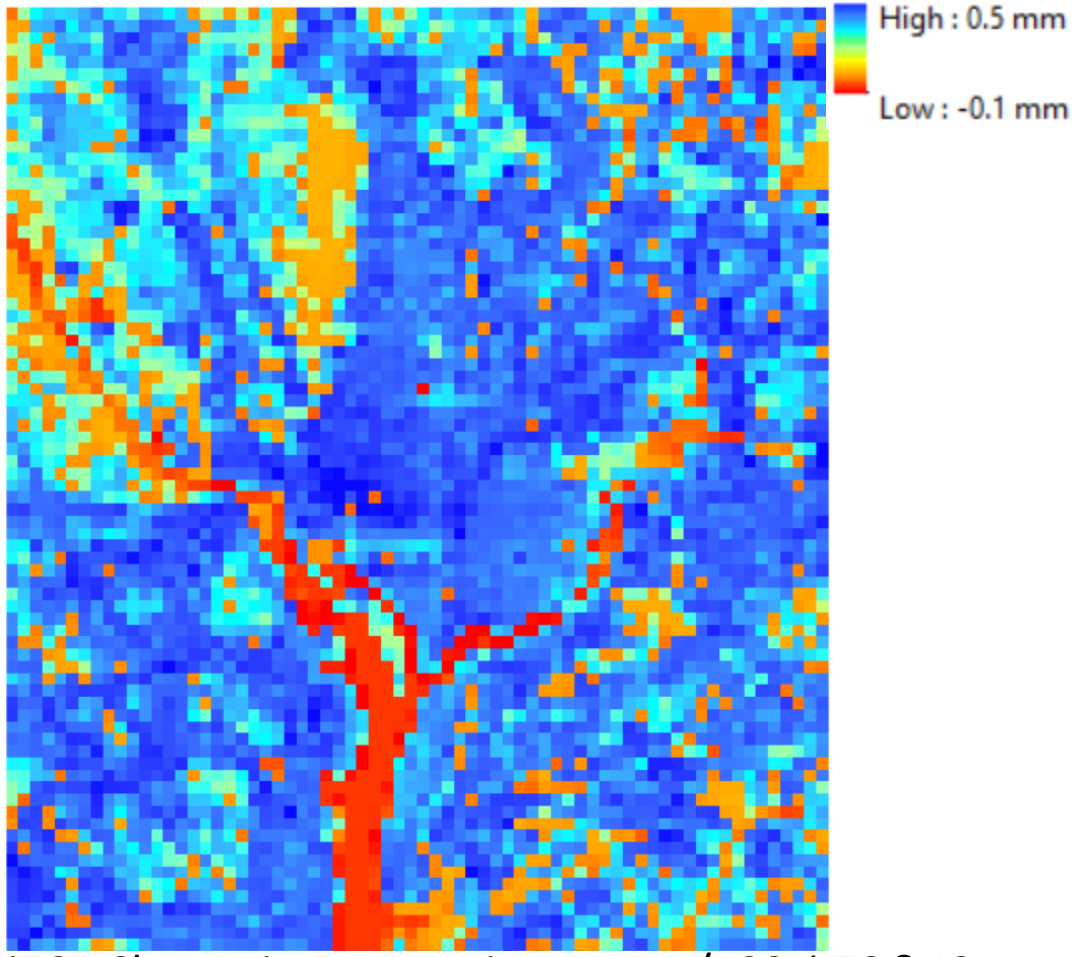
iTCA Air Temperature: Base Case



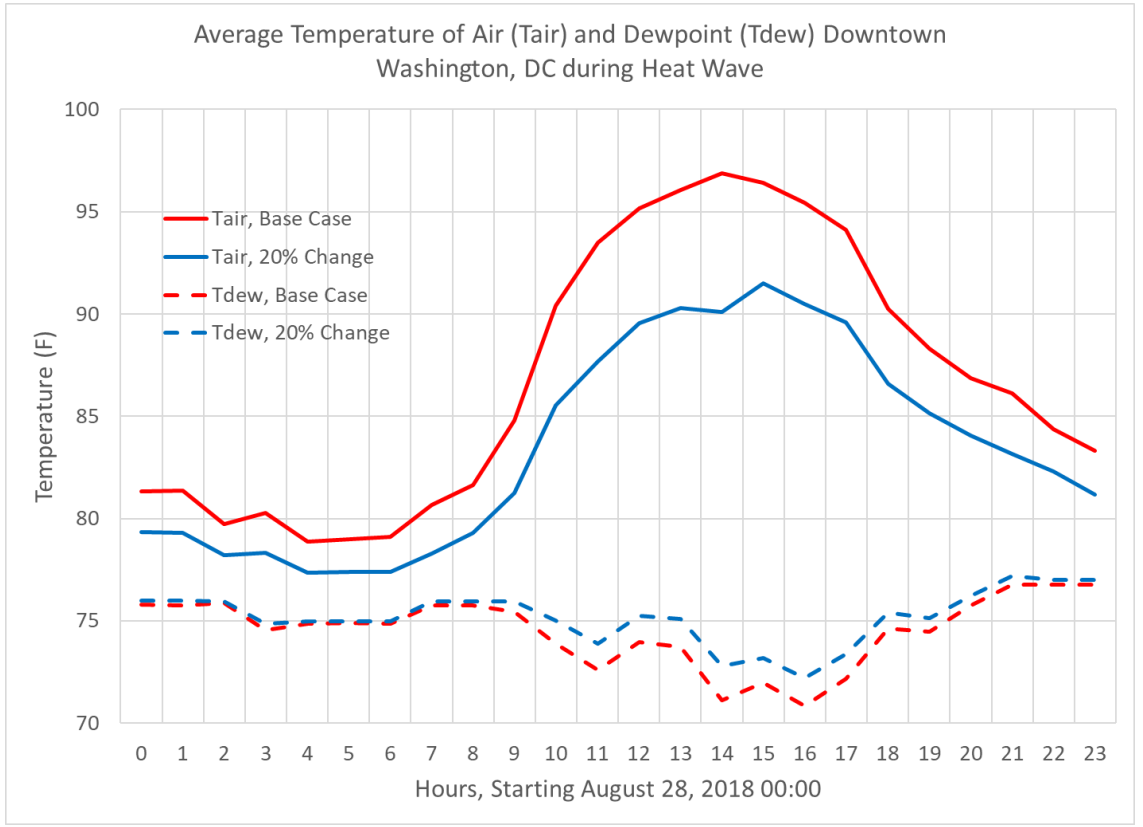
iTCA Air Temperature: +/- 20% TC & IC

Sinha, P., Coville, R. C., Hirabayashi, S., Lim, B., Endreny, T. A., & Nowak, D. J. (2022). Variation in Estimates of Heat-Related Mortality Reduction due to Tree Cover in U.S. Cities. Journal of Environmental Management, 301, 113751. doi:https://doi.org/10.1016/j.jenvman.2021.113751.

Output of Scenario Differences: Map of Evaporation, Time Series of Temperature

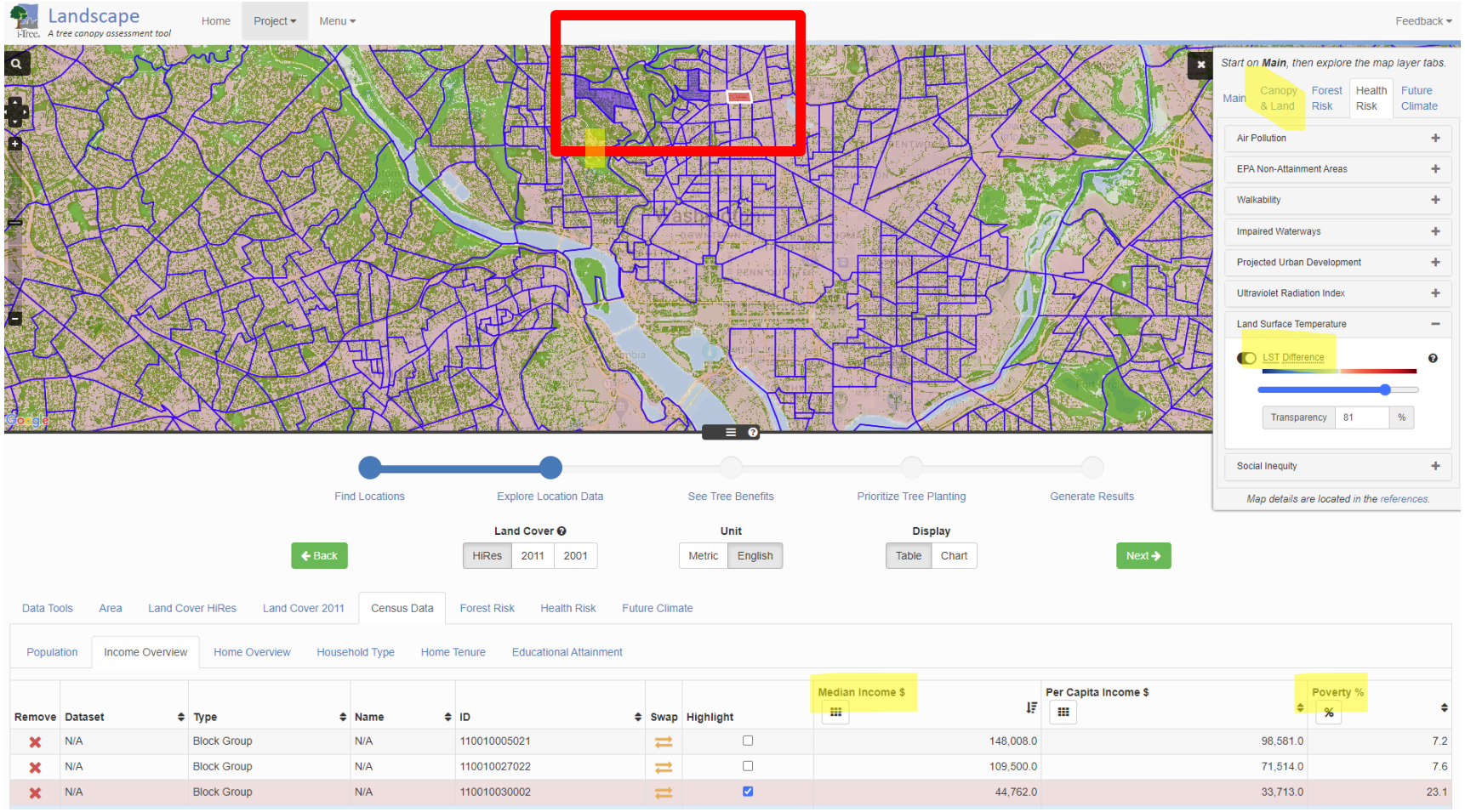


iTCA Change in Evaporation: Base +/- 20% TC & IC



iTCA Time Series of Base Case vs Scenario +/- 20% TC & IC

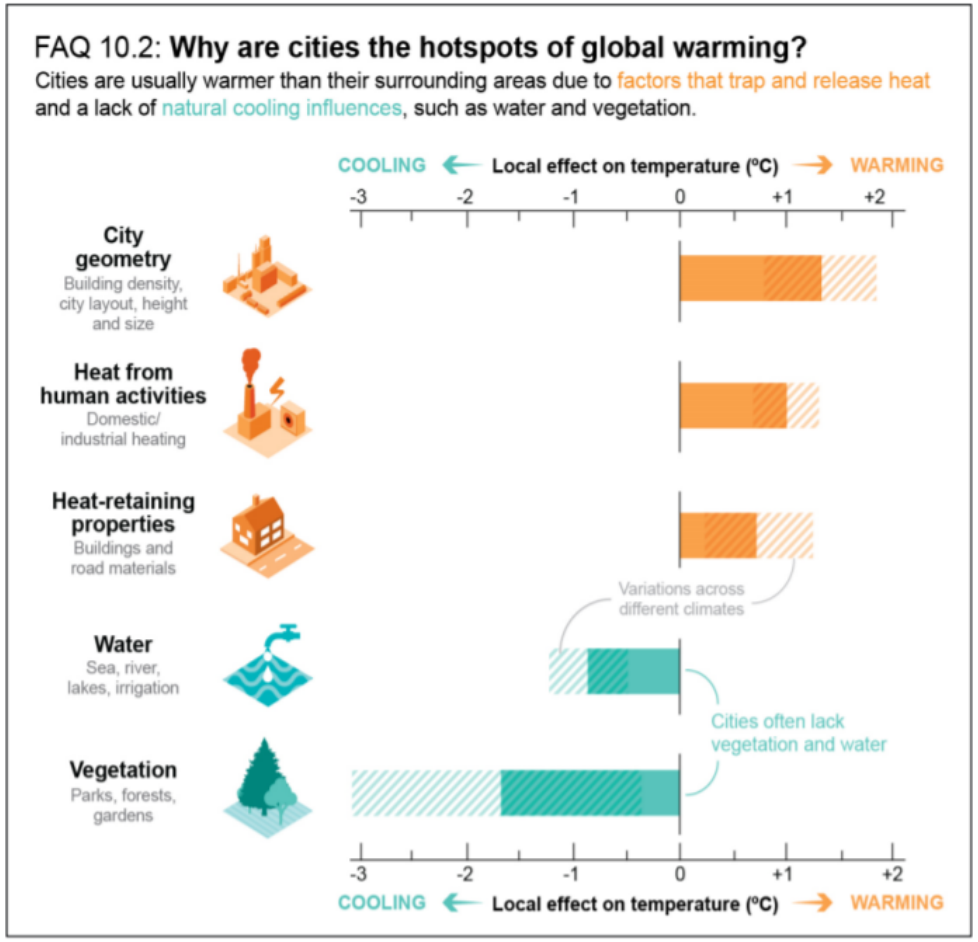
Discussion: i-Tree Landscape Finds Vulnerability via Overlay of Demographic Data & Ecosystem Services



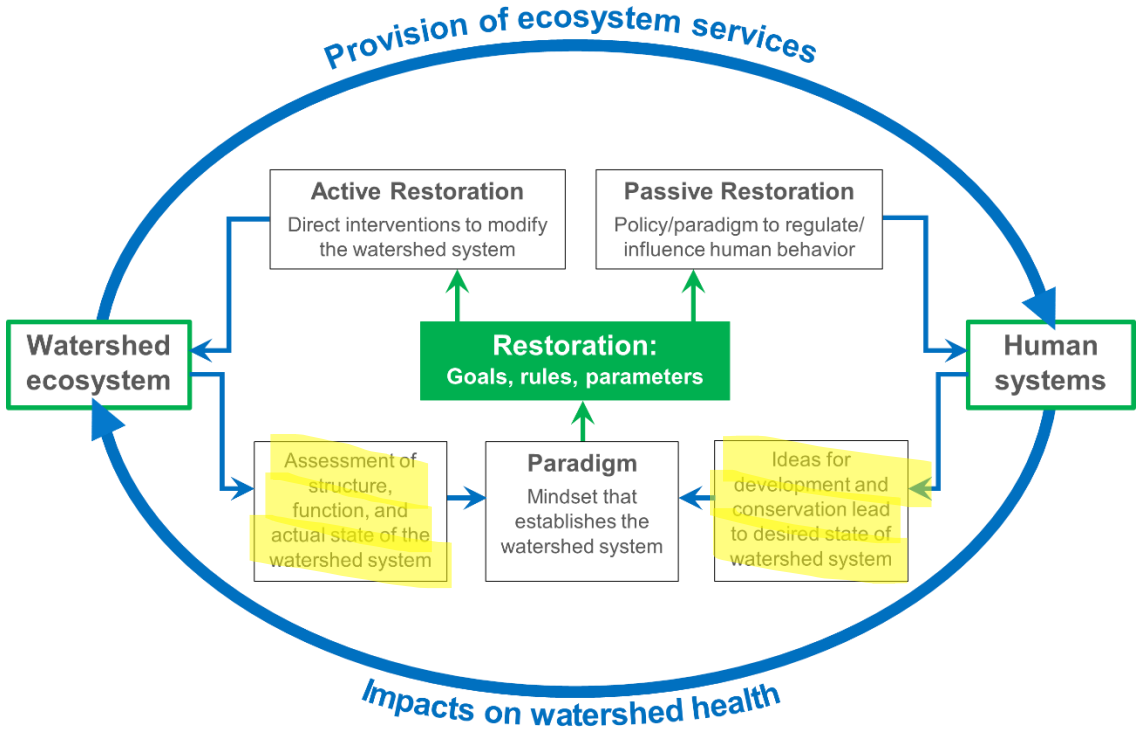
Exploring 3 Census Block Groups w/ Table of Income Overview & Map Overlay w/ HiRes Tree Cover, LST (Land Surface Temperature) Difference from Median of LandSAT scene. Map & Table show Vulnerability.

Discussion: Climate Change Exacerbates Threats to Urban Sustainability

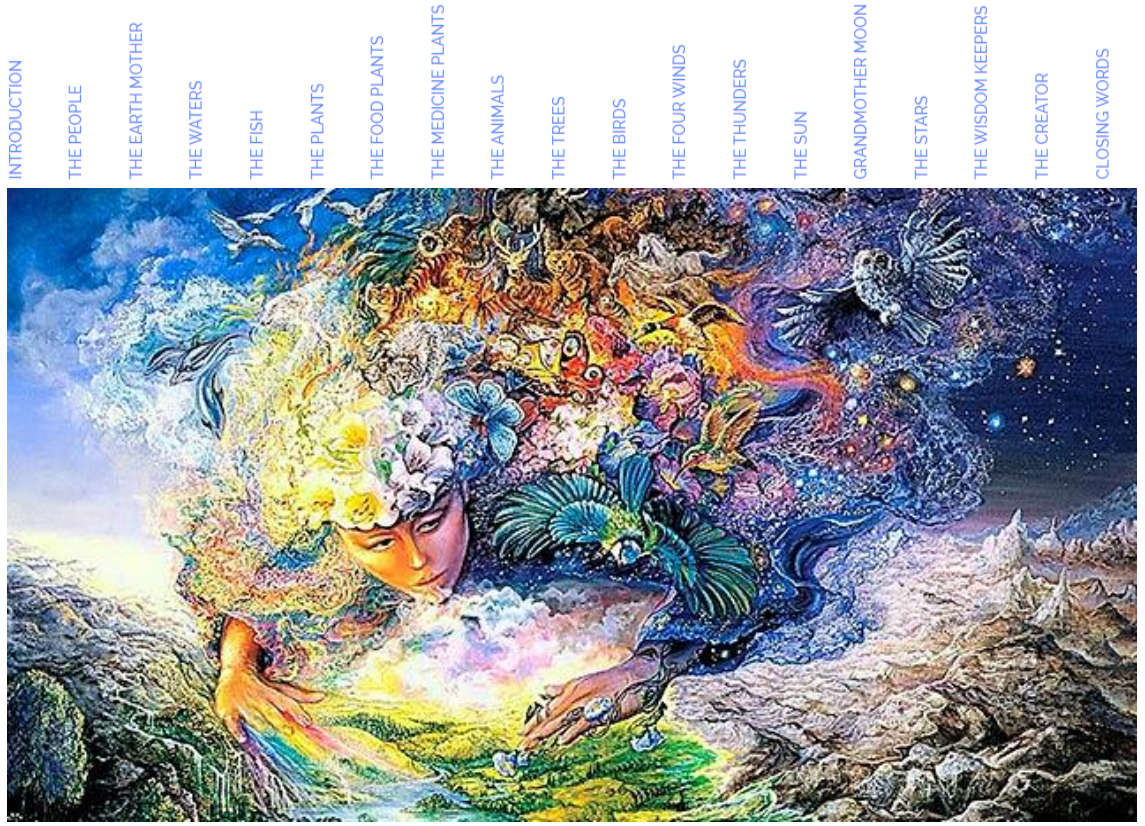
- IPCC AR6 WG1 Physical Science Basis
  - Based on CMIP6, assessing multiple RCPs and SSPs
- Model, Observational, & Attribution Findings: Regional Fact Sheets
  - Forecast North American urban areas receive more extreme air pollution episodes in heavily polluted environments
  - Forecast Urban Areas receive more frequent extreme climate events, such as heatwaves, with more hot days and warm nights adding to heat stress in cities
  - Forecast Urban Areas receive sea level rise, storm surge, and extreme rainfall events will increase the probability of flooding



Discussion: Leverage Points to Improve the State of our Watershed; Resetting our Paradigms



Watershed state or conditions reveals its purpose.



https://danceforallpeople.com/haudenosaunee-thanksgiving-address/haudenosaunee-thanksgiving-address-2/

Today we have gathered and we see that the cycles of life continue.

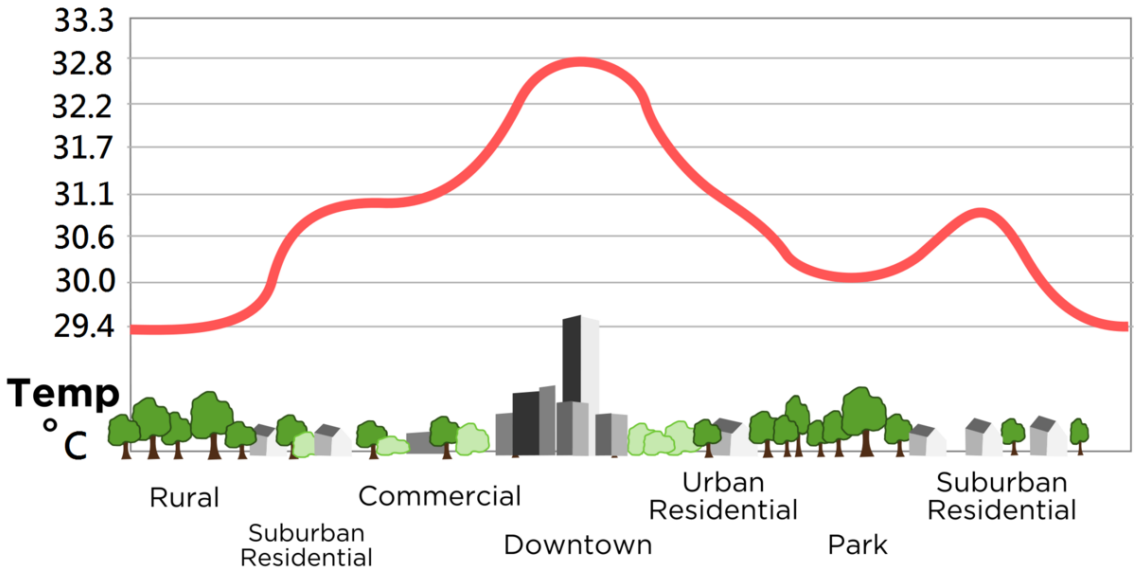
...

Now our minds are one.

Endreny, T. A. (2020). Leverage Points Used in a Systems Approach of River and River Basin Restoration. *Water, 12*(9). doi:10.3390/w12092606

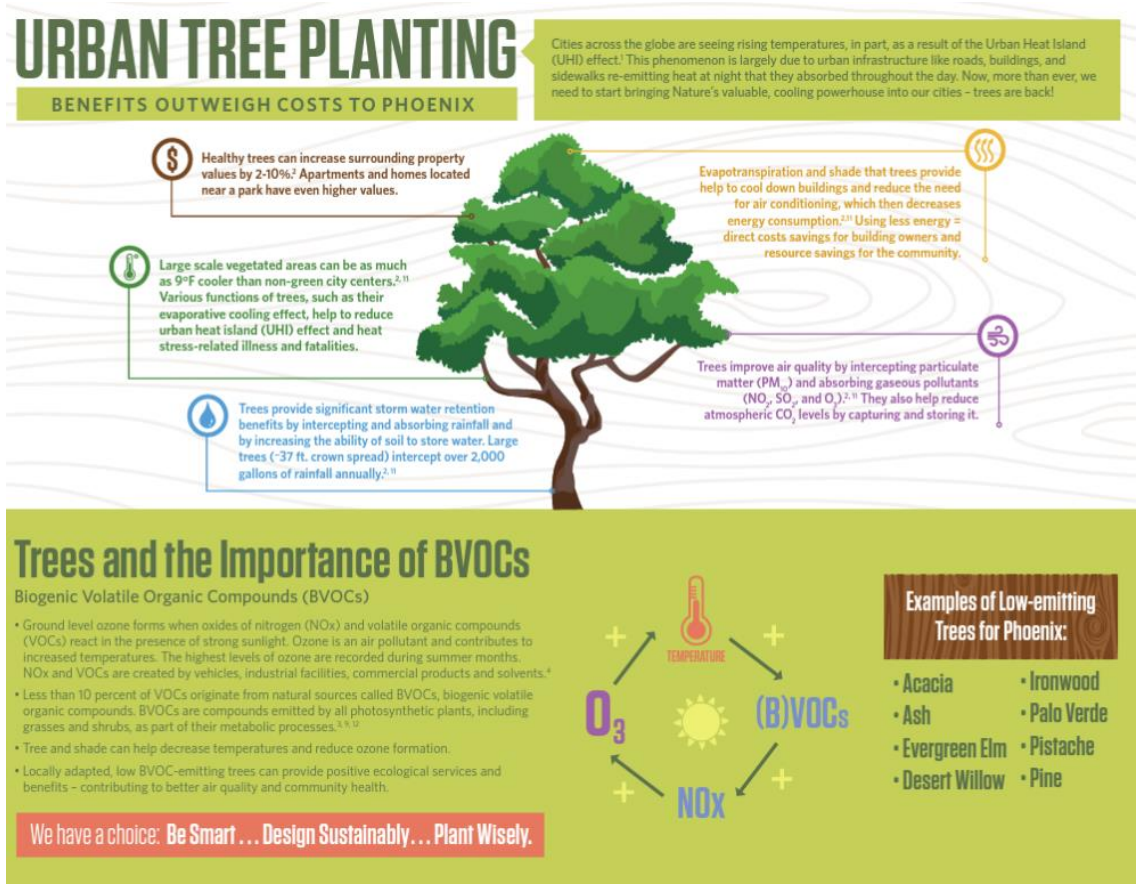
Conclusions

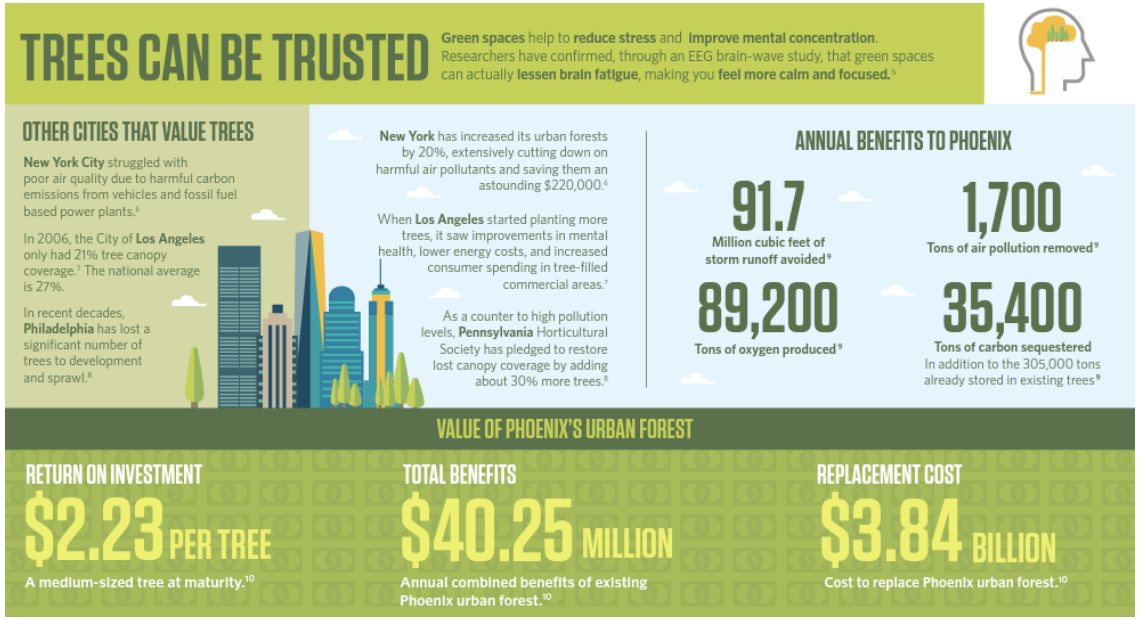
- Urban forests restore water & energy balance
- Urban forest expansion cools cities, saves lives



Do you?

Extra Material: Monetized Services & Disservices give Return on Investment > $2 per mature tree





https://www.phoenix.gov/parkssite/Documents/PKS_Forestry/PKS_Forestry_Infographic_Urban_Forestry_Benefits_Costs.pdf