Earth Observation for Implementing U.S. Ecosystem Accounts

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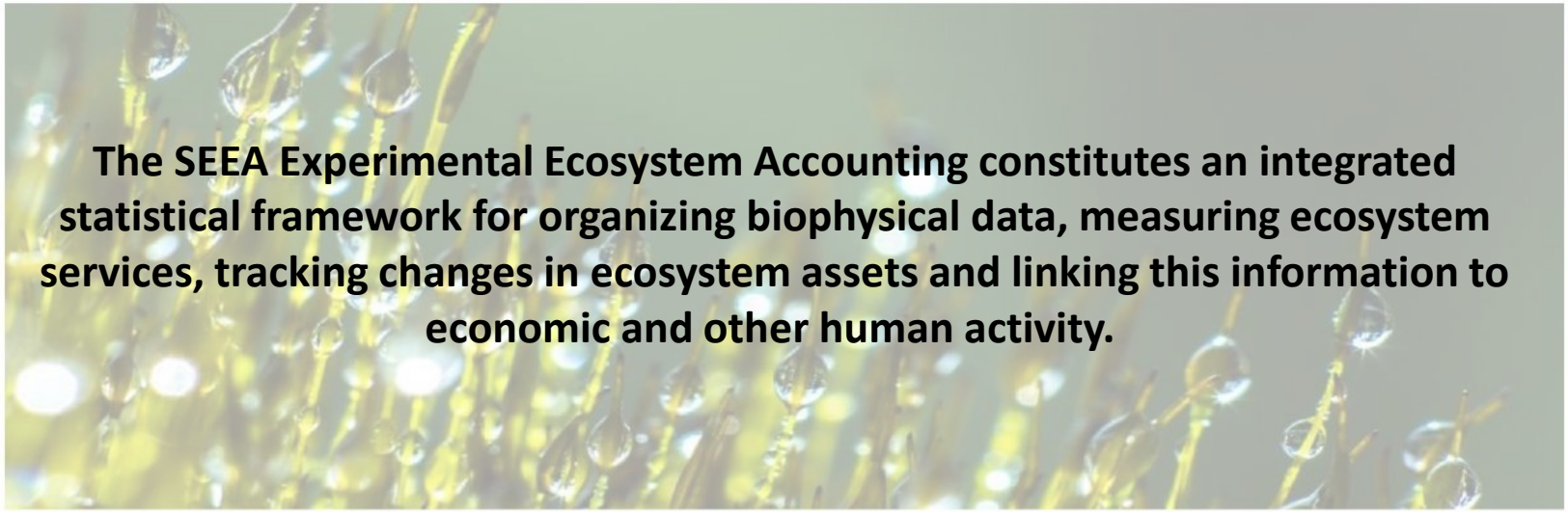
SYSTEM OF ENVIRONMENTAL ECONOMIC ACCOUNTING

Ecosystem Accounting



What is it?

The SEEA Experimental Ecosystem Accounting constitutes an integrated statistical framework for organizing biophysical data, measuring ecosystem services, tracking changes in ecosystem assets and linking this information to economic and other human activity.

SEEA Experimental Ecosystem Accounting and the Central Framework

The SEEA Experimental Ecosystem Accounting complements the SEEA Central Framework by taking a different perspective. The Central Framework looks at "individual environmental assets", such as water resources, energy resources, etc. and how those assets move between the environment and the economy. In contrast, the SEEA Experimental Ecosystem Accounting takes the perspective of ecosystems and considers

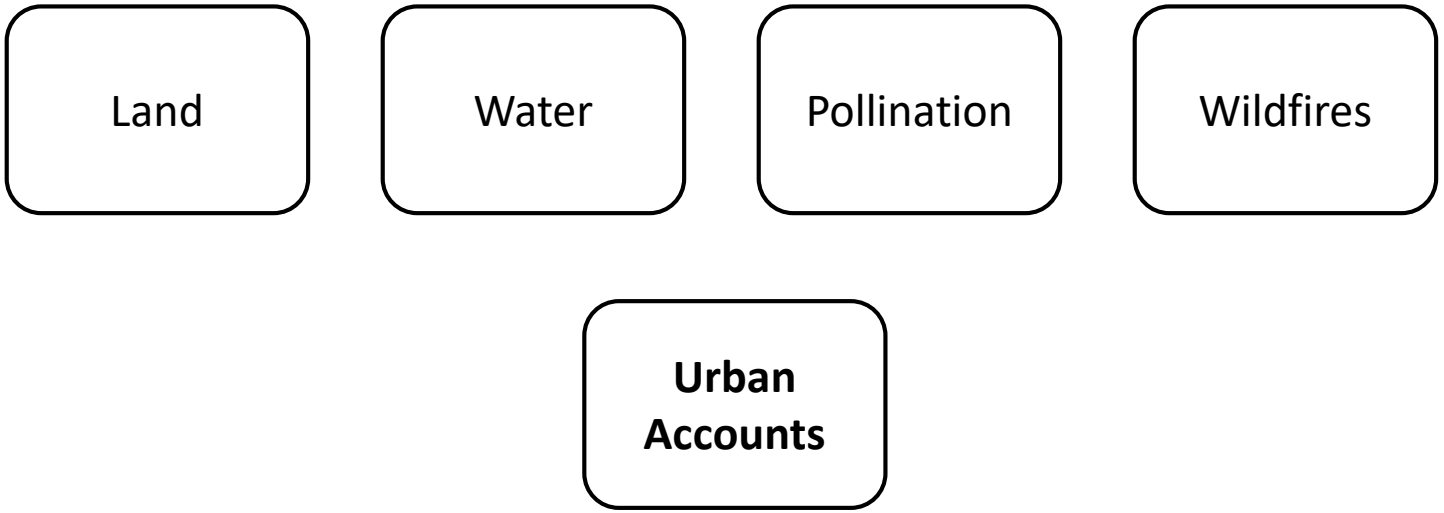
SEEA EEA Revision

Please see the SEEA EEA Revision dedicated website here.

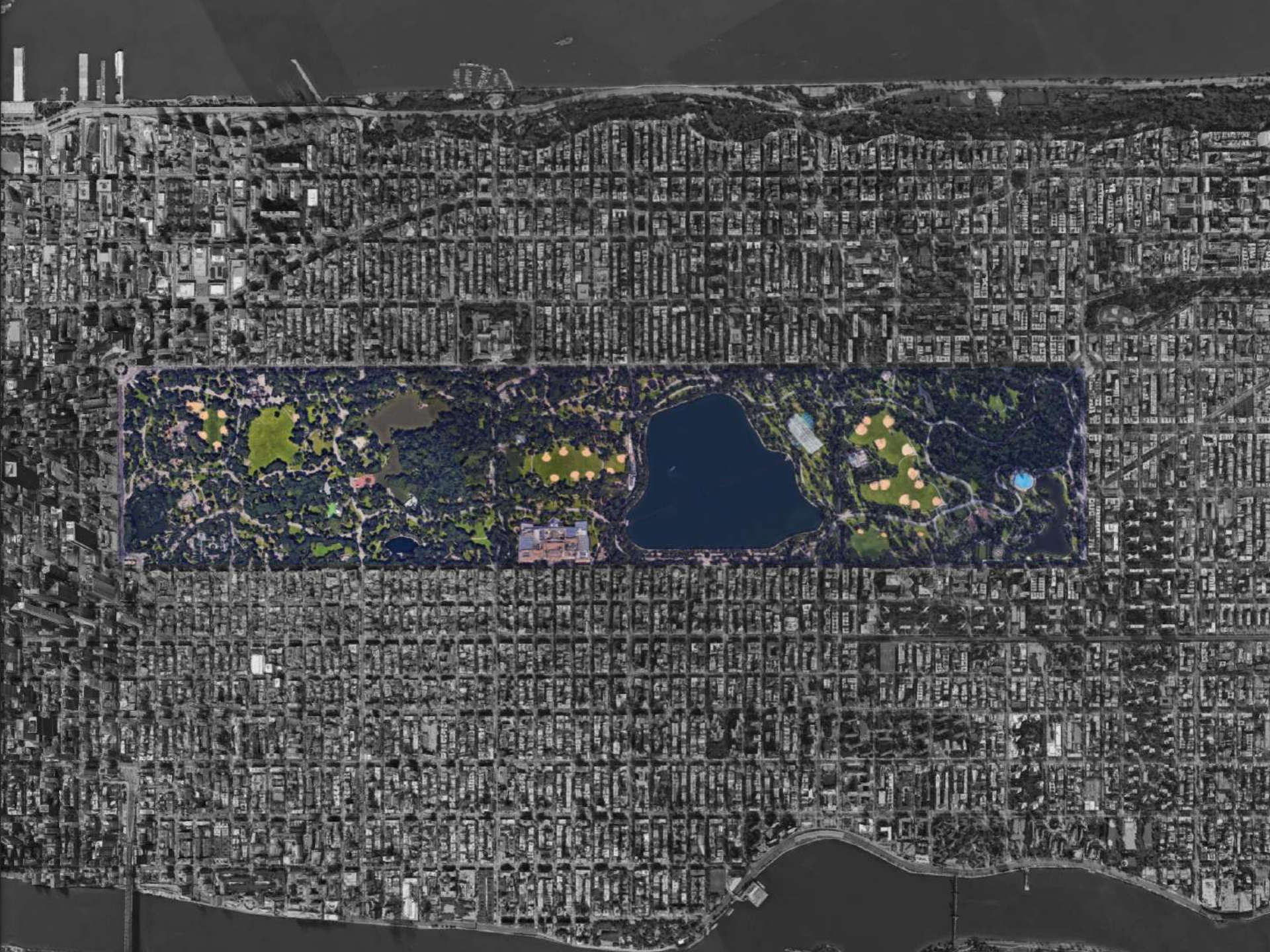
Manuals

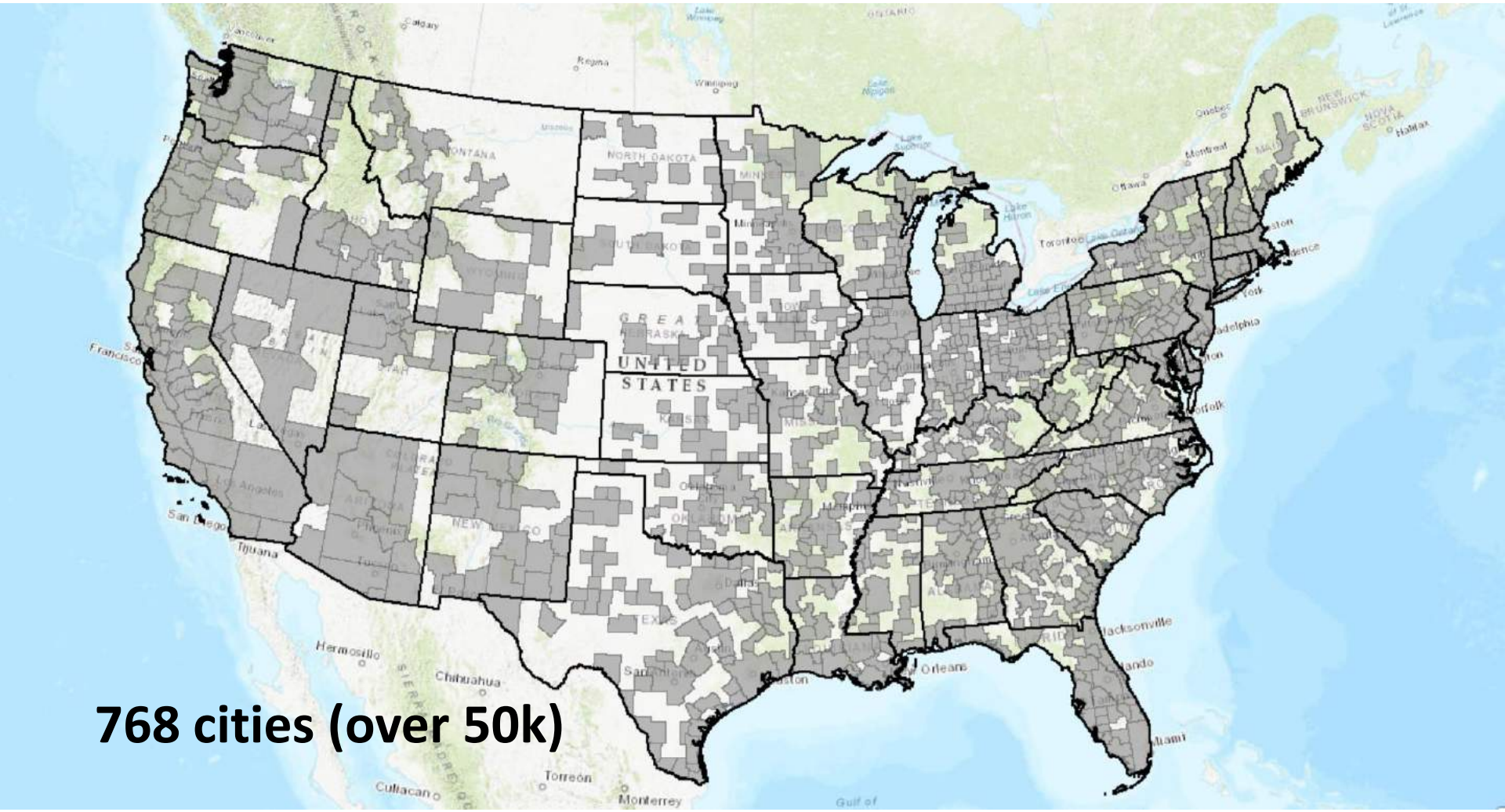
SEEA Experimental Ecosystem Accounting

Final: English


Land
Water
Pollination
Wildfires
Urban Accounts


$500,000





768 cities (over 50k)

Heat mitigation impact of trees

Surface temperature

NLCD Tree Canopy

NLCD Land Cover

Weather station data

Building footprint data

Building energy use data

Rainfall interception

NLCD Tree Canopy

NLCD Land Cover

Weather station

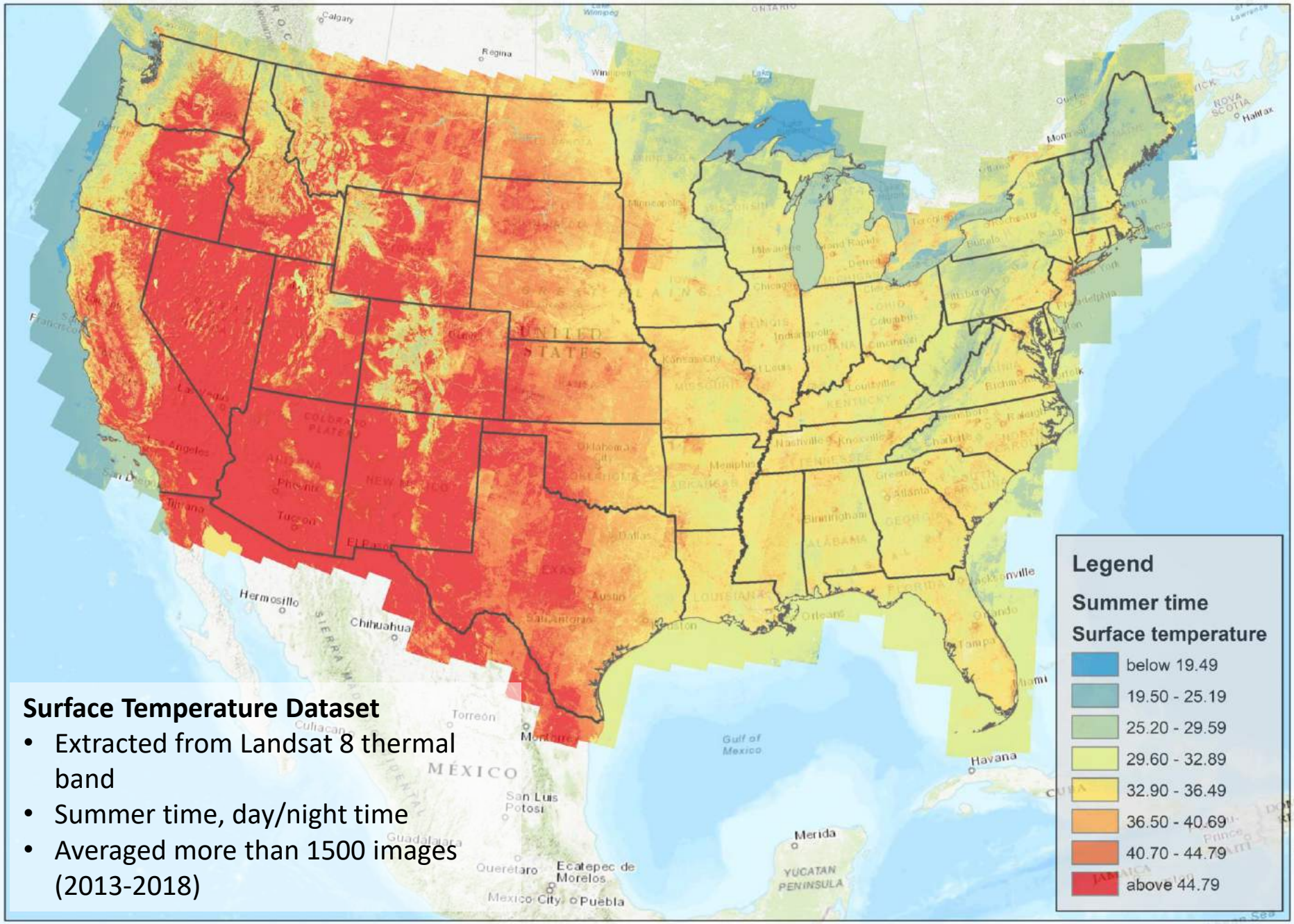
MODIS seasonality


Chicago
New York
Seattle
Washington, DC
Philadelphia
Minneapolis
Legend
Tree Coverage
% of Cells (30mX30m)
0
0-10%
10-20%
20-35%
35-55%
55-100%
0
1
2
4
Miles

Heat Mitigation

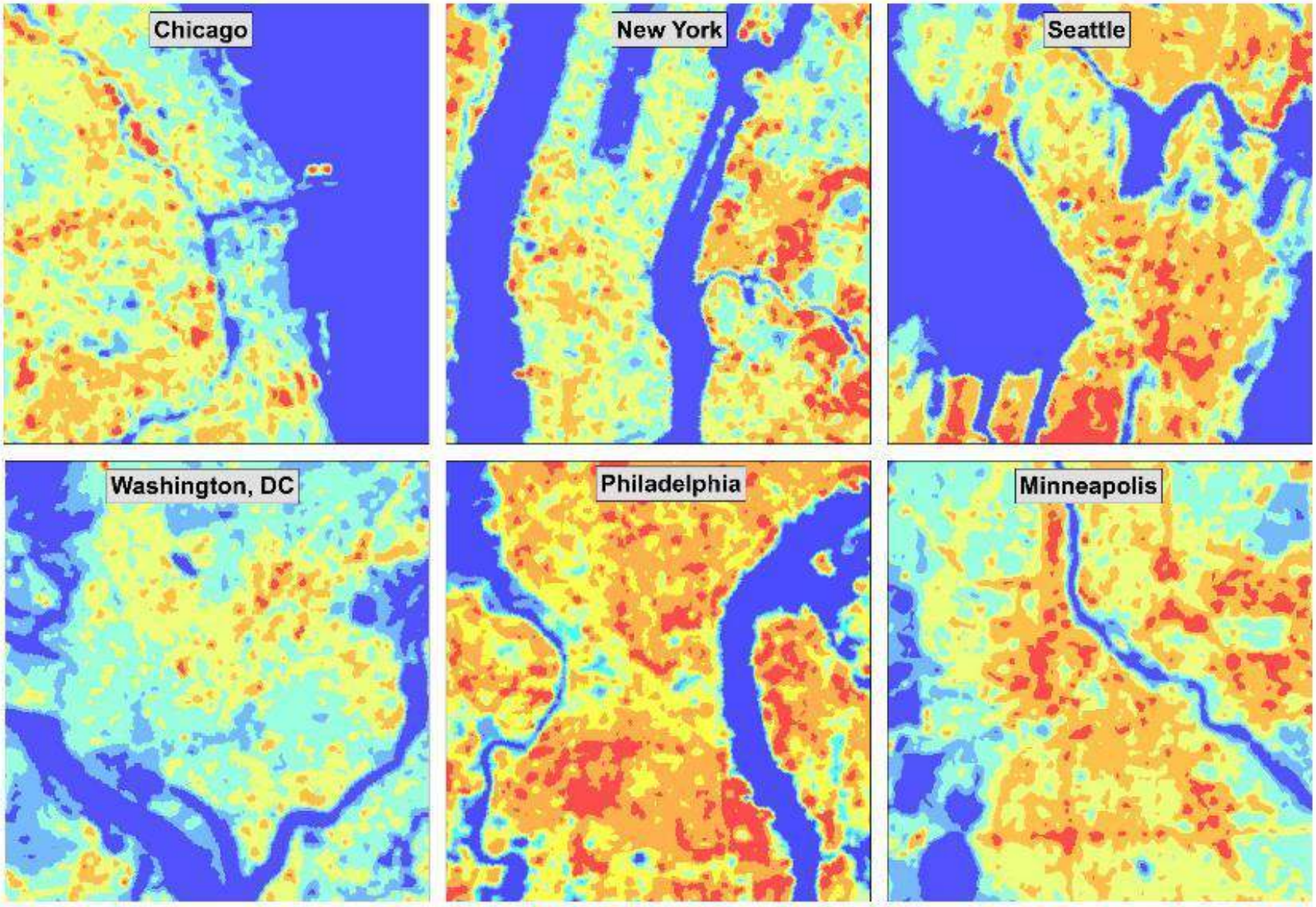
cooling energy savings

Data Infrastructure

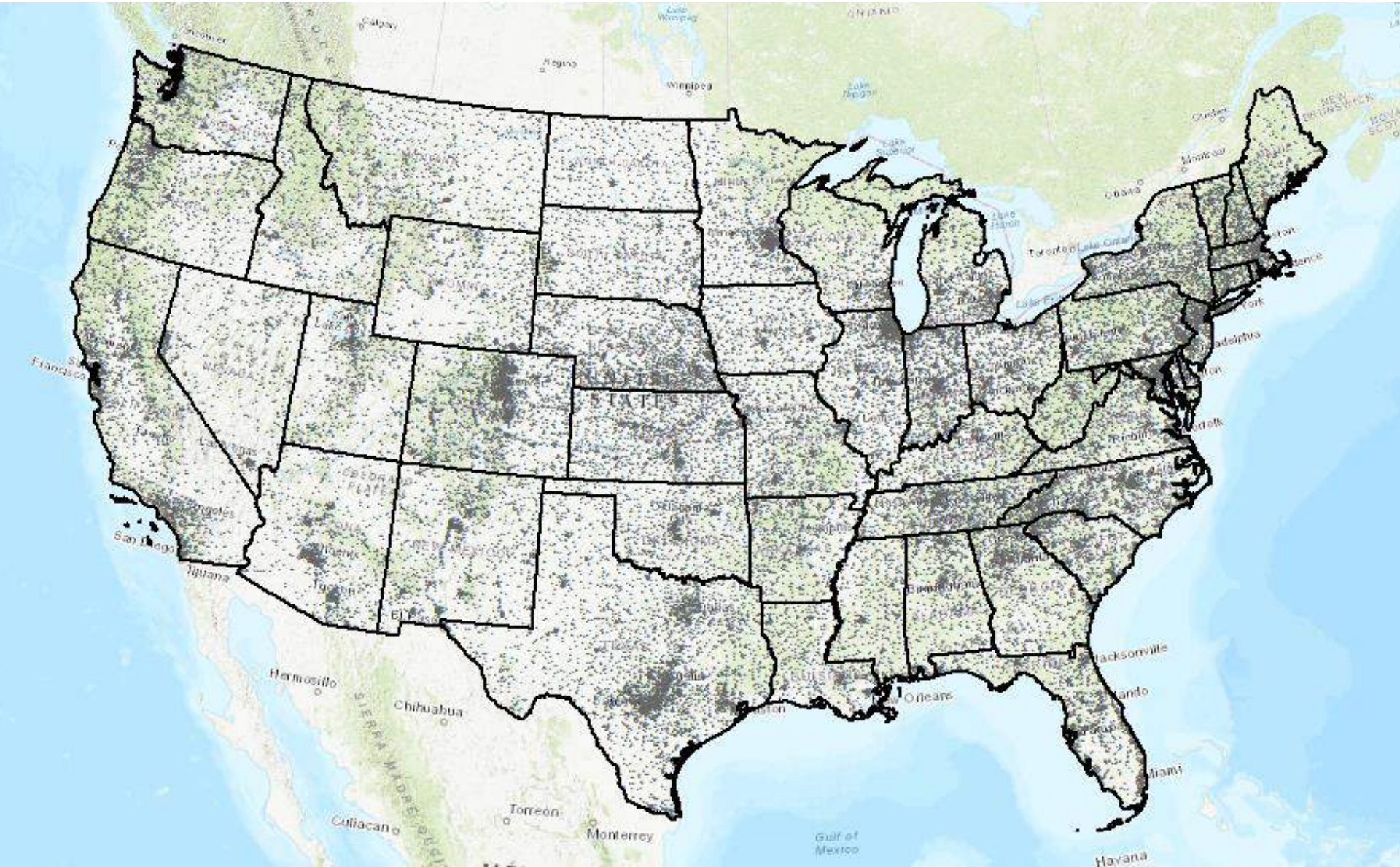


Surface Temperature Dataset

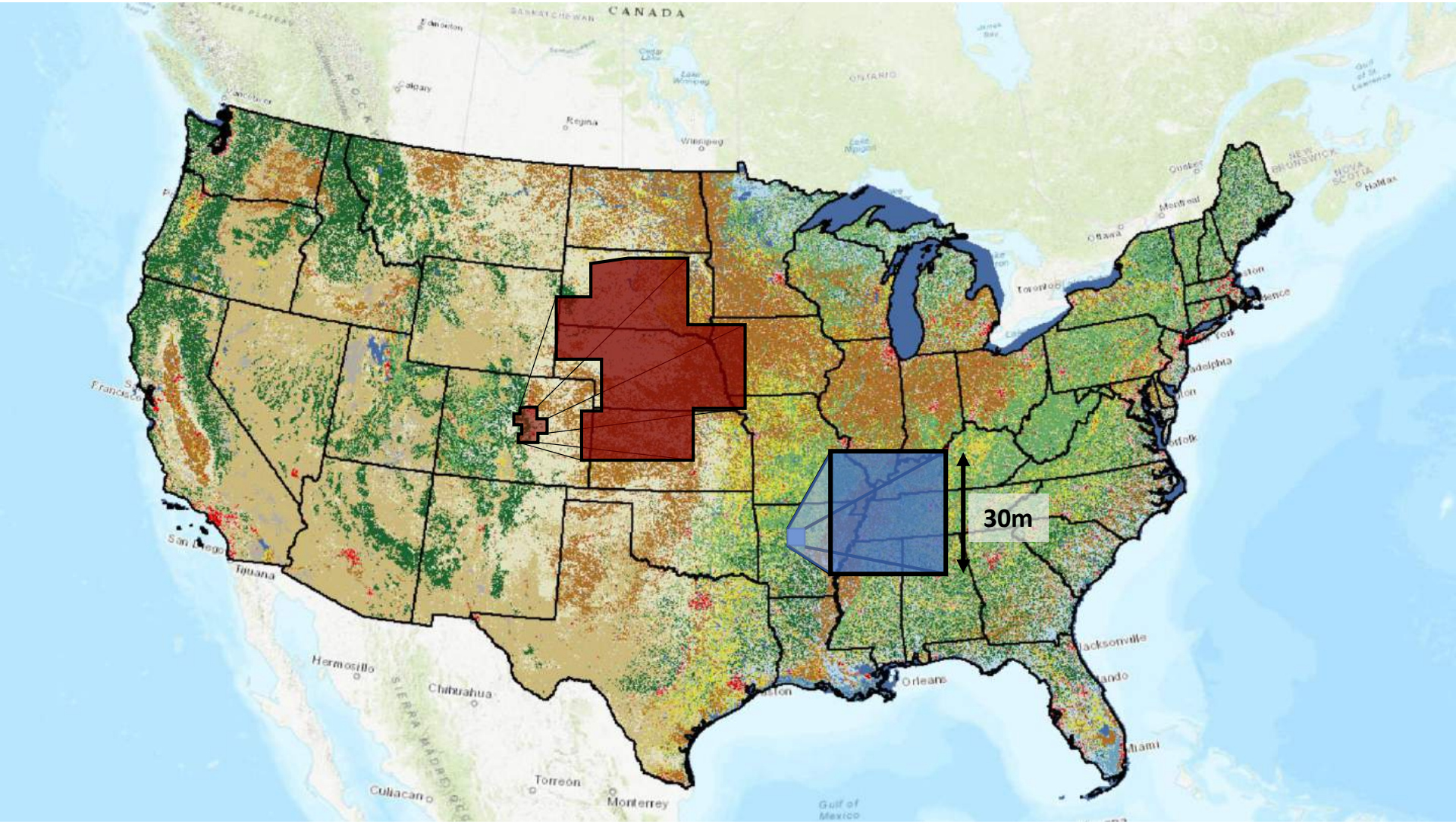
- Extracted from Landsat 8 thermal band
- Summer time, day/night time
- Averaged more than 1500 images (2013-2018)

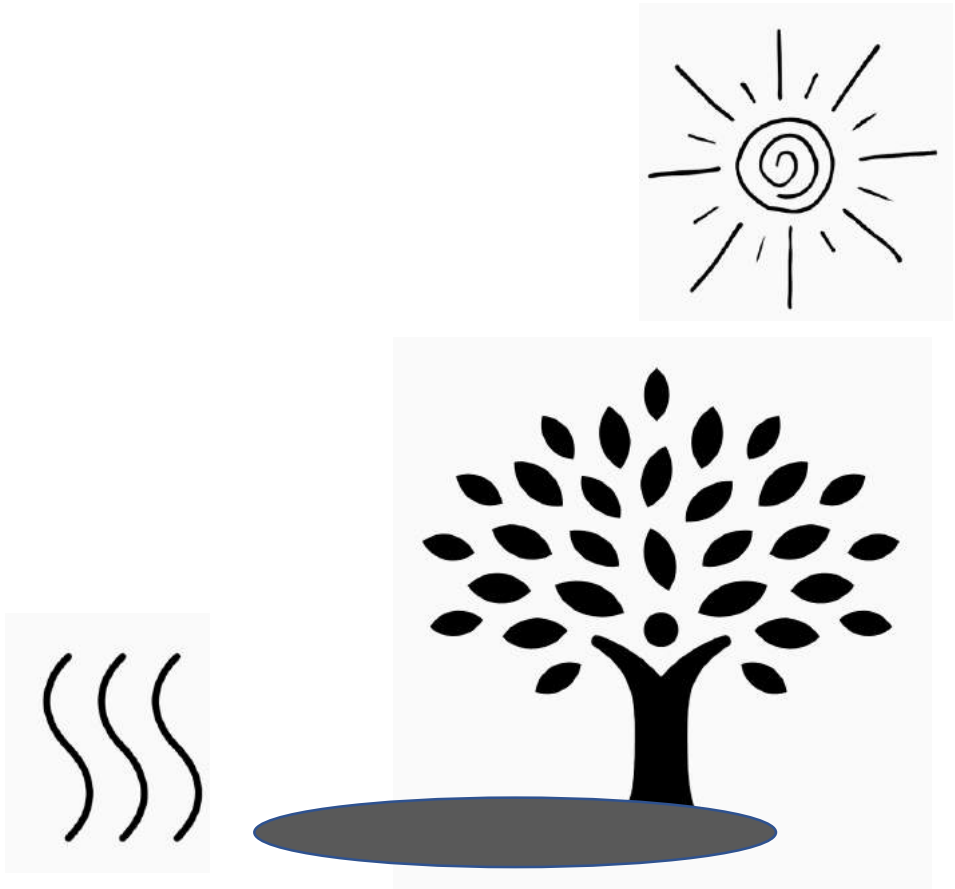

Chicago
New York
Seattle
Washington, DC
Philadelphia
Minneapolis
Legend
Surface Temperature
°C
21.4 - 36.1
36.2 - 38.1
38.2 - 39.8
39.9 - 41.3
41.4 - 43.4
43.5 - 60.8
0
1
2
4
Miles

56k Weather Stations

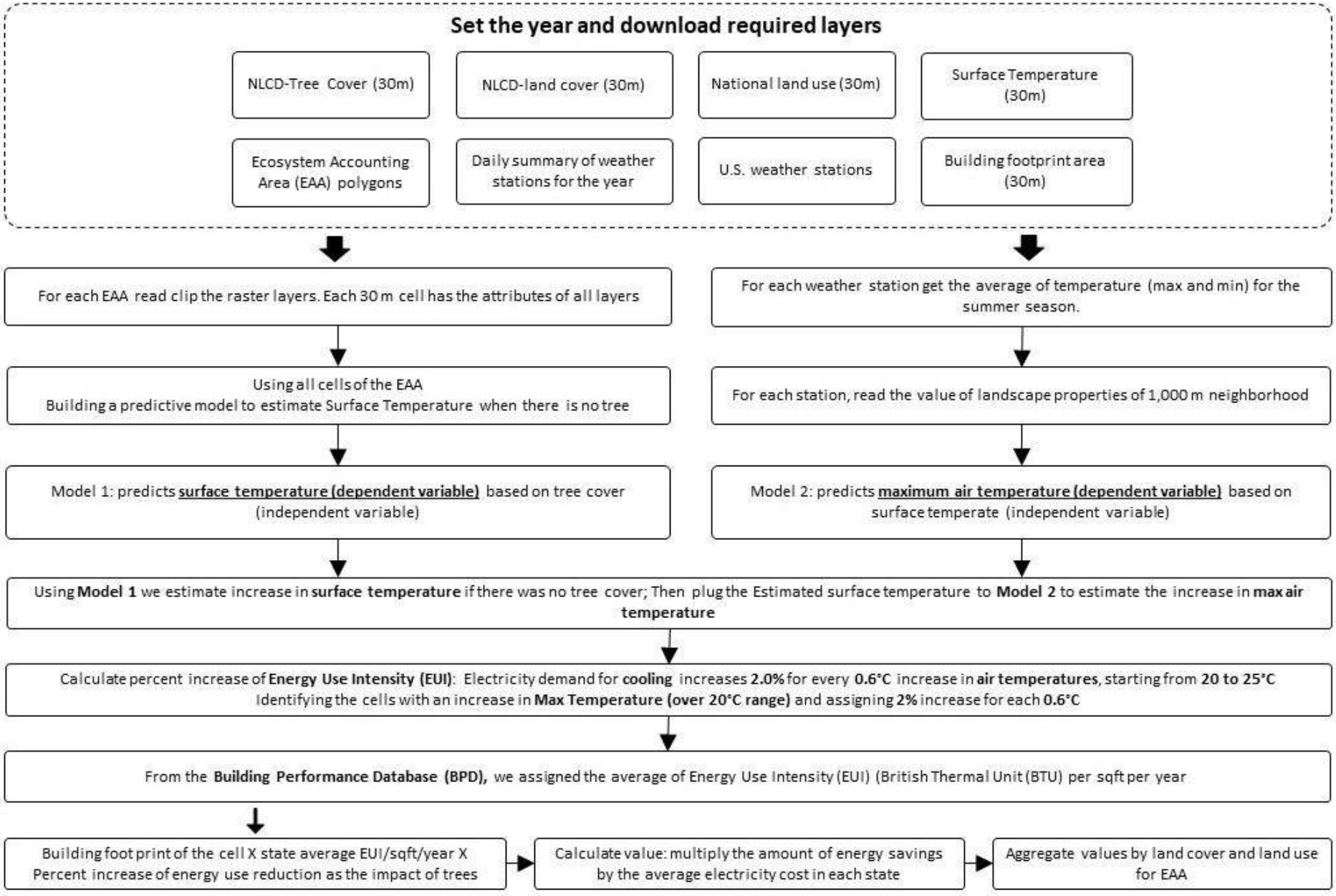


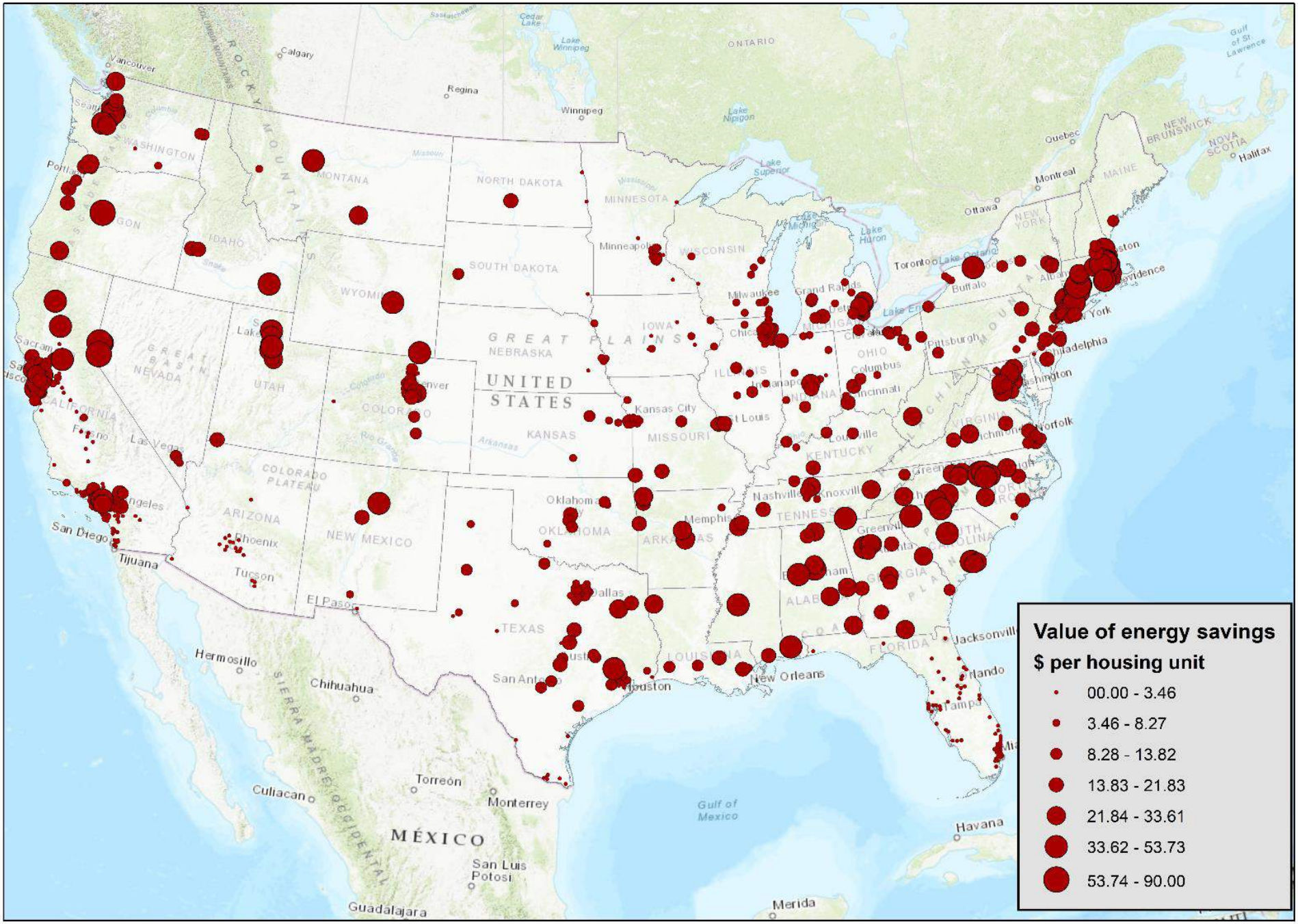
Spatial Data Unit vs Ecosystem Accounting Area





Trees ⇨ ST ⇨ AT

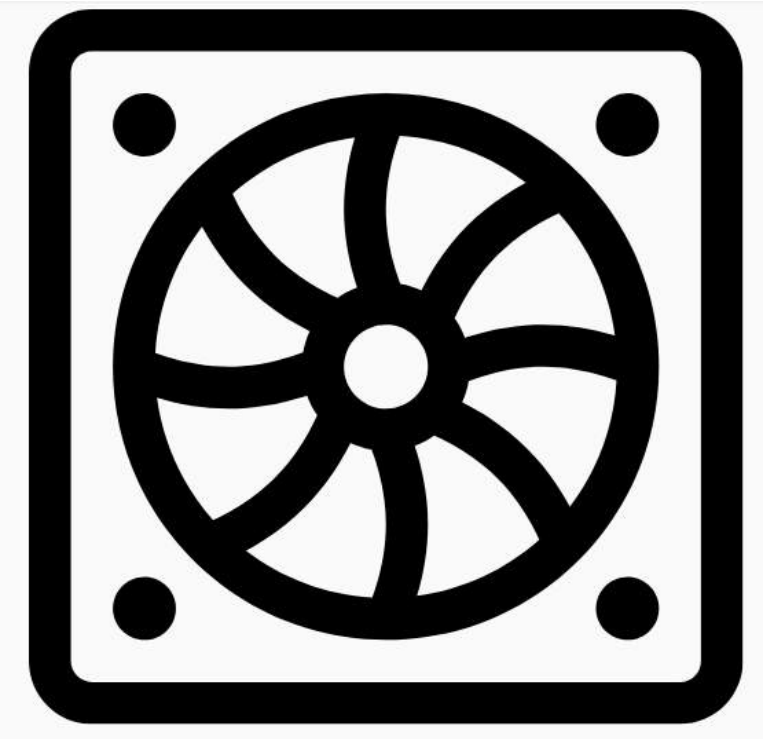

Set the year and download required layers
NLCD-Tree Cover (30m)
NLCD-land cover (30m)
National land use (30m)
Surface Temperature (30m)
Ecosystem Accounting Area (EAA) polygons
Daily summary of weather stations for the year
U.S. weather stations
Building footprint area (30m)
For each EAA read clip the raster layers. Each 30 m cell has the attributes of all layers
For each weather station get the average of temperature (max and min) for the summer season.
Using all cells of the EAA
Building a predictive model to estimate Surface Temperature when there is no tree
For each station, read the value of landscape properties of 1,000 m neighborhood
Model 1: predicts surface temperature (dependent variable) based on tree cover (independent variable)
Model 2: predicts maximum air temperature (dependent variable) based on surface temperate (independent variable)
Using Model 1 we estimate increase in surface temperature if there was no tree cover; Then plug the Estimated surface temperature to Model 2 to estimate the increase in max air temperature
Calculate percent increase of Energy Use Intensity (EUI): Electricity demand for cooling increases 2.0% for every 0.6°C increase in air temperatures, starting from 20 to 25°C
Identifying the cells with an increase in Max Temperature (over 20°C range) and assigning 2% increase for each 0.6°C
From the Building Performance Database (BPD), we assigned the average of Energy Use Intensity (EUI) (British Thermal Unit (BTU) per sqft per year
Building foot print of the cell X state average EUI/sqft/year X Percent increase of energy use reduction as the impact of trees
Calculate value: multiply the amount of energy savings by the average electricity cost in each state
Aggregate values by land cover and land use for EAA


Value of energy savings
$ per housing unit
00.00 - 3.46
3.46 - 8.27
8.28 - 13.82
13.83 - 21.83
21.84 - 33.61
33.62 - 53.73
53.74 - 90.00
UNITED STATES
MÉXICO
GREAT PLAINS
ROCKY MOUNTAINS
Vancouver
Calgary
Regina
Winnipeg
Seattle
Portland
Minneapolis
Milwaukee
Chicago
Toronto
Ottawa
Montreal
Quebec
Halifax
Buffalo
Pittsburgh
Philadelphia
Boston
Providence
New York
Detroit
Cleveland
Columbus
Cincinnati
Kansas City
St Louis
Denver
Las Vegas
Los Angeles
San Diego
Tijuana
Phoenix
Tucson
El Paso
Albuquerque
Oklahoma
Dallas
Houston
San Antonio
Memphis
Nashville
Knoxville
Louisville
Atlanta
New Orleans
Jacksonville
Orlando
Tampa
Miami
Norfolk
Richmond
Hermosillo
Chihuahua
Culiacan
Torreón
Monterrey
San Luis Potosí
Guadalajara
Merida
Havana
Gulf of Mexico
Lake Superior
Lake Michigan
Lake Huron
Lake Erie
Lake Ontario
Lake Winnipeg
Lake Nipigon
Cedar Lake
Gulf of St Lawrence

Saved in 2011:

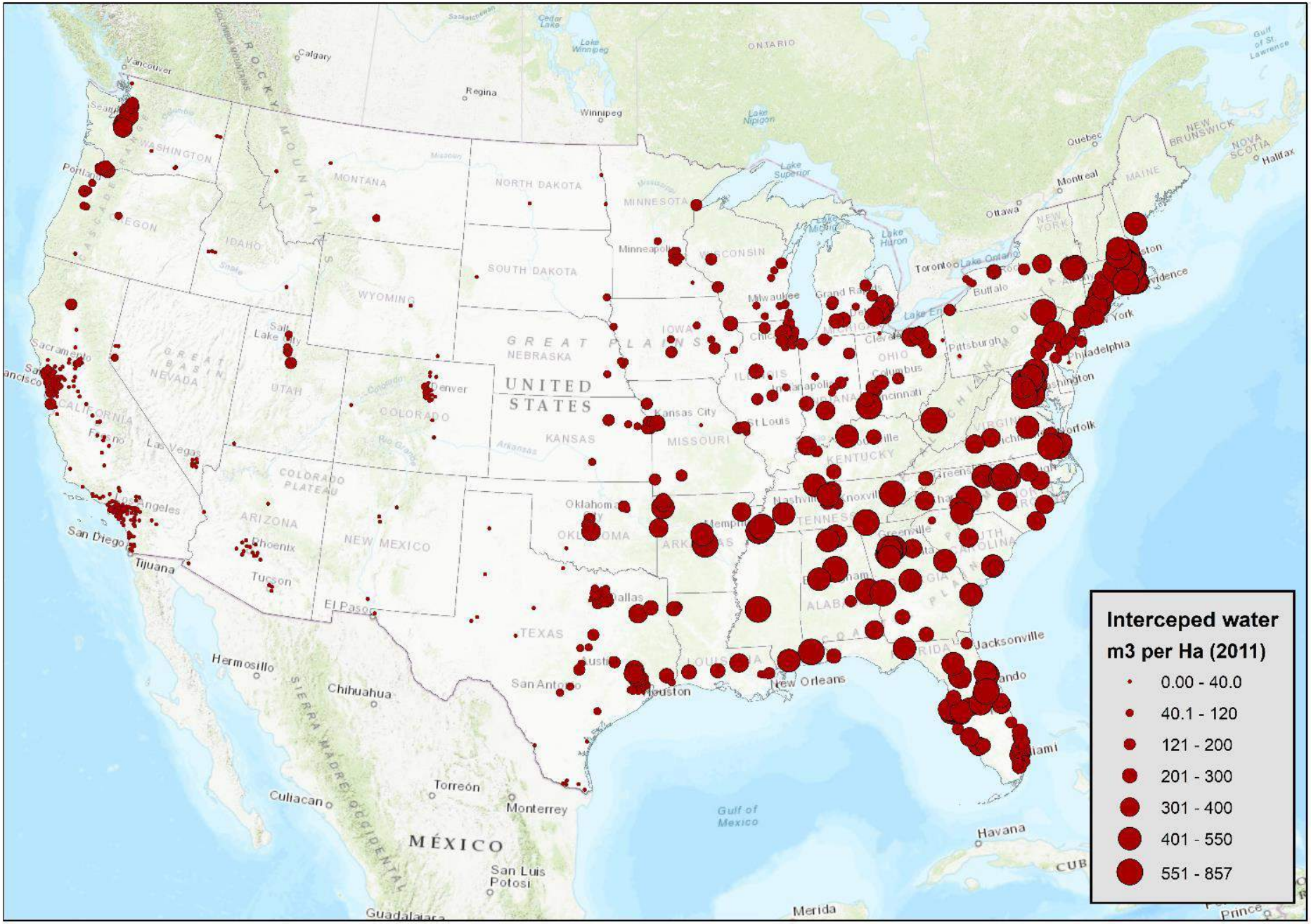
3,856 GWh

$452 million



Intercepted water in 2011:

1,873 million m3


Interceped water m3 per Ha (2011)
0.00 - 40.0
40.1 - 120
121 - 200
201 - 300
301 - 400
401 - 550
551 - 857
UNITED STATES
MÉXICO
Gulf of Mexico
Vancouver
Calgary
Regina
Winnipeg
Seattle
Portland
Sacramento
San Francisco
Los Angeles
San Diego
Tijuana
Las Vegas
Phoenix
Tucson
El Paso
Albuquerque
Denver
Salt Lake City
Boise
Kansas City
St Louis
Minneapolis
Milwaukee
Chicago
Detroit
Toronto
Buffalo
Pittsburgh
Cleveland
Columbus
Cincinnati
Indianapolis
Nashville
Memphis
Oklahoma City
Dallas
Houston
San Antonio
New Orleans
Jacksonville
Miami
Atlanta
Charlotte
Norfolk
Philadelphia
New York
Boston
Providence
Montreal
Ottawa
Quebec
Halifax
Hermosillo
Chihuahua
Culiacan
Torreón
Monterrey
San Luis Potosi
Guadalajara
Merida
Havana
Lake Superior
Lake Michigan
Lake Huron
Lake Erie
Lake Ontario
Lake Winnipeg
Lake Nipigon
Cedar Lake
Gulf of St Lawrence
ROCKY MOUNTAINS
SIERRA MADRE OCCIDENTAL
GREAT PLAINS
GREAT BASIN
COLORADO PLATEAU
WASHINGTON
OREGON
CALIFORNIA
NEVADA
IDAHO
MONTANA
WYOMING
UTAH
COLORADO
ARIZONA
NEW MEXICO
NORTH DAKOTA
SOUTH DAKOTA
NEBRASKA
KANSAS
OKLAHOMA
TEXAS
MINNESOTA
IOWA
MISSOURI
ARKANSAS
LOUISIANA
WISCONSIN
ILLINOIS
MICHIGAN
INDIANA
OHIO
KENTUCKY
TENNESSEE
MISSISSIPPI
ALABAMA
GEORGIA
FLORIDA
SOUTH CAROLINA
NORTH CAROLINA
VIRGINIA
WEST VIRGINIA
PENNSYLVANIA
NEW YORK
MAINE
VERMONT
NEW HAMPSHIRE
MASSACHUSETTS
CONNECTICUT
RHODE ISLAND
NEW JERSEY
DELAWARE
MARYLAND
ONTARIO
NEW BRUNSWICK
NOVA SCOTIA
CUB

			Rainfall Intercept Outputs		Heat Mitigation Outputs		
rank	Population	Area of the city	Intercepted water 2011 (1000 m^3)	Intercepted water per Acre 2011 (m^3/Acre)	Energy savings mWh 2011	kWh Per Housing Unit 2011	Total Energy Cost 2011 (milion $)
1st	New York, NY	Jacksonville, FL	Suffolk, VA	Taunton, MA	Charlotte, NC	Reno, NV	Charlotte, NC
2nd	Los Angeles, CA	Houston, TX	Chesapeake, VA	Suffolk, VA	Reno, VA	Carson City, NV	Los Angeles, CA
3rd	Chicago, IL	Oklahoma City, OK	Nashville, TN	Sandy Springs, GA	Memphis, TN	Chapel Hill, NC	Reno, NV
4th	Houston, TX	Phoenix, AZ	Memphis, TN	Haverhill, MA	Los Angeles, CA	Bend, OR	Memphis, TN
5th	Philadelphia, PA	Nashville, TN	Louisville, KY	Little Rock, AR	Raleigh, NC	Bellevue, WA	Raleigh, NC
6th	Phoenix, AZ	Los Angeles, CA	Jacksonville, FL	Chattanooga, TN	Nashville, TN	Cary, NC	Houston, TX
7th	San Antonio, TX	San Antonio, TX	Charlotte, NC	Chesapeake, VA	Houston, TX	Marietta, GA	Nashville, TN
8th	San Diego, CA	Suffolk, VA	Columbus, GA	Charleston, WV	Denver, CO	Sparks, NV	Denver, CO
9th	Dallas, TX	Dallas, TX	Augusta-Richmond, GA	Durham, NC	Austin, TX	Jackson, MS	Austin, TX
10th	San Jose, CA	Buckeye, AZ	Huntsville, AL	Brookline, MA	Dallas, TX	Greenville, SC	Dallas, TX

Supply Table

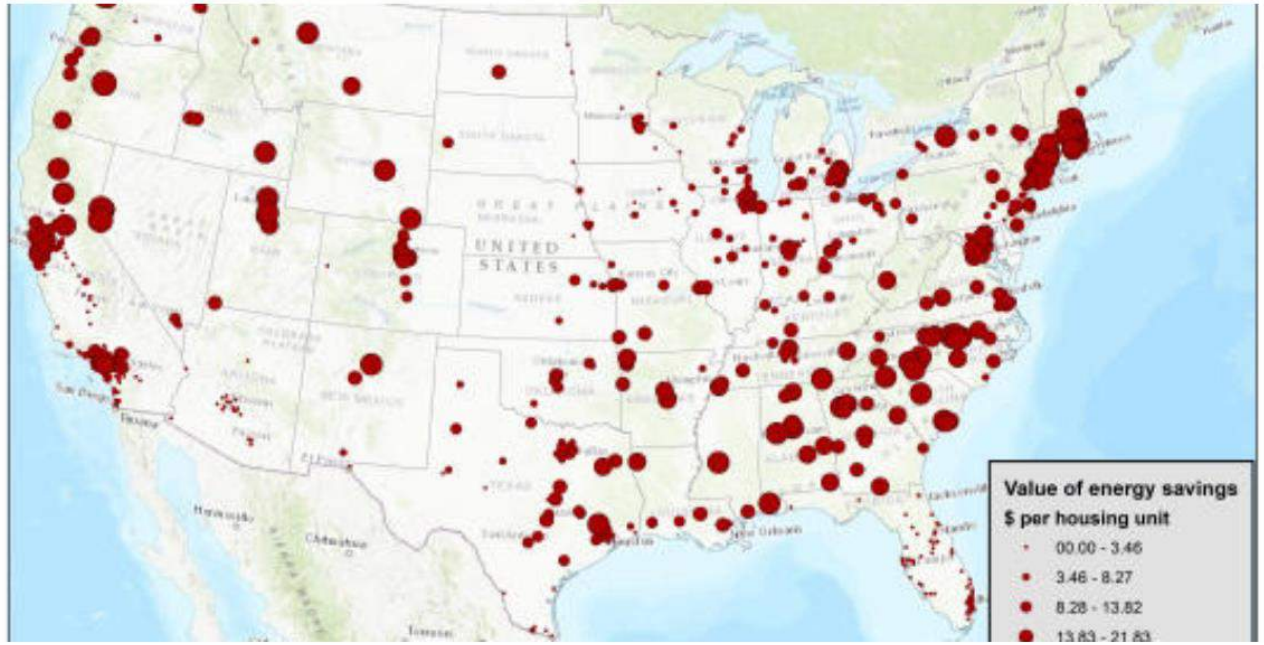
Ecosystem Accounting Area	Service Type	year	Ecosystem types (Land cover)															
			Open Water	Developed - Open	Developed - Low	Developed - Medium	Developed - High	Barren	Deciduous Forest	Evergreen Forest	Mixed Forest	Scrub/Shrub	Grassland/Herbaceous	Pasture/Hay	Cultivated Crops	Woody Wetlands	Emergent Herbaceous Wetlands	Total
All U.S. cities (population>=50,000)	Intercepted water by urban trees (1000m3)	2001	7,647.7	320,911.4	209,883.4	54,797.1	3,327.4	1,199.0	422,914.2	260,253.1	69,532.0	37,858.4	22,132.8	18,067.9	10,728.6	300,915.5	15,339.8	1,755,508.2
		2011	5.5	404,770.9	266,974.4	70,641.5	7,073.8	1,872.6	433,311.9	184,358.4	59,537.3	49,801.8	35,074.9	25,727.2	14,510.1	303,279.8	16,909.7	1,873,849.7
	Energy Savings by urban trees mWh	2001	0.0	686,907.8	1,195,035.5	436,080.9	39,102.9	716.8	193,749.1	134,299.6	36,265.7	25,264.6	14,026.5	12,641.4	16,846.8	32,990.7	1,291.7	2,825,220.1
		2011		967,225.9	1,799,185.3	733,586.3	87,435.7	622.4	117,722.0	70,589.8	19,465.6	20,085.0	14,030.8	8,470.0	2,902.2	13,480.5	1,210.8	3,856,012.2
Colorado	Intercepted water by urban trees (1000m3)	2001	12.3	626.6	1,684.2	258.3	6.7	0.1	134.8	579.8	0.4	184.0	36.1	6.3	12.2	216.9	16.7	3,775.3
		2011	0.0	770.6	2,317.4	665.4	59.2	1.1	131.7	522.5	0.6	350.7	80.2	11.7	22.0	235.6	23.1	5,191.8
	Energy Savings by urban trees mWh	2001		11,578.5	51,036.4	8,749.4	315.5	0.3	442.0	571.3	0.9	532.6	140.0	24.4	83.5	814.1	65.2	74,354.1
		2011		16,970.1	93,034.7	30,284.4	3,441.3	6.4	486.9	628.3	5.0	876.0	216.9	30.0	32.5	720.0	62.6	146,795.0
Denver	Intercepted water by urban trees (1000m3)	2001	2.5	151.7	410.8	53.0	1.9	0.0	0.7	0.5	0.0	0.6	1.8	0.2	1.0	23.7	1.0	649.4
		2011	0.0	174.0	515.8	142.8	19.6	0.1	0.8	0.4	0.1	0.7	3.0	0.1	4.8	23.8	0.8	886.8
	Energy Savings by urban trees mWh	2001	0.0	4,206.0	16,498.0	2,267.8	109.2	0.0	16.4	0.3	0.8	6.2	5.2	0.0	2.3	49.1	2.0	23,163.4
		2011	0.0	6,974.7	30,416.9	8,983.4	1,445.6	0.0	22.6	0.5	4.5	2.9	15.8	0.0	1.2	65.7	3.1	47,936.7
Sensitivity analysis on Denver	Intercepted water by urban trees (1000m3)	2011	32.1	3,156.6	10,063.7	3,172.1	432.4	2.0	7.0	3.8	0.7	3.9	36.9	2.9	37.1	222.5	4.8	17,178.4
	Energy Savings by urban trees mWh	2011	0.0	6,585.6	38,124.8	12,476.1	1,880.9	0.4	14.4	0.3	2.0	3.8	5.7	0.0	3.1	40.9	1.6	59,139.7

Use Table

Ecosystem Accounting Area	Service Type	Year	Economic units											
			NAICS 11 Livestock	Wastewater treatment 221320	NAICS 31-33 Manufacturing	NAICS 44-45 Retail	NAICS 48-49 Transport warehousing	NAICS 51-56 Offices	NAICS 61 Educational services	NAICS 62 Health care & social assistance	NAICS 71 Entertainment	NAICS 92 Government	Households (No NAICS Code)	No NAICS equivalent	Total
All U.S. cities (population>=50,000)	Intercepted water by urban trees (1000m3)	2001	0.0	1,755,508.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1,755,508.2
		2011	0.0	1,873,849.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1,873,849.7
	Energy Savings by urban trees MegaWh	2001	325.6	0.0	16,047.8	28,927.2	10,951.7	28,933.7	26,132.7	9,097.3	840.5	8,615.9	2,624,267.5	71,080.1	2,825,220.1
		2011	302.3	0.0	17,722.2	25,660.4	13,799.7	31,539.6	33,475.0	9,472.4	1,421.8	6,816.4	3,639,349.7	76,452.6	3,856,012.2
Colorado	Intercepted water by urban trees (1000m3)	2001	0.0	3,775.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3,775.3
		2011	0.0	5,191.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5,191.8
	Energy Savings by urban trees MegaWh	2001	0.5	0.0	76.5	248.1	98.4	311.0	561.1	166.3	11.8	177.5	71,386.3	1,316.6	74,354.1
		2011	2.7	0.0	411.0	1,218.9	330.1	1,428.8	1,621.2	513.6	77.4	611.2	137,884.7	2,695.4	146,795.0
Denver	Intercepted water by urban trees (1000m3)	2001	0.0	649.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	649.4
		2011	0.0	886.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	886.8
	Energy Savings by urban trees MegaWh	2001	0.0	0.0	15.9	38.6	34.3	76.8	297.2	64.7	9.9	114.2	22,199.4	312.5	23,163.4
		2011	0.8	0.0	167.1	340.1	169.4	465.5	772.3	198.1	70.5	408.2	44,609.0	735.9	47,936.7
Sensitivity analysis on Denver	Intercepted water by urban trees (1000m3)	2011	0.0	17,178.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	17,178.4
	Energy Savings by urban trees MegaWh	2011	2.1	0.0	257.0	305.3	280.3	742.2	951.5	20.7	37.6	520.7	56,004.4	17.2	59,139.7

Geosciences and Environmental Change Science Center

Accounting for natural capital: building the numbers to track and sustain the nation's natural resources



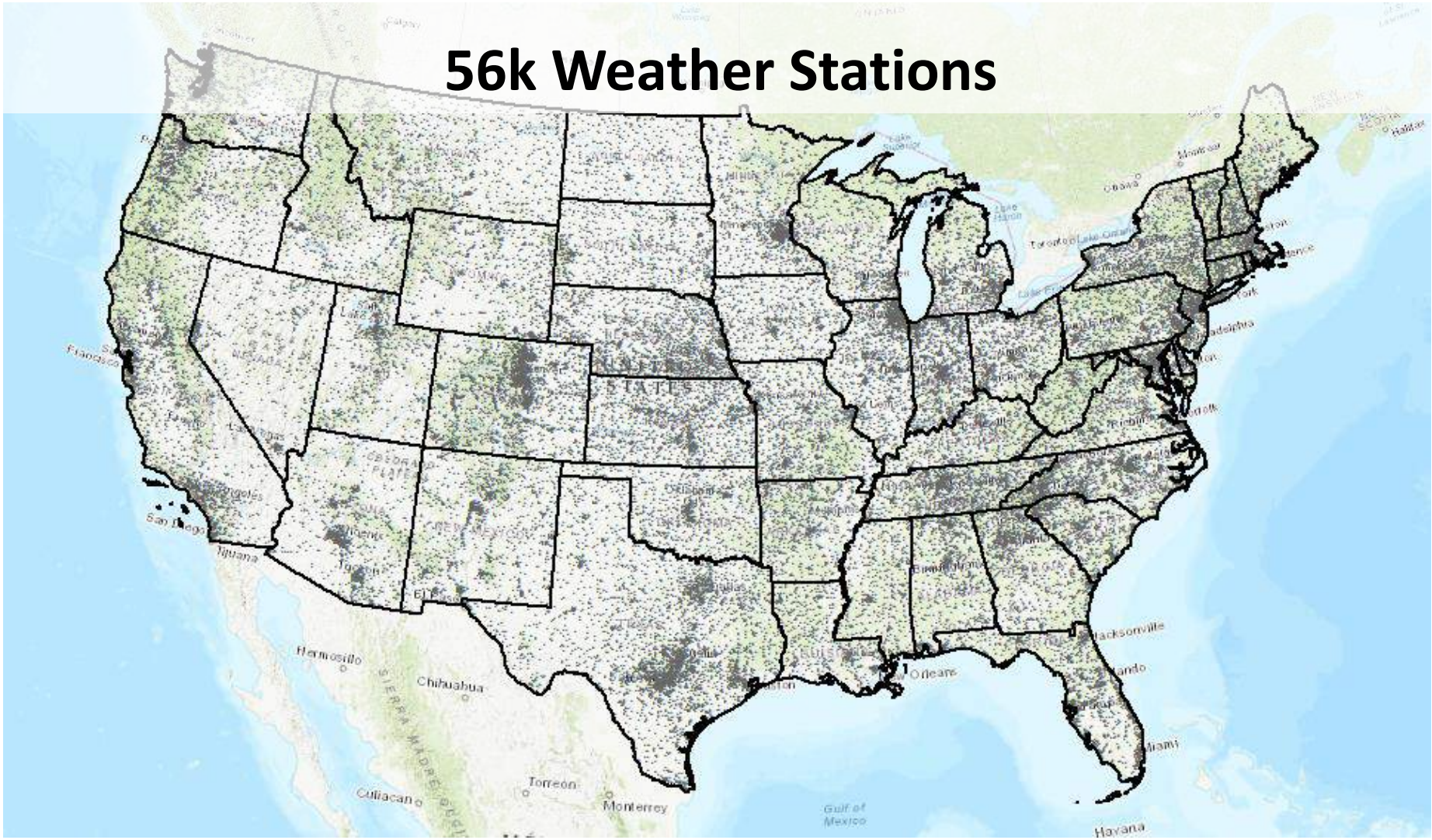
Overview | Publications

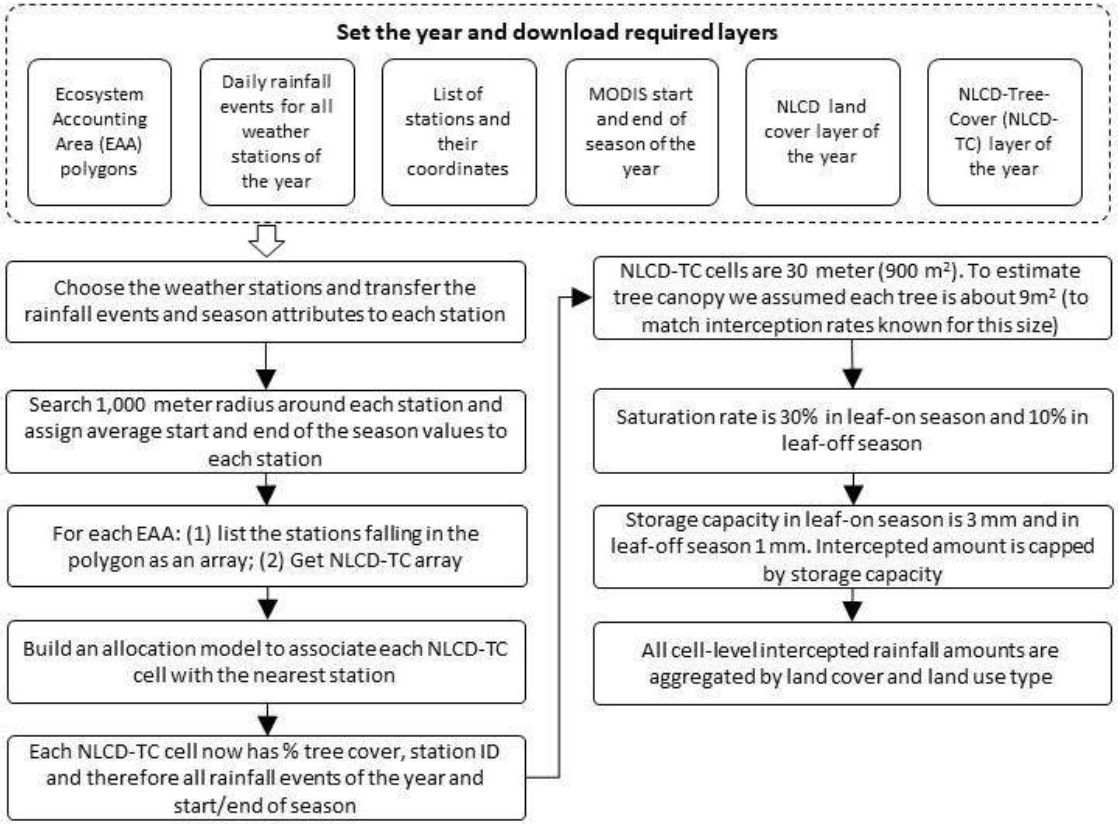
Accounting for ecosystem services - the benefits that nature provides to society and the economy - is gaining increasing traction worldwide as governments and the private sector use them to monitor integrated environmental and economic trends. When they are well understood and managed

Status - Active

Rainfall Interception

56k Weather Stations




Set the year and download required layers
Ecosystem Accounting Area (EAA) polygons
Daily rainfall events for all weather stations of the year
List of stations and their coordinates
MODIS start and end of season of the year
NLCD land cover layer of the year
NLCD-Tree-Cover (NLCD-TC) layer of the year
Choose the weather stations and transfer the rainfall events and season attributes to each station
Search 1,000 meter radius around each station and assign average start and end of the season values to each station
For each EAA: (1) list the stations falling in the polygon as an array; (2) Get NLCD-TC array
Build an allocation model to associate each NLCD-TC cell with the nearest station
Each NLCD-TC cell now has % tree cover, station ID and therefore all rainfall events of the year and start/end of season
NLCD-TC cells are 30 meter (900 m²). To estimate tree canopy we assumed each tree is about 9m² (to match interception rates known for this size)
Saturation rate is 30% in leaf-on season and 10% in leaf-off season
Storage capacity in leaf-on season is 3 mm and in leaf-off season 1 mm. Intercepted amount is capped by storage capacity
All cell-level intercepted rainfall amounts are aggregated by land cover and land use type