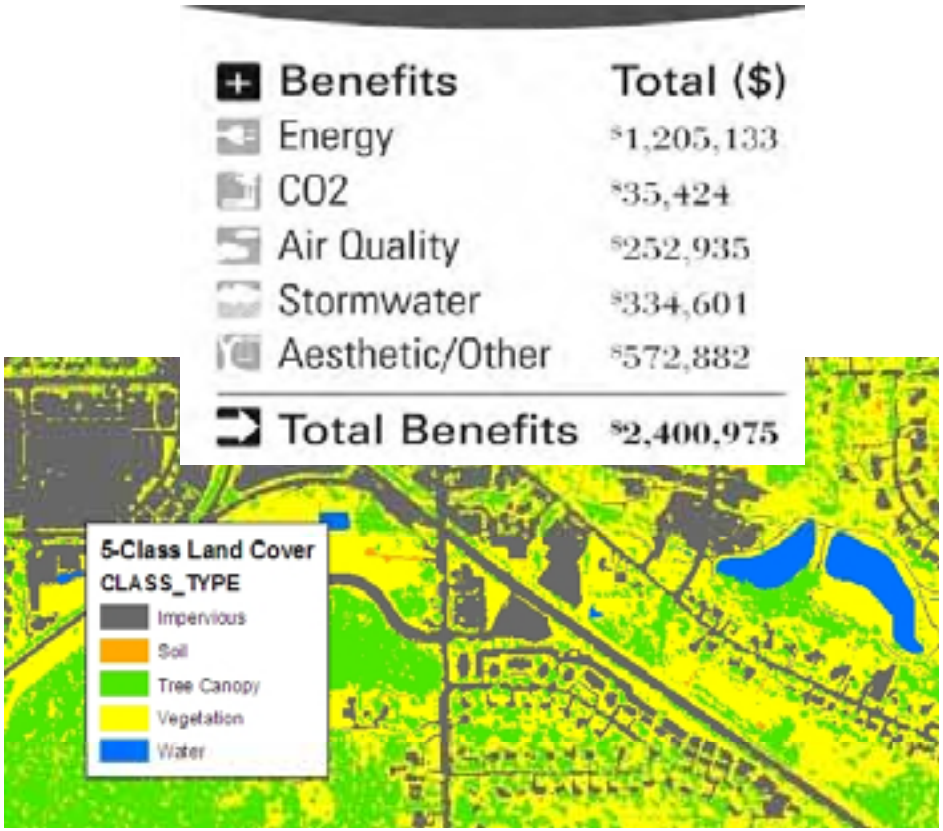
ESRI Health GIS Conference, Denver, Colorado

October 19, 2010

"Establishing Links between Urban Forestry, Geospatial Technologies, and Public Health"



Credits:

US Forest Service, Davey Resource Group,
Texas Trees Foundation

AMEC Earth & Environmental, Inc – www.amec.com

Agenda

- Overview of the social, environmental, and economic benefits of urban trees
- Modeling ecosystem services: CITYgreen and U.S. Forest Service i-Tree software
- Geospatial technologies to plan for, measure and monitor
- Linkages and current research or data gaps

Urban Forestry Across the Country

Federal or National Level:

- ❑ State & Private Forestry
- ❑ Urban & Community Forestry
- ❑ Regional USFS Offices
- ❑ National Associations (SMA, ISA)

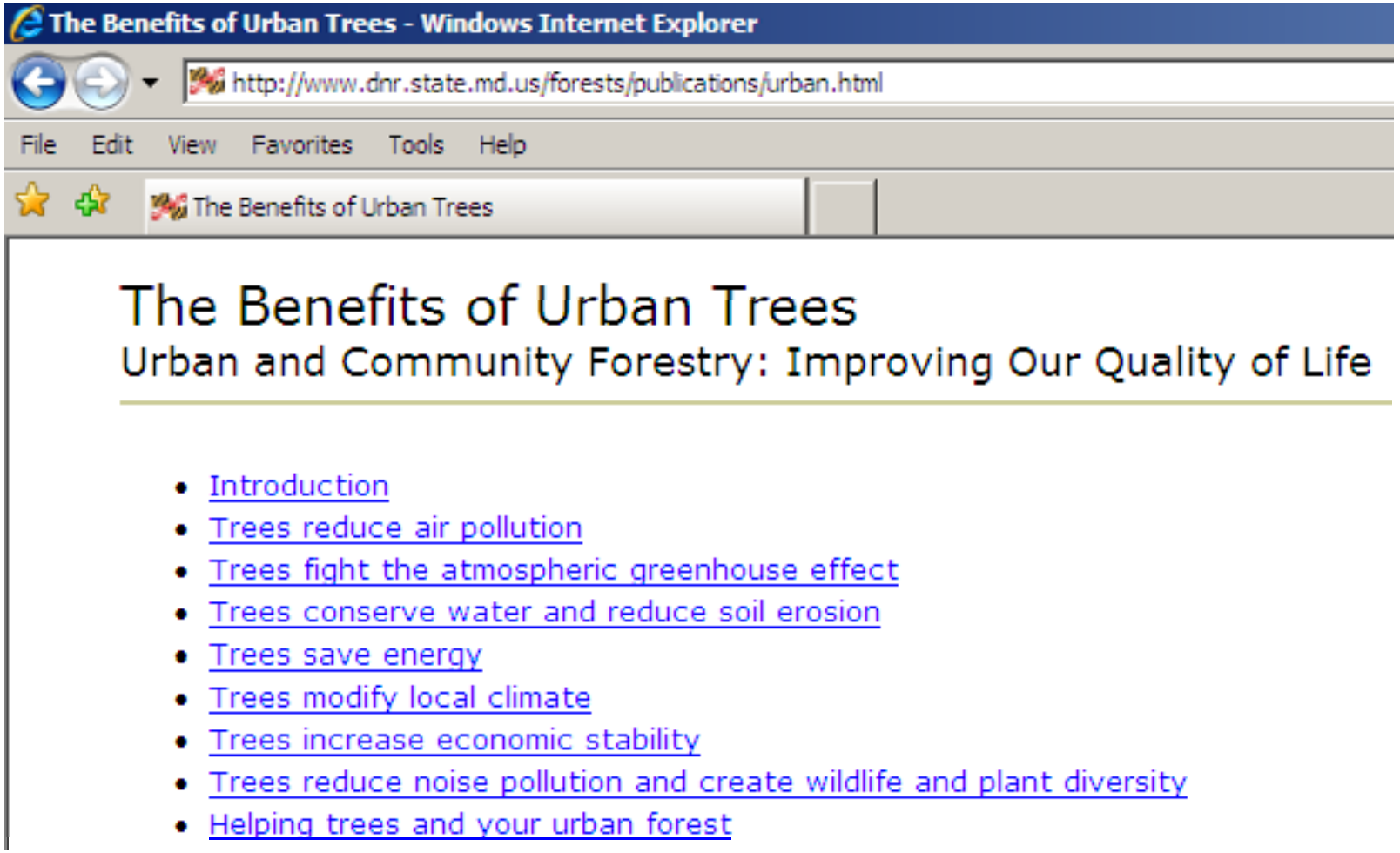
State Level:

- ❑ Urban Forest Councils
- ❑ DNR State Coordinators
- ❑ Extension and State Associations

Local Level:

- ❑ Non-profits
- ❑ Tree Planting Initiatives
- ❑ Economic Development
- ❑ University/Academic
- ❑ Industry
- ❑ The Public (the Community!)

Benefits of Urban Forestry



Benefits of Urban Forestry

Economic – Environmental – Social

USFS "Value of Trees Summary – Statistics Sheet"

- "Trees reduce runoff and erosion from storms by about 7% and reduce the need for erosion control structures, saving cities money on materials, installation and maintenance." - MD Dept of Natural Resources
- "Shade from two large trees on the west side of a house and one on the east side can save up to 30% of a typical residence's annual air conditioning costs." - Center for Urban Forest Research (CUFR)
- Trees in Davis, CA parking lots reduced asphalt temperatures by as much as 36F, and car interior temperatures by 47F." - CUFR
- "An increase of 10% canopy in the NYC Area were shown to reduce peak ozone levels by up to 4 parts per billion (nearly 3% of the max and 37% of the amount by its air quality standard)." - USFS, Northern Research Station

Benefits of Urban Forestry

"Trees help improve air quality by reducing air temperature, removing air pollutants and providing shade that lowers energy use in buildings, thus reducing air-polluting emissions from power plants."

"Planting trees near roadways has the potential to reduce particles at the nano level. Canopy has the potential to protect those living near roads. 36 million Americans live within 300 feet of a four-lane highway, railroad or airport."
Max Zhang, Assistant Professor, Cornell

Urban Forest
Ecosystem Services Modeling

Urban Forest Dollar Value

Community Tree Guide

USDA

Benefits, Costs, and Strategic Planting

Benefits

- Saving Energy
- Reducing Atmospheric Carbon Dioxide
- Improving Air Quality
- Reducing Stormwater Runoff and Improving Hydrology
- Aesthetics and Other Benefits

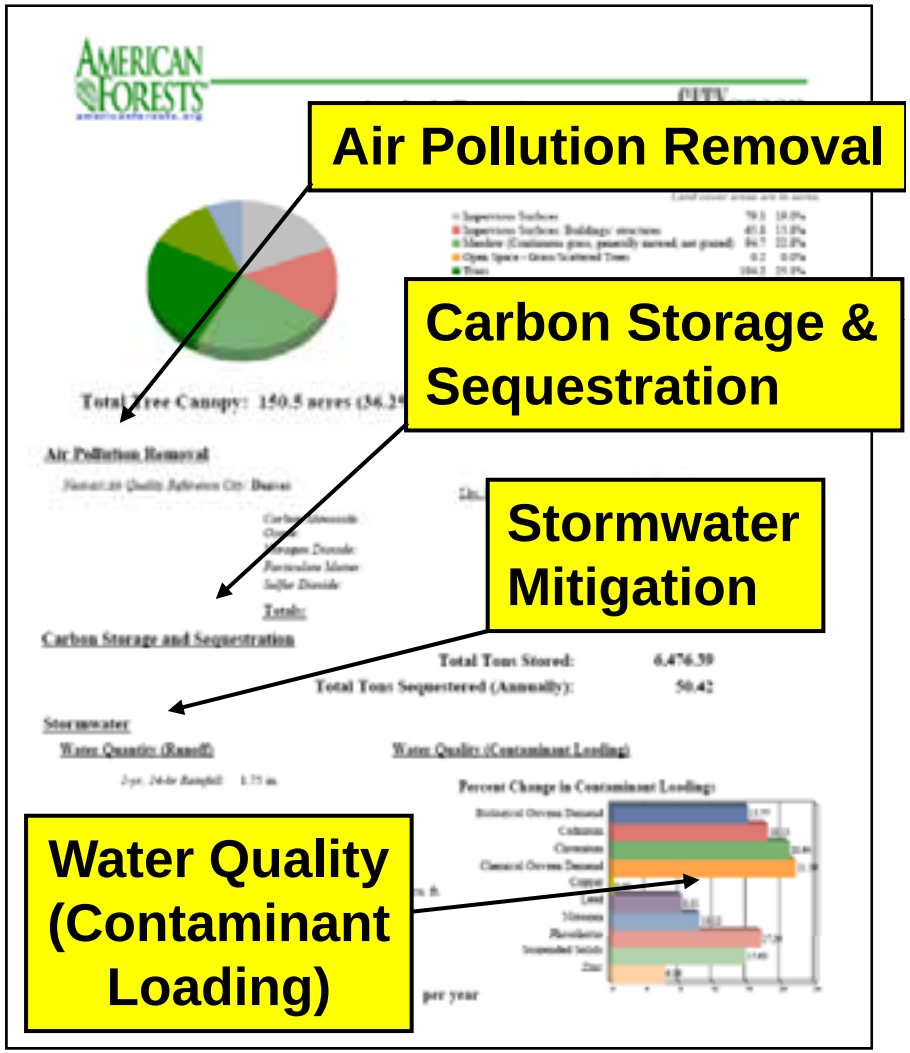
Costs

- Planting and Maintaining Trees
- Conflicts with Urban Infrastructure
- Wood Salvage, Recycling, and Disposal

Table 1. Estimated annual benefits and costs for a yard tree opposite a west-facing wall 20 years after planting

	Flowering dogwood Small tree 20 ft tall 20 ft spread Leaf surface area=613 ft²			Southern magnolia Medium tree 32 ft tall 24 ft spread Leaf surface area=1,031 ft²			Red maple Large tree 47 ft tall 32 ft spread Leaf surface area=1,912 ft²			Loblolly pine Conifer tree 53 ft tall 27 ft spread Leaf surface area=1,318 ft²		
Benefit category	**Units**		**Total $**	**Units**		**Total $**	**Units**		**Total $**	**Units**		**Total $**
Electricity savings ($0.0739/kWh)	129	kWh	$9.76	143	kWh	$10.85	228	kWh	$16.99	193.4	kWh	$14.53
Natural gas savings ($0.0105/kBtu)	206	kBtu	$2.48	121	kBtu	$1.28	363	kBtu	$3.80	192.4	kBtu	$2.01
Carbon dioxide ($0.0075/lb)	206	lb	$1.77	167	lb	$1.25	371	lb	$2.78	286.3	lb	$2.15
Ozone ($6.55/lb)	0.13	lb	$0.83	0.24	lb	$1.55	0.16	lb	$1.04	0.28	lb	$1.86
NO_x ($6.55/lb)	0.22	lb	$1.47	0.25	lb	$1.65	0.28	lb	$2.46	0.35	lb	$2.27
SO_x ($1.91/lb)	0.44	lb	$0.84	0.49	lb	$0.94	0.77	lb	$1.47	0.70	lb	$1.33
PM_{10} ($2.31/lb)	0.16	lb	$0.38	0.30	lb	$0.70	0.23	lb	$0.53	0.29	lb	$0.66
VOCs ($0.23/lb)	0.09	lb	$0.23	0.09	lb	$0.23	0.08	lb	$0.40	0.05	lb	$0.24
BVOCs ($6.23/lb)	0.00	lb	$0.00	-0.67	lb	-$4.15	-0.23	lb	-$1.43	-1.52	lb	-$9.49
Rainfall interception ($0.0099/gal)	1,098	gal	$10.87	1,656	gal	$16.39	3,067	gal	$30.36	2,078	gal	$20.53
Environmental subtotal			**$28.61**			**$36.68**			**$68.63**			**$36.69**
Other benefits			$6.98			$13.51			$18.75			$20.17
Total benefits			**$35.59**			**$44.18**			**$87.38**			**$56.66**
Total costs (see Table 3)			$5.81			$5.38			$7.43			$3.42
Net benefits			**$29.68**			**$38.81**			**$80.74**			**$53.24**

CITYgreen Software



AMEC Earth & Environmental, Inc – www.amec.com

A Suite of Tools for Urban Forest Inventory & Assessment

The National Arbor Day Foundation

DAVEY RESOURCE GROUP

i-Tree is…

Development, Dissemination, Support, & Refinement

- Credible, USDA FS peer-reviewed tools
- Public Domain Software
- Accessible
- Technical Support

"Putting USFS Urban Forest science into the hands of users"

Source: Scott Maco, Davey Institute

Components

Benefit Analysis Tools

Street Tree Populations

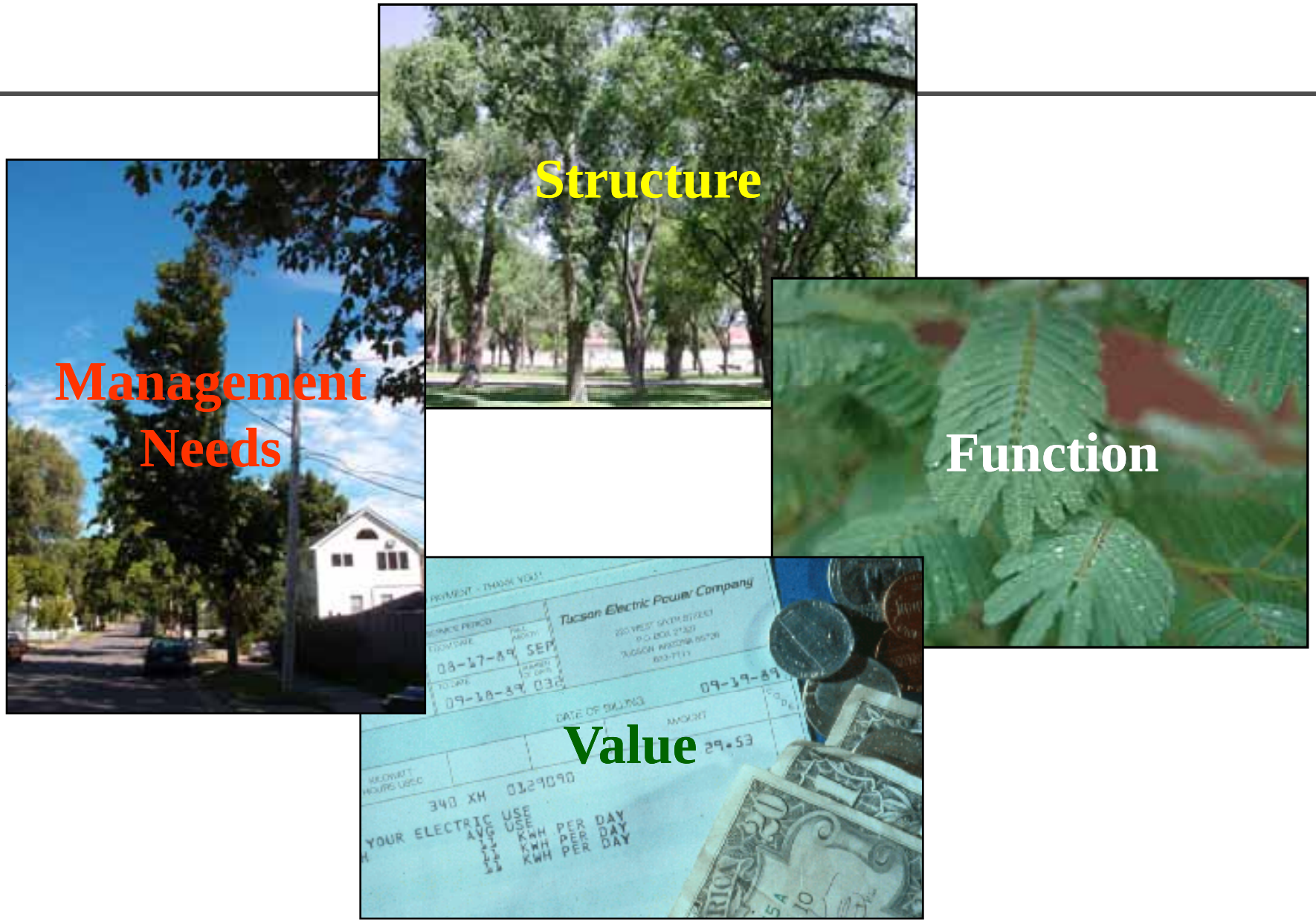
- Streets

Urban Ecosystems

- Eco

Utilities

- MCTI (inventory)
- Storm Damage Assessment Protocol
- Sample generator


Structure
Management
Needs
Function
Value
Tucson Electric Power Company
08-17-89 SEP
09-18-89 032
09-19-89
39.53
340 XH 0129090
YOUR ELECTRIC USE
AVG USE
KWH PER DAY
KWH PER DAY
KWH PER DAY

Source: Scott Maco, Davey Institute

Sacramento Example

Annual Environmental Benefits of Sacramento's Urban Forest[27]

	Annual Benefit	Total Value	Average Annual Benefit /Tree
Air Conditioning Saved	157 GWh	$18.5 million	$3.08
Air Pollutant Uptake	1,603 Tons	$28.7 million	$4.78
Carbon Dioxide Reduction	334,400 Tons	$3.3 million	$0.55
Total Benefits		$50.5 million	$8.41

Trees Pay Us Back

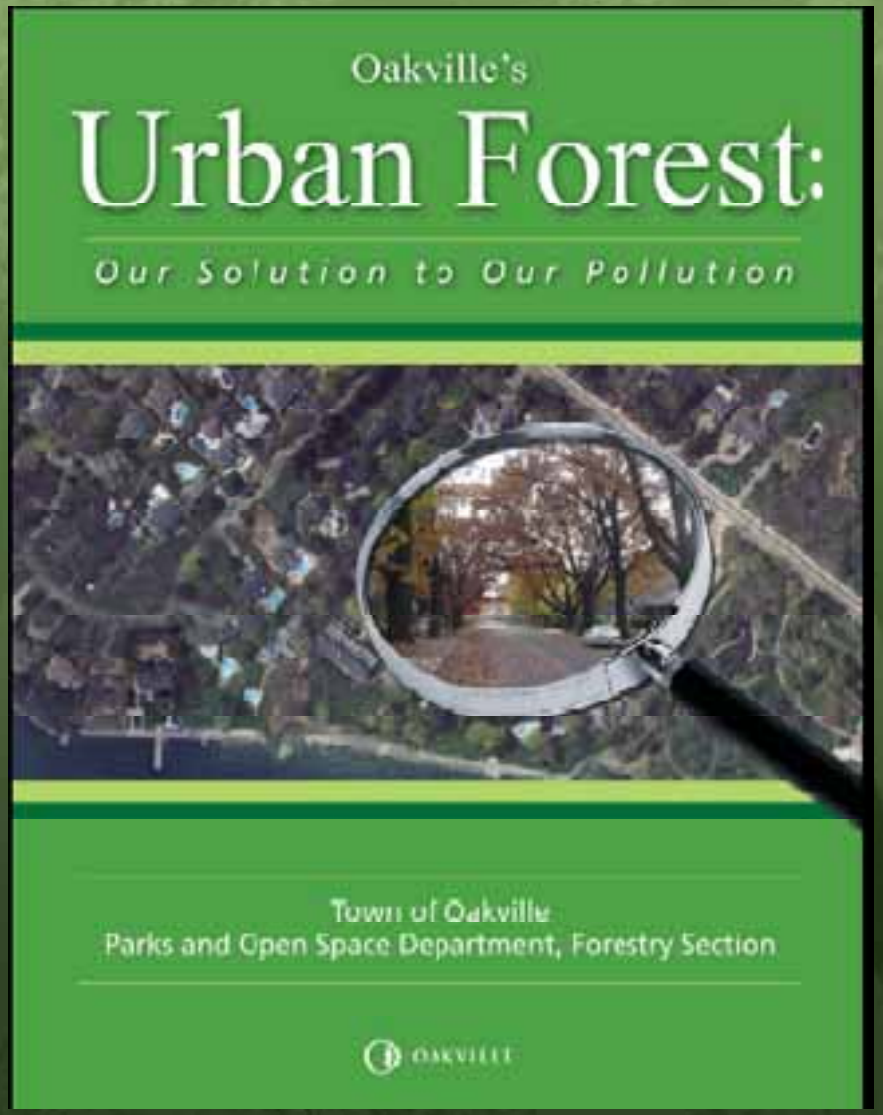
100 Trees Over 40 Years...

Benefits = $379,000

- Energy
- Air Quality
- Runoff
- Real Estate

Costs = $148,000

- Planting - Pruning
- Removal/Disposal
- Irrigation
- Sidewalk Repair
- Litter
- Legal - Admin



Pay Off: $231,000

Table 2. Estimated percent air quality improvement in selected US cities due to air pollution removal by urban trees

City	%tree cover	% air quality improvement				
		CO	NO_2	O_3	PM_{10}	SO_2
Atlanta, GA	32.9	0.002 (0.001–0.009)	0.5 (0.1–2.5)	0.7 (0.1–4.4)	0.7 (0.3–2.8)	0.7 (0.1–4.3)
Boston, MA	21.2	0.002 (0.000–0.006)	0.4 (0.0–1.8)	0.6 (0.1–3.4)	0.6 (0.1–1.8)	0.5 (0.1–3.4)
Dallas, TX	28.0	0.002 (0.001–0.008)	0.4 (0.1–2.2)	0.6 (0.1–3.9)	0.6 (0.2–2.4)	0.6 (0.1–3.8)
Denver, CO	26.0	0.001 (0.000–0.007)	0.2 (0.0–1.5)	0.3 (0.0–2.1)	0.4 (0.1–2.2)	0.3 (0.0–2.0)
Milwaukee, WI	19.1	0.001 (0.000–0.005)	0.3 (0.0–1.5)	0.4 (0.1–2.7)	0.4 (0.1–1.6)	0.4 (0.0–2.7)
New York, NY	16.6	0.001 (0.000–0.005)	0.3 (0.0–1.4)	0.4 (0.1–2.6)	0.5 (0.1–1.4)	0.4 (0.1–2.6)
Portland, OR	42.0	0.003 (0.001–0.012)	0.6 (0.1–2.7)	0.8 (0.1–3.7)	1.0 (0.3–3.5)	0.7 (0.1–4.0)
San Diego, CA	8.6	0.001 (0.000–0.002)	0.2 (0.0–0.7)	0.3 (0.0–1.4)	0.3 (0.1–0.7)	0.3 (0.0–1.4)
Tampa, FL	9.6	0.001 (0.000–0.003)	0.2 (0.0–0.8)	0.2 (0.0–1.4)	0.2 (0.1–0.8)	0.2 (0.0–1.4)
Tucson, AZ	13.7	0.001 (0.000–0.004)	0.1 (0.0–1.0)	0.1 (0.0–1.7)	0.2 (0.1–1.2)	0.1 (0.0–1.7)
Washington, DC	31.1	0.002 (0.001–0.009)	0.4 (0.2–2.3)	0.6 (0.1–3.9)	0.7 (0.2–2.6)	0.6 (0.1–3.9)

"The combined total effects of trees on air pollutants are significant enough that urban tree management could provide a viable means to improve air quality and help meet clean air standards in the United States."

Dr. Dave Nowak, USFS Northern Research Station

i-Tree Version-3: Hydro

UFORE-Hydro: a GIS-based program that *estimates stream flow and water quality change based on tree cover and impervious surface attributes within a watershed*. It is calibrated against actual stream flow data and designed specifically to estimate effects as a result of changes in vegetation cover.

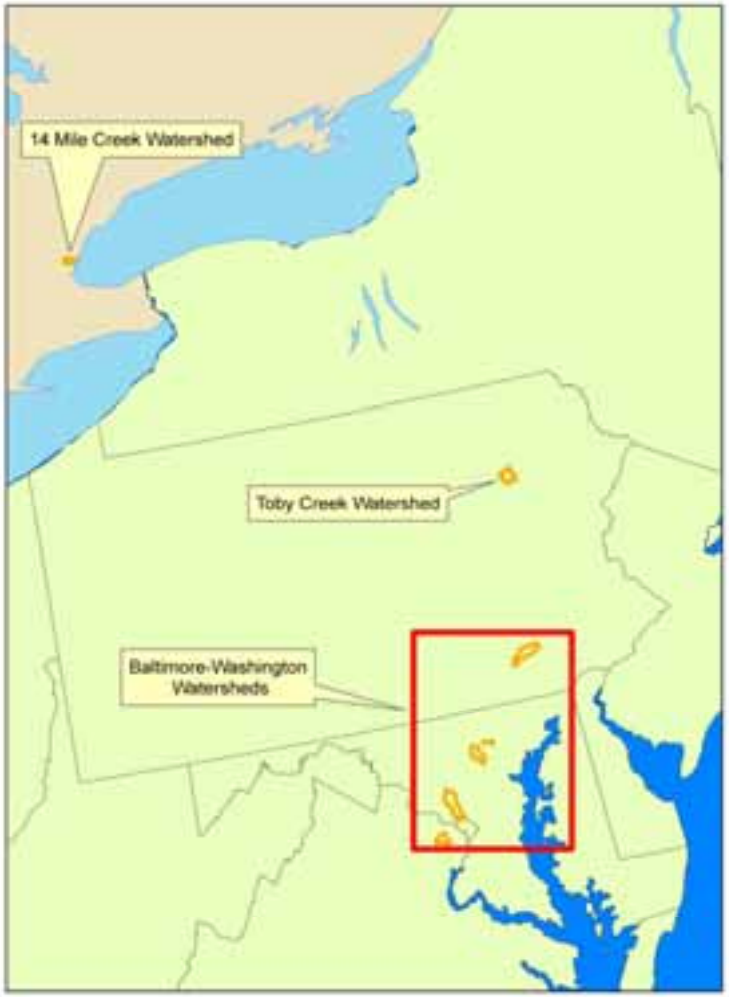
Inputs: weather / precipitation, elevation, land cover, gauging stations data, watershed boundary

Parameters: 9 channel, soil, and vegetation

Resolution: 10-meter & 30-meter so far, but 1-meter is possible with <5sqkm area

Other: no dollar-value associated (resource units only), also testing in Minnesota, Oregon, Colorado, Florida, and Phoenix

Eastern U.S. Beta Testing Sites



i-Tree Version-3: Spatial

Spatial Model Components

City Scale Mapping (i-Tree Vue; *released in version 3.0) – illustrate current ecosystem services across a city and how changes in tree cover will affect these services. The goal of i-Tree is to move this mapping capability to a web server (i-Tree Geo) to allow for more sophisticated analyses and determine the best locations to plant trees, for example to improve water quality or protect the most people in the warmest and most polluted parts of the city. This work is well underway.*

Future effects (i-Tree Future; *in development) – project future tree population totals, tree cover and ecosystem services within land use types*

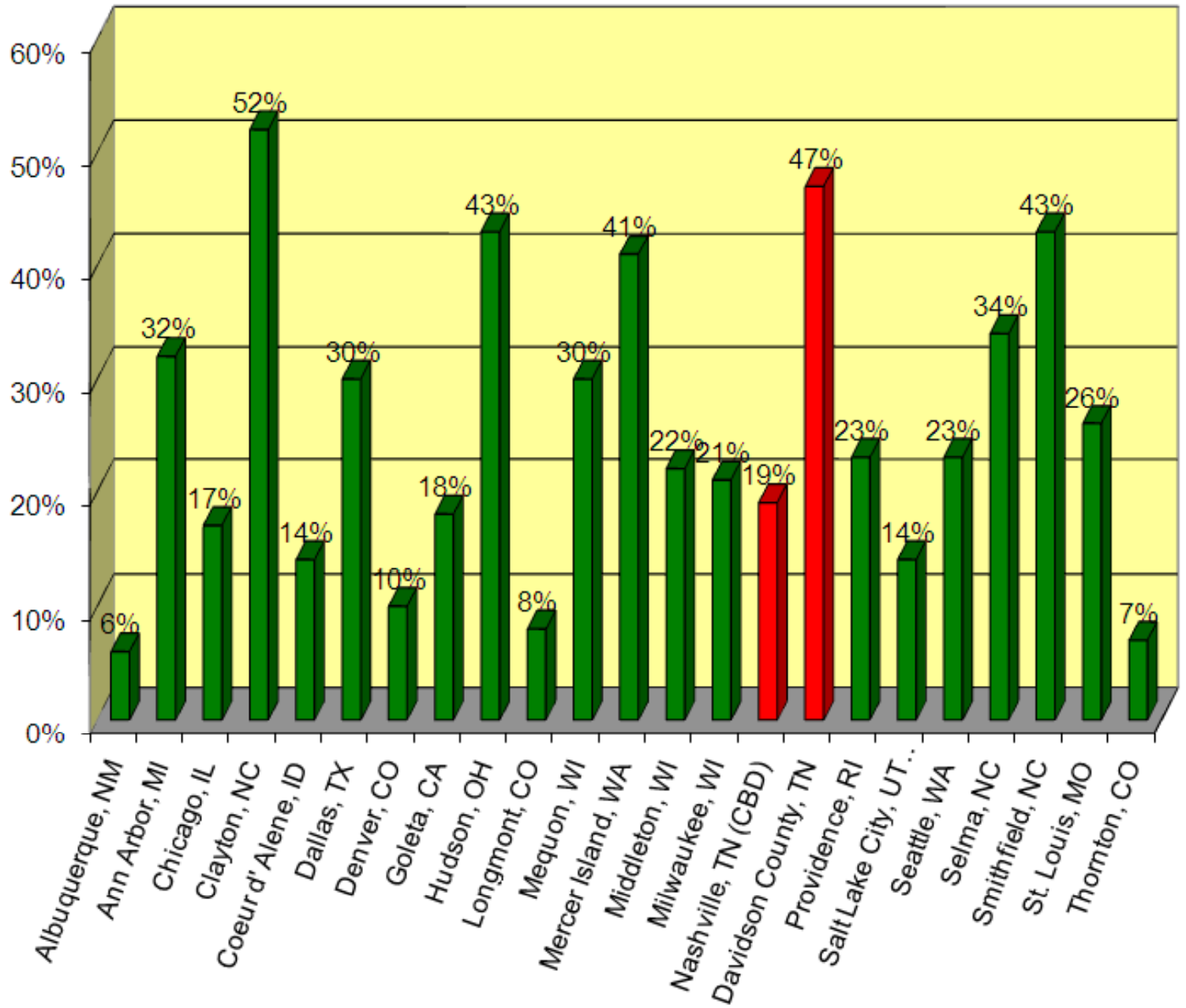
Local Scale Site Design (i-Tree Design; *proposed) – this web-based tool will allow users to draw their local site on maps (e.g., building outlines, existing trees on a residential lot) to: a) map the best locations on the site for optimizing ecosystem services; b) provide suggestions for the best trees for various locations on the site given site constraints; and c) allow users to virtually "move" new trees around the site to illustrate effects on future tree benefits and cover on the site.*

Research Mission: Effects of Urban Forests and their Management on Environmental Quality and Associated Human Health USDA Forest Service, Northern Research Station, Syracuse, NY.

Geospatial Technologies for Measuring and Monitoring Urban Forests

- **Urban Tree Canopy Assessment**
- **GIS Analysis for Planting Prioritization**
- **Geospatial Community Tree Inventory**

Existing Urban Tree Canopy (UTC)



Urban Tree Canopy (UTC)

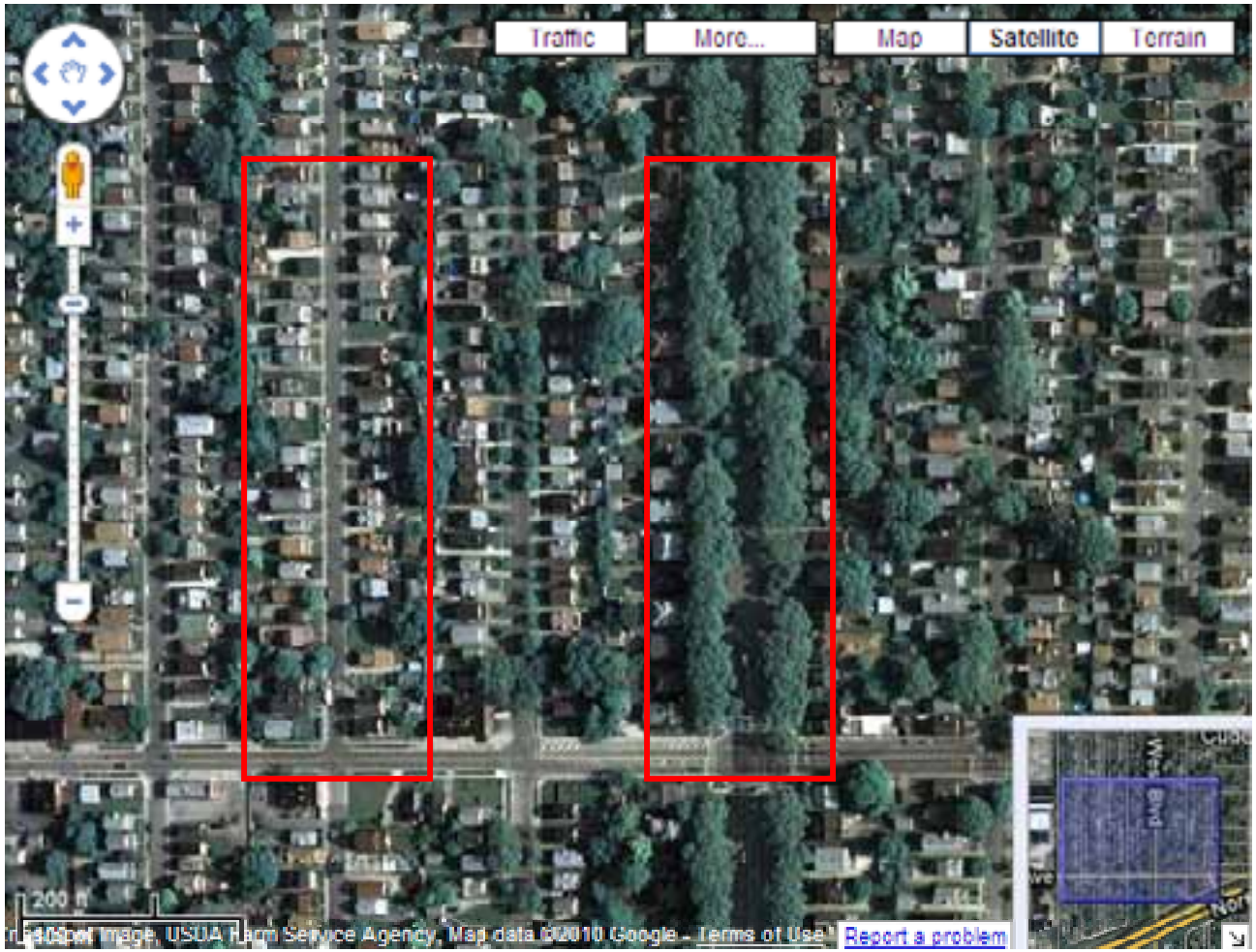
Discontinuity in Urban Tree Canopy (UTC)

Environmental and Social Injustice?

Opportunities can be identified using GIS and Demographic Analysis

Ecosystem services can be assessed

Policy can be improved



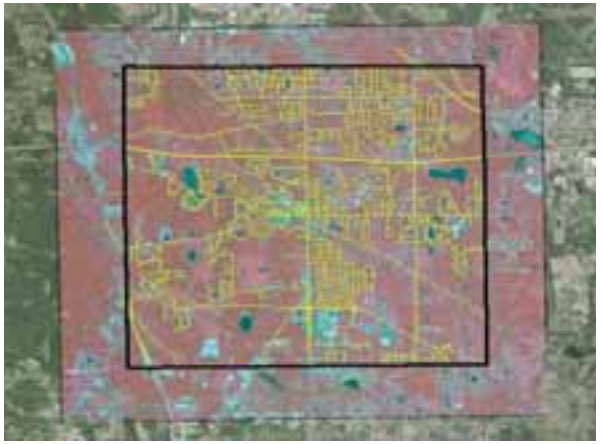
Hudson, OH UTC Assessment

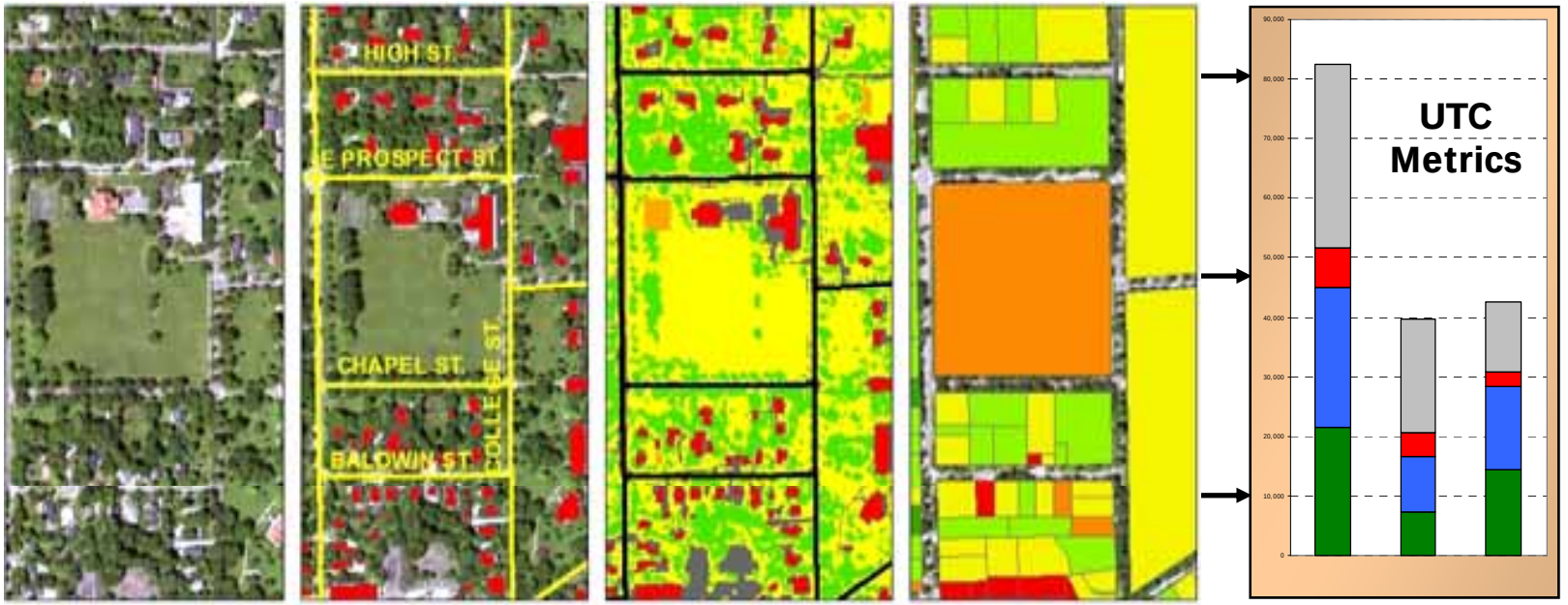
Hudson Current UTC: 41.4% (6,669 acres)

Hudson Possible UTC: 53.3% (8,585 acres)

UTC in Right-of-Way: 31.5% (494 acres)

Hudson Urban Forest Value Calculated Using CITYgreen Software: TBD





5-Class Land Cover Data

Aerial imagery

Tree canopy

5-class land cover

2-ft Color-Infrared Aerial Imagery

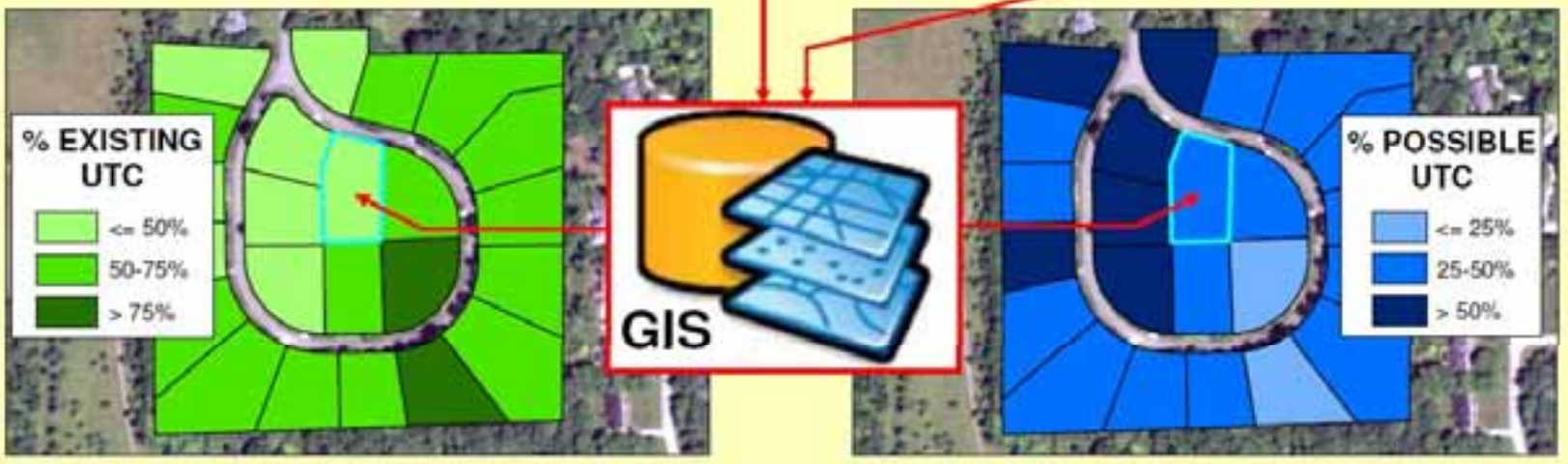
2-ft CIR Imagery and GIS-Based Tree Canopy Layer

Hudson, OH UTC by Individual Parcel Lots

PARCEL DATABASE FIELD KEY

T_POSS_PC — Percent total possible UTC
T_POSS_AC — Acres of total possible UTC
P_IMPRV_PC — Percent possible impervious UTC
P_IMPRV_AC — Acres of possible impervious UTC
P_VEG_PC — Percent possible vegetation UTC
P_VEG_AC — Acres of possible vegetation UTC
E_UTC_PC — Percent existing UTC
E_UTC_AC — Acres of existing UTC
ACRE_NU_PC — Percent not suitable for UTC
ACRE_NU — Acres not suitable for UTC
ACRES — Acres in parcel

PARID	ADDR	ACRES	ACRE_NU	ACRE_NU_PC	E_UTC_AC	E_UTC_PC	P_VEG_AC	P_VEG_PC	P_IMPRV_AC	P_IMPRV_PC	T_POSS_AC	T_POSS_PC
3000541	6306 ELMCREST DR	0.77	0.04	5.2	0.24	31.3	0.45	58.7	0.04	4.8	0.49	63.5
3001537	6492 ELMCREST DR	0.92	0.05	5.4	0.31	33.9	0.47	51.3	0.09	9.5	0.56	60.7
3002911	6330 ELMCREST DR	1.31	0.04	3	0.86	65.4	0.37	28.1	0.05	3.5	0.41	31.6
3001167	6342 ELMCREST DR	1.19	0.06	4.8	0.72	60.3	0.37	30.8	0.05	4.1	0.42	35
3002403	6476 ELMCREST DR	0.78	0.03	3.9	0.47	60.1	0.24	30.9	0.04	5.2	0.28	36
3000731	6477 ELMCREST DR	0.8	0.04	5.2	0.31	39.2	0.42	52.1	0.03	3.5	0.44	55.5
3003384	6311 ELMCREST DR	0.91	0.03	3	0.43	47.3	0.39	43.1	0.06	6.6	0.45	49.7
3001257	6335 ELMCREST DR	0.88	0.05	5.4	0.49	55.8	0.3	34.1	0.04	4.7	0.34	38.8
3002436	6354 ELMCREST DR	0.85	0.02	2.9	0.54	63	0.25	29.2	0.04	4.8	0.29	34



Seattle UTC Change 2002-2007

Seattle UTC Change 2002-2007

Land Use Category	2002 Canopy Cover	2007 Canopy Cover	Goal Canopy Cover
Commercial/ Mixed Use	8.4%	9.7%	15%
Developed Park or Boulevard	25.9%	25.5%	25%
Downtown	4.2%	4.7%	12%
Major Institution	18.4%	19.4%	20%
Manufacturing/ Industrial	3.8%	4.3%	10%
Multi-Family	16.6%	17.1%	20%
Parks Natural Area	82.5%	80.4%	80%
Single Family	25.2%	25.7%	31%
Total	22.5%	22.9%	30%

UTC Calculator - Land Use Districts of St. Louis, MO

USER INPUTS	Increase UTC % By	Update UTC % To	Update Number of Trees by:
Area Commercial District			
Central Business District			
Industrial District			
Jefferson Memorial District			
Local Commercial and Office District			
Multiple-Family Residential Dwelling District			
Neighborhood Commercial District			
Not Zoned			
Public Right-of-Way			
Single-Family Residential Dwelling District			
Two-Family Residential Dwelling District			
Unclassified			
Unrestricted District			
Estimated Crown Diameter (ft):	30		
Estimated Crown Areas (Acres):	0.016219		

Warnings and Errors

**** User inputs not filled in***

*NOTE: Only one of entry is acceptable per row, per column. For example, Commercial may not have entries in "Increase UTC % By" and "Increase UTC % To."

RESULTS

Classified District	Total Acres	Acres Not Suitable	Existing UTC Acres	Existing UTC %	Total Additional Possible UTC Acres	Total Possible UTC %	% Change	Updated %	Updated UTC Acres	UTC Acreage Change	Number of Trees Required
Area Commercial District	685	311	62	9.1	312	45.6	-	-	-	-	-
Central Business District	542	334	22	4.1	186	34.3	-	-	-	-	-
Industrial District	2,214	1,001	153	6.9	1,059	47.8	-	-	-	-	-
Jefferson Memorial District	180	93	27	15.2	59	33.0	-	-	-	-	-
Local Commercial and Office District	766	329	86	11.2	352	45.9	-	-	-	-	-
Multiple-Family Residential Dwelling District	3,641	1,514	737	20.3	1,389	38.2	-	-	-	-	-
Neighborhood Commercial District	1,479	635	177	12.0	667	45.1	-	-	-	-	-
Not Zoned	11	6	1	10.5	4	35.7	-	-	-	-	-
Public Right-of-Way	9,146	6,366	1,616	17.7	1,164	12.7	-	-	-	-	-
Single-Family Residential Dwelling District	10,304	3,565	2,753	26.7	3,986	38.7	-	-	-	-	-
Two-Family Residential Dwelling District	4,768	1,977	1,201	25.2	1,590	33.3	-	-	-	-	-
Unclassified	570	343	39	6.8	188	33.0	-	-	-	-	-
Unrestricted District	5,432	2,703	343	6.3	2,387	43.9	-	-	-	-	-

SUMMARY RESULTS

Target Geography Totals	Geographic Area (Acres)	Existing UTC (Acres)	Existing %	Total Trees Added	Total Trees Added Acres	New UTC Acres	New %
Classified District	**39,737**	**7,218**	**18%**	-	-	-	-

UTC Calculator - Land Use Districts of St. Louis, MO

USER INPUTS	Increase UTC % By	Update UTC % To	Update Number of Trees by:
Area Commercial District			1,000
Central Business District			5,000
Industrial District	10.0%		
Jefferson Memorial District	20.0%		
Local Commercial and Office District	20.0%		
Multiple-Family Residential Dwelling District		50.0%	
Neighborhood Commercial District	20.0%		
Not Zoned	0.0%		
Public Right-of-Way	20.0%		
Single-Family Residential Dwelling District		50.0%	
Two-Family Residential Dwelling District		50.0%	
Unclassified	0.0%		
Unrestricted District	10.0%		
Estimated Crown Diameter (ft):	30		
Estimated Crown Areas (Acres):	0.016219		

Warnings and Errors
UTC Exceeds Possible Limit

**** User inputs filled in***

*NOTE: Only one of entry is acceptable per row, per column. For example, Commercial may not have entries in "Increase UTC % By" and "Increase UTC % To."

RESULTS

Classified District	Total Acres	Acres Not Suitable	Existing UTC Acres	Existing UTC %	Total Additional Possible UTC Acres	Total Possible UTC %	% Change	Updated %	Updated UTC Acres	UTC Acreage Change	Number of Trees Required
Area Commercial District	685	311	62	9.1	312	45.6	2.4	11.5	78.5	16.2	1,000
Central Business District	542	334	22	4.1	186	34.3	15.0	19.1	103.3	81.1	5,000
Industrial District	2,214	1,001	153	6.9	1,059	47.8	10.0	16.9	374.1	220.7	13,608
Jefferson Memorial District	180	93	27	15.2	59	33.0	20.0	35.2	63.2	35.9	2,214
Local Commercial and Office District	766	329	86	11.2	352	45.9	20.0	31.2	239.1	153.4	9,458
Multiple-Family Residential Dwelling District	3,641	1,514	737	20.3	1,389	38.2	29.7	50.0	1,820.6	1,083.2	66,786
Neighborhood Commercial District	1,479	635	177	12.0	667	45.1	20.0	32.0	473.2	296.4	18,275
Not Zoned	11	6	1	10.5	4	35.7	-	-	-	-	-
Public Right-of-Way	9,146	6,366	1,616	17.7	1,164	12.7	20.0	37.7	3,448.0	1,831.7	112,935
Single-Family Residential Dwelling District	10,304	3,565	2,753	26.7	3,986	38.7	23.3	50.0	5,151.9	2,399.1	147,919
Two-Family Residential Dwelling District	4,768	1,977	1,201	25.2	1,590	33.3	24.8	50.0	2,383.8	1,182.8	72,927
Unclassified	570	343	39	6.8	188	33.0	-	-	-	-	-
Unrestricted District	5,432	2,703	343	6.3	2,387	43.9	10.0	16.3	885.4	542.9	33,473

SUMMARY RESULTS

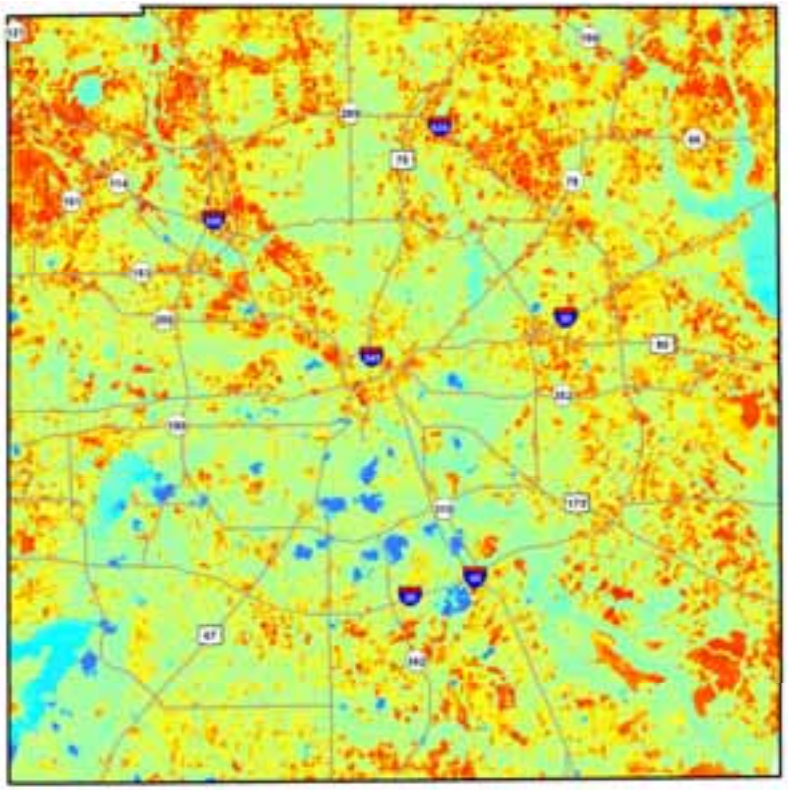
Target Geography Totals	Geographic Area (Acres)	Existing UTC (Acres)	Existing %	Total Trees Added	Total Trees Added Acres	New UTC Acres	New %
Classified District	**39,737**	**7,218**	**18%**	**483,594**	**7,843**	**15,061**	**38%**

Planting Sites Analysis and Prioritization

Dallas, TX - Texas Trees Foundation

Purpose: increase funding opportunities with a practical model that will identify and prioritize tree planting sites using GIS, remote sensing and environmental factors

Partners: City of Dallas, Texas Forest Service, NCTCOG, Urban Renewal, EPA, Houston Advanced Research Center, USDA Forest Service and UC-Davis



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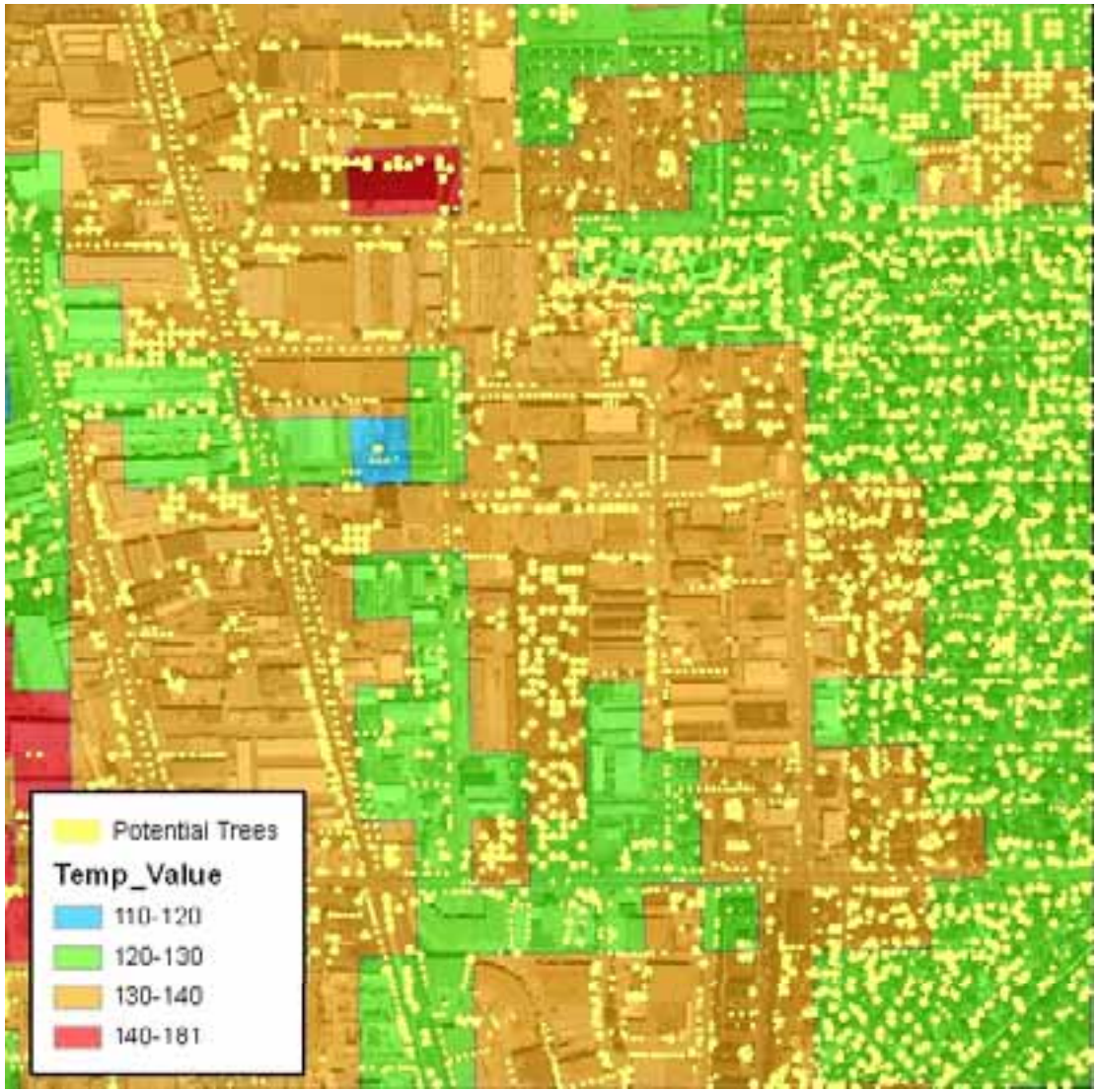
Existing Tree Canopy and Potential Planting Sites

Planting Sites in Heat Islands

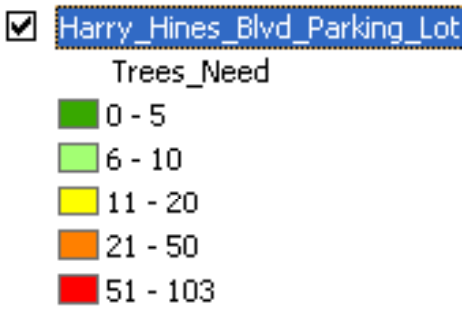
Planting Sites That Would Best Mitigate Urban Heat Islands



Energy Savings (East/West, yellow dots) vs. Other Planting Sites (green dots)

GIS Data Inputs:

Parking Lots



(# of trees needed to reach 15% canopy cover)

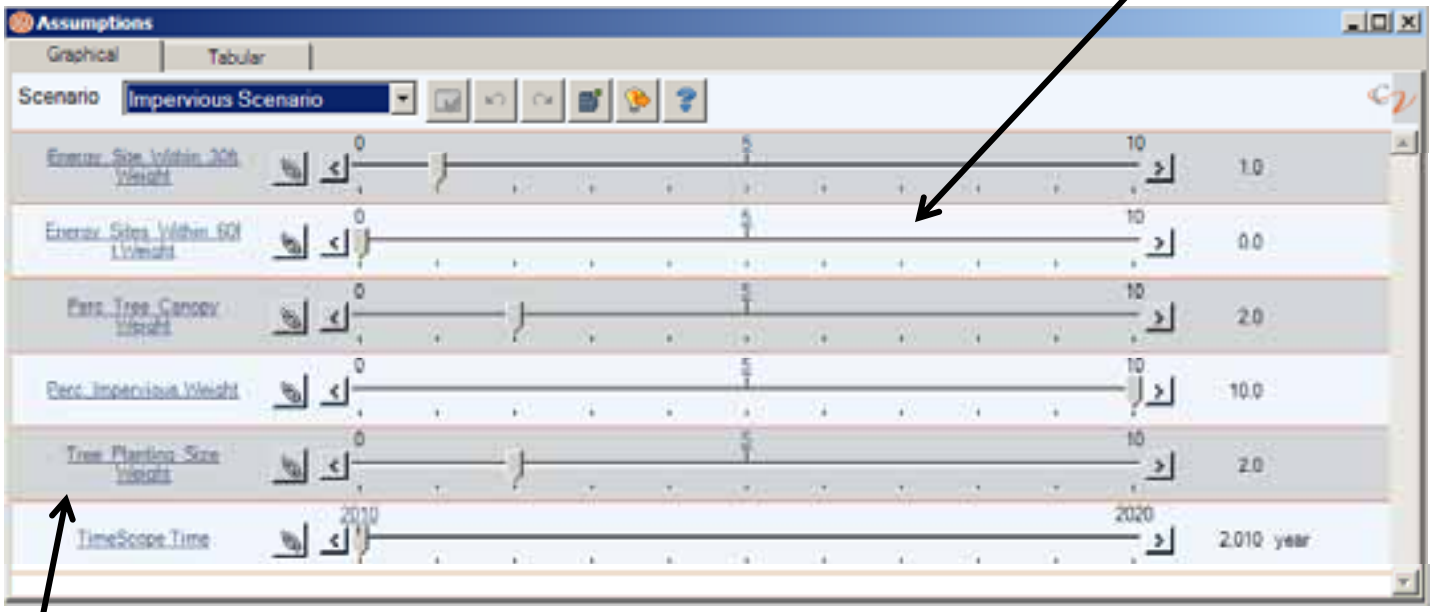
Dallas Roadmap

"**Web Map**"

- Doesn't require GIS software or training
- Includes reporting functionality
- Communicate, plan and visualize with partners and funding sources for successful tree planting programs

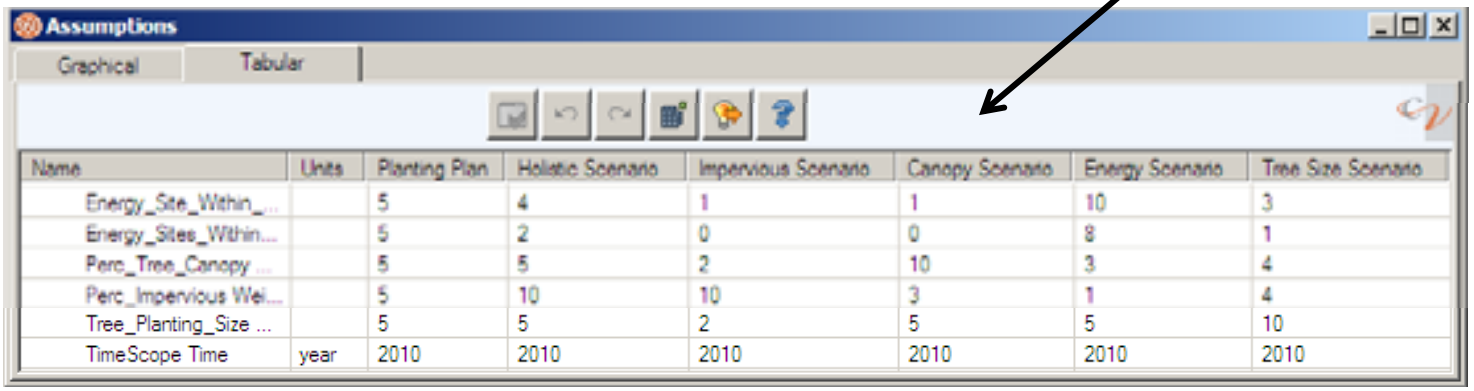
Suitability Modeling

Weights (applied to factors)



Factors

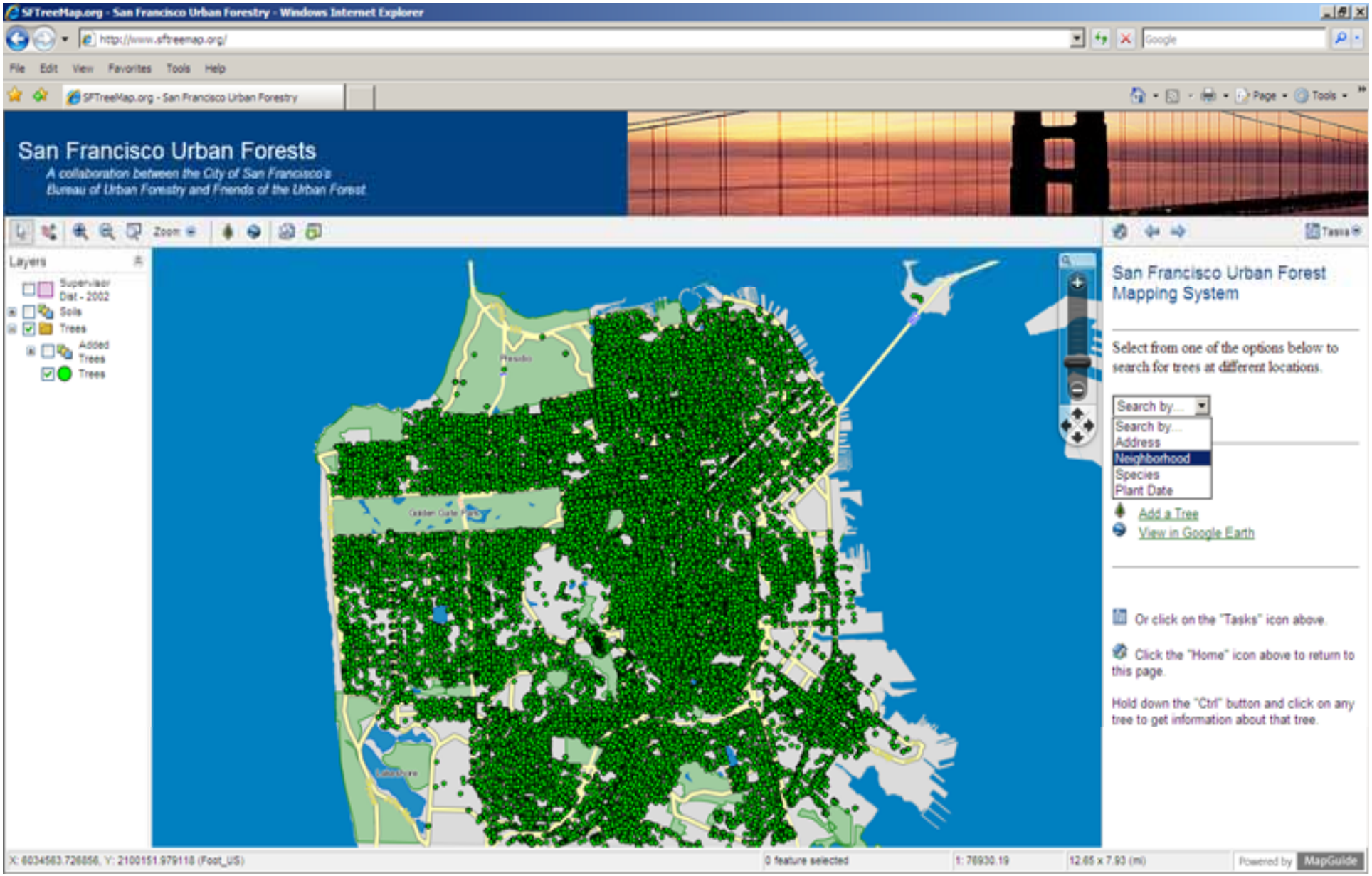
Scenarios



Name	Units	Planting Plan	Holistic Scenario	Impervious Scenario	Canopy Scenario	Energy Scenario	Tree Size Scenario
Energy_Site_Within_...		5	4	1	1	10	3
Energy_Sites_Within...		5	2	0	0	8	1
Perc_Tree_Canopy ...		5	5	2	10	3	4
Perc_Impervious Wei...		5	10	10	3	1	4
Tree_Planting_Size ...		5	5	2	5	5	10
TimeScope Time	year	2010	2010	2010	2010	2010	2010

Community Tree Inventory Programs

Community Tree Inventory Programs



Sample Web Resources

- http://www.itreetools.org/index.php
- http://www.itreetools.org/eco/resources/UFUG_Air_Pollution_Removal.pdf
- http://www.phillywatersheds.org/ltcpu/Vol02_TBL.pdf
- http://www.urbanforestrysouth.org/
- www.cufr.ucdavis.edu/
- www.dnr.state.md.us/forests/publications/urban.html
- www.treelink.org/

Research or Data Gaps

- Public Health data at the local level for spatial analysis with land cover and demographic data
- Partnerships between Public Health and tree planting and maintenance programs
- Research linking environmental benefits related to air quality with asthma, ozone reduction, etc
- Others??

Discussion

- Do you think urban forests have a significant role in public health?
- What partnership opportunities do you see?
- What initiatives are underway in your area?
- What is the biggest hurdle to incorporating urban vegetation into public health policy?
- What will you do with this information?

Contact Information

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