Air Pollution Removal by Green Infrastructure and i-Tree Software

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Overview

- Ecosystem services

- Vegetation and air pollution
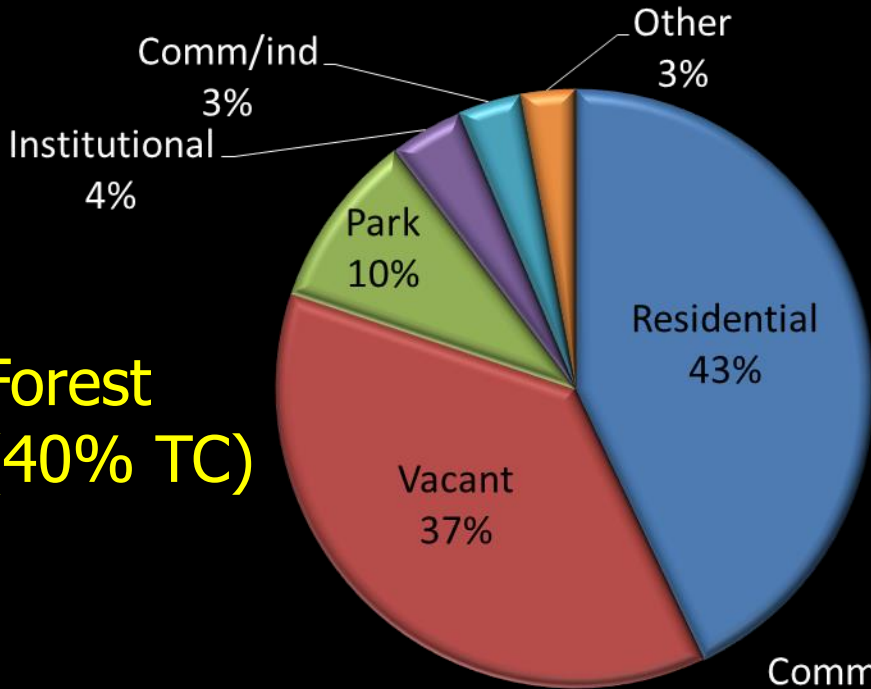
- i-Tree

- Management guidelines

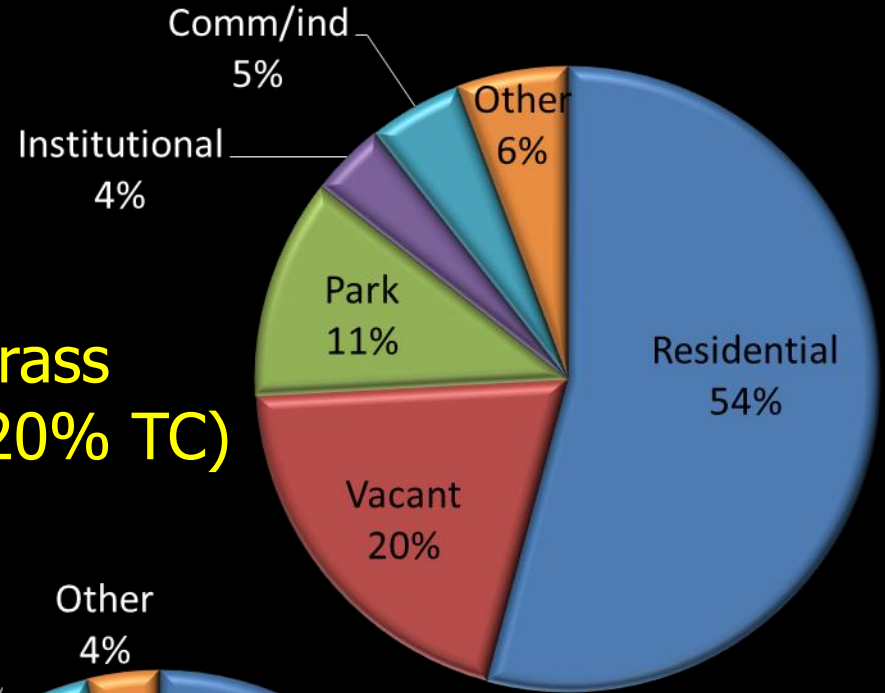# Percent of Total Tree Cover in Cities by Land Use

Forest (40% TC)

- Other 3%
- Comm/ind 3%
- Institutional 4%
- Park 10%
- Residential 43%
- Vacant 37%

Grass (20% TC)

- Comm/ind 5%
- Other 6%
- Institutional 4%
- Park 11%
- Residential 54%
- Vacant 20%

Desert (10% TC)

- Other 4%
- Comm/ind 11%
- Institutional 4%
- Park 7%
- Vacant 2%
- Residential 72%
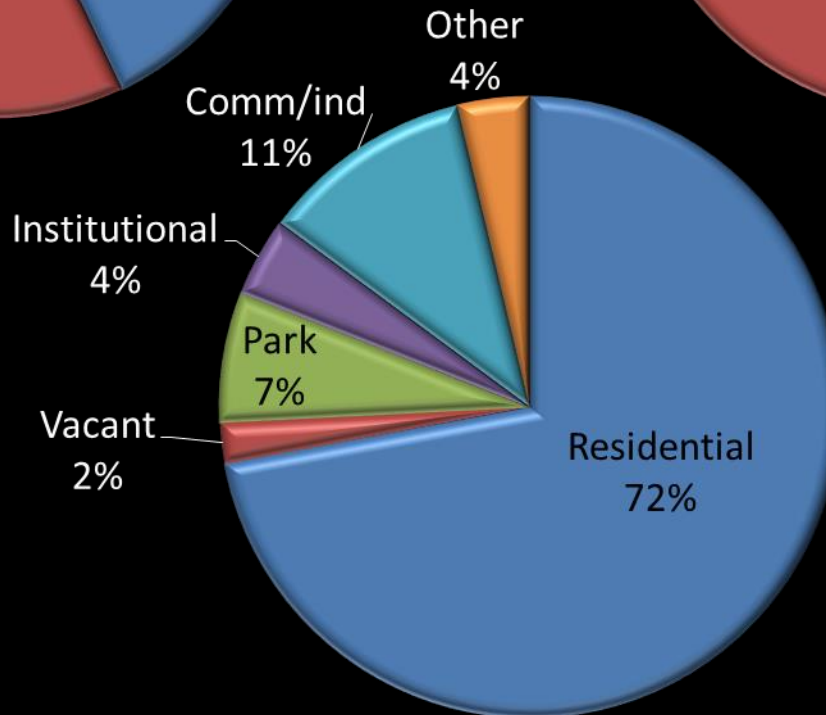
Vegetation and Ecosystem Services

Structure ⇨ **Function** ⇨ **Value**
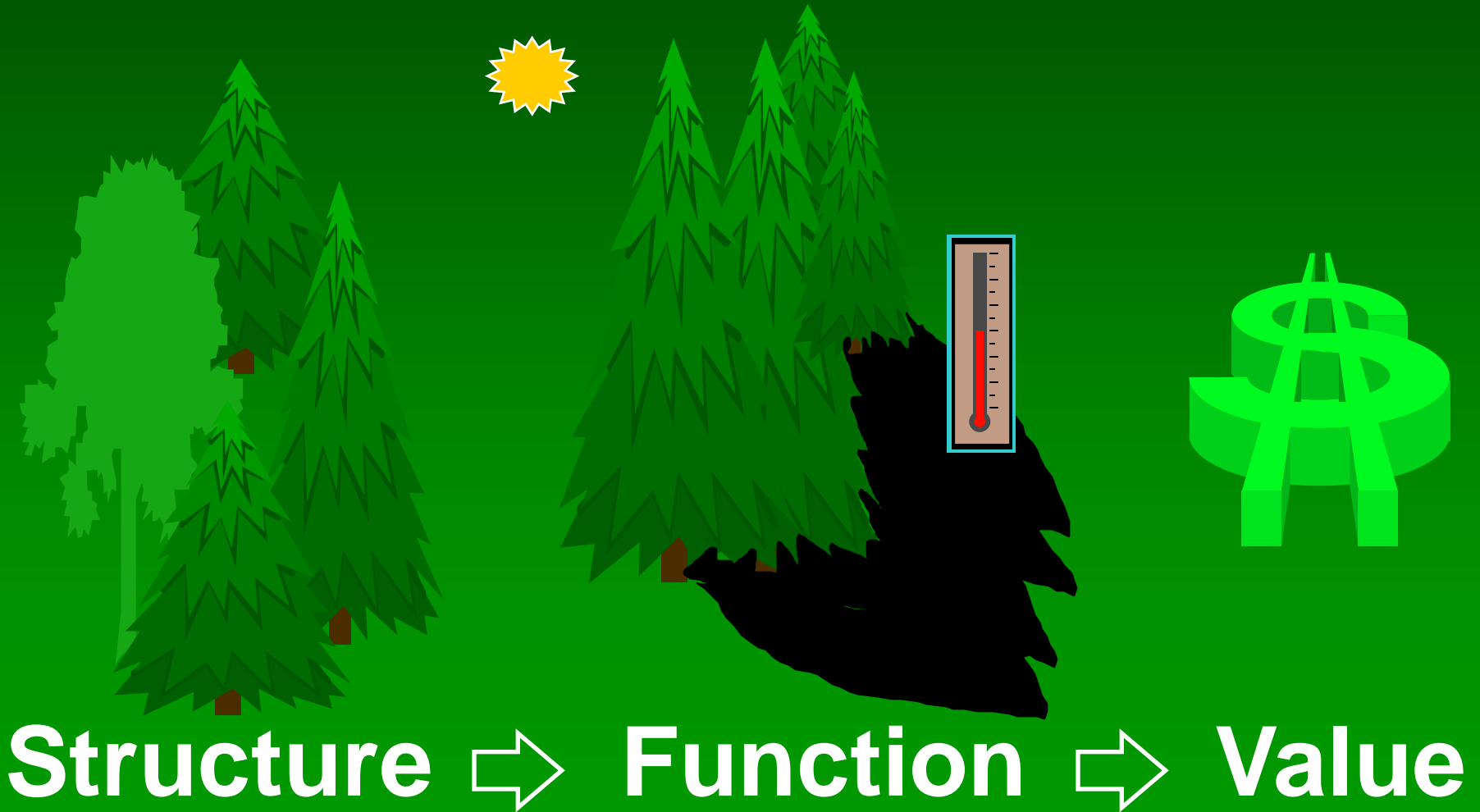
Urban Vegetation Benefits

- Cooler air temperatures
- Social / Physiological benefits / Aesthetics
- Air quality improvement
- Water quality improvement
- Building energy conservation
- Greenhouse gas reduction
- UV radiation reduction
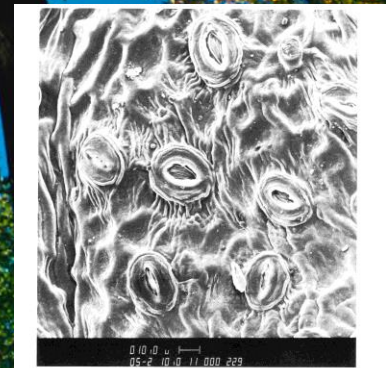- Wildlife habitat
- Noise reduction
- Oxygen production

Figure 5-6. Scanning electron microscope micrograph of the abaxial surface of a 3-week-old London plane leaf showing stomates. Scale, 10 μm.

Temperature reduction

R

E

E

Sketch of an Urban Heat-Island Profile
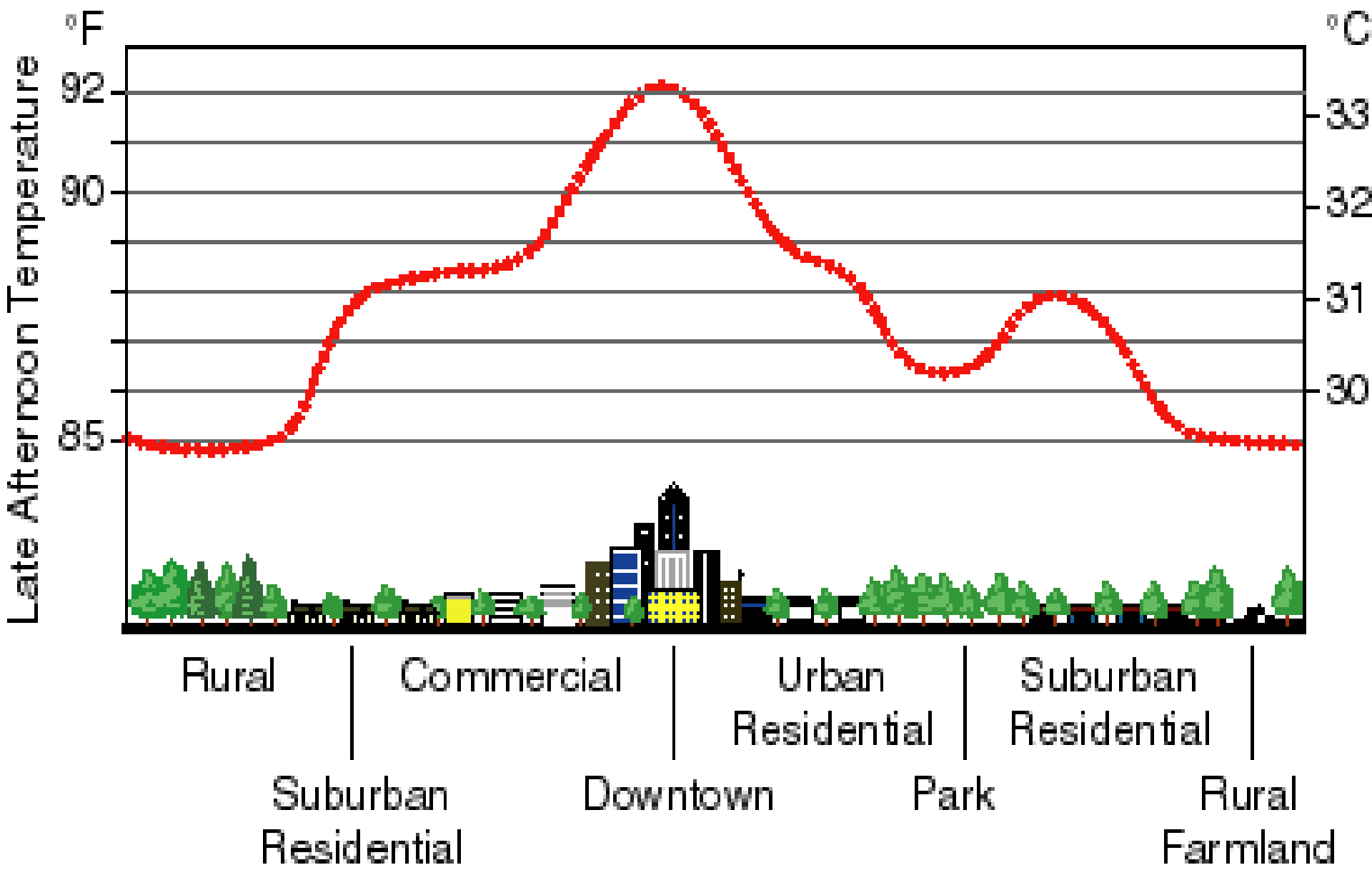
Y-axis (left): Late Afternoon Temperature °F — 85, 90, 92

Y-axis (right): °C — 30, 31, 32, 33

X-axis labels: Rural | Commercial | Urban Residential | Suburban Residential

Suburban Residential | Downtown | Park | Rural Farmland

Temperature and Smog

AFTERNOON TEMPERATURE IN L.A.

100°F — 40°C

80°F — 30°C

— 20°C

60°F

SMOG PROBABILITY

100%

50%

0%

Temperature reduction

Removal

E

E

MOLECULES OF GASEOUS
AIR POLLUTANT

WET
LEAF

DRY
LEAF

BOUNDARY
LAYER

H₂O LAYER

STOMA

UPPER
EPIDERMIS

PALISADE

MESOPHYLL
CELLS

SPONGY

LOWER
EPIDERMIS

0 10.0 u
02-2 10.0 08 000 118
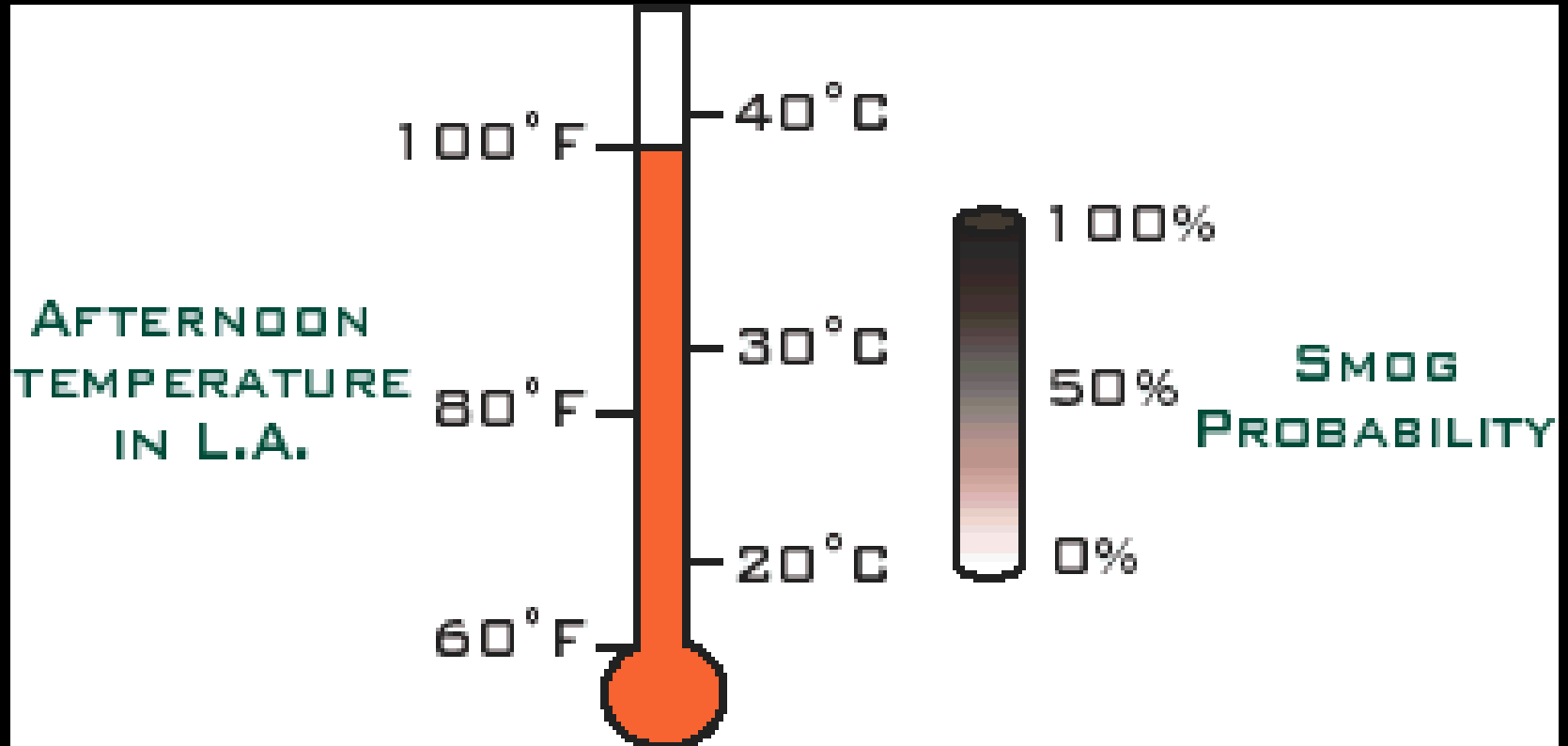
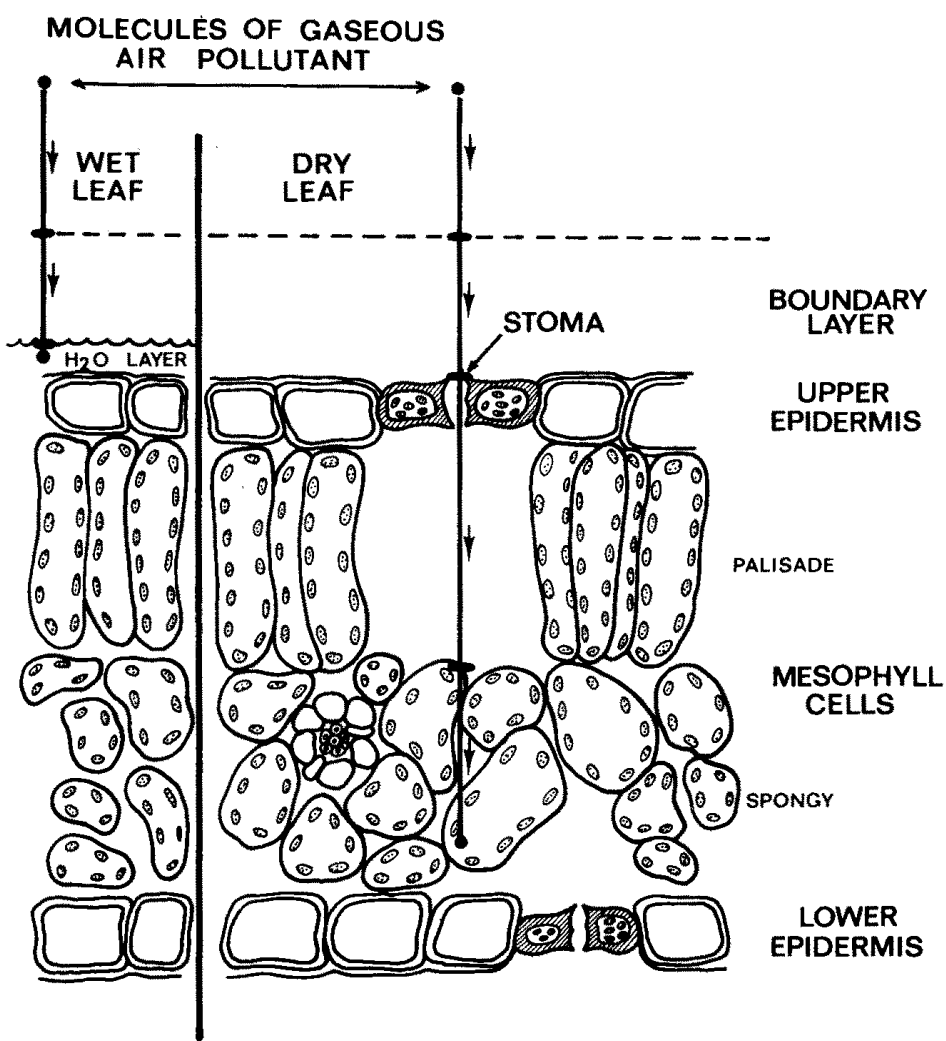**Figure 5-3.** Scanning electron microscope micrograph of the adaxial surface of an 8-week-old London plane leaf. Spore, pollen, carbonaceous, angular, and aggregate particles are visible. Scale, 10 μm.

U.S. Pollution Removal by Trees

Pollutant	Urban Areas		Rural Areas	
	Removal (t × 1000)	Value ($ × 1000)	Removal (t × 1000)	Value ($ × 1000)
NO_2	68	29,500	1,371	8,939
	(41-85)	(17,650-37,930)	(958-1,661)	(5,736-10,900)
O_3	523	1,497,000	13,810	721,600
	(201-691)	(550,000-1,988,000)	(7,130-17,829)	(314,400-929,800)
$PM_{2.5}$	27	3,127,000	669	1,452,000
	(4-58)	(414,700-6,928,000)	(91-1,503)	(193,000-3,141,000)
SO_2	33	4,923	873	2,534
	(20-52)	(2,864-7,793)	(564-1,339)	(1,527-3,891)
Total	651	4,659,000	16,720	2,185,000
	(266-887)	(985,000-8,960,000)	(8,740-22,330)	(515,000-4,090,000)

Total removal = 17.4 million tonnes / yr (96% rural)
Total value = $6.8 billion / yr (68% urban)

Ozone Health Effects

Adverse Health Effect	Conterminous US		Urban Areas		Rural Areas	
	Inc[a]	$ Value (Millions)	Inc[a]	Value	No. Inc[a]	Value
Mortality	275	2,138	185	1,439,586,000	90	698,044,000
Acute Respiratory Symptoms	481,275	41.1	345,581	29,543,000	135,695	11,600,000
Hospital Admissions	1,977	20.3	1,776	13,852,000	201	6,474,000
School Loss Days	202,399	19.9	146,939	14,428,000	55,460	5,446,000
Emergency Room Visits	231	0.1	167	70,000	63	26,000
Total		2,219		1,497,479,000		721,590,000

Total avoided mortality = 850 incidences nationally
Avoided acute respiratory symptoms = 670,000 incidences

Storage and Sequestration (tonnes)

State	Storage ($\times 10^6$)	
	Urban	SE
Alabama (AL)	18.7	3.6
Arizona (AZ)	5.5	1.4
Arkansas (AR)	7.7	1.6
California (CA)	31.4	6.0
Colorado (CO)	4.4	1.2
Connecticut (CT)	23.3	4.3
Delaware (DE)	2.3	0.5
Florida (FL)	42.9	8.0
Georgia (GA)	38.5	7.1
Idaho (ID)	1.1	0.3
Illinois (IL)	18.7	3.7
Indiana (IN)	9.7	2.2
Iowa (IA)	3.8	1.0
Kansas (KS)	4.8	1.1
Kentucky (KY)	6.5	1.6
Louisiana (LA)	10.6	2.2
Maine (ME)	3.8	0.8
Maryland (MD)	11.9	2.5
Massachusetts (MA)	35.9	6.6
Michigan (MI)	22.9	4.5
Minnesota (MN)	9.3	2.0
Mississippi (MI)	7.4	1.6
Missouri (MS)	11.2	2.4
Montana (MT)	0.5	0.2
US48[c]	638.8	23.8

Storage = $50.5 billion; Sequestration = $ 2 billion/yr

Temperature reduction

Removal

Emissions

E

Emissions

- Volatile Organic Compounds (VOCs)

   - isoprene (light and temperature dependent)

   - monoterpenes (temperature dependent)

- Maintenance emissions

Temperature reduction

Removal

Emissions

Energy Conservation

Winter Winds

N

Coniferous windbreaks protect house from cold winter winds.

Trees close to house on east and west protect against summer sun.

Trees on south side should be deciduous to permit winter sun while shielding the summer sun.

Avoid dense trees in the direction of summer winds that block desired cooling breezes.

Summer Winds
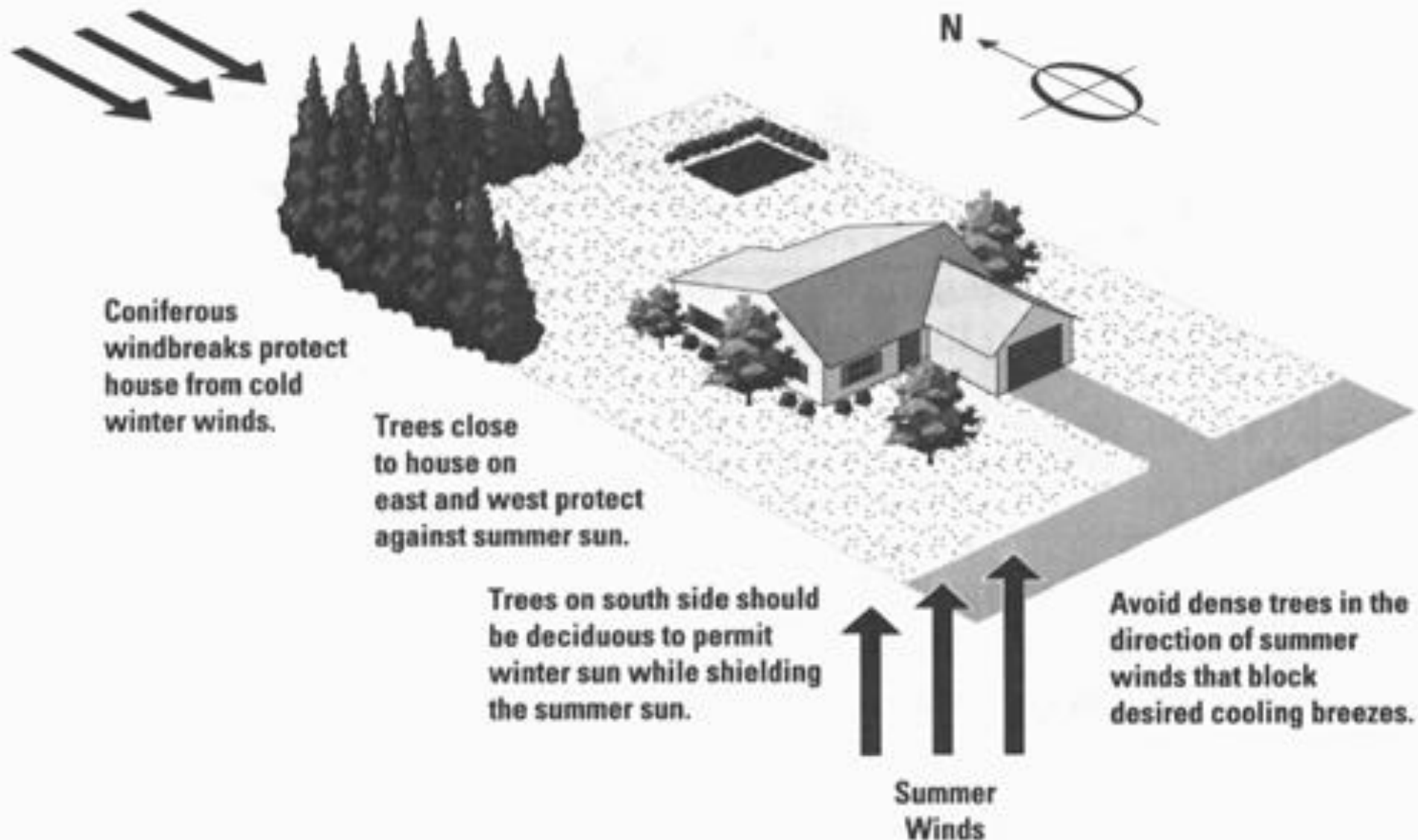
National Building Energy Conservation

- 36 million MWh energy production avoided annually ($4.3 billion)

- 228 million MMBTU energy production avoided annually ($2.9 billion)

- Preliminary results

Avoided Emissions – Conterminous US

Pollutant	Tonnes avoided/yr	$ millions/yr
Carbon dioxide	19,800,000	425
Carbon monoxide	16,200	26
Course PM	1,720	97
Fine PM	4,190	590
Methane	459	0.2
Nitrogen oxides	17,100	161
Sulfur dioxide	45,300	405
VOCs	1,100	1
Total		1,705

Summary – US Urban Annual Values

- Avoided energy use = $7.2 billion
- Air pollution removal = $4.7 billion
- Carbon sequestration = $2.0 billion
- Avoided emissions = $1.7 billion
- Total = $15.6 billion
  - $1,870 per hectare of tree cover

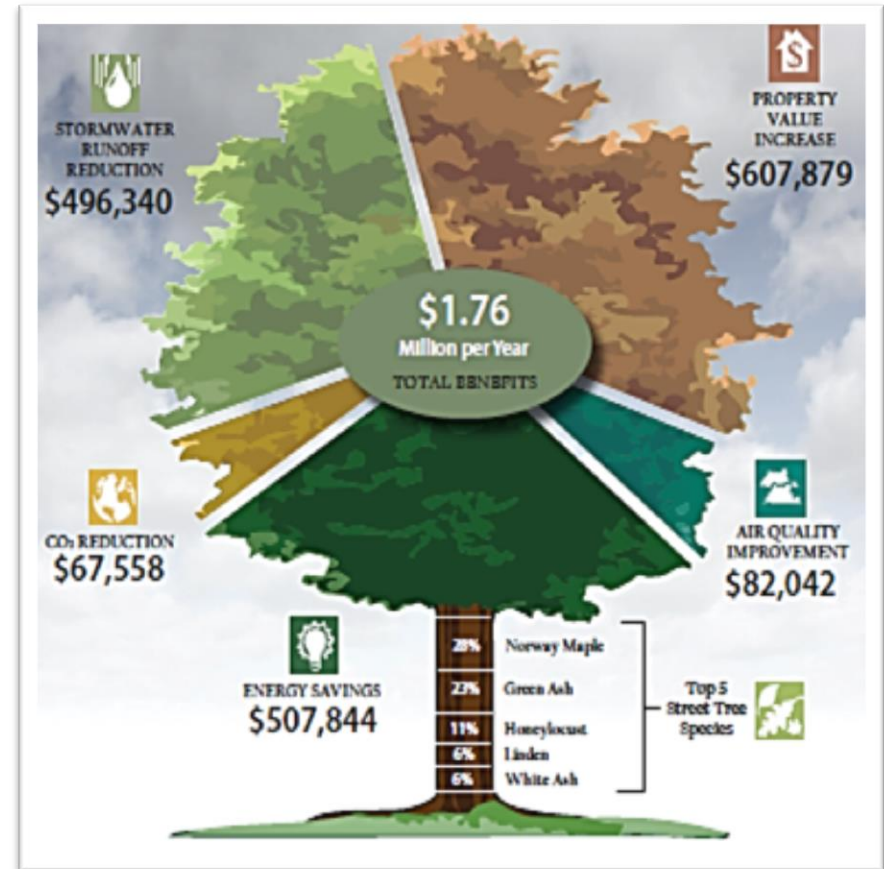 - Current carbon storage value = $50.5 billion

What is i-Tree?

A collaborative public-private partnership and suite of tools that provides:

* Assessment of current and future forest structure and benefits
* Optimal tree planting and design
* Sustainable and resilient forest management
* Public engagement in stewardship

i-Tree user base continues to grow…

Since its release in 2006, over 13,500 copies have been distributed in over 100 countries. An additional 20,000 unique users of i-Tree web tools were added in since 2011.

i-Tree Vegetation Benefits

- Air quality improvement
- Water quality improvement
- Greenhouse gas reduction
- Building energy use conservation
- Oxygen production
- Health benefits
- Cooler air temperatures
- UV radiation reduction
- Wildlife habitat
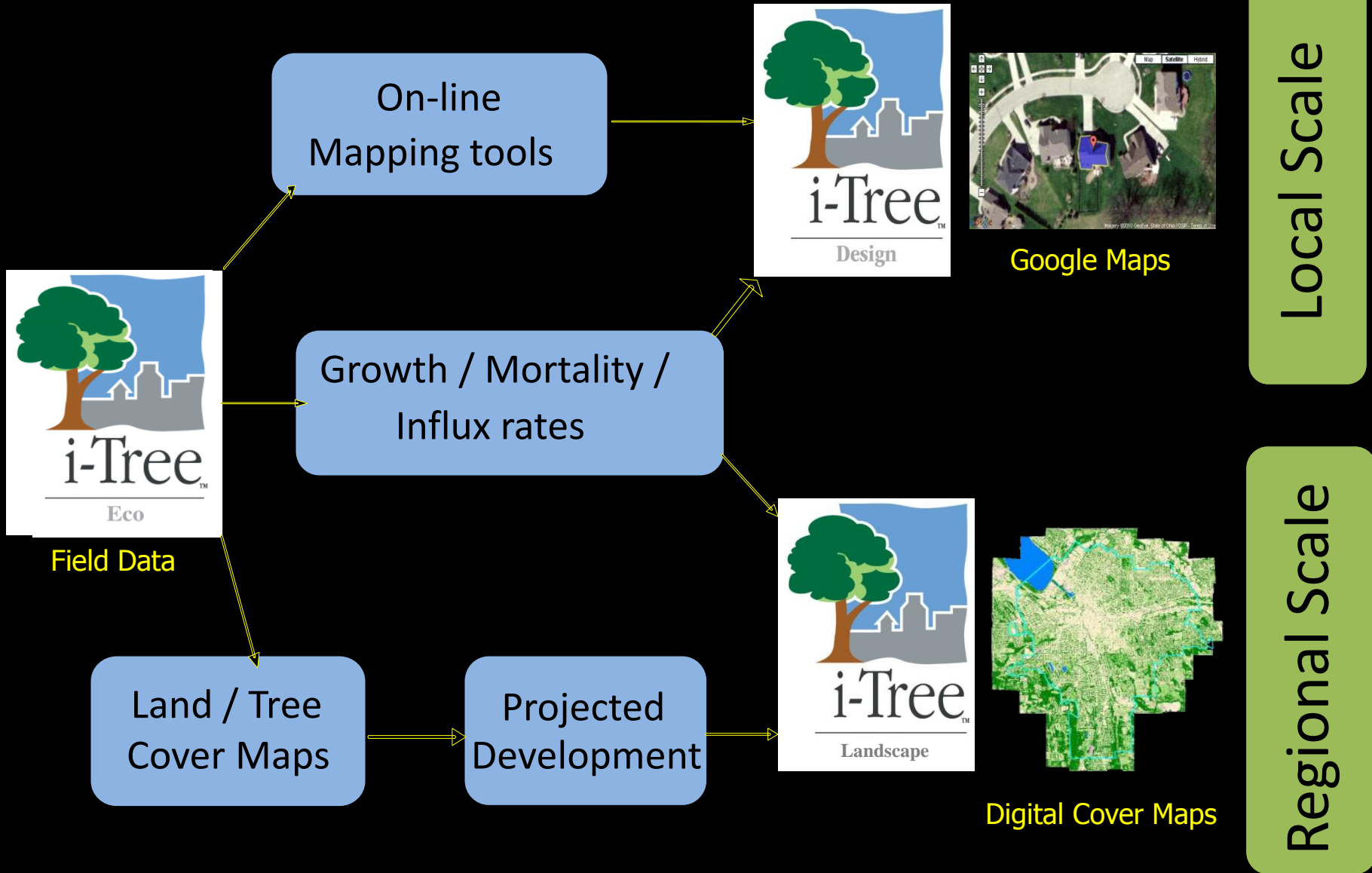- Products: timber, food, fiber, ethanol

i-Tree

i-Tree 2ⁿᵈ Generation (3 Flagship Programs)

On-line
Mapping tools

i-Tree
Design

Google Maps

Local Scale

i-Tree
Eco

Field Data

Growth / Mortality /
Influx rates

Land / Tree
Cover Maps

Projected
Development

i-Tree
Landscape

Digital Cover Maps

Regional Scale

Management Recommendations

- Increase / sustain healthy trees & tree cover
- Sustain large, healthy trees
- Plant long-lived species
- Use low maintenance, urban adapted species
- Consider projected climate change
  - Temperature, precipitation, insects, disease changes
- Minimize fossil fuel use
- Plant trees to cool air temperatures
- Plant trees in energy conservation location and use wood for energy or products
- Provide trees ample water

Thank you

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