# Vegetation Characteristics and Pollution Removal

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# Overview

- Research program
- Forest effects
- Tree effects
- 4 questions

# Research Program

- Assess urban vegetation and ecosystem services
- Develop management tools

# What is i-Tree?

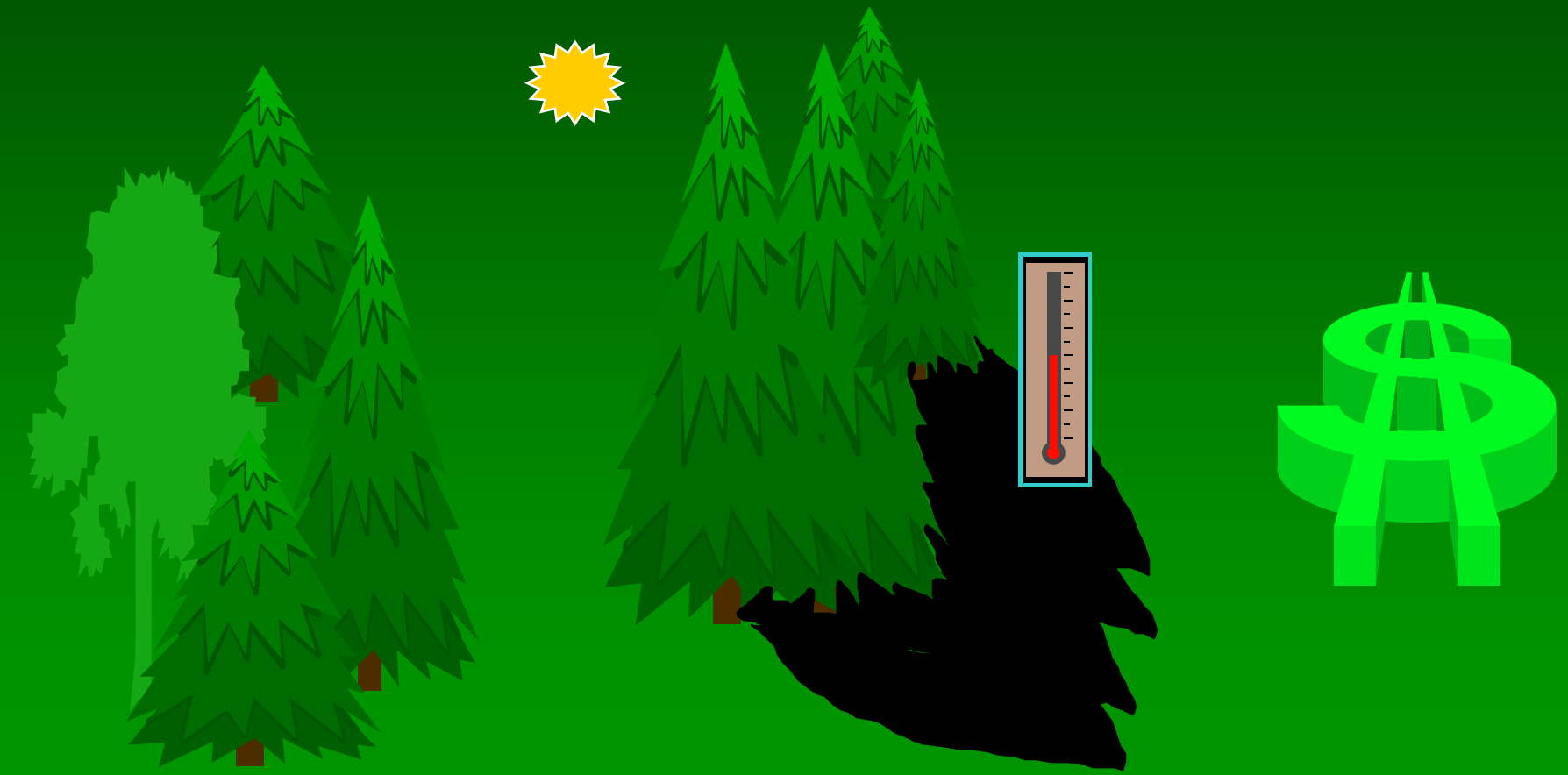
- A suite of tools to assess urban vegetation and their ecosystem services and values




# Public-Private Partnership

- USDA Forest Service
- Davey Tree Expert Co.
- National Arbor Day Foundation
- Society of Municipal Arborists
- International Society of Arboriculture

# Measurement is Critical



**Structure ⇨ Function ⇨ Value**

# i-Tree Eco Use

- Eco has been used worldwide in over 60 cities (9 countries)


Distributed to over 80 countries

# Forest Effects

T

R

E

E

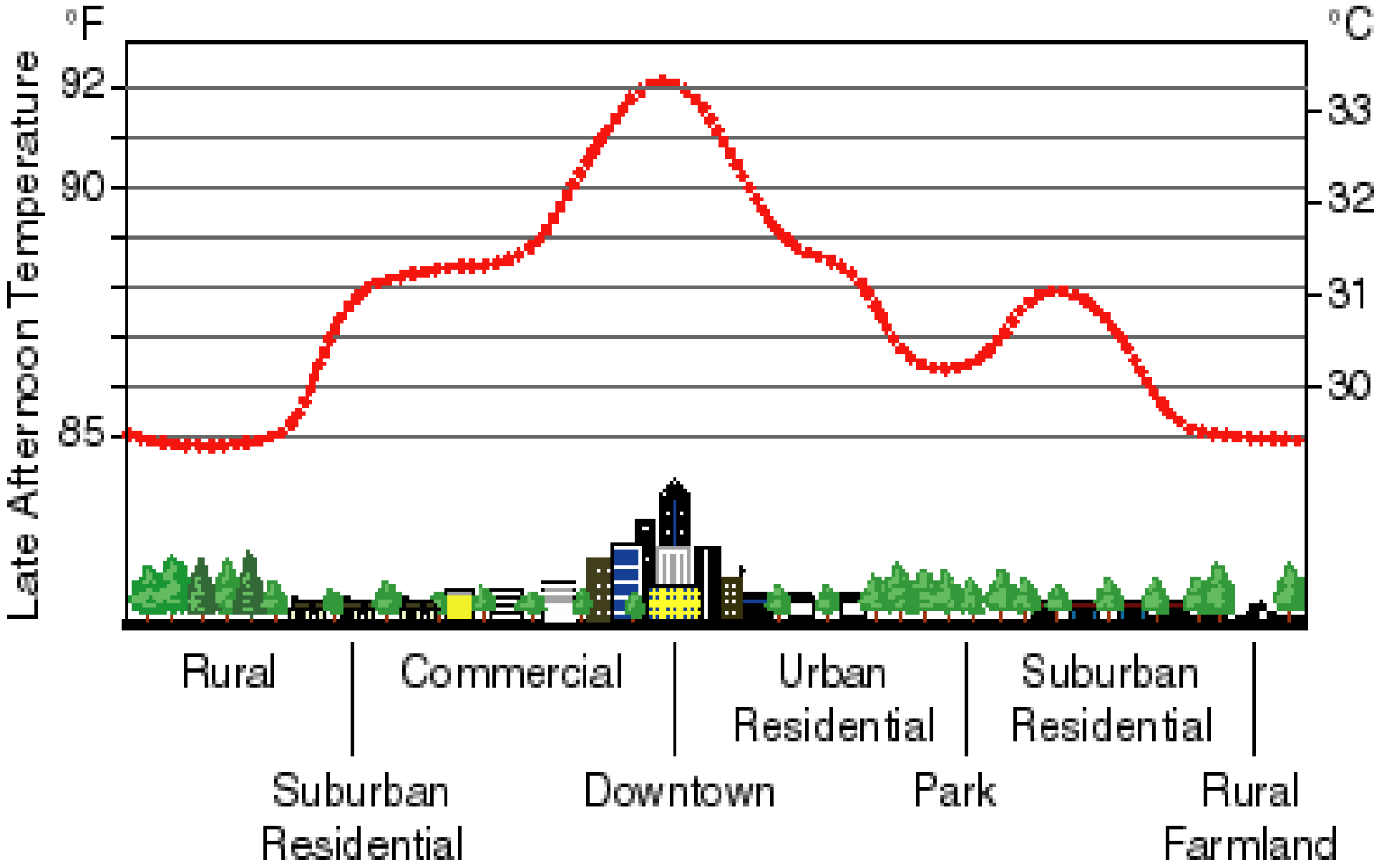
# Temperature reduction

R

E

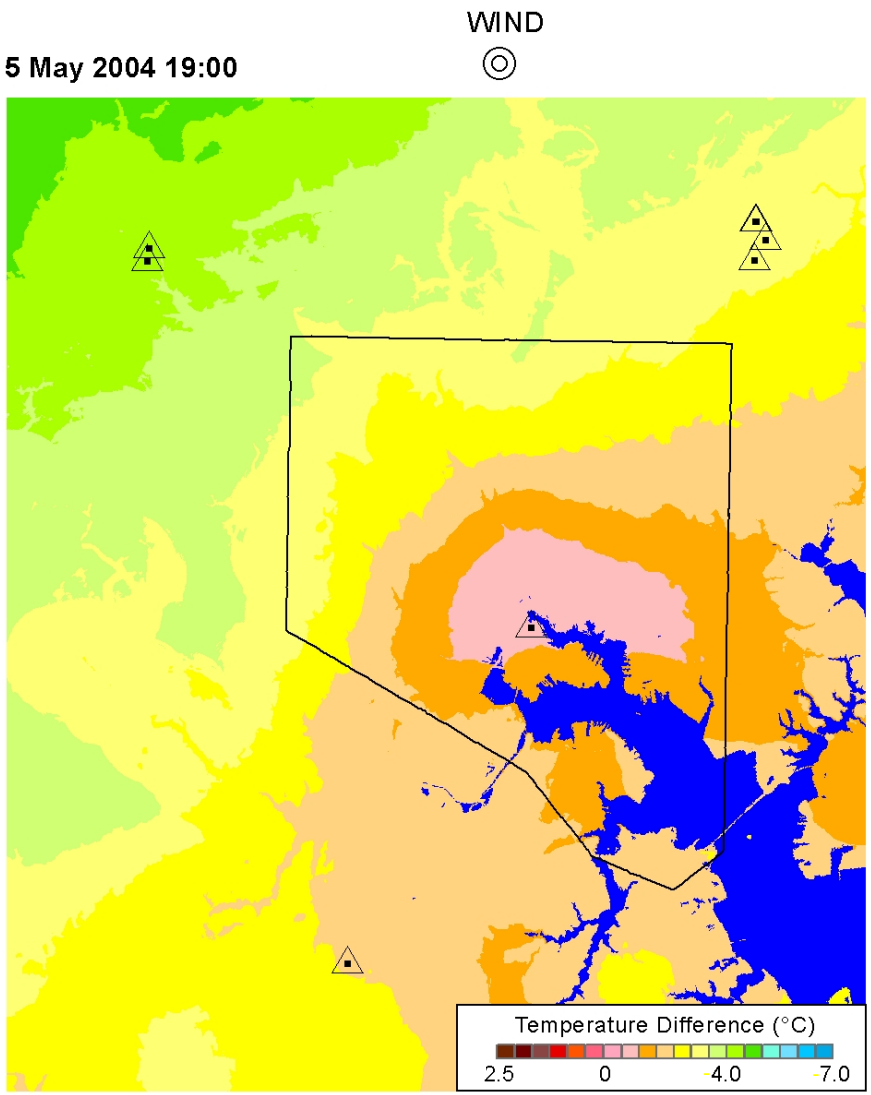
E

# Sketch of an Urban Heat-Island Profile



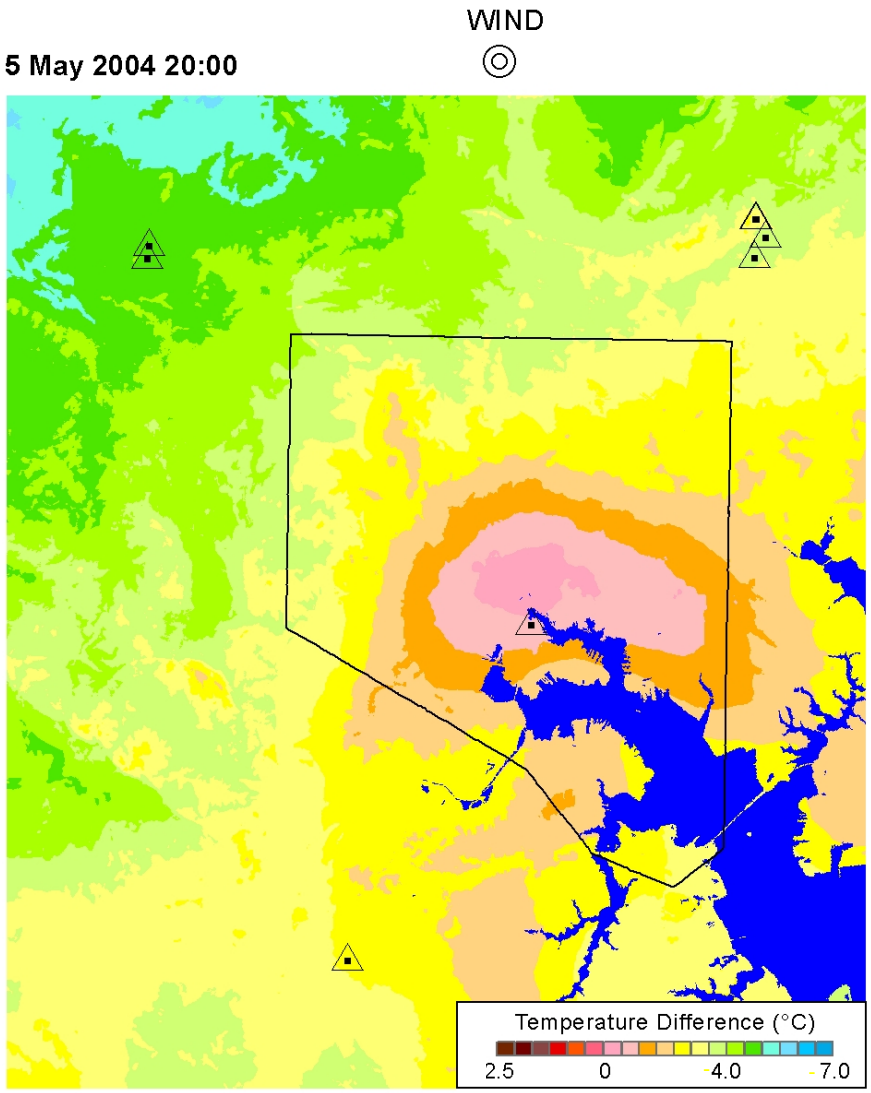

*Source: Heat Island Group, LBNL, http://EETD.LBL.gov/HeatIsland* ( from Akbari et al., 1992)

# Temperature Mapping




Heat Island – Baltimore, Maryland

Source: Heisler et al., USFS

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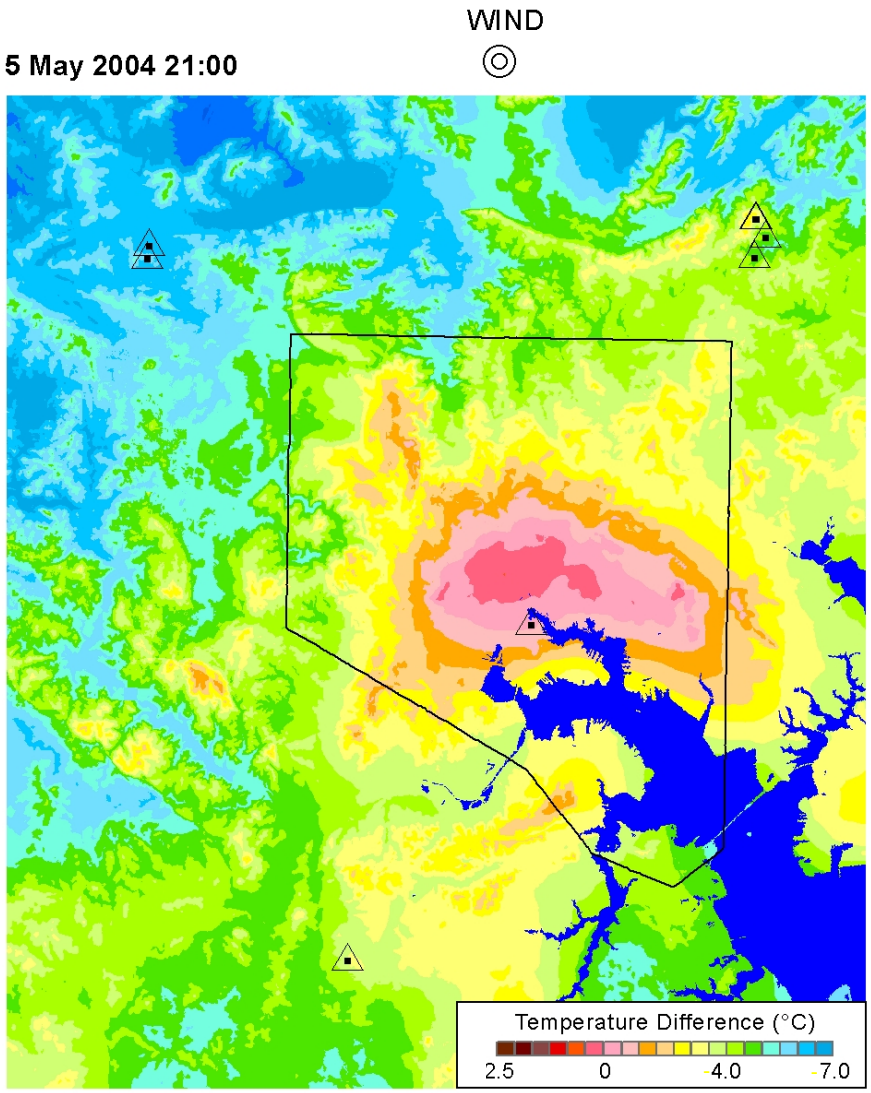



Heat Island – Baltimore, Maryland

Source: Heisler et al., USFS

# Temperature reduction

Removal

E

E

# Pollution Removal Methods

Flux (F) = Deposition Velocity ($V_d$) x Pollutant Conc. (C)

($g/m^2/sec$) ($m/sec$) ($g/m^3$)

$$V_d = 1/(R_a + R_b + R_c)$$

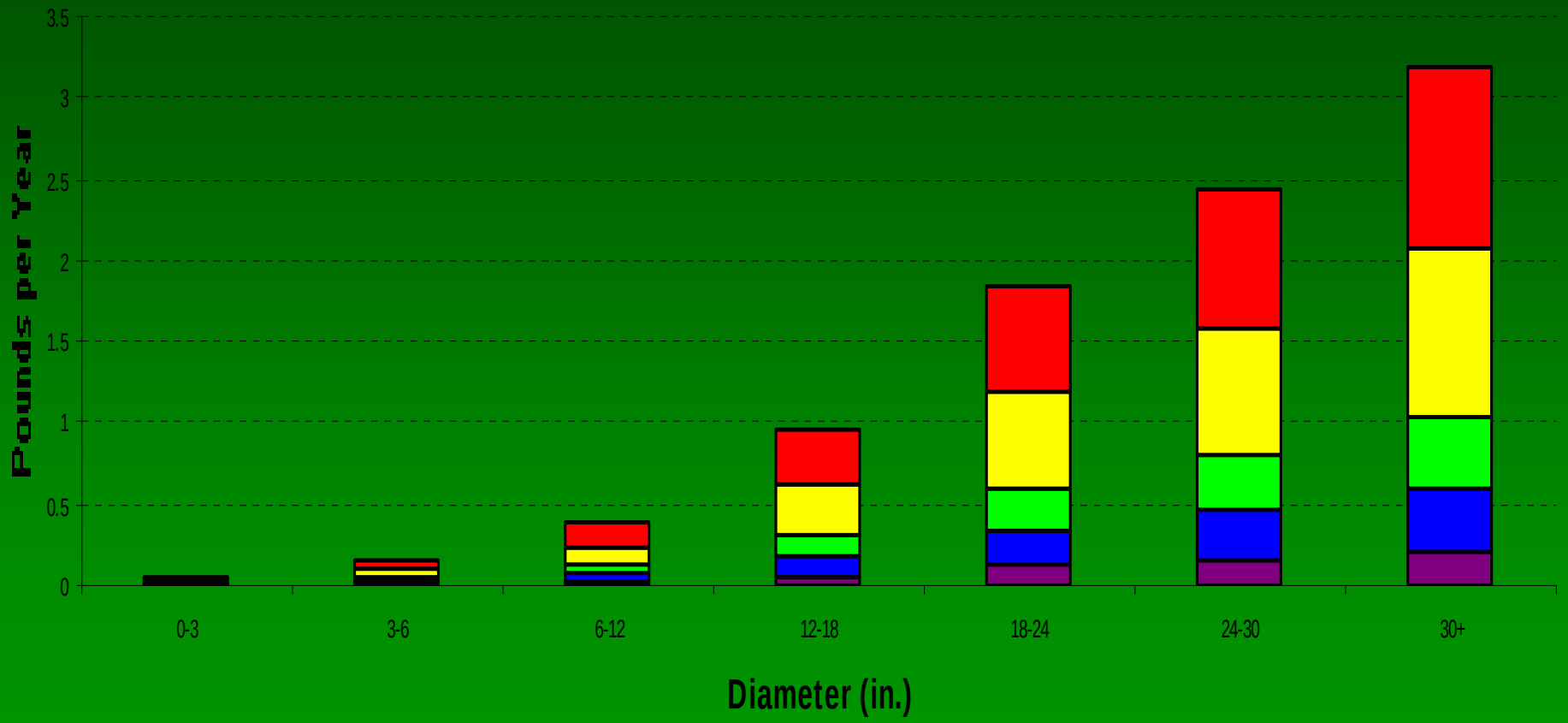
$R_a$ = aerodynamic resistance

$R_b$ = quasi-laminar boundary-layer resistance

$R_c$ = canopy resistance (Baldocchi et al., 1987)

Inputs: Hourly meteorological and pollution data; leaf area

# Pollution Removal by Trees



# Pollution Removal

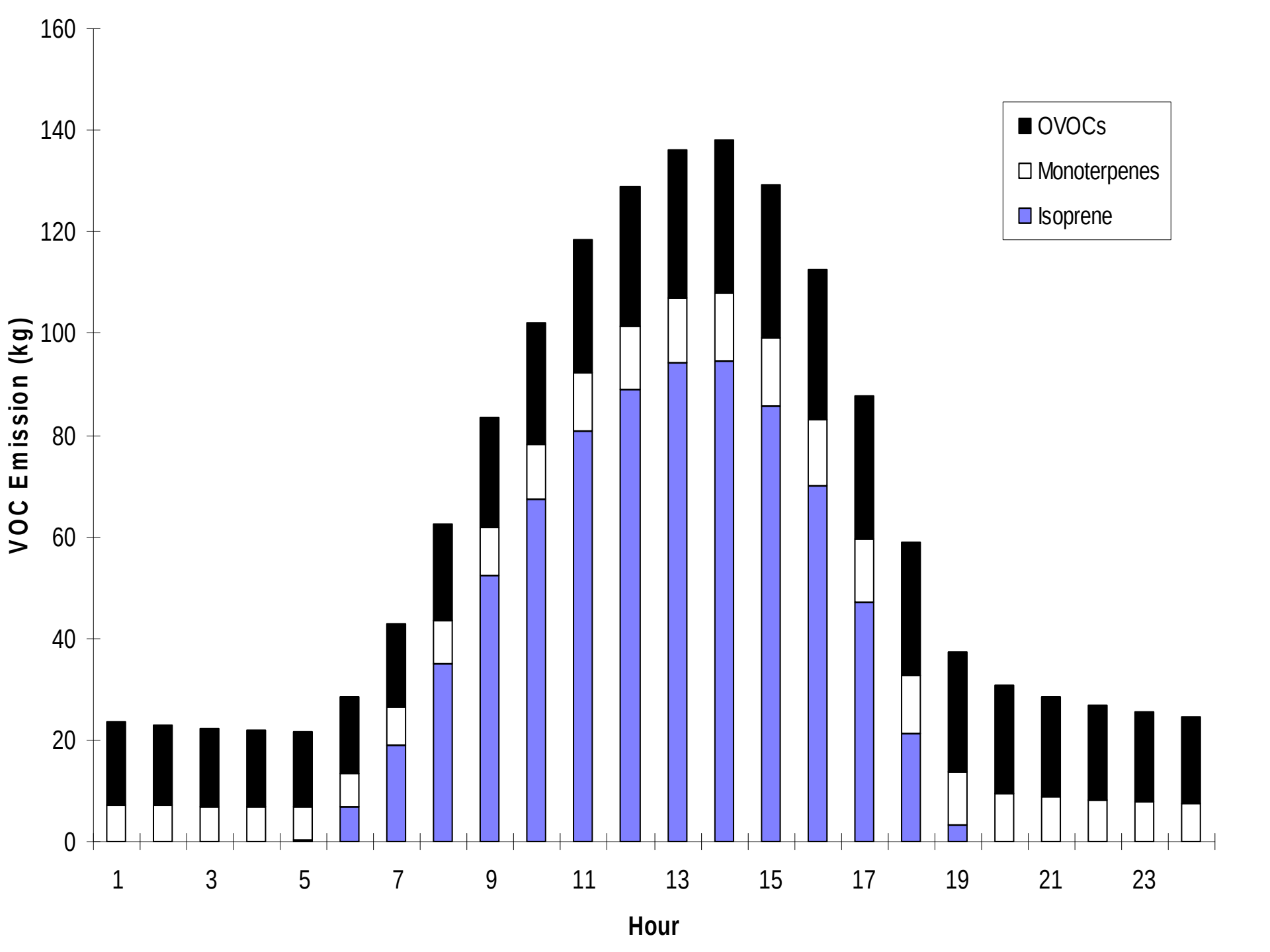
| City | CO | NO2 | O3 | PM10 | SO2 | Total | Range | g/m2 | $ | $/ha |
|---|---|---|---|---|---|---|---|---|---|---|
| Beijing, China | na | 132 | 256 | 772 | 101 | 1,261 | na | 27.5 | 6,264,000 | na |
| Santiago, Chile | 68 | 201 | 420 | 1,410 | 131 | 2,230 | (948-3,857) | 15.3 | 28,176,000 | 1,934 |
| Atlanta, GA | 39 | 181 | 672 | 528 | 89 | 1,509 | (538-2,101) | 12 | 8,321,000 | 663 |
| Freehold, NJ | 1 | 3 | 9 | 6 | 1 | 20 | (7-27) | 11.4 | 110,000 | 632 |
| San Juan, PR | 56 | 55 | 161 | 153 | 86 | 511 | (222-768) | 11.2 | 2,342,000 | 511 |
| Woodbridge, NJ | 6 | 42 | 66 | 62 | 15 | 191 | (72-267) | 10.8 | 1,037,000 | 586 |
| Fuenlabrada, Spain | 0 | 1 | 1 | 1 | 0 | 3 | (1-5) | 10.2 | 19,000 | 567 |
| Moorestown, NJ | 2 | 14 | 43 | 38 | 9 | 107 | (41-157) | 10.1 | 576,000 | 541 |
| Baltimore, MD | 9 | 94 | 223 | 142 | 55 | 522 | (183-725) | 9.9 | 2,876,000 | 545 |
| Philadelphia, PA | 10 | 93 | 185 | 194 | 41 | 522 | (203-742) | 9.7 | 2,826,000 | 527 |
| New York, NY | 67 | 364 | 536 | 354 | 199 | 1,521 | (619-2,185) | 9.1 | 8,071,000 | 482 |
| San Francisco, CA | 7 | 25 | 47 | 42 | 7 | 128 | (51-195) | 9 | 693,000 | 486 |
| Toronto, Canada | 36 | 224 | 460 | 288 | 91 | 1,099 | (410-1,466) | 8.5 | 6,105,000 | 470 |
| Jersey City, NJ | 2 | 9 | 13 | 9 | 5 | 37 | (16-56) | 8.4 | 196,000 | 445 |
| Washington, DC | 18 | 50 | 152 | 107 | 51 | 379 | (150-568) | 8.3 | 1,956,000 | 429 |
| Boston, MA | 6 | 48 | 108 | 73 | 23 | 257 | (94-346) | 8.1 | 1,426,000 | 447 |
| Morgantown, WV | 1 | 5 | 26 | 18 | 9 | 60 | (22-98) | 7.5 | 311,000 | 387 |
| Syracuse, NY | 2 | 12 | 55 | 23 | 7 | 99 | (37-134) | 6.6 | 568,000 | 378 |

Temperature reduction

Removal

Emissions

E

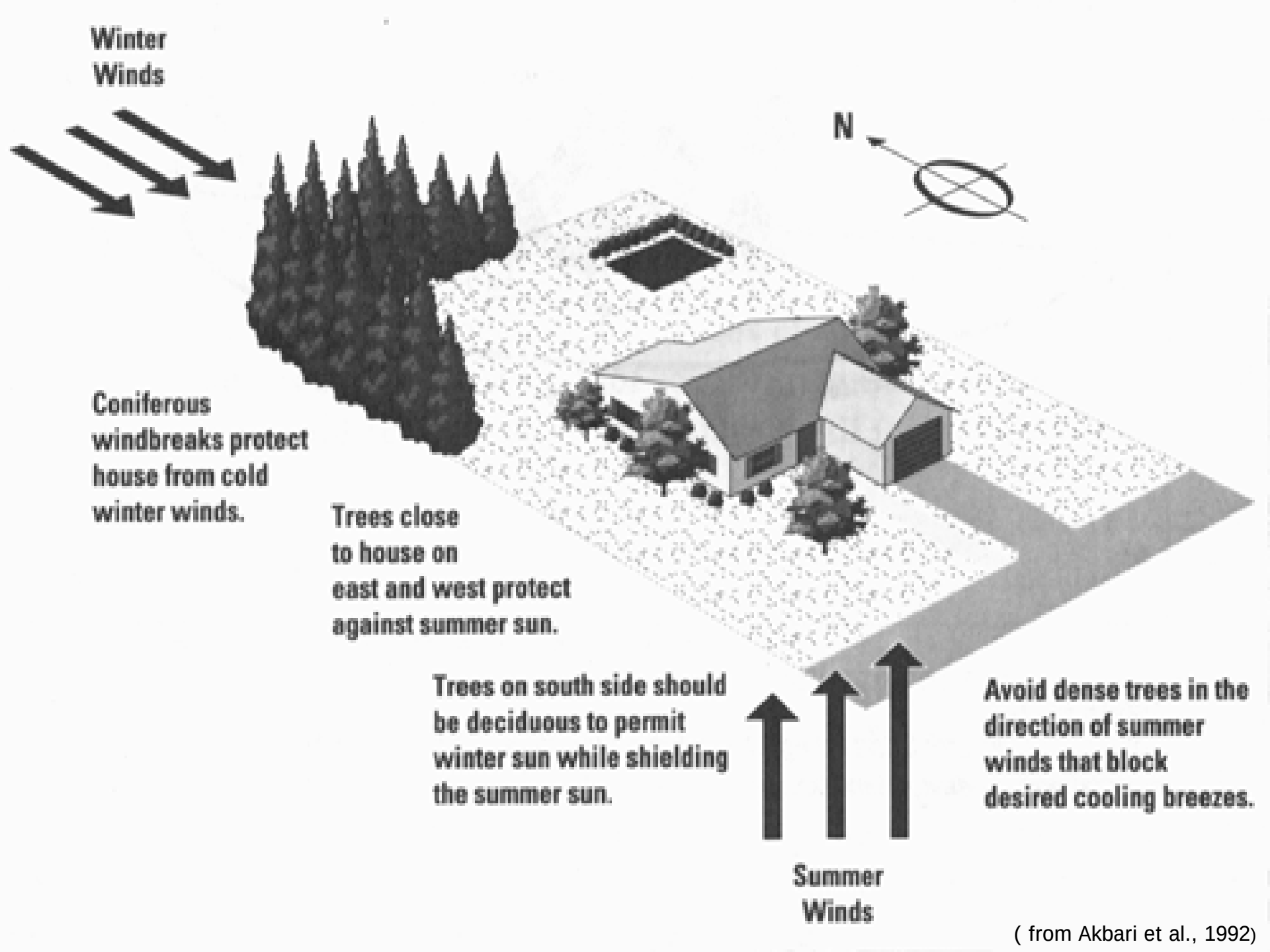

160
140
120
100
80
60
40
20
0
VOC Emission (kg)
1
3
5
7
9
11
13
15
17
19
21
23
Hour
OVOCs
Monoterpenes
Isoprene

Temperature reduction

Removal

Emissions

Energy Conservation




( from Akbari et al., 1992)

# Urban Trees and Ozone in the Northeastern United States

- Increased urban tree cover:
  - Reduced ozone ($O_3$) in urban areas (-1 ppb daytime)
  - Increased $O_3$ regionally (0.3 ppb), particularly downwind
- Physical effects of trees on pollution removal, air temperature, wind speed and boundary layer height are important
- Tree removal of $NO_x$ lead to increased $O_3$ at night (loss of $NO_x$ scavenging of $O_3$)
- Tree VOC emissions had no detectable (<1 ppb) effect on $O_3$

(Nowak, Civerolo, Rao, Sistla and Luley, 2000)


Species Effects

# Species Characteristics

- Leaf Area / Canopy size
- Transpiration / $V_d$
- Leaf biomass / VOC rates

- Landscape design is also important
  - Source vs. sink

# Leaf Characteristics (PM)

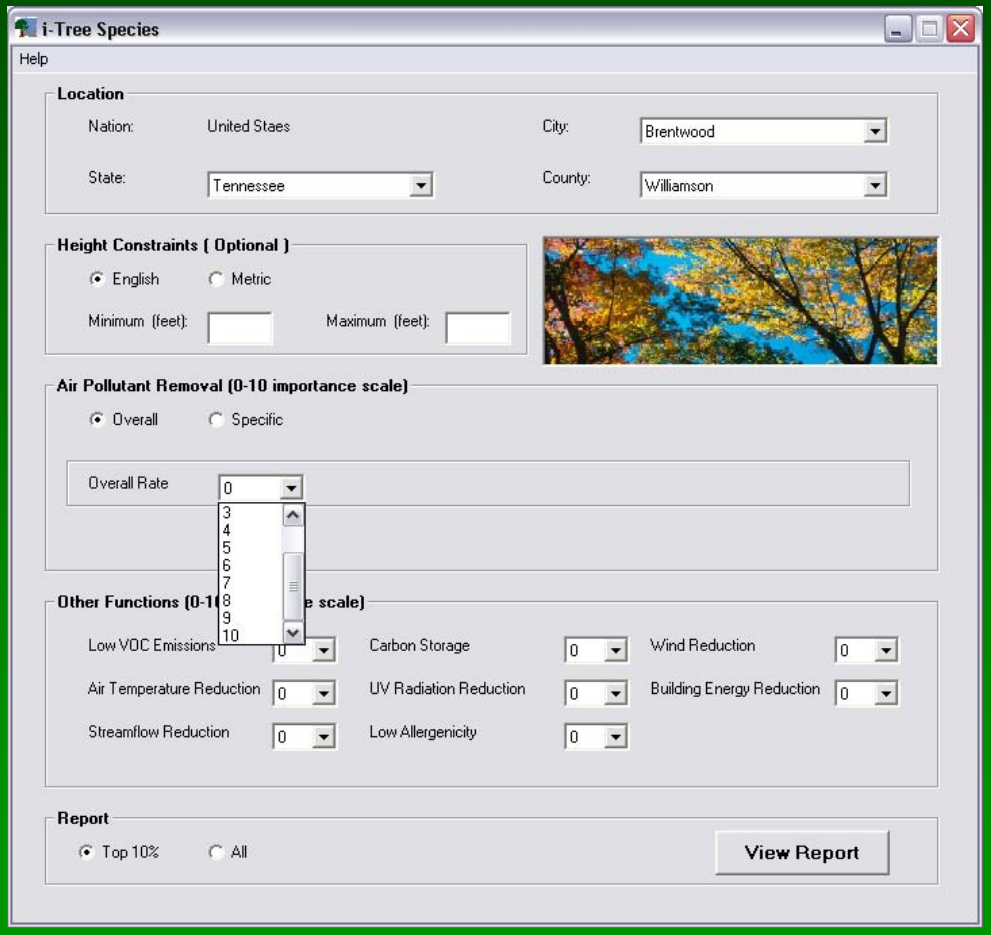
- Crown texture (fine)
- Leaf complexity (pinnate)
- Leaf size (small)
- Leaf surface
  - Rough, resinous, hairy, sticky, etc.
- Leaf margins
  - Ciliate, serrulate, filamentous

**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 $\mu$m.

( from Smith, 1990)

# i-Tree Tools


i-Tree
Species


i-Tree Species
Help
Location
Nation:
United Staes
City:
Brentwood
State:
Tennessee
County:
Williamson
Height Constraints ( Optional )
English
Metric
Minimum (feet):
Maximum (feet):
Air Pollutant Removal (0-10 importance scale)
Overall
Specific
Overall Rate
0
3
4
5
6
7
8
9
10
Other Functions (0-10 importance scale)
Low VOC Emissions
Carbon Storage
Wind Reduction
Air Temperature Reduction
UV Radiation Reduction
Building Energy Reduction
Streamflow Reduction
Low Allergenicity
Report
Top 10%
All
View Report

# Beneficial Characteristics

- Large leaf area
- High transpiration
- Low VOC emissions
- Evergreen
- Long-lived
- Low maintenance
- Healthy – right tree for location
- Leaf texture (particles)

# Research Gaps

- Local-scale studies
  - Vegetation configuration*
    - Leaf area distribution
  - Species
    - General classes
- Integrated studies
  - Local to regional

# Existing Species Information

- Near roadside studies
- Integrated ozone studies
- Air temperature modeling
- Ozone Forming Potential (Benjamin and Winer)
- i-Tree Species (~1,600 species)

# Promising Approaches

- Integrated modeling
  - EPA, FS, Universities

# Communicating Research

- Targeted outreach
  - State officials, planners, etc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