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http://www.unri.org/research-documents/
WHAT WE DO
The Urban Natural Resources Institute (UNRI) is a science-based source for information and answers to questions on urban natural resources stewardship.

PUBLIC AWARENESS
A goal of the Institute is to strengthen public awareness of activities related to urban natural resources research and management.

COLLABORATORS
The Institute consists of Forest Service scientists, conducting science-based research on urban natural resource issues across the country.

HOW CAN WE HELP YOU?
The Institute's scientific resources are available to you. Ask a question of our researchers and we will work to get you the latest answers and solutions.
Some Key Points

• Benefits of Trees Are Variable
• We Can Calculate Benefits of Trees
• We Don’t Need to Be Scientists
• Benefits are Very Often Overlooked
• Make it Part of Your Annual Planning
Urban Growth (1990-2000)

Growth 1990-2000
- < 1%
- 1 - 5%
- 5 - 10%
- > 10%
Percent Urban (2050)
## Urban Land (1990-2000)

<table>
<thead>
<tr>
<th></th>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(km²)</td>
<td>(%)</td>
<td>(km²)</td>
<td>(%)</td>
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<tr>
<td>RI</td>
<td>862</td>
<td>30.2</td>
<td>1,026</td>
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<td>NJ</td>
<td>6,280</td>
<td>31.2</td>
<td>7,304</td>
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<td>CT</td>
<td>3,947</td>
<td>30.6</td>
<td>4,591</td>
<td>35.5</td>
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<td>MA</td>
<td>6,218</td>
<td>29.2</td>
<td>7,273</td>
<td>34.2</td>
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<td>DE</td>
<td>572</td>
<td>10.9</td>
<td>787</td>
<td>15.0</td>
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<td>MD</td>
<td>3,873</td>
<td>14.3</td>
<td>4,680</td>
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<td>FL</td>
<td>12,518</td>
<td>8.3</td>
<td>16,260</td>
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<td>5.0</td>
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<td>PA</td>
<td>8,803</td>
<td>7.5</td>
<td>11,048</td>
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<td>6,888</td>
<td>4.5</td>
<td>9,700</td>
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<td>194,908</td>
<td>2.5</td>
<td>239,742</td>
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<td>US50</td>
<td>196,164</td>
<td>2.1</td>
<td>241,336</td>
<td>2.6</td>
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</table>
National average percent increase in urban land within counties (1990-2000) by percent urban land in 1990.
Percent Urban (lower 48 states)
Urban Growth (lower 48 states)

• 1990 – 2000: about the area of Vermont and New Hampshire combined

• 2000 – 2050: larger than Montana
In 1920, the urban and rural population were about equal. Today, our nation's population is > 80% urban.
Tree Cover - Nationally

Urban/Community Tree Cover

- Average US tree cover = 34.2%
- Urban/comm. tree cover = 35.1%
- Rural tree cover = 34.1%
- Urban/comm. imp. cover = 17.5%
- Rural impervious cover = 1.5%

Region and population density influence tree cover

US Tree Cover
Percent of Total Tree Cover in Cities by Land Use

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

**Grass**
- Residential: 54%
- Vacant: 20%
- Park: 11%
- Comm/ind: 4%
- Institutional: 4%
- Other: 6%

**Desert**
- Residential: 72%
- Vacant: 7%
- Park: 11%
- Comm/ind: 4%
- Institutional: 4%
- Other: 2%
Percent of Total Tree Cover in Cities by Land Use

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

- Percent of Total Tree Cover in Cities by Land Use.
Tree Cover – Urban vs Rural

Difference in Tree Cover between Urban / Community Land and Rural Land
Nature and Humans - Locally

What percent of trees in cities are planted?

- Natural regeneration: 67%
- Planted: 33%
Planting varies by city population density and region

<table>
<thead>
<tr>
<th>City</th>
<th>%Planted</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Los Angeles, CA</td>
<td>89.0</td>
<td>1.2</td>
</tr>
<tr>
<td>Mississauga, Ont.</td>
<td>57.7</td>
<td>2.0</td>
</tr>
<tr>
<td>Toronto, Ont.</td>
<td>45.9</td>
<td>1.0</td>
</tr>
<tr>
<td>Chicago, IL</td>
<td>45.0</td>
<td>1.2</td>
</tr>
<tr>
<td>Markham, Ont.</td>
<td>33.7</td>
<td>1.4</td>
</tr>
<tr>
<td>Ajax, Ont.</td>
<td>30.0</td>
<td>1.1</td>
</tr>
<tr>
<td>London, Ont.</td>
<td>29.0</td>
<td>0.9</td>
</tr>
<tr>
<td>Richmond Hill, Ont.</td>
<td>27.4</td>
<td>1.0</td>
</tr>
<tr>
<td>Vaughan, Ont.</td>
<td>25.9</td>
<td>1.1</td>
</tr>
<tr>
<td>Brampton, Ont.</td>
<td>19.9</td>
<td>1.2</td>
</tr>
<tr>
<td>Pickering, Ont.</td>
<td>18.4</td>
<td>0.7</td>
</tr>
<tr>
<td>Syracuse, NY</td>
<td>12.8</td>
<td>1.3</td>
</tr>
<tr>
<td>Hartford, CT</td>
<td>11.1</td>
<td>1.1</td>
</tr>
<tr>
<td>Baltimore, MD</td>
<td>7.3</td>
<td>2.1</td>
</tr>
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</table>
Percent planting varies by land use

<table>
<thead>
<tr>
<th>Land use</th>
<th>% Planted</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential</td>
<td>74.8</td>
<td>0.5</td>
</tr>
<tr>
<td>Commercial/Industrial</td>
<td>61.2</td>
<td>1.8</td>
</tr>
<tr>
<td>Institutional</td>
<td>19.7</td>
<td>1.5</td>
</tr>
<tr>
<td>Utilities/Transportation</td>
<td>15.1</td>
<td>1.5</td>
</tr>
<tr>
<td>Other</td>
<td>13.8</td>
<td>1.4</td>
</tr>
<tr>
<td>Park/Cemetery/Golf</td>
<td>10.7</td>
<td>0.5</td>
</tr>
<tr>
<td>Open Space/Vacant</td>
<td>7.1</td>
<td>0.3</td>
</tr>
<tr>
<td>Agriculture</td>
<td>2.0</td>
<td>0.5</td>
</tr>
<tr>
<td>Wetland/Water</td>
<td>0.8</td>
<td>0.8</td>
</tr>
</tbody>
</table>

SE = standard error.
In Addition to Expanding, Cities are Changing
Tree Cover Change

Graph showing the percentage change in tree cover for various cities. The x-axis lists cities such as Albuquerque, NM (2006-2009), Boston, MA (2001-2005), and the y-axis shows the percentage change from Year 1 to Year 2, ranging from 0% to 60%.
Tree Cover Change

- Albuquerque, NM (2006-2009)
- Atlanta, GA (2005-2009)
- Boston, MA (2001-2005)
- Chicago, IL (2005-2009)
- Denver, CO (2005-2009)
- Detroit, MI (2005-2009)
- Houston, TX (2004-2009)
- Kansas City, MO (2003-2009)
- Los Angeles, CA (2005-2009)
- Miami, FL (2003-2008)
- Minneapolis, MN (2003-2008)
- Pittsburgh, PA (2004-2008)
- Portland, OR (2002-2007)
- Spokane, WA (2003-2009)
- Syracuse, NY (2006-2008)
- Tacoma, WA (2001-2005)
US Urban Forest Statistics

- Acres of urban (2010) = 68 million
- Percent tree cover (urban) = 35%
- Estimated number of urban trees = 4.9 billion*
- Carbon storage = $50.5 billion
- Carbon sequestration = $2 billion / yr
- Pollution removal = $5.7 billion / yr*
- Energy conservation = $4.4 billion / yr*
- Avoided emissions = $1.7 billion / yr*

*unpublished
Looking at Environmental Benefits
Assessing Urban Forests

Top-down  Bottom-up
Assessing Urban Forests

**Top-down**
- Produces good cover estimates
- Can detail and map tree and other cover locations

**Bottom-up**
- Provides detailed management information
  - No. trees, spp. composition, tree sizes and health, tree locations, risk information...
- Provides better means to assess and project ecosystem services and values
  - Air pollution removal, carbon storage...
Trees in Our City: Benefits and Values
PLANTING THE SEEDS OF SUCCESS.
Trees. Worth Our Time. Worth Our Resources.

- Part of community infrastructure
- Vital to community health
- Community legacy
- Positive impact on business and tax base
- Wise investment of community dollars
Trees. Vital to Community Health.

- Tree-filled neighborhoods:
  - Lower levels of domestic violence
  - Are safer and more sociable
- Tree-filled landscapes reduce stress
- Trees decrease need for medication and speed recovery times
Trees. Important to Human Health.

- 100 trees remove five tons of CO$_2$/year
- 100 trees remove about 1000 lbs of pollutants per year, including:
  - 400 lbs of ozone
  - 300 lbs of particulates
Trees Save the Environment.

- 100 mature trees catch about 100,000 gallons of rainwater per year...
  - Less $ for stormwater control
  - Cleaner water
Trees. A Savings for Homeowners.

- Save up to 30% of annual air conditioning costs
- Save 10-25% of winter heating costs
Trees Sell Houses. (At higher prices.)

- Each large front yard tree adds 1% to sales price
- Large specimen trees can add 10%, or more, to property values.
Trees Mean Better Business.

In tree-lined commercial districts...
• More frequent shopping
• Longer shopping trips
• Shoppers spend more for parking
• Shoppers spend 12% more for goods
Trees Pay Us Back.

100 Trees Over 40 Years...

Benefits = $225,000
- Energy
- Air Quality
- Runoff
- Real Estate

Costs = $82,000
- Planting - Pruning
- Removal/Disposal
- Irrigation
- Sidewalk Repair
- Litter
- Legal - Admin

Pay Off:  $140,000
The Bottom Line

• Quality of life depends on tree benefits
• Benefits depend on healthy trees
• Healthy trees require quality care
• Quality care depends on each of us
So, Now We Know Trees Have Value...

Where do we go from here?
Managing the Urban Forest

- Methods are variable
- Individual opportunities
- Common concepts
- Shifting priorities
- Planning Guidelines
The Planning Process

1. Vision
2. Assessment
3. Strategic Planning
4. Annual Work Plan
5. Evaluation

Progressively larger cycle loops indicate growth in project scope.
Planning Steps

• Step 1: Vision
• Step 2: Assessment
• Step 3: Strategic Planning
• Step 4: Annual Work Plan
• Step 5: Evaluation

Results in a Successful and Sustainable Program
Planning Steps

- Step 1: Vision
  - Where You Want to Go
  - Includes Strategic Goal
  - May be a Mission Statement

Step 1: Vision
Step 2: Assessment
Step 3: Strategic Planning
Step 4: Annual Work Plan
Step 5: Evaluation
Planning Steps

• Step 2: Assessment
  – What We Have - The Inventory
  – Sample or Complete Type
  – Identifies and Quantifies the Resource

Step 1: Vision
Step 2: Assessment
Step 3: Strategic Planning
Step 4: Annual Work Plan
Step 5: Evaluation
Planning Steps

• Step 3: Strategic Planning
  – How to Close the Gap
  – Steps to Take
  – Prioritization of Efforts
  – Budgeting - Time & Resources

Step 1: Vision
Step 2: Assessment
Step 3: Strategic Planning
Step 4: Annual Work Plan
Step 5: Evaluation
Planning Steps

• Step 4: Annual Work Plan
  – Getting the Job Done
  – Tasks & Activities
  – Includes Partnerships, Education, Management and Planting
  – Budgeting - Staff and Resources

Step 1: Vision
Step 2: Assessment
Step 3: Strategic Planning
Step 4: Annual Work Plan
Step 5: Evaluation
Planning Steps

• Step 5: Evaluation
  – Did it get Done?
  – How Did You Do?
  – Justification for Increases - Funding, Staffing & Support
  – Important Step, but Often Not Completed
Key Component - Assessment

- Step 1: Vision
- Step 2: Assessment
- Step 3: Strategic Planning
- Step 4: Annual Work Plan
- Step 5: Evaluation

Providing a Baseline
## Projected Budget Estimates

**Based on Inventory Data**

<table>
<thead>
<tr>
<th>Description</th>
<th>Quantity</th>
<th>Price per Unit</th>
<th>Total</th>
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<tbody>
<tr>
<td>Crown Cleaning</td>
<td>500</td>
<td>$100</td>
<td>$50,000</td>
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<tr>
<td>Crown Lifting</td>
<td>300</td>
<td>$55</td>
<td>$16,500</td>
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<tr>
<td>Crown Reduction</td>
<td>120</td>
<td>$95</td>
<td>$11,400</td>
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<tr>
<td>Removal</td>
<td>20</td>
<td>$400</td>
<td>$8,000</td>
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<tr>
<td>Stumps</td>
<td>45</td>
<td>$175</td>
<td>$7,875</td>
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<tr>
<td>Vacant planting sites</td>
<td>125</td>
<td>$350</td>
<td>$43,750</td>
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</table>

**TOTAL** $137,525
Long Term Projected Cost of Maintenance

Total Estimated Costs  $137,525

- Year One  $40,000
- Year Two  $45,000
- Year Three  $52,525
Valuation

- Psychological and Aesthetic Values
- Social Values
- Historic Values
- Environmental Values
- Monetary Values
- Economics and Decision Making
Fiscal Valuation

- Size
- Species
- Condition
- Location
Valuation

This tree pays us back $9,006 in potential lifetime benefits. For more information, visit www.heartandtreealliance.org.
Valuation

Tree Facts

Serving Size: 27 in DBH (68.6 cm)
Species: Red Maple, Acer rubrum

<table>
<thead>
<tr>
<th>Amount Per Serving</th>
<th>Carbon sequestered</th>
<th>222 lbs</th>
<th>avoided 4.66 lbs</th>
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<tbody>
<tr>
<td>Total Carbon</td>
<td>690 lbs</td>
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<tr>
<td>O3</td>
<td>$4.24</td>
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<tr>
<td>VOC (Volatile Organic Compounds)</td>
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<tr>
<td>NO2 (Deposited)</td>
<td>$1.83</td>
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<tr>
<td>NO2 (Avoided)</td>
<td>$6.06</td>
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<td>SO2 (Deposited)</td>
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<td>SO2 (Avoided)</td>
<td>$2.37</td>
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<td>PM10 (Deposited)</td>
<td>$3.83</td>
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<tr>
<td>PM10 (Avoided)</td>
<td>$0.71</td>
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</table>

Conserved Kilowatt/hours: 155 KwH
Reduced oil/natural gas consumption: 56 therm(s)

Stormwater Intercepted: 3,472 gallons

Property value increase: $168.00
Natural Gas: $79.09

Storm water: $27.77
Electricity: $21.76

*Based on data from the National Forest Service and the U.S. Forest Service, Inc. This information is provided for educational purposes only. The values are approximate and may vary based on local conditions and practices.*
Focus for today...

- i-Tree Background
- Ground Based Assessment Tools
- Aerial Based Assessment Tools
Credible, USDA FS peer-reviewed tools

Public Domain Software

Accessible

Continuously improved

www.itreetools.org
Benefit Based Approach

- Comprehensive Value
- Environmental Services
- Structure
- i-Tree Tools
- Strategic Management
Since its release in 2006, over 12,600 copies have been distributed in over 100 countries. An additional 10,000 unique users of i-Tree web tools were added since 2011.
What is i-Tree?

Core programs—bottom-up approach

- All or any trees
- Street trees
- Individual trees
Minneapolis Street Tree Assessment

- $6.8 million in energy savings
- $9.1 million in reduced storm water runoff
- $1 million improvements to air quality
- $7.1 million increase in property value
Milwaukee i-Tree Eco Assessment

EAB Structural Impacts:
- 17.4% Canopy Loss
- $221 Million structural damage (citywide)

EAB Functional Impacts:
- $243,785 less pollutant removal
- $138,000 less energy savings (cooling costs)
- $2.6 million reduction in storm water benefits (1996 study)
i-Tree: Demonstrating Tree Value
i-Tree: Key Tools

Field Data

Web

Web

Desktop

Streets

Eco

Design

Canopy

Vue
Assessing Street Tree Populations

Streets assesses:
- Structure
- Function
  - Energy
  - Air pollution
  - Stormwater
  - Carbon
  - Aesthetic Value *
- Cost Benefit Ratio *
- Management needs *
- Pest Detection Module
Structure
- Number of Trees, species distribution, canopy cover, etc.

Functions / Ecosystem Services
- Energy use
- Air pollution
- Carbon
- Biogenic VOC emissions
- Rainfall interception

Management needs
- Pest risk
- Tree health
- Exotic/invasive spp.

$ Value
**Eco Inventory Option**

- Structural analysis
- Carbon sequestration & storage
- Structural tree value
- Annual pollution removal & value
- Energy effects & stormwater interception available in v5
• Human health impacts & values (e.g., reduced sick days, asthma cases, mortality, etc.)

• Rainfall interception modeling

• Pest detection & risk evaluation

• Google Maps-based sample plot generator
Eco v5 Updates

- Web-based data collection system for mobile devices
- New pollution model, including PM 2.5 & VOC estimates
- Expansion to Canada & Australia
### Human Health Impacts and Values

- Link to EPA BenMAP program
- Estimates health impacts and values due to tree effects on air quality via pollution removal

<table>
<thead>
<tr>
<th>Health Effects</th>
<th>O₃</th>
<th>NO₂</th>
<th>SO₂</th>
<th>PM₂.₅</th>
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<tr>
<td>Acute Bronchitis</td>
<td></td>
<td></td>
<td></td>
<td>√</td>
</tr>
<tr>
<td>Acute Myocardial Infarction</td>
<td></td>
<td></td>
<td></td>
<td>√</td>
</tr>
<tr>
<td>Acute Respiratory Symptoms</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>Asthma Exacerbation</td>
<td></td>
<td></td>
<td></td>
<td>√</td>
</tr>
<tr>
<td>Chronic Bronchitis</td>
<td></td>
<td></td>
<td></td>
<td>√</td>
</tr>
<tr>
<td>Emergency Room Visits</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td>√</td>
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<tr>
<td>Hospital Admissions</td>
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<tr>
<td>Lower Respiratory Symptoms</td>
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<td>√</td>
</tr>
<tr>
<td>Mortality</td>
<td>√</td>
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<td></td>
<td>√</td>
</tr>
<tr>
<td>School Loss Days</td>
<td></td>
<td></td>
<td></td>
<td>√</td>
</tr>
<tr>
<td>Upper Respiratory Symptoms</td>
<td></td>
<td></td>
<td></td>
<td>√</td>
</tr>
<tr>
<td>Work Loss Days</td>
<td></td>
<td></td>
<td></td>
<td>√</td>
</tr>
</tbody>
</table>
## Human Health Impacts - PM2.5 removal

### New York City

<table>
<thead>
<tr>
<th>Condition</th>
<th>No.</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>Acute Bronchitis</td>
<td>4.5</td>
<td>$398</td>
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<tr>
<td>Acute Myocardial Infarction</td>
<td>1.4</td>
<td>$129,347</td>
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<tr>
<td>Acute Respiratory Symptoms</td>
<td>2,931</td>
<td>$287,280</td>
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<tr>
<td>Asthma Exacerbation</td>
<td>1,919</td>
<td>$156,020</td>
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<td>Chronic Bronchitis</td>
<td>2.4</td>
<td>$681,773</td>
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<tr>
<td>Emergency Room Visits</td>
<td>8</td>
<td>$3,326</td>
</tr>
<tr>
<td>Hospital Admissions, Cardiovascular</td>
<td>1.2</td>
<td>$46,150</td>
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<tr>
<td>Hospital Admissions, Respiratory</td>
<td>0.7</td>
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<tr>
<td>Lower Respiratory Symptoms</td>
<td>55.7</td>
<td>$2,892</td>
</tr>
<tr>
<td>Mortality</td>
<td>7.6</td>
<td>$58,708,876</td>
</tr>
<tr>
<td>Upper Respiratory Symptoms</td>
<td>45</td>
<td>$2,019</td>
</tr>
<tr>
<td>Work Loss Days</td>
<td>504</td>
<td>$92,089</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>na</td>
<td><strong>$60,132,856</strong></td>
</tr>
</tbody>
</table>
i-Tree Design

- Parcel level analysis of individual or multiple trees
- General public use
- Web accessible by all
This year your 36 inch American elm tree will reduce atmospheric carbon dioxide by 1,631 pounds.

How significant is this number? Most car owners of an "average" car (mid-sized sedan) drive 12,000 miles generating about 11,000 pounds of CO₂ every year. A flight from New York to Los Angeles adds 1,400 pounds of CO₂ per passenger.

Trees can have an impact by reducing atmospheric carbon in two primary ways (see figure at left):

- They sequester ("lock up") CO₂ in their roots, trunks, stems and leaves while they grow, and in wood products after they are harvested.
- Trees near buildings can reduce heating and air conditioning demands, thereby reducing emissions associated with power production.

Combating climate change will take a worldwide, multifaceted approach, but by planting a tree in a strategic location, driving fewer miles, or replacing business trips with conference calls, it's easy to see how we can each reduce our individual carbon "footprints."

For more information see the USDA Forest Service's Community Tree Guide series.
This 36 inch American elm provides overall benefits of: $148 every year.

While some functional benefits of trees are well documented, others are difficult to quantify (e.g., human social and communal health). Trees' specific geography, climate, and interactions with humans and infrastructure is highly variable and makes precise calculations that much more difficult. Given these complexities, the results presented here should be considered initial approximations to better understand the environmental and economic value associated with trees and their placement.

Benefits of trees do not account for the costs associated with trees' long-term care and maintenance.

If this tree is cared for and grows to 41 inches, it will provide $163 in annual benefits.
In 15 years, your selected trees will provide overall benefits of: $291.06.

While some functional benefits of trees are well documented, others are difficult to quantify (e.g., human social and communal health). Trees' specific geography, climate, and interactions with humans and infrastructure is highly variable and makes precise calculations that much more difficult. Given these complexities, the results presented here should be considered initial approximations to better understand the environmental and economic value associated with trees and their placement.

Benefits of trees do not account for the costs associated with trees' long-term care and maintenance.

Breakdown of your tree's benefits

Click on one of the tabs above for more detail
Step 2: Map Your House

1. Draw Outline of House
   - Use the trace tool to outline your house. Once outlined and by clicking the finish trace icon, or double click. Watch Video Tutorial.

2. Pick Your Tree
   - Choose one of these pre-selected trees great for your area to help save energy.

3. Place Your Tree
   - Once you have selected your tree simply click on the map where you want to plant.

4. See Your Savings
   - Estimated savings based on research.
   - Estimate My Savings →

---

Tree: Crape Myrtle, Common
Community Savings: $17
Energy Savings: 6.2 kWh
Watt-hours: 18,672
Model Tree Planting Projects

Photo courtesy of Gene Hyde
In 25 years, your selected trees will intercept 49517.60 gallons of stormwater.

Urban stormwater runoff (or "non-point source pollution") washes chemicals (oil, gasoline, salts, etc.) and litter from surfaces such as roadways and parking lots into streams, wetlands, rivers and oceans. The more impervious the surface (e.g., concrete, asphalt, rooftops), the more quickly pollutants are washed into our community waterways. Drinking water, aquatic life and the health of our entire ecosystem can be adversely affected by this process.

Trees act as mini-reservoirs, controlling runoff at the source. Trees reduce runoff by:

- Intercepting and holding rain on leaves, branches and bark
- Increasing infiltration and storage of rainwater through the tree's root system
- Reducing soil erosion by slowing rainfall before it strikes the soil

For more information see the USDA Forest Service's Community Tree Guide series.
Main Screen

- Web App
- No Login
- Required

1. Define area
2. Configure survey
3. Assess points
### Cover Report

**Percent Cover (±SE)**

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>22.6</td>
<td>26.2</td>
<td>14.8</td>
<td>8.80</td>
<td>21.0</td>
</tr>
<tr>
<td>±1.87</td>
<td>±1.97</td>
<td>±1.59</td>
<td>±1.25</td>
<td>±1.82</td>
</tr>
<tr>
<td>4.20</td>
<td>2.60</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>±0.90</td>
<td>±0.71</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cover Class</th>
<th>Description</th>
<th>Abbr.</th>
<th>% Cover</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grass/Herbaceous</td>
<td>H</td>
<td></td>
<td>22.6 ±1.87</td>
</tr>
<tr>
<td>Tree/Shrub</td>
<td>T</td>
<td></td>
<td>26.2 ±1.97</td>
</tr>
<tr>
<td>Impervious Buildings</td>
<td>IB</td>
<td></td>
<td>14.8 ±1.59</td>
</tr>
<tr>
<td>Impervious Road</td>
<td>IR</td>
<td></td>
<td>8.80 ±1.25</td>
</tr>
<tr>
<td>Impervious Other</td>
<td>IO</td>
<td></td>
<td>21.0 ±1.82</td>
</tr>
<tr>
<td>Water</td>
<td>W</td>
<td></td>
<td>4.20 ±0.90</td>
</tr>
<tr>
<td>Soil/Bare Ground</td>
<td>S</td>
<td></td>
<td>2.50 ±0.71</td>
</tr>
</tbody>
</table>

**About i-Tree Canopy**

The concept and prototype of this program were developed by David J. Nowak, Jeffery T. Walton and Eric J. Greenfield (USDA Forest Service). The current version of this program was developed and adapted to i-Tree by David Ellingsworth, Mike Binkley, and Scott Macei (The Davey Tree Expert Company).

**Limitations of i-Tree Canopy**

The accuracy of the analysis depends upon the ability of the user to correctly classify each point into its correct class. As the number of points increase, the precision of the estimate will increase as the standard error of the estimate will decrease. If too few points are classified, the standard error will be...
Aerial Based Assessment Tools

- NLCD National Land Cover Dataset (i-Tree Vue)
- UTC Urban Tree Canopy Analysis - high resolution imagery
- Photo-interpretation
- (i-Tree Canopy)
- NASA Landsat 7
- 1999 - present
- 440 miles altitude

- Land Cover
  - 29 classes:
    - Developed/Urban
    - Forested
    - Wetland
    - Agriculture

- Tree Canopy
  - 0 - 100%

- Impervious Cover
  - Pavement
  - Buildings
  - 0 - 100%

- Lincoln Memorial
- U.S. Capitol
- 14th St Bridge
- Pentagon
i-Tree Vue

NASA Landsat
+ MRLC NLCD
+ USFS Research
+ i-Tree Development

Urban Forest Estimates
i-Tree Vue: Obtaining Data

Free!
Nationwide!
Easy to Download!

www.mrlc.gov
Startup:

Load & Clip Imagery
Differences in tree canopy cover estimates between photo-interpreted values and NLCD 2001 by mapping Zone. (Nowak & Greenfield, 2010)
# Tree Canopy Ecosystem Services Benefits

**Executive Summary of Estimates**

*More than just beauty and shade, trees work for us all every day to clean the air we breathe.*

**Date:** 12/18/2013 9:29:20 PM

## LAID COVER

<table>
<thead>
<tr>
<th></th>
<th>Area</th>
<th>Impervious</th>
<th>Tree Canopy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>acres</td>
<td>%</td>
<td>acres</td>
</tr>
<tr>
<td>Entire Area</td>
<td>12,622.5</td>
<td>100</td>
<td>1,764.5</td>
</tr>
<tr>
<td>Developed, All Classes</td>
<td>7,534.1</td>
<td>58.1</td>
<td>1,760.0</td>
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<tr>
<td>Forested, All Classes</td>
<td>2,174.8</td>
<td>17.2</td>
<td>2.7</td>
</tr>
<tr>
<td>Wetlands, All Classes</td>
<td>932.9</td>
<td>7.4</td>
<td>0.5</td>
</tr>
<tr>
<td>Agriculture, All Classes</td>
<td>1,768.0</td>
<td>14.0</td>
<td>1.4</td>
</tr>
<tr>
<td>Miscellaneous, All Classes</td>
<td>185.0</td>
<td>0.8</td>
<td>0.0</td>
</tr>
<tr>
<td>Water</td>
<td>307.6</td>
<td>2.4</td>
<td>n/a</td>
</tr>
</tbody>
</table>

## CARBON DIOXIDE

<table>
<thead>
<tr>
<th></th>
<th>Annual Sequestration</th>
<th>Total Storage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CO2 stored each year</td>
<td>total accumulated CO2</td>
</tr>
<tr>
<td></td>
<td>short tons</td>
<td>short tons</td>
</tr>
<tr>
<td>Entire Area</td>
<td>19,555.4</td>
<td>379,873.7</td>
</tr>
<tr>
<td>Developed, All Classes</td>
<td>8,343.4</td>
<td>162,074.8</td>
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<tr>
<td>Forested, All Classes</td>
<td>6,895.9</td>
<td>133,956.9</td>
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<tr>
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<td>3,161.7</td>
<td>61,417.2</td>
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<tr>
<td>Agriculture, All Classes</td>
<td>1,086.5</td>
<td>21,105.6</td>
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<tr>
<td>Miscellaneous, All Classes</td>
<td>67.9</td>
<td>1,319.4</td>
</tr>
</tbody>
</table>

## AIR POLLUTION

<table>
<thead>
<tr>
<th></th>
<th>TOTAL</th>
<th>CO</th>
<th>NO2</th>
<th>O3</th>
<th>Sulfur</th>
<th>PM10</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>all pollutants</td>
<td>Carbon</td>
<td>Monoxide</td>
<td>Nitrogen</td>
<td>Oxide</td>
<td>Sulfur</td>
</tr>
<tr>
<td></td>
<td>total</td>
<td>total $</td>
<td>$</td>
<td>$</td>
<td>$</td>
<td>$</td>
</tr>
<tr>
<td>Entire Area</td>
<td>220,065.1</td>
<td>967,641.4</td>
<td>3,534.4</td>
<td>2,635.8</td>
<td>39,423.7</td>
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<td>93,891.8</td>
<td>412,848.4</td>
<td>1,550.6</td>
<td>1,124.6</td>
<td>16,820.3</td>
<td>85,886.4</td>
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<tr>
<td>Forested, All Classes</td>
<td>77,602.7</td>
<td>341,224.4</td>
<td>1,281.6</td>
<td>925.5</td>
<td>13,902.2</td>
<td>79,986.2</td>
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<tr>
<td>Wetlands, All Classes</td>
<td>35,579.6</td>
<td>156,446.2</td>
<td>587.6</td>
<td>426.1</td>
<td>6,373.9</td>
<td>32,546.1</td>
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<tr>
<td>Agriculture, All Classes</td>
<td>12,226.7</td>
<td>53,761.6</td>
<td>201.9</td>
<td>146.4</td>
<td>2,190.4</td>
<td>11,184.2</td>
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<tr>
<td>Miscellaneous, All Classes</td>
<td>764.3</td>
<td>3,560.9</td>
<td>12.6</td>
<td>9.2</td>
<td>136.9</td>
<td>699.2</td>
</tr>
</tbody>
</table>
Easily determine best species for desired tree benefits
• Quantifies effects of:
  - Tree cover
  - Impervious cover

• on:
  - Hourly stream flow
  - Water quality

• Gwynns Falls Watershed, Baltimore

* Current vs. Management Scenario

Percent Tree Cover

Percent Change (%)
i-Tree: What’s new in Version 5.0 (2012)?
## Reducing Risk

| Spp. Risk | Common Name          | ALB | EAB | OW  | LAT | PSB | WPBR | BC  | GM  | SB  | AL  | DA  | BBW | SBW | LWD | SW  | SPB | HWA | FR  | SOD | WSB | TCD | MPB | DFB | FE  | JPB | POCR | WPB | DED | CB  |
|-----------|----------------------|-----|-----|-----|-----|-----|------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| 14        | Willow spp           |     |     |     |     |     |      |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 14        | Quaking aspen        |     |     |     |     |     |      |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 14        | Peachleaf willow     |     |     |     |     |     |      |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 14        | Pussy willow         |     |     |     |     |     |      |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 14        | Black willow         |     |     |     |     |     |      |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 14        | Weeping willow       |     |     |     |     |     |      |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 14        | Narrowleaf willow    |     |     |     |     |     |      |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 13        | Norway spruce        |     |     |     |     |     |      |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 12        | Eastern white pine   |     |     |     |     |     |      |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 11        | River birch          |     |     |     |     |     |      |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 11        | Paper birch          |     |     |     |     |     |      |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 11        | Gray birch           |     |     |     |     |     |      |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 10        | Scotch pine          |     |     |     |     |     |      |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 9         | Douglas fir          |     |     |     |     |     |      |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 8         | Green ash            |     |     |     |     |     |      |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 8         | Northern red oak     |     |     |     |     |     |      |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 8         | Austrian pine        |     |     |     |     |     |      |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 8         | Pin oak              |     |     |     |     |     |      |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
### Invasive Tree Species

**Trees on Maryland Invasive Species List within Baltimore**

<table>
<thead>
<tr>
<th>Species</th>
<th>% of Population</th>
<th>No. Trees</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tree of heaven</td>
<td>5.6</td>
<td>138,000</td>
</tr>
<tr>
<td>Norway maple</td>
<td>0.7</td>
<td>17,700</td>
</tr>
<tr>
<td>Callery pear</td>
<td>0.7</td>
<td>17,200</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>7.0</strong></td>
<td><strong>172,900</strong></td>
</tr>
</tbody>
</table>
### Human Health Impacts and Values

#### Link to EPA BenMAP program

Estimates health impacts and values due to tree effects on air quality via pollution removal

<table>
<thead>
<tr>
<th>Health Effects</th>
<th>$O_3$</th>
<th>$NO_2$</th>
<th>$SO_2$</th>
<th>$PM_{2.5}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acute Bronchitis</td>
<td></td>
<td></td>
<td></td>
<td>√</td>
</tr>
<tr>
<td>Acute Myocardial Infarction</td>
<td></td>
<td></td>
<td></td>
<td>√</td>
</tr>
<tr>
<td>Acute Respiratory Symptoms</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>Asthma Exacerbation</td>
<td></td>
<td></td>
<td></td>
<td>√</td>
</tr>
<tr>
<td>Chronic Bronchitis</td>
<td></td>
<td></td>
<td></td>
<td>√</td>
</tr>
<tr>
<td>Emergency Room Visits</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>Hospital Admissions</td>
<td>√</td>
<td>√</td>
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<td>√</td>
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<tr>
<td>Lower Respiratory Symptoms</td>
<td></td>
<td></td>
<td></td>
<td>√</td>
</tr>
<tr>
<td>Mortality</td>
<td>√</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>School Loss Days</td>
<td></td>
<td></td>
<td></td>
<td>√</td>
</tr>
<tr>
<td>Upper Respiratory Symptoms</td>
<td></td>
<td></td>
<td></td>
<td>√</td>
</tr>
<tr>
<td>Work Loss Days</td>
<td></td>
<td></td>
<td></td>
<td>√</td>
</tr>
</tbody>
</table>
Some Key Points

• Benefits of Trees Are Variable
• We Can Calculate Benefits of Trees
• We Don’t Need to Be Scientists
• Benefits are Very Often Overlooked
• Make it Part of Your Annual Planning
Find this presentation online

http://www.unri.org/research-documents/
Placing a Value on Trees

David Bloniarz
USDA Forest Service
Amhest, MA